

PROTA

Medicinal plants 1

Plant Resources of Tropical Africa 11(1)

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- I. Vandebroek, Institute of Economic Botany, The New York Botanical Garden, Kazimiroff Boulevard and 200 Street, Bronx, New York 10458, United States (*Capsella bursa-pastoris*)
- E.A. Wheeler, Department of Wood and Paper Science, College of Forest Resources, North Carolina State University, P.O. Box 8005, Raleigh, NC 27695-8005, United States (wood anatomy)
- C. Zimudzi, Department of Biology, National University of Lesotho, P.O. Roma 180, Lesotho (*Adenia lobata*, *Lycopodium clavatum*, *Phytolacca dodecandra*, *Piper capense*)

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Introduction

Choice of species

PROTA 11(1): 'Medicinal plants 1' is the first volume of 4 describing the wild, and sometimes cultivated, plant species of tropical Africa traditionally used in local medicine. Some of these plants are not only used for human health care, but are also applied as veterinary medicine or as poisonous plants used as pesticide, fish poison or dart poison, and narcotic plants. Most species have several other, secondary, uses. PROTA normally assigns one primary use and if relevant, one or more secondary uses to all plant species used in Africa. For instance, the primary use of *Voacanga africana* Stapf is as a medicinal plant, and thus it is treated in PROTA 11, but it has several secondary uses, e.g. the branches are used in construction and to make musical instruments, the wood is used for firewood, good fibre for rope and yarn can be obtained from the bark and the fruits are considered edible. In Tanzania *Voacanga africana* is planted for ornamental purposes because of its sweet-scented white flowers. Pharmaceutical companies in Europe extract tabersonine from the seeds, which is readily converted into vincamine, a compound widely used in medicines for geriatric patients. Seed extracts are also used in medicines to treat heart diseases, to lower blood pressure and to treat cancer. Also *Carissa spinarum* L. (synonym: *Carissa edulis* (Forssk.) Vahl) is quite important as a medicinal plant, but its primary use is as a fruit, and consequently it is described in PROTA 6: 'Fruits'.

The remaining 'primary use' medicinal plants will be included in tomes 11(2) to 11(4). In the final tome 11(4), the 'secondary use' medicinal plants will be listed as 'Medicinal plants with other primary use' and referred to other Handbook volumes. In PROTA 11(1), one species is treated which, in addition to the primary use as medicinal plant, also has another primary use and consequently will be described in 2 commodity groups. This species is *Jatropha curcas* L. (also in PROTA 14: 'Vegetable oils').

In this volume the medicinal plant species of several important medicinal plant-containing families are treated, the largest families being *Apocynaceae*, *Asphodelaceae*, *Caesalpiniaceae*, *Euphorbiaceae*, *Loganiaceae*, *Menispermaceae* and *Solanaceae* as well as 19 other families with few but important medicinal plants.

In PROTA 11(1): 'Medicinal plants 1' comprehensive descriptions are given of 134 important medicinal plant species. These major medicinal plants comprise most wild species, but also several cultivated or partly domesticated species. The accounts are presented in a detailed format and illustrated with a line drawing and a distribution map. In addition, accounts of 272 medicinal plants of minor importance are given. Because information on these species is often scanty, these accounts are in a simplified format and usually do not include a drawing or map. For another 488 species the medicinal information was too scarce to justify an individual treatment and they have only been mentioned in the accounts of related species. Each account will highlight traditional and modern uses, phytochemical and pharmacological properties, will make identification of useful species easier and more reliable, will describe

most convenient collection (harvest), cultivation and application methods, and will indicate the research and conservation status of the plants.
About two third of the plant species used in tropical Africa have some documented medicinal use, but the actual number is probably higher. For PROTA 11, however, only species have been chosen for which proof was found in the literature on African useful plants that they actually are or have been used as a medicinal plant. Such literature, however, is scarce, often old and usually poor in details about the use. Only species for which at least a practical application is known have been considered for treatment. This means that species mentioned in the literature but only with remarks such as 'the plant is medicinally used' or 'the roots are medicinally used' have not been included.
In Sub-Saharan Africa, traditional medicine has been for centuries and still is the most affordable and accessible health care system. Medicinal plants contribute significantly to rural livelihoods of the people and social equilibrium in Africa. The demand of local and international markets is continuously growing, as well as bioprospecting activities searching for sources of news drugs.
As a result of their widely and unsustainable use, increasing economic importance, and environmental factors, medicinal plant resources are diminishing at an alarming rate. Besides, the loss of indigenous knowledge on medicinal plants and traditional medicine is increasing, especially in Africa, as a result of death of the older people who have traditionally been the custodians of this knowledge, and the sociocultural transformation of societies. This situation calls for policies and research programmes, both at national and international levels, for conservation and sustainable use of medicinal plants, as well as for the protection of indigenous communities' rights over the use of their traditional knowledge.

Plant names

Family: Apart from the classic family name, the family name in accordance with the Angiosperm Phylogeny Group (APG) classification is also given where it differs from the classic name.
Synonyms: Only the most commonly used synonyms and those that may cause confusion are mentioned.
Vernacular names: Only names in official languages of regional importance in Africa are included: English, French, Portuguese and Swahili. It is beyond the scope of PROTA to give an extensive account of the names of a species in all languages spoken in its area of distribution. Checking names would require extensive fieldwork by specialists. Although regional forms of Arabic are spoken in several countries in Africa, the number of African plant species that have a name in written, classical Arabic is limited. Arabic names are therefore omitted. Names of plant products are mentioned under the heading 'Uses'.

Origin and geographic distribution

To avoid long lists of countries in the text, a distribution map is added for major species. The map indicates in which countries a species has been recorded, either wild or planted. For many species, however, these maps are incomplete because they are prepared on the basis of published information, the quantity and quality of

which varies greatly from species to species. This is especially the case for wild species which are not or incompletely covered by the regional African floras, and for cultivated species which are only planted on a small scale (e.g. in home gardens). For some countries (e.g. Central African Republic, Chad, Sudan, Angola) there is comparatively little information in the literature. Sometimes they are not covered by recent regional or national floras and although species may be present there, this cannot be demonstrated or confirmed.

Properties

The phytochemistry of the different plant parts is given, with emphasis on the bioactive compounds. Where possible, a link is made between the traditional uses of a plant part, the active compounds isolated from it and pharmacological tests confirming or not confirming the activity of these active compounds, or of the plant extracts containing active compounds.

Description

A morphological characterization of the species is given. The description is in 'telegram' style and uses botanical terms. Providing a description for the general public is difficult as more generally understood terms often lack the accuracy required in a botanical description. A line drawing is added for all major and some lesser-known species to complement and visualize the description.

Management

Descriptions of husbandry methods including fertilizer application, irrigation, and pest and disease control measures are given under 'Management' and under 'Diseases and pests'. These reflect actual practices or generalized recommendations, opting for a broad overview but without detailed recommendations adapted to the widely varying local conditions encountered by farmers. Recommendations on chemical control of pests and diseases are merely indicative and local regulations should be given precedence. PROTA will participate in the preparation of derived materials for extension and education, for which the texts in this volume provide a basis, but to which specific local information will be added.

Genetic resources

The genetic diversity of many plant species in Africa is being eroded, sometimes at an alarming rate, as a consequence of habitat destruction and overexploitation. The replacement of landraces of cultivated species by modern cultivars marketed by seed companies is another cause of genetic erosion. Reviews are given of possible threats for plant species and of the diversity within species and reference is made to the IUCN red list of threatened species where relevant. Information on ex-situ germplasm collections is mostly extracted from publications of Bioversity International (formerly the International Plant Genetic Resources Institute – IPGRI).

References

The main objective of the list of references given is to guide readers to additional information; it is not intended to be complete or exhaustive. Authors and editors have selected major and other references; major references are limited to 10 references (5 for minor species), the number of other references is limited to 20 (10 for minor species). The references listed include those used in writing the account. Where data available on the internet have been used, the website and date are also cited.

Alphabetical treatment of medicinal plants

ACALYPHA CILIATA Forssk.

Protologue Fl. aegypt.-arab.: 162 (1775).
Family Euphorbiaceae
Chromosome number $n = 10$
Origin and geographic distribution *Acalypha ciliata* occurs from Senegal east to Ethiopia and south to Namibia and South Africa. It also occurs in Yemen, Pakistan, India and Sri Lanka, and probably elsewhere as a weed.

Uses In Côte d'Ivoire a leaf decoction is drunk to treat female sterility. In Ghana mashed leaves are applied as a dressing to sores. In East Africa a root infusion is taken to treat schistosomiasis. In Senegal, Benin and Nigeria the leaves are eaten as a vegetable. In Senegal the plant is widely browsed by cattle, sheep and goats, but not by horses.

Properties In an in-vitro experiment an aqueous leaf extract reduced the growth of *Fusarium moniliforme* (*Gibberella fujikuroi*) on maize grain. In field trials the leaf extract showed moderate activity against brown blotch disease (*Colletotrichum capsici*) and insect pests (*Ootheca mutabilis*, *Nezara viridula*, *Clavigralla tomentosicollis* and *Maruca testulalis*) of cowpea.

Botany Monoecious, annual herb up to 1 m tall; stems shortly hairy. Leaves arranged spirally, simple; stipules linear, c. 2 mm long; petiole up to 7.5 cm long; blade ovate to elliptical-ovate, 4–10 cm × 1.5–5 cm, base cuneate to rounded, apex acuminate, margins coarsely toothed, membranous, sparingly and shortly hairy on both surfaces, later almost glabrous, 3–5-veined at base and with 4–5 pairs of lateral veins. Inflorescence an axillary, solitary or paired spike up to 5 cm long, densely flowered, lower 35–70% with female flowers, upper part with male flowers, sometimes terminated by a female flower; bracts in female flowers transversely ovate, becoming c. 6 mm × 12 mm, with many filiform segments 1.5–3 mm long. Flowers unisexual, sessile, petals absent; male flowers with 4-lobed, minute, granular dotted, greenish calyx, stamens 8, anthers yellow; female flowers with 3 ovate-lanceolate, c. 1 mm long, ciliate sepals, ovary superior, c. 0.5 mm in diameter, 3-celled, slightly 3-lobed, styles 3, free, c. 2 mm long, fringed, white. Fruit a 3-lobed capsule c. 1.5 mm × 2.5 mm, smooth, almost glabrous, splitting into 3 cocci, each 2-valved and 1-seeded. Seeds ovoid-globose, c. 1 mm in diameter, smooth, brown, caruncle elliptical.

Acalypha comprises about 460 species and occurs throughout the tropics, subtropics and warm temperate regions, excluding Europe. In tropical Africa about 65 species occur and in Madagascar and other Indian Ocean islands about 35 species.

Ecology *Acalypha ciliata* occurs on open and wooded grassland, in deciduous and coastal bushland, often in rocky or damp localities, near lakes and on flood plains, from sea-level up to 1650 m altitude. It is also a weed in fields. It avoids high rainfall areas.

Management As a weed, *Acalypha ciliata* can be controlled well by handweeding and several herbicides. In India *Acalypha ciliata* is a host of powdery mildew (*Erysiphe cichoracearum*); in Ghana it was found to be a host of root-knot nematodes (*Meloidogyne* spp.).

Genetic resources and breeding *Acalypha ciliata* is widespread and weedy and not threatened by genetic erosion.

Prospects *Acalypha ciliata* is not commonly used as a medicinal plant, and its use will probably remain limited. With respect to crop protection, its insecticidal and fungicidal properties merit further research.

Major references Burkill, 1994; Halvankar et al., 2005; Neuwinger, 2000; Owolade, Amusa & Osikanlu, 2000; Radcliffe-Smith, 1996a.
Other references Owolade et al., 2004.
Authors G.H. Schmelzer

ACALYPHA FRUTICOSA Forssk.

Protologue Fl. aegypt.-arab.: 161 (1775).
Family Euphorbiaceae
Chromosome number $2n = 20$
Vernacular names Gonasokola, mchacha, mnukovunda (Sw).
Origin and geographic distribution *Acalypha fruticosa* occurs from Sudan east to Somalia and south through East Africa and DR Congo to southern Africa, avoiding the humid Congo Basin. It is also found in Yemen, southern India, Sri Lanka and Myanmar.

Uses The Suiei hunter-gatherers of northern Kenya boil the root in goat bone soup and drink the soup to treat liver problems, and stomachache caused by eating too much honey. A root decoction is drunk to treat convulsions, fever, colds and swellings of the scrotum. A root infusion is taken to treat whooping cough. The filtrate of the macerated leaves in water or milk is taken to treat constipation. The stem and root are chewed to treat toothache. In southern Africa a root decoction is taken to treat snake-

bites, fever and ulcers of venereal origin. In Tanzania a leaf decoction is drunk to treat epilepsy. A leaf infusion is taken to treat stomach problems and swellings of the body. A leaf maceration is used as eye-drops to treat eye infections. Leaf sap is swallowed or used as nose drops to treat cough and chest problems. Ground leaves are applied as a paste to scabies and sores. Ground fresh leaves mixed with water are rubbed in and inhaled as a sedative. Stems ground in water are applied to wounds of animals.

The Suiei people of northern Kenya use the stem to make arrow shafts, and beehive lids. In Tanzania the leafy shoots of *Acalypha fruticosa* are eaten as a vegetable. In East Africa *Acalypha fruticosa* is an important browse plant of sheep. In Ethiopia the dried leaves are used as a substitute for tea.

Properties An aqueous leaf extract showed significant antibacterial activity against *Staphylococcus aureus* and *Enterococcus faecalis* in vitro. The root extract did not show any antifungal activity. The methanol leaf extract showed antioxidant activity in vitro and anti-inflammatory activity in rats. In laboratory experiments larvae of several species of livestock ticks were particularly attracted to *Acalypha fruticosa* because of the odour of the plant. In the wild, larvae of especially *Rhipicephalus appendiculatus* are commonly found on *Acalypha fruticosa*.

Botany Monoecious, much-branched, aromatic shrub up to 4 m tall; stems hairy and green at first, later almost glabrous and reddish brown. Leaves arranged spirally, simple; stipules narrowly lanceolate, 3–4 mm long, brown; petiole 0.5–4.5(–7) cm long; blade broadly ovate to rhombic-ovate, (1–)3–7(–9) cm × 1–5 cm, base cuneate to rounded, apex acuminate, margins toothed, sparingly to evenly shortly hairy on both surfaces, sparingly to evenly yellowish gland-dotted beneath, membranous, 5(–7)-veined at base and with (2–)4–5 pairs of lateral veins. Inflorescence an axillary, solitary spike up to 5 cm long, the lower part interrupted, with 1–4(–7) female flowers, the upper part with densely congested male flowers, terminated by a female flower; peduncle hairy; bracts in female flowers broadly ovate to kidney-shaped, c. 1 cm × 1–1.5 cm, toothed, sparingly yellow gland-dotted, prominently ribbed. Flowers unisexual, sessile, petals absent; male flowers with 4-lobed, minute, densely white hairy calyx, stamens 8; female flowers with 3 ovate-lanceolate, c. 1 mm long, ciliate sepals, ovary superior, c. 0.5 mm in diameter, 3-celled, 3-lobed to almost globose, densely shortly hairy, styles 3, free, c. 4 mm long, fringed, pink or red. Fruit a 3-lobed capsule c. 2 mm × 3 mm, yellow gland-dotted, densely shortly hairy, splitting into 3 cocci, each 2-valved and 1-seeded. Seeds ellipsoid-ovoid, 1.5–2 mm × 1–1.5 mm, smooth, brown, caruncle elliptical.

The ratio of male to female flowers per inflorescence increases from bottom to top inflorescences and also increases with altitude.

Acalypha comprises about 460 species and occurs throughout the tropics, subtropics and warm temperate regions, excluding Europe. In tropical Africa about 65 species occur and in Madagascar and other Indian Ocean islands about 35 species. Several other perennial *Acalypha* species with male and female flowers on the same inflorescence have medicinal uses. A root decoction of *Acalypha engleri* Pax & K.Hoffm. from south-eastern Kenya and Tanzania is taken to treat back-ache. The head is rubbed with a leaf extract to treat headache. In East Africa a root decoction of *Acalypha neptunica* Müll.Arg., occurring from Ghana to East Africa, is taken as a diuretic. The twigs are used as arrow shafts. A root decoction of *Acalypha volkensii* Pax from East Africa is taken in milk to treat gonorrhoea. The ground whole plant is applied to scabies, and the root juice to sores. Ground leaves are inhaled to treat severe cough. A root infusion is taken as a purgative. The branches are used to make arrows.

Ecology *Acalypha fruticosa* occurs in coastal and deciduous bushland and thickets, wooded grassland, riverine grassland, on rocky shores or outcrops, and in humid localities, from sea-level up to 1400 m altitude. It is common in overgrazed areas.

Genetic resources and breeding *Acalypha fruticosa* is relatively common in its distribution area and not threatened by genetic erosion.

Prospects *Acalypha fruticosa* has several interesting medicinal uses, but information concerning the chemical compounds responsible for these activities is lacking. Information concerning the antibacterial activities is incomplete; more research is therefore warranted.

Major references Alasbahi, Safiyeva & Craker, 1999; Gupta et al., 2003b; Neuwinger, 2000; Radcliffe-Smith, 1996a.

Other references le Floc'h et al., 1985; Hassan, Dipeolu & Malonza, 1994; Ichikawa, 1987;

Khan, 2001; Kokwaro, 1993; Terashima & Ichikawa, 2003.

Authors G.H. Schmelzer

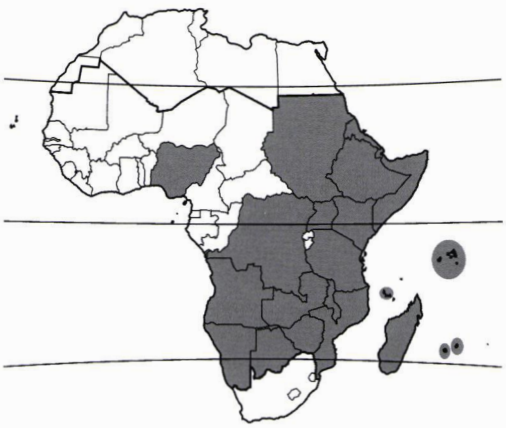
ACALYPHA INDICA L.

Protologue Sp. pl. 2: 1003 (1753).
Family Euphorbiaceae
Chromosome number $2n = 20, 28$
Vernacular names Indian acalypha, Indian nettle, three-seeded mercury (En). Ricinelle des Indes, oreille de chatte, herbe chatte (Fr).

Origin and geographic distribution *Acalypha indica* occurs in Nigeria and from Sudan east to Somalia and south through DR Congo and East Africa to southern Africa including South Africa. It is also widespread in the Indian Ocean islands and occurs furthermore in India, South-East Asia and Oceania. It was introduced into the warmer parts of the New World.

Uses In East Africa the leaf sap is used as eye drops to treat eye infections. In Namibia ground leaves in water are used for this purpose. Leaf powder is applied to maggot-infested wounds. In Comoros a leaf decoction is used as a massage cream to treat pain of the joints. In the Seychelles and Réunion a root infusion or decoction is taken to treat asthma, and also to clean the liver and kidneys. In the Seychelles a root decoction is also taken to treat intestinal worms and stomach-ache. A leaf infusion together with a tuber infusion of *Jumellea fragrans* (Thouars) Schltr. and sweetened with honey is taken to treat bronchitis. The leaves are emetic and an infusion together with the roots of *Tylophora indica* (Burm.f.) Merr. is taken in Réunion in case of poisoning. A leaf infusion is also taken as a purgative. In Madagascar the crushed aerial parts are applied to skin parasites and an infusion is taken as a purgative and vermifuge. In Mauritius the juice of the crushed leaves mixed with salt or a decoction of the aerial parts is applied to scabies and other skin problems. A poultice made from the whole plant is applied to treat headache. The leaf sap is taken as an emetic and the root decoction as a laxative. *Acalypha indica* was formerly listed in the British Pharmacopoeia. It has numerous medicinal uses in India and is listed in the Pharmacopoeia of India as an expectorant to treat asthma and pneumonia.

In north-eastern Africa *Acalypha indica* is browsed by sheep and goats. In India and Indonesia the plant is cultivated for its edible shoots and leaves, which are cooked as a vegetable.



Acalypha indica – wild

Properties The dried aerial parts contain a cyanogenic glycoside, acalyphin (0.3%) which is a 3-cyanopyridone derivative. Flavonoids, notably the kaempferol glycosides mauritianin, clitorin, nicotiflorin and biorobin, have been isolated from the flowers and leaves. The plant also contains tannins, β-sitosterol (0.1%), acalyphamide, aurantiamide, succinimide and the pyranoquinolinone alkaloid flindersin. Some of the compounds of *Acalypha indica* cause intense, dark chocolate-brown discolouration of blood, and gastro-intestinal irritation in rabbits. Furthermore, ingestion of herbal medicine containing *Acalypha indica* may lead to haemolysis in patients suffering from glucose-6-phosphatase dehydrogenase deficiency.

Ethanol extracts of *Acalypha indica* show significant selective activity against vesicular stomatitis viruses. Cytotoxic activity was observed against HeLa cell lines.

An ethanol leaf extract showed significant inhibition to *Viper russelli* venom-induced lethality, haemorrhage, necrotizing and mast cell degranulation in rats and the cardiotoxic and neurotoxic effects in isolated frog tissue. Administration of an ethanol extract also significantly inhibited venom-induced lipid peroxidation and catalase levels of rat kidney tissue. Petroleum ether and ethanol extracts of the whole plant showed significant post-coital antifertility activity in female rats, and this anti-implantation activity was reversible on withdrawal of the extracts. Both extracts showed estrogenic activity at 600 mg/kg body weight. An ethanol extract of the aerial parts showed

moderate wound-healing activity when topically applied to rats.
Crude extracts as well as hexane, chloroform, acetone and methanol fractions of shoots, leaves and roots showed antibacterial and antifungal activity; the chloroform extract of shoots and leaves demonstrated the highest activity. It also showed larvicidal activity against the larvae of *Aedes aegypti* and *Tribolium casteneum*. A leaf paste showed significant in vitro (48 hr) and in vivo (14 days) acaricidal activity against *Psoroptes cuniculi* infesting rabbits.
Acalyphin is used as a substitute for ipecacuanha from *Psychotria ipecacuanha* (Brot.) Stokes, as a vermifuge, expectorant and emetic.
Analysis of the shoots yielded per 100 g edible portion: water 80 g, energy 269 kJ (64 kcal), protein 6.7 g, fat 1.4 g, carbohydrate 6 g, fibre 2.3 g, Ca 667 mg, P 99 mg, Fe 17 mg and ascorbic acid 147 mg.

Description Monoecious, annual to sometimes short-lived perennial herb up to 1.5(–2.5) m tall; stems sparingly to densely hairy. Leaves arranged spirally, simple; stipules linear, c. 2 mm long; petiole up to 12 cm long; blade broadly ovate to ovate-lanceolate, 2–9 cm × 1–5 cm, base cuneate, apex acute, margins toothed, membranous, sparingly shortly hairy to almost glabrous on both surfaces, more hairy along the midrib, 5-veined at base and with 4(–5) pairs of lateral veins. Inflorescence an axillary, solitary or paired spike up to 6(–10) cm long, lower 75% with laxly arranged female flowers, upper part with densely congested male flowers, usually terminated by a female flower; bracts in female flowers transversely ovate to almost orbicular, 0.5–1 cm × 1–1.5 cm, toothed, each subtending 1–2(–5) flowers. Flowers unisexual, sessile, petals absent; male flowers with 4-lobed, minute, granular dotted, greenish calyx, stamens 8; female flowers with 3 triangular-ovate, c. 1 mm long, ciliate sepals, ovary superior, c. 0.5 mm in diameter, 3-celled, slightly 3-lobed, styles 3, fused at base, c. 2 mm long, fringed, white. Fruit a 3-lobed capsule c. 1.5 mm × 2 mm, granular dotted, shortly hairy, splitting into 3 cocci, each 2-valved and 1-seeded. Seeds ovoid, c. 1.5 mm × 1 mm, smooth, grey, caruncle linear, appressed; terminal flower producing 1 seed.

Other botanical information *Acalypha* comprises about 460 species and occurs throughout the tropics, subtropics and warm temperate regions, excluding Europe. In tropical Africa about 65 species occur and in Madagascar and other Indian Ocean islands about 35 species. Several other annual *Acalypha* species with male and female flowers in the same inflorescence have medicinal uses. The leaf sap of *Acalypha supera* Forssk. (synonym: *Acalypha brachystachya* Hornem.), from Central and East Africa and other parts of the Old World tropics, is used as eye drops in Gabon to treat headache. The leaf powder of *Acalypha lanceolata* Willd. from Central and southern Africa and other parts of the Old World tropics, mixed with castor oil (*Ricinus communis* L.) is applied to scabies. In South-East Asia the uses of *Acalypha lanceolata* are similar to those of *Acalypha indica*; in India the plant is cultivated for its edible shoots, which are eaten as a cooked vegetable.



Acalypha indica – 1, flowering twig; 2, female flowers with bract; 3, apex of inflorescence.
Source: PROSEA

Growth and development *Acalypha indica* flowers throughout the year in regions without a pronounced dry season.

Ecology *Acalypha indica* occurs on sandy margins of rivers and seasonal water courses, usually in the shade of thickets, also on rocky hillsides, often in disturbed localities and as a weed of fields, from sea-level up to 1350 m altitude.

Propagation and planting *Acalypha indica* is only propagated by seed.

Management Although *Acalypha indica* is cultivated in India for its edible shoots, not much information is available on its management. The plants need fair amounts of water and nutrients to grow quickly and stay tender. *Acalypha indica* is often considered a noxious weed.

Diseases and pests The leaves of *Acalypha indica* may suffer from *Alternaria* leaf spot; in India the plant is sometimes severely affected by *Pseudocercospora acalyphae*. It is also a host of several plant viruses, e.g. pumpkin yellow vein mosaic virus, okra yellow vein mosaic virus, leaf curl virus and Nicotiana virus 10, often resulting in very severe and recurrent outbreaks in crops. Roots may suffer from nematode infestation (e.g. *Meloidogyne* spp.). In India *Acalypha indica* is a host of the spiralling whitefly (*Aleurodicus dispersus*).

Harvesting Leaves, roots or whole plants of *Acalypha indica* are harvested when in full bloom.

Handling after harvest After harvesting, the plants are used fresh or simply dried for future use.

Genetic resources *Acalypha indica* is a common plant with a weedy nature and is therefore not threatened by genetic erosion.

Prospects *Acalypha indica* is an important medicinal plant in the Indian Ocean islands as well as in India for its expectorant properties. It also has significant antibacterial and antifungal activities, both against human and plant pathogens, and it would be worthwhile continuing research to isolate the active compounds. Care needs to be taken when using the species as a vegetable as it contains several alkaloids as well as hydrocyanic acid.

Major references Burkill, 1994; Gopalakrishnan et al., 2000; Gurib-Fakim, Guého & Bissoondoyal, 1996; Hiremath et al., 1999; Lavergne & Véra, 1989; Masih & Singh, 2005; Nahrstedt, Hungeling & Petereit, 2006; Neuwinger, 2000; Shirwaikar et al., 2004; Siregar, 2001.

Other references Adjanohoun et al., 1983a; Adjanohoun et al. (Editors), 1982; Ali et al., 1996; Andriamanga, 1995; Gurib-Fakim et al., 1993; Hiremath et al., 1993; Lamabadusuriya & Jayantha, 1994; Prema, 2004; Reddy, Rao &, 2002; Samy, Ignacimuthu & Raja, 1999; Singh et al., 2004; Solomon, Kallidass & Vimalan, 2005; Talapatra, Goswami & Talapatra, 1981.

Sources of illustration Siregar, 2001.

Authors G.H. Schmelzer

ACALYPHA INTEGRIFOLIA Willd.

Protologue Sp. pl. 4(1): 530 (1805).

Family Euphorbiaceae

Vernacular names Bois queue de rat, bois de crève cœur, bois de Charles (Fr).

Origin and geographic distribution *Acalypha integrifolia* occurs in Madagascar, Réunion and Mauritius.

Uses In Réunion and Mauritius a leaf decoction is taken as an astringent and purgative, used to eliminate intestinal worms. A bath in the leaf decoction is taken to treat skin infections.

Properties The leaves, stems and roots contain saponins, tannins, sterols, terpenes and traces of alkaloids.

Botany Monoecious shrub up to 2 m tall; branches erect and branchlets spreading, glabrous. Leaves arranged spirally, simple; stipules narrowly triangular, 1–9 mm long; petiole 2–20 mm long; blade elliptical-ovate, obovate-elliptical to oblong, 4–13(–18) cm × 1–4.5(–6.5) cm, base rounded, truncate or cordate, apex acute to obtuse, margins toothed, membranous, glabrous, pinnately veined, green, sometimes with red margins, or green above and purple to red below. Male inflorescence an axillary, solitary spike up to 20 cm long, many-flowered, flowers in groups, peduncle short, shortly hairy; female inflorescence an axillary cluster, 1–5-flowered, bracts broad, obovate, 2–5 mm long. Flowers unisexual, sessile, petals absent; male flowers with 4-lobed, minute, almost glabrous calyx, green to reddish, stamens 8, free, anthers curled; female flowers with 3 minute sepals, ovary superior, covered with fleshy spines, 3-celled, styles 3, fused at base, deeply fringed, red. Fruit a 3-lobed capsule 3–4 mm long, spiny. Seeds ovoid, 2.5–3 mm long, pale brown.

Acalypha comprises about 460 species and occurs throughout the tropics, subtropics and warm temperate regions, excluding Europe. In tropical Africa about 65 species occur and in Madagascar and other Indian Ocean islands about 35 species. *Acalypha integrifolia* is a variable species and 3 subspecies and 7 varieties have been distinguished. Several other *Acalypha* species with medicinal uses are endemic to the Indian Ocean islands. A leaf decoction of *Acalypha lyallii* Baker, from Madagascar and the Comoros, is used to massage parts of the body to treat rheumatism. A decoction of the aerial parts or stem bark of *Acalypha andringitrensis* Leandri and *Acalypha*

radula Baill., both from Madagascar, is taken or inhaled to treat fever and syphilis. The crushed leaves are topically applied to treat scabies. A leaf infusion of *Acalypha decaryana* Leandri from Madagascar is taken as a purgative to treat dysentery. A decoction of the leafy stems of *Acalypha spachiana* Baill. from Madagascar is taken to treat venereal diseases. The flexible stems are used to make baskets. The stems also yield a black dye.

Ecology *Acalypha integrifolia* occurs in shrub land from sea-level up to 1000 m altitude.

Genetic resources and breeding *Acalypha integrifolia* is relatively common and not threatened by genetic erosion, although several of the subspecies and varieties are restricted to small areas and/or known from few collections.

Prospects *Acalypha integrifolia* is only occasionally used as a medicinal plant and is likely to remain of local importance, unless new pharmacological research reveals interesting pharmacological activities.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Coode, 1982; Gurib-Fakim & Brendler, 2004; Lavergne, 2001.

Other references Adjanohoun et al. (Editors), 1982; Neuwinger, 2000; Pernet & Meyer, 1957; Said & Petitjean, 1995.

Authors G.H. Schmelzer

ACALYPHA ORNATA Hochst. ex A.Rich.

Protologue Tent. fl. abyss. 2: 247 (1851).

Family Euphorbiaceae

Vernacular names Mchakati, mjiakhati, mckakari, mchacha (Sw).

Origin and geographic distribution *Acalypha ornata* occurs from Nigeria east to Eritrea and south to Namibia, Botswana, Zimbabwe and Mozambique.

Uses In southern Nigeria the leaves are pounded together with those of other plants in water, and the liquid is given to children with rabies. In the Central African Republic cooked leaves are eaten to relieve post-partum pain and a root decoction is taken as a laxative. In Tanzania water in which leaves have been soaked is used to wash children with scabies. A leaf decoction is used as a bath to treat haemorrhoids, and a root decoction is also drunk for the same purpose. An infusion of the aerial parts is applied to an infected navel in newborn babies. A fresh root decoction is drunk and used as a wash to treat leprosy and menstruation pain. Plant ash is rubbed on the chest to treat pain. Powdered leaves together with powdered flowers of *Psorospermum febrifugum* Spach are sprinkled on circumcision wounds.

In Tanzania the stems are woven into baskets and fish traps. The leaves are chopped and cooked and eaten with rice or pounded maize; sometimes groundnut, coconut milk, onion or tomato are added to improve the taste. In East Africa the foliage is browsed by livestock. The leaves are used for bedding material. In DR Congo the stems are used to make arrow shafts. The wood is sometimes used as firewood. *Acalypha ornata* is sometimes planted as an ornamental.

Properties Leaf and root extracts show slight molluscicidal activity against the fresh water snail *Bulinus globulus*.

Botany Monoecious, much-branched, perennial herb or lax shrub up to 2.5(–5) m tall; stems almost glabrous to hairy. Leaves arranged spirally, simple; stipules linear-lanceolate, 4–10 mm long, soon falling; petiole (2–)3–10(–15) cm long; blade ovate to elliptical-ovate, 5–16 cm × 3–10 cm, base cuneate, rounded, truncate or shallowly cordate, apex acuminate, margins coarsely toothed, membranous, sparingly shortly hairy to almost glabrous on both surfaces, more hairy along the midrib, 5-veined at base and with 4–7 pairs of lateral veins. Male inflorescence an axillary, solitary raceme up to 15 cm long, many-flowered, peduncle short; female inflorescence a terminal, solitary spike up to 17 cm long, peduncle short, bracts ovate-rhomboid, c. 1.5 cm × 2.5 cm, toothed, enlarging in fruit. Flowers unisexual, petals absent; male flowers with pedicel c. 1.5 mm long, calyx 4-lobed, minute, almost glabrous, green to reddish, stamens 8, free, anthers curled, yellowish white; female flowers sessile, sepals 3, triangular, c. 1 mm long, ciliate, ovary superior, c. 1 mm in diameter, 3-lobed and 3-celled, styles 3, free, c. 3 mm long, fringed, red. Fruit a 3-lobed capsule c. 3 mm × 4 mm, apex sparingly hairy, splitting into 3 cocci, each 2-valved and 1-seeded. Seeds ovoid-globose, c. 2 mm × 1.5 mm, smooth, purplish grey, caruncle elliptical, brownish yellow.

Acalypha comprises about 460 species and occurs throughout the tropics, subtropics and warm temperate regions, excluding Europe. In tropical Africa about 65 species occur and in Madagascar and other Indian Ocean islands about 35 species. Several other shrubby *Acalypha* species with male and female flowers on

separate inflorescences have medicinal uses. The leaf sap of *Acalypha chirindica* S.Moore, known from DR Congo, Tanzania and southern Africa, is taken in Tanzania to treat dizziness; a root decoction is drunk to treat kidney pain. A leafy stem decoction of *Acalypha manniana* Müll.Arg., occurring from Ghana east to Uganda, Rwanda and Burundi, is taken by the Abayanda people of Uganda to treat diarrhoea. *Acalypha racemosa* Baill. occurs in tropical Africa, India, Sri Lanka and some islands of Indonesia. In East Africa a leaf poultice is applied to the back to treat kidney pain and hernia. Leaf ash is rubbed into cuts to relieve body pain. Root and leaf decoctions are taken as an emetic and antidote. In India *Acalypha racemosa* is grown as a vegetable.

Ecology *Acalypha ornata* occurs in forest undergrowth and forest margins, wooded grassland, deciduous woodland and thickets, often in riverine or rocky localities, or in secondary vegetation, from sea-level up to 2000 m altitude.

Management The leaves and roots of *Acalypha ornata* are mainly collected from the wild during the rainy season. Plants can be propagated by seed and cuttings. In Central Africa *Acalypha ornata* is a host of the cotton helopeltis (*Helopeltis schoutedeni*), one of the most important pests of cotton and *Eucalyptus* spp.

Genetic resources and breeding *Acalypha ornata* is common throughout its large distribution area and therefore not threatened by genetic erosion.

Prospects *Acalypha ornata* has several medicinal uses, but nothing is known on the chemistry and pharmacology of the plant. Unless more research is done, the species will remain of local importance only. Its uses as a vegetable, fibre plant and ornamental deserve further research.

Major references Burkill, 1994; Neuwinger, 2000; Radcliffe-Smith, 1996a; Ruffo, Birnie & Tengnäs, 2002.

Other references Haerdi, 1964; Hamill et al., 2000; Ichikawa, 1987; Kokwaro, 1993; Mtengeti & Mhelela, 2006; Terashima & Ichikawa, 2003.

Authors G.H. Schmelzer

ACALYPHA PSILOSTACHYA Hochst. ex A.Rich.

Protologue Tent. fl. abyss. 2: 246 (1850).

Family Euphorbiaceae

Origin and geographic distribution *Acalypha psilostachya* occurs from Sudan and Ethiopia south to Malawi, Zambia, Angola and Mozambique.

Uses In Burundi a leaf decoction is taken to treat headache, to expel a retained placenta and as a tonic for pregnant women. The leaf sap is taken to stop bleeding during pregnancy and to treat amenorrhoea. A decoction of leafy twigs is used as an eye bath and the leaf sap is used as eye drops to treat conjunctivitis. A leaf decoction is drunk or the ash of leafy twigs is sniffed to treat pain in the side. An infusion of the leafy twigs is drunk and the steam is inhaled to treat dizziness. A leaf decoction is used as an enema to treat diarrhoea, and the decoction is drunk to treat intestinal parasites.

Botany Monoecious, erect, perennial herb or shrub up to 3 m tall; stems sparsely to densely hairy, with or without glandular hairs. Leaves arranged spirally, simple; stipules linear-lanceolate, 2–4 mm long; petiole up to 11 cm long, slender; blade ovate to ovate-lanceolate, 2–15 cm × 1–9 cm, base rounded to cordate, apex acuminate, margins toothed, membranous, shortly hairy to almost glabrous on both surfaces, more hairy along the midrib, (5–)7–9-veined at base and with 4–6 pairs of lateral veins. Inflorescence an axillary, solitary or paired spike up to 9(–12) cm long, with mainly male flowers and (1–)3–4(–8) female flowers at the base; peduncle hairy; bracts of female flowers deeply 5–7-lobed, lobes linear-lanceolate to ovate-lanceolate, the median lobe up to 8 mm × 12 mm. Flowers unisexual, sessile, petals absent; male flowers with 4-lobed, minute, shortly hairy, reddish calyx, stamens 8, free, anthers yellowish; female flowers with 3 ovate, c. 0.5 mm long, ciliate sepals, ovary superior, c. 0.5 mm in diameter, slightly 3-lobed, densely shortly hairy, 3-celled, styles 3, free, 2–3 mm long, fringed, white. Fruit a 3-lobed capsule c. 1.5 mm × 2.5 mm, densely shortly hairy. Seeds ovoid-globose, c. 1 mm × 1 mm, smooth, brown, caruncle small.

Acalypha comprises about 460 species and occurs throughout the tropics, subtropics and warm temperate regions, excluding Europe. In tropical Africa about 65 species occur and in Madagascar and other Indian Ocean islands about 35 species. *Acalypha psilostachya* comprises 2 varieties with mainly overlapping dis-

tribution areas; var. *psilostachya*, with densely hairy stem and inflorescence, and var. *glandulosa* Hutch., which is variably hairy, but also has glandular hairs.

Ecology *Acalypha psilostachya* grows in moist submontane forest undergrowth, in valleys, also in submontane grassland and swamp forest, persisting in disturbed localities, at 500–3000 m altitude.

Management The leaves and leafy stems of *Acalypha psilostachya* are mainly collected from the wild during the rainy season.

Genetic resources and breeding *Acalypha psilostachya* is relatively widespread in the mountainous regions of its distribution area and there are no signs that it is genetically threatened.

Prospects The only known uses of *Acalypha psilostachya* are from Burundi, where it has numerous medicinal applications. Research into the chemical composition and pharmacological activities of the compounds is warranted.

Major references Neuwinger, 2000; Radcliffe-Smith, 1996a.

Other references Radcliffe-Smith, 1987.

Authors G.H. Schmelzer

ACALYPHA VILLICAULIS Hochst.

Protologue Sched. Schimperi Iter. Abyss., sectio secunda, coll. no.: 737 (1842).

Family Euphorbiaceae

Synonyms *Acalypha brachiata* Krauss (1845), *Acalypha petiolaris* Hochst. ex C.Krauss (1845), *Acalypha senensis* Klotzsch (1861), *Ricinocarpus petiolaris* (Hochst. ex C.Krauss) Kuntze (1891).

Origin and geographic distribution *Acalypha villicaulis* occurs from Senegal east to Ethiopia and south to South Africa and Swaziland.

Uses The Tenda people of Senegal place the chopped leaves on wounds to improve healing. The steam of a leaf decoction is inhaled to treat fever. Leaf ash in water is taken to treat elephantiasis. In Rwanda the pounded leaves, twigs and flowers are applied to snakebites. The fresh or dried aerial parts are crushed and the decoction drunk to treat liver diseases. In East and southern Africa a leaf infusion is applied to wounds and sores. In Uganda a leaf maceration is taken to treat epilepsy. A root infusion is given to children who suffer from burning urine. A root decoction is widely taken to treat diarrhoea, and also to treat cough, as an aphrodisiac, and to prevent premature ejaculation. In southern Africa a root decoction is drunk as an abortifacient and contraceptive. The root powder or paste with fat is applied to treat itch. In Namibia a root decoction is taken to treat cough. The pounded and heated leaves are applied to wasp stings. In Zimbabwe a root decoction is taken to treat bloody diarrhoea, asthma and male sterility. In Senegal and Zimbabwe the water in which roots are soaked is used to bathe constipated babies; the water may also be drunk.

Botany Monoecious perennial herb or small shrub up to 2 m tall, with woody rootstock; stems erect, ascending or decumbent, hairy. Leaves arranged spirally, simple; stipules subulate-filiform, 1.5–4(–6) mm long, glandular at base; petiole 1–3(–5) cm long, hairy, with 2 glands at base; blade ovate-lanceolate to lanceolate, (2–)5–12.5(–14) × 1–4 cm, base cordate, apex acuminate, margins coarsely toothed, membranous, shortly hairy on both surfaces, more hairy along the midrib, 7-veined at base and with 5–8 pairs of lateral veins. Male inflorescence an axillary, solitary raceme up to 12 cm long, many-flowered; female inflorescence a terminal, solitary, head-shaped spike up to 3 cm long, peduncle short, bracts transversely ovate, c. 0.5 cm × 1 cm, toothed, with glandular hairs, enlarging in fruit. Flowers unisexual, petals absent; male flowers with pedicel c. 1 mm long, calyx 4-lobed, minute, almost glabrous, yellowish green, stamens 8, free, anthers curled, yellow; female flowers sessile, sepals 3, ovate-lanceolate, c. 1 mm long, ciliate, ovary superior, c. 1 mm in diameter, 3-lobed to globular, 3-celled, styles 3, free, c. 1.5 mm long, fringed, red. Fruit a 3-lobed capsule c. 4 mm × 5 mm, sparingly hairy, splitting into 3 cocci, each 2-valved and 1-seeded. Seeds ovoid-globose, c. 2.5 mm × 2 mm, smooth, dark grey, caruncle depressed-hemispherical.

Acalypha comprises about 460 species and occurs throughout the tropics, subtropics and warm temperate regions, excluding Europe. In tropical Africa about 65 species occur and in Madagascar and other Indian Ocean islands about 35 species. Several other small perennial *Acalypha* species with male and female flowers in separate inflorescences have medicinal uses. In Burundi a root decoction of *Acalypha ambigua* Pax, occurring from Burundi south to Namibia and Zimbabwe, is drunk or used as an enema or in a vapour bath to treat insanity and possession. The plant is widely browsed by livestock. *Acalypha allenii* Hutch. occurs in

south-eastern Africa; in Zimbabwe an infusion of the pounded roots mixed with bone meal is taken to treat oedema. Root paste is used as an enema to treat diarrhoea of children. A root infusion is drunk as an aphrodisiac.

Ecology *Acalypha villicaulis* is widespread in open woodland and grassland, and also in coastal and lakeshore grassland, sometimes in riverine and submontane forest, from sea-level up to 2200 m altitude.

Genetic resources and breeding *Acalypha villicaulis* has a large distribution area and is common. It is therefore not threatened by genetic erosion.

Prospects *Acalypha villicaulis* has many medicinal uses, especially in eastern and southern Africa to treat diarrhoea and cough, and externally to treat wounds. The species will remain of local importance only though, unless research into the chemical composition and pharmacology gives interesting results.

Major references Gelfand et al., 1985; Neuwinger, 2000; Radcliffe-Smith, 1996a.

Other references Burkill, 1994; Ramathal & Ngassapa, 2001; Stäuble, 1986; Tabuti, Lye & Dhillion, 2003.

Authors G.H. Schmelzer

ACOKANTHERA OBLONGIFOLIA (Hochst.) Codd

Protologue Bothalia 7: 449 (1961).

Family Apocynaceae

Chromosome number $2n = 22$

Synonyms *Acokanthera spectabilis* (Sond.) Hook.f. (1878), *Carissa spectabilis* (Sond.) Pichon (1948).

Vernacular names Dune poison bush, wintersweet (En).

Origin and geographic distribution *Acokanthera oblongifolia* occurs in southern Mozambique and eastern South Africa.

Uses *Acokanthera oblongifolia* is used medicinally to treat snakebites and as an emetic. To treat snakebites, a small amount of the leaves is eaten, a leaf decoction is drunk and the leaf pulp is rubbed into the wound, root powder is sniffed and roots or leaves are put on the swollen part as a dressing. Root scrapings are rubbed into the skin against itch. A wood or leaf decoction is drunk or administered as an enema as a cure for internal worms, and to combat evil spirits. The fruit is highly toxic, especially when unripe, but the ripe fruits have also caused fatalities in children. The stem bark and root bark are used as a potent arrow poison, for homicide, suicide and to kill stray dogs.

Properties Numerous cardenolides were detected in the wood, leaves, seeds and fruit, the most important being acovenosides A and B, which both have cardio-vascular properties. Other cardenolides that were isolated are acovenoside C, spectabiline and acopieroside II. The last compound shows a higher activity than digitalin and digoxin as a cardiotonic. The seeds yielded acobioside A and 14-O-acetylacovenoside C; the latter showed marked cardiotonic activity in dogs.

Botany Evergreen shrub or small tree up to 6 m tall; young branches glabrous, conspicuously angled and ribbed. Leaves decussately opposite, simple and entire; stipules absent; petiole 4–12 mm long; blade elliptical, 6–12 cm × 1.5–5 cm, base cuneate or rounded, apex acute to obtuse, mucronate, leathery, glossy, glabrous, pinnately veined, lateral veins inconspicuous, with looping connections. Inflorescence a dense axillary cyme, many-flowered. Flowers bisexual, regular, 5-merous, fragrant; sepals free, ovate to lanceolate, 2.5–3 mm long, apex acuminate to acute, shortly hairy or glabrous outside, ciliate; corolla tube cylindrical, 14–20 mm long, glabrous or shortly hairy outside, inside sparsely hairy in the upper half and wrinkled below, white tinged pink, lobes broadly ovate, 3–7 mm long, apex rounded, glabrous to shortly hairy on both sides, ciliate or not, white; stamens inserted near the top of the corolla tube, included; ovary superior, ellipsoid, faintly ribbed, 2-celled, style slender, stigma minutely bifid. Fruit an ellipsoid to globose berry 2–2.5 cm long, purple when ripe, 1–2-seeded. Seeds ellipsoid, plano-convex, c. 1.5 cm long, smooth, glabrous.

Acokanthera comprises 5 species and is restricted to Africa, with one species also found in Yemen. It is related to *Carissa*. *Acokanthera oblongifolia* fruits from February to April.

Ecology *Acokanthera oblongifolia* occurs in dry forest and thickets on coastal dunes.

Genetic resources and breeding There are no indications that *Acokanthera oblongifolia* is at risk of genetic erosion.

Prospects The cardenolides isolated from *Acokanthera oblongifolia* are highly poisonous. Most of them have not been pharmacologically investigated, and more research is needed to evaluate the possible prospects of the various compounds. *Acokanthera oblongifolia* is easy to propagate, like the other *Acokanthera* species,

and it would be a beautiful ornamental in gardens. However, this is not recommended because of its toxicity.

Major references Hanna et al., 1998; Kupicha, 1982; Neuwinger, 2000.

Other references Coates Palgrave, 1983; Karawya, Abdel-Wahab & Niazi, 1974; van Wyk, van Heerden & van Oudtshoorn, 2002.

Authors G.H. Schmelzer

ACOKANTHERA OPPOSITIFOLIA (Lam.) Codd

Protologue Bothalia 7: 448 (1961).

Family Apocynaceae

Synonyms *Acokanthera longiflora* Stapf (1922).

Vernacular names Bushman poison, wintersweet, common poison bush (En). Msunguti (Sw).

Origin and geographic distribution *Acokanthera oppositifolia* occurs from Kenya south to South Africa, and to southern DR Congo in the west.

Uses Bark, root, wood and leaves are used in the preparation of arrow poison, and also for hunting, suicide and homicide. The only treatment against the poison is immediate excision of the flesh around the wound. The poison is also used for killing wild animals (hyenas, elephants, buffaloes, leopards, lions) and stray dogs. Fatal accidents have been caused by eating meat grilled over a fire of sticks from this tree. To treat snakebites and spider bites, a small amount of the leaves is eaten, a leaf or root decoction is drunk and the leaf or root pulp is rubbed into the wound. Alternatively, root powder is sniffed and a dressing made of roots or leaves is put on the swollen part. A root infusion is taken to treat syphilis. In South Africa root powder or leaf powder is sniffed to cure headache, while a leaf infusion is used as a nasal spray for this purpose. Small pieces of the stem are chewed against toothache. A leaf infusion is taken to treat abdominal pain, colds, measles and blood poisoning. A root infusion is taken to expel tapeworm and to treat excessive and irregular menstruation. Poisoning of livestock is rare, but the risk increases during droughts.



Acokanthera oppositifolia – wild

The pulp of the ripe fruit is edible and has a sweetish bitter taste. It is relished by birds and animals and has also been used in making jams and preserves. The unripe fruits and seeds are highly poisonous, and accidental poisoning of children has been recorded. Children use the latex of the fruit as chewing gum. *Acokanthera oppositifolia* has beautiful flowers and is grown as an ornamental although it is poisonous. It is sometimes marketed as a container plant in South Africa and in subtropical and temperate regions.

Production and international trade The poison made from the wood, leaves and roots of *Acokanthera oppositifolia* is traded in small amounts among tribes. Arrow tips are also smeared with the poison in exchange for money. There are no data on traded volumes or value.

Properties All parts of *Acokanthera oppositifolia*, except for the pulp of the ripe fruit, contain large amounts of cardiac glycosides (cardenolides), of which about 15 have been identified. The glycosides are responsible for the activity as arrow poison, but also act as cardiac stimulant. The main compound is acovenoside A (1.2–2.4%), with acovenosigenin as aglycone, followed by acolongifloroside K (acolongifloriside K) (0.3–0.4%), with ouabagenin as aglycone. *Acokanthera oppositifolia* plants from South Africa contain twice as much acovenoside A as plants from Kenya, but less acolongifloroside K. Minor components include acovenoside C, opposide, acofrioside L, acolongifloroside H and and traces of ouabain. The constitution is location dependent.

Patent applications have been submitted for the use of acovenoside A for treating muscle pain. Acolongifloroside K, opposide and ouabain are the most cardioactive compounds; they are highly toxic and can cause death even in minute doses. The other compounds are slightly less toxic. Cardiac glycosides are given in low doses to treat patients suffering from

congestive heart failure. In higher doses, cardiac glycosides have a direct inhibiting action on the atrioventricular conduction and cause a decrease of the heart rate. Injection of the arrow poison into an animal causes death almost immediately, while humans inflicted with an arrow wound die in 30 minutes to 2 hours. Animals that eat the leaves or immature fruit show dullness, followed by violent spasms, paralysis and finally death.

Adulterations and substitutes Another arrow poison plant, *Strophanthus gratus* (Wall. & Hook.) Baill., contains mainly ouabain, and to a lesser extent acolongifloroside K.

Description Evergreen shrub or small tree up to 6(–7) m tall; bark brown, deeply fissured; young branches reddish, glabrous, conspicuously angled and ribbed. Leaves decussately opposite, simple and entire; stipules absent; petiole 2–6 mm long; blade obovate to elliptical, 4–13.5 cm × 1.5–8 cm, base cuneate or rounded, apex acute, obtuse or rounded, with hard mucro, leathery, glossy, usually glabrous, pinnately veined, lateral veins prominent, without looping connections. Inflorescence a dense axillary cyme, many-flowered. Flowers bisexual, regular, 5-merous, fragrant; sepals free, ovate to lanceolate, (1.5–)2–3.5 mm long, apex acuminate to acute, shortly hairy or glabrous outside, ciliate; corolla tube cylindrical, 6.5–20 mm long, shortly hairy outside, inside sparsely hairy in the upper half and wrinkled below, pink or red, lobes broadly elliptical, 2–5 mm long, apex acute, shortly hairy on both sides, ciliate, white; stamens inserted at 12.5–15 mm from the base of the corolla tube, slightly exserted; ovary superior, ellipsoid, 2-celled, style slender, 11–16 mm long, stigma minutely bifid. Fruit an ellipsoid berry 1.5–3(–4) cm long, purple when ripe, pulp green to deep red, 1–2-seeded. Seeds ellipsoid, plano-convex, 6–10 mm long, smooth, glabrous.



Acokanthera oppositifolia – 1, flowering shoot; 2, flower; 3, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Acokanthera* comprises 5 species and is restricted to Africa, with one species also found in Yemen. It is related to *Carissa*.

Growth and development *Acokanthera oppositifolia* is a moderately fast growing tree, which is drought and shade tolerant, and frost resistant. It flowers from late January to March, and fruits from April to July in South Africa and Tanzania; in Kenya it fruits from February to March. Insects are the major pollinators and animals the major seed dispersers.

Ecology *Acokanthera oppositifolia* occurs at 1000–2400 m altitude in areas with an annual rainfall of 600–1000 mm. It thrives in rocky, red clay and clay-loam soils, often on termite mounds. It is usually found on rocky hillsides, in riparian forest edges, coastal bush, or open woodland.

Propagation and planting *Acokanthera oppositifolia* can be propagated by seed or semi-hardwood cuttings. Seeds require no pretreatment and should be sown fresh owing to their poor storage nature. They have a high water content and lose their viability easily on storage. Wildlings can also be used for propagation.

Management *Acokanthera oppositifolia* is commonly left standing in pasture fields and farm land as a shade plant. Pruning and pollarding can be used in managing the tree.

Harvesting The fruits are handpicked or harvested with the aid of a pole.

Yield To prepare 100 g of *Acokanthera oppositifolia* poison, 1 kg of wood, together with 250 g roots and 100 g leaves are needed.

Handling after harvest The wood or roots of *Acokanthera oppositifolia* are boiled in water for a long time until a tar-like substance is obtained. The latter is filtered and stored in an airtight container away from children. Addition

of plant and animal parts to the arrow poison is common in southern Africa. Fresh latex of *Euphorbia* spp. and bulbs of *Boophone disticha* (L.f.) Herb. are commonly used additives for poison production. Numerous animal additives, e.g. poisonous spiders, insects, dried and powdered cobra and viper glands may also be added to increase poison toxicity.

Genetic resources *Acokanthera oppositifolia* is a relatively common species, and there are no indications that it is at risk of genetic erosion. In southern Africa it is an invasive colonizer with weedy tendencies.

Prospects The cardenolides isolated from *Acokanthera oppositifolia* are highly poisonous. Most of them have not been pharmacologically investigated, and more research is needed to evaluate the possible prospects of the various compounds. *Acokanthera oppositifolia* has attractive leathery, dark green leaves, beautiful, fragrant inflorescences and is drought and frost tolerant; these characteristics make it interesting as an ornamental, although its poisonous properties make it dangerous.

Major references Coates Palgrave, 1983; Hauschild-Rogat, Weiss & Reichstein, 1967; Kupicha, 1982; Maundu & Tengnäs, 2005; Neuwinger, 1996; Neuwinger, 2000; Omino, 2002.

Other references Dharani, 2002; Hanna et al., 1998; Karawya, Abdel Wahab & Niazi, 1974; Kokwaro, 1993; Laudadio & Davis, 2003; Maundu et al., 2001; Maundu, Ngugi & Kabuye, 1999; Pieri, Arnould Guerin & Sefraoui, 1992; Ruffo, Birnie & Tengnäs, 2002; Tyiso & Bhat, 1998; van Wyk, van Heerden & van Oudtshoorn, 2002; van Wyk, van Oudtshoorn & Gericke, 1997; Watt & Breyer-Brandwijk, 1962.

Sources of illustration Kupicha, 1982.

Authors O.O. Bethwell

ACOKANTHERA SCHIMPERI (A.DC.) Schweinf.

Protologue Bol. Soc. Afr. Italia 10(11–12): 12 (1891).

Family Apocynaceae

Synonyms *Carissa schimperi* A.DC. (1844), *Acokanthera ouabaio* Poisson (1888).

Vernacular names Common poison bush, arrow-poison tree (En). Msunguti, msungu (Sw).

Origin and geographic distribution *Acokanthera schimperi* occurs from Eritrea south to Tanzania and west to Uganda, Rwanda and eastern DR Congo. It is also found in southern Yemen.



Acokanthera schimperi – wild

Uses *Acokanthera* species are among the most commonly used plant species for the preparation of poison in East Africa. It is either used on its own or mixed with other plant or animal parts. The bark, wood and roots are the usual ingredients for arrow poison, and they are also used for suicide and homicide. The only treatment against the poison is immediate excision of the flesh around the wound, or sucking the blood from the wound. The poison is also used in killing wild animals and stray dogs from fields and homes.

In Ethiopia the leaves and bark are applied to the skin to treat skin disorders, and an infusion of the leaves is gargled to treat tonsillitis. Dried pulverized leaves with honey are taken as an antifertility medicine. In Kenya Samburu women drink a bark decoction when their menstruation does not stop. In Kenya and Tanzania a hot infusion of the pounded root is drunk in small quantities to treat sexually transmitted diseases, and also as an aphrodisiac. In Uganda a leaf decoction is given to cattle that have a cold. A mixture made from the leaves, bark and butter is used for gall-bladder problems. The smoke of dried roots and twigs is insect repellent; too much smoke is harmful for humans as well.

The fruits are edible and an important famine food. They are sweet and slightly bitter when fully ripe. They are also used to make jams. The unripe fruits and seeds are highly poisonous, and several cases of accidental poisoning of children have been recorded. The latex in the fruits is used as chewing gum by children. The

wood is very hard and compact and branches are used in making spear shafts. In Uganda, it is used as firewood and to make charcoal. *Acokanthera schimperi* serves as an ornamental, shade or live fence tree in parks or around houses.

Production and international trade The stem bark and roots of *Acokanthera schimperi* are locally traded for poison production. The ready-made poison is also sold in East Africa. There are no data on traded volumes and value.

Properties All plant parts of *Acokanthera schimperi*, except the pulp of the ripe fruit, contain large amounts of cardiac glycosides (cardenolides), of which nearly 20 have been identified. The glycosides are responsible for the activity as arrow poison, but also act as cardiac stimulant. The main compounds are acovenoside A (0.3–1.8%), with acovenosigenin as aglycone, followed by ouabain (0.1–5%) with ouabagenin as aglycone, and traces of acolongifloroside K. *Acokanthera schimperi* plants from the Nairobi region in Kenya contain the highest amounts of acovenoside A, and lowest amounts of ouabain. Plants from the coastal region of Kenya contain mainly ouabain, while plants from Eritrea contain only half as much acovenoside A as those from Nairobi, but much more ouabain. Minor components also vary with origin and may include acoschimperosides N, P, Q and V. The main differences with *Acokanthera oppositifolia* (Lam.) Codd are the higher amounts of ouabain and the lower amounts of acolongifloroside K, but both species are equally poisonous. Ouabain and acolongifloroside K are the most cardioactive compounds; they are highly toxic and can cause death even in minute doses. The other compounds are slightly less toxic. Cardiac glycosides are given in low doses to patients suffering from congestive heart failure. In higher doses, they have a direct inhibiting action on the atrioventricular conduction together with a decrease of the heart rate. Injection of the arrow poison into an animal causes death almost immediately, while humans inflicted with an arrow wound die in 30 minutes to 2 hours. In medicine, ouabain is used as a remedy for congestive heart failure, like glycosides from *Digitalis*.

A methanol extract from the leaves showed significant antiviral activity against influenza virus A, coxsackievirus B3 and HSV-1 by inhibiting their replication. The extract also exhibited significant antibacterial activity against *Staphylococcus aureus* and *Pseudomonas aeruginosa*, and significant antifungal activity against *Trichophyton mentagrophytes*.

Adulterations and substitutes Poison from *Acokanthera oppositifolia* (Lam.) Codd may be used as a substitute for that of *Acokanthera schimperi*, although the latter species is more widely used for poison production. Dishonest dealers sometimes adulterate the poison with black earth.

Description Much-branched, evergreen tree, sometimes a shrub, up to 9(–10) m tall, with short trunk; bark brown, soft; crown dense, rounded; young branches glabrous or hairy, conspicuously angled and ribbed. Leaves decussately opposite, simple and entire; stipules absent; petiole 1–6(–9) mm long; blade elliptical to ovate or broadly ovate, 2–10 cm × 1.5–6.5 cm, base cuneate or rounded, apex acute, obtuse or rounded, with hard mucro, leathery, glossy, glabrous or shortly hairy, pinnately veined, lateral veins obscure, with looping connections. Inflorescence a dense axillary cyme, many-flowered. Flowers bisexual, regular, 5-merous, fragrant; sepals free, ovate to lanceolate, (1–)1.5–2.5 mm long, apex acuminate to acute, shortly hairy or glabrous outside, ciliate; corolla tube cylindrical, 8–12.5 mm long, glabrous or shortly hairy outside, inside sparsely hairy in the upper half and wrinkled below, pink or red, lobes ovate, 2.5–5 mm long, apex acute, glabrous above, glabrous to shortly hairy below, ciliate, white; stamens inserted at 7–10 mm from the base of the corolla tube, slightly exserted; ovary superior, ellipsoid, 2-celled, style slender, 7–10 mm long, stigma minutely bifid. Fruit an ellipsoid berry 1–2.5 cm long, purple when ripe, pulp green to deep red, 1–2-seeded. Seeds ellipsoid, plano-convex, 6–13 mm long, smooth, glabrous.

Other botanical information *Acokanthera* comprises 5 species and is restricted to Africa, although *Acokanthera schimperi* is also found in Yemen. The genus is related to *Carissa*. There are two types of *Acokanthera schimperi*: a large-leaved (up to 11 cm) and a small-leaved one. A third type that is climbing and has shortly and sharply recurved leaf margins has been reported in Kenya. *Acokanthera schimperi* has been domesticated in coastal Kenya by the Giriama people. The domestication process has increased the genetic variability of the species; the large-leaved, possibly domesticated types have very high amounts of ouabain.

The stem bark of *Acokanthera laevigata* Kupicha from Tanzania and Malawi, also

called 'msunguti' in Swahili, is widely used to make arrow poison. It contains similar alkaloids as the other *Acokanthera* species. The tough stems are suitable for building poles, tool handles and firewood.

Growth and development *Acokanthera schimperi* has a moderate growth rate. In Kenya fruiting occurs from February to March and in Tanzania from April to July. The flowers are pollinated chiefly by bees and seeds dispersed by animals.

Ecology *Acokanthera schimperi* occurs at the margins of dry forest, in relict forest, thickets, grasslands and bushland, at 1100–2400 m altitude and with 600–1000 mm annual rainfall. It is drought resistant. It prefers well-drained, red or black rocky soils, but also grows on black cotton soil and poor soil of dry sites. Lowland distribution appears to be associated with human introduction.

Propagation and planting *Acokanthera schimperi* regenerates naturally by seed. In Kenya and Ethiopia wildlings are transplanted to home gardens. The seeds have high moisture content and lose viability easily under ambient conditions and on storage. There are 400–450 seeds per kg. Seed germination is low.

Management *Acokanthera schimperi* can be pruned and pollarded in intercropping systems.

Harvesting *Acokanthera schimperi* is not equally poisonous throughout the year. The toxic potential of trees is sometimes established by observation of dead insects or dead birds under the tree. The fruits are handpicked or harvested with aid of a pole.

Yield One kg of wood of *Acokanthera schimperi*, together with 250 g of roots and 100 g of leaves yields 100 g of poison. The wood of twigs and roots yields 0.2% of ouabain.

Handling after harvest Stem wood is chopped into 15 cm long pieces. Chopped stems, roots, leaves and less commonly seeds of *Acokanthera schimperi*, together with animal and other plant additives, are put in a large clay container filled with water, and boiled with occasional stirring for up to 10 hours over a fire in a secluded place. Additional water is added in case the water evaporates before the poison is ready. In some communities, the making of the poison is complex, and ritual aspects, such as chanting, are observed to improve the efficacy of the poison. Once all the water has evaporated, a thick sticky black substance is left in the container. Used plant parts are discarded and the substance is then cut into pieces, put into containers or wrapped. Before use, the sticky extract is made into balls and spread in small amounts on arrow tips. Plant and animal parts are frequently added to increase poison potency and for magical reasons. In Kenya many different plant additives are used together with poison from *Acokanthera schimperi*, whereas in Tanzania mainly *Strophanthus* spp. are used, and to a lesser amount *Euphorbia candelabrum* Kotschy and *Urginea* spp. In Rwanda mainly *Strychnos usambarensis* Gilg is mixed with the poison. The poison is traded the same way as 150 years ago, in the form of a characteristic 'poison cigar', where the poison is packed securely in maize leaves. It is sometimes sold wrapped in paper, leaves, cloths, or foil or in open cans. The poison needs to be stored in a cool, dark place, and will keep its potency for decades.

Genetic resources *Acokanthera schimperi* is not at risk but considered rare in southern Ethiopia.

Prospects *Acokanthera schimperi* plants from the coastal zone of Kenya contain a high percentage of ouabain, and could thus have medical and commercial potential in congestive heart failure treatment.

Major references Kupicha, 1982; Maundu & Tengnäs, 2005; Neuwinger, 1996; Neuwinger, 2000; Tadeg et al., 2005.

Other references Abebe et al., 2001; Cassels, 1985; Dharani, 2002; Gebre-Mariam et al., 2006; Giday et al., 2003; Jansen, 1981; Katende, Birnie & Tengnäs, 1995; Lovett et al., 2006; Maundu et al., 2001; Maundu, Ngugi & Kabuye, 1999; Omino, 2002; Ruffo, Birnie & Tengnäs, 2002; van Wyk, van Oudtshoorn & Gericke, 1997; Watt & Breyer-Brandwijk, 1962.

Authors O.O. Bethwell

ADENIA CISSAMPELOIDES (Planch. ex Hook.) Harms

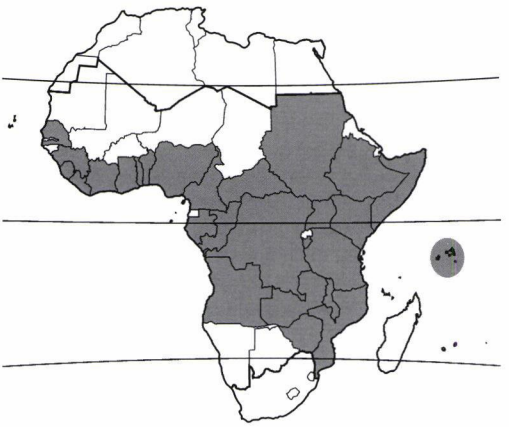
Protologue Engl. & Prantl, Nat. Pflanzenfam. Nachtr. 1: 255 (1897).

Family Passifloraceae

Synonyms *Adenia gracilis* Harms (1897), *Adenia gummifera* (Harv.) Harms (1897), *Adenia guineensis* W.J.de Wilde (1971).

Vernacular names Monkey rope, snake climber, wild granadilla (En). Mandali, mkengeti (Sw).

Origin and geographic distribution *Adenia cissampeloides* occurs from Senegal east to Somalia, and south throughout Central and



Adenia cissampeloides – wild

East Africa to southern Africa including South Africa. It is also found in the Seychelles.

Uses *Adenia cissampeloides* has many uses in traditional medicine throughout tropical Africa. Most frequently recorded are the uses of an infusion or decoction of the root, stem or leaves for the treatment of gastro-intestinal complaints, such as stomach-ache, constipation, diarrhoea and dysentery. Such infusions or decoctions are also taken to treat various inflammatory ailments, commonly oedema and rheumatism, and for pain relief, particularly against headache and back pain.

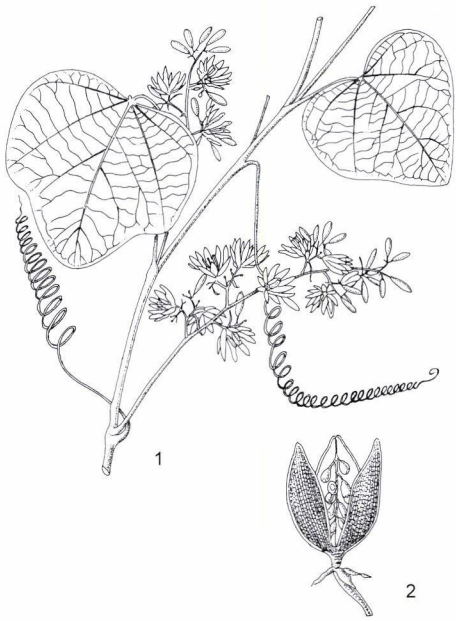
A decoction of the leaves or root is taken to treat fever and malaria, and as a diuretic. Pounded roots, and sometimes other plant parts, are widely used to dress wounds and sores. For leprosy, a decoction of the leaves is applied to the sores, and a root decoction taken orally together with a vapour bath prepared from the leaves. In Kenya and Tanzania ashes of the bark or root are mixed with castor oil to treat scabies. In eastern Africa a root decoction is drunk to treat cholera and, taken with milk, to treat anaemia. An extract of the root and stems is administered orally to treat intestinal worms. A leaf decoction is drunk to treat liver ailments. In Tanzania a paste of the leaves is applied to broken bones and fractures. In DR Congo, eastern and southern Africa the powdered leaf and stem are macerated and taken to treat complaints of the gall bladder. Bronchitis and other lung ailments are treated with the leaves, eaten raw with salt and palm oil or cooked as a vegetable with meat or fish. Infusions of the root or aerial parts are taken to treat venereal diseases and sterility. In the Central African Republic root shavings are introduced into the vagina, or the uterus rinsed with root decoction, as an abortifacient. A root decoction may also be taken to treat excessive menstruation. In Zimbabwe an infusion of the root and leaves is drunk, and the powdered root and leaves eaten in porridge, to prevent threatened abortion. In Nigeria leaves are rubbed on women's breasts to stimulate milk flow. A decoction of the peeled root is drunk to treat swollen testicles. An infusion of the leaf is used as a stimulant to treat depression, and, in Zimbabwe, insanity. The Mano people of Liberia use the inner bark to induce amnesia. Roots are chewed to treat snakebites and are used as antidote for *Acokanthera* arrow poison. In West Africa, the Central African Republic and Ethiopia crushed stems are thrown in water as a fish poison. Leaves, branches, bark, wood and roots may also be used in fish or arrow poisons. In Central, eastern and southern Africa the leaves are cooked and eaten as a vegetable, alone or with other ingredients. The reddish sap is used as a facial cosmetic. In Gabon the stems are made into rope. In Sierra Leone the juice of the stems is used to give a smooth surface to mud floors. Placing crushed twigs near the entrance of a bee hive pacifies the bees for a short time. In Botswana the smoke of burning roots is also used to calm bees before harvesting the honey.

Production and international trade A 1980s survey in KwaZulu-Natal, South Africa, showed that some herbal traders purchased more than 450 sacks of fresh wild-harvested *Adenia cissampeloides* from gatherers in a year.

Properties The stem, leaves, fruit and roots of *Adenia cissampeloides* contain the cyanogenic glycosides tetraphyllin B (barterin) and epitetraphyllin B (volkenin). The leaves also contain gummiferol, a cytotoxic polyacetylenic di-epoxide, which has shown in vitro anticancer activity. Excessive use of *Adenia cissampeloides* among the Zulu people in South Africa has been associated with liver complaints, and in-vivo tests have confirmed the presence of compounds causing liver damage. Leaves and root bark are rich in iron; the average iron content of the leaves per 100 g dry matter is 32.5 mg, of stem bark 9.9 mg and of root bark 32.1 mg. In a laboratory test aqueous extracts of the plant had a dose dependant depressing effect on the blood pressure of cats. The effect was neutralized by small doses of atropine. A second active principle might be

sympathomimetic and have vasoconstrictive action. The effect of the plant against *Plasmodium falciparum* in vitro is negligable. A diethyl-ether extract from the bark, formulated as an emulsifiable concentrate, is an effective anaesthetic for the African honeybee (*Apis mellifera adansonii*). Stem pulp showed a significant larvicidal effect on the beet armyworm *Spodoptera exigua*.

Description Robust liana up to 30 m long, usually dioecious; stem up to 10 cm in diameter, striped bluish-green, older stems often with whitish powder; stems with simple or 3-fid tendrils 10–20 cm long. Leaves alternate, simple; stipules 0.5(–1) mm long, broadly rounded to triangular, irregularly cleft; petiole (1–)1.5–11 cm long; blade entire or more or less deeply 3(–5)-lobed, orbicular to ovate or rhomboid in outline, (1–)3–14 cm long, base cordate to truncate or cuneate, apex obtuse or retuse, rarely acute, with a single gland at base, up to 4 glands on lower leaf surface and 3–7 glands on the margins. Inflorescence an axillary cyme, often with up to 2(–4) cm long tendrils between the branches, up to 35-flowered in male, 2–6-flowered in female inflorescence; peduncle (0.5–)1–12(–16) cm long; bracts and bracteoles narrowly triangular, 0.5–1 mm long, acute, minutely toothed. Flowers unisexual, regular, 5-merous, pale greenish; pedicel 2–10(–15) mm long in male flowers, slightly shorter in female ones; sepals and petals free; male flowers with sepals up to 8 mm long and petals 8–11 mm long, filaments of stamens fused at base, ovary rudimentary; female flowers with sepals up to 6.5 mm long and petals up to 4.5 mm long, ovary superior, ovoid, 3–6 mm long, 3(–6)-ribbed, stigmas almost sessile, kidney-shaped, stamens rudimentary. Fruit an ovoid capsule 2.5–4.5 cm × 1.5–3 cm, leathery to woody, pale green, 30–50-seeded. Seeds ovoid, 3.5–5.5 mm × 3–4 mm × 2 mm, pitted.



Adenia cissampeloides – *1, branch with male inflorescence and leaves; 2, dehisced fruit. Redrawn and adapted by Achmad Satiri Nurhaman*

Other botanical information *Adenia* comprises about 95 species, with about 60 species on the African continent, 20 in Madagascar and 15 in Asia. The genus is subdivided in 6 sections. *Adenia cissampeloides* belongs to section *Ophiocaulon*. Several other species belonging to this section have medicinal properties. *Adenia dinklagei* Hutch. & Dalziel occurs from Senegal to Ghana; in Côte d'Ivoire the leaves are ground with salt and water and the liquid is taken to treat palpitations. An infusion of the leaves of *Adenia tricostata* W.J.de Wilde, occurring in Central Africa and Uganda, is used to treat fever. *Adenia bequaertii* Robyns & Lawalrée occurs in DR Congo, Rwanda, Burundi, Kenya and Uganda; in DR Congo its leaf sap or a leaf decoction is drunk to treat headache, whereas a leaf decoction and maceration is drunk or used as a bath to treat insanity and possession.

Growth and development *Adenia cissampeloides* can be found flowering and fruiting throughout the year.

Ecology *Adenia cissampeloides* occurs in primary and secondary rainforest, forest margins and in gallery, savanna and swamp forest, from sea-level up to 2200 m altitude.

Propagation and planting *Adenia cissampeloides* is retained or cultivated in Chagga homegardens on Mount Kilimanjaro, Tanzania. It can be grown from seed and cuttings. Stem cuttings with 2–3 nodes are treated with growth hormone before being planted in polythene bags, and are watered regularly until sprouting.

Diseases and pests *Adenia cissampeloides* is a host plant of passion fruit ring spot virus (PFRSV), to which *Passiflora edulis* Sims is very susceptible.

Handling after harvest *Adenia cissampeloides* roots, stems and leaves are usually used fresh, after collection.

Genetic resources *Adenia cissampeloides* is widespread in a range of habitats, very common in its area of distribution, and not in danger of genetic erosion. Germplasm of plants used as vegetables has been collected in Malawi.

Prospects *Adenia cissampeloides* has many interesting medicinal uses. More research into the chemical composition and pharmacological activities of the compounds of *Adenia cissampeloides* and related species is warranted. *Adenia cissampeloides* could be grown as an attractive ornamental climber.

Major references Bouquet, 1969; Burkill, 1997; de Wilde, 1971; de Wilde, 1975; Morah, 1988; Neuwinger, 2000; Neuwinger, 2004; Nyarko & Addy, 1990; Omolo, Chhabra & Nyagah, 1997; Robyns, 1995.

Other references Adewunmi et al., 2001; Aké Assi et al., 1985; Cunningham, 1997; de Wijs, 1975; Fullas et al., 1995; Getahun, 1976; Kraft et al., 2003; Kwapata & Maliro, 1997; Maite, 1994; Morris, 1996; Noumi & Tchakonang, 2001; Olafsdottir, Andersen & Jaroszewski, 1989; Oliver-Bever, 1982; Raponda-Walker & Sillans, 1961; Ruffo, Birnie & Tengnäs, 2002; Sandberg & Cronlund, 1982; Senoo, 1992; Tabuti, Lye & Dhillion, 2003; Yeboah-Gyan & Oppong-Boachie, 2000.

Sources of illustration Keay, 1954a.

Authors O.M. Grace & D.G. Fowler

ADENIA DIGITATA (Harv.) Engl.

Protologue Bot. Jahrb. Syst. 14: 375 (1891).

Family Passifloraceae

Vernacular names Wild granadilla (En).

Origin and geographic distribution *Adenia digitata* occurs from Tanzania south to South Africa and west to Angola.

Uses *Adenia digitata* is deadly poisonous. The Tswana people of Botswana have used the fruit for homicide. The fruit is also eaten or a root extract is drunk as a suicide poison. Accidental poisoning mainly occurs when the root of *Adenia digitata* is mistaken for edible tubers, particularly those of *Coccinia* species. Children are often poisoned as a result of eating the attractive fruit. In Botswana the root is rubbed into swellings or applied warm to treat knee swellings. To treat skin ailment, leprosy or ulcers, the Nyanja people of Malawi and Zambia rub the skin with boiled roots or a root decoction. The Venda people of South Africa apply a root decoction externally and also drink it to treat swollen legs.

Because of its impressive tuber, which can be partly above ground, *Adenia digitata* is cultivated as an ornamental worldwide.

Production and international trade *Adenia digitata* is collected, traded and grown as an ornamental by plant amateurs.

Properties The tuber of *Adenia digitata* contains cyanogenic glycosides, mainly tetraphyllin B (barterioside), and the very potent toxin modeccin, a toxalbumin, which inhibits protein synthesis in vitro.

Botany Perennial climbing herb, usually dioecious, with a tuber up to 60 cm in diameter; stems annual, up to 3 m long. Leaves alternate, deeply (3–)5-cleft or -foliolate, orbicular in outline; stipules narrowly triangular, 1–3 mm long, withering; petiole 1–9 cm long; lobes or leaflets ovate to obovate or linear, sometimes deeply lobed, 1.5–15 cm × 1–4(–7) cm, rounded to acute at apex, with glands at base. Inflorescence an axillary cyme, with a 2–10 cm long tendril between the branches, 1–20(–60)-flowered; peduncle up to 7 cm long. Flowers usually unisexual, regular, 5-merous; pedicel up to 3 cm long, jointed about halfway; calyx tube about as long as lobes; petals free, included in calyx, usually toothed; male flowers up to 2.5 cm long, filaments of stamens fused in lower half and anthers curved inward and clinging together, ovary rudimentary; female flowers up to 2 cm long, ovary superior, ovoid to oblong, styles 3, fused at base, stigmas kidney-shaped, stamens rudimentary. Fruit a stalked ovoid to ellipsoid capsule 3–5.5(–7.5) cm × 2–4 cm, smooth, orange to yellow when ripe, many-seeded. Seeds ovoid to ellipsoid, flattened, 6–8 mm × 4.5–6.5 mm × 3 mm, brown, pitted.

Adenia comprises about 95 species, with about 60 species on the African continent, 20 in Madagascar and 15 in Asia. The genus is subdivided in 6 sections. *Adenia digitata* is classified in section *Blepharanthes*. *Adenia repanda* (Burch.) Engl. from section *Paschanthus* also occurs in southern Africa, from Angola east to Zimbabwe and south to South Africa, and is reported to be deadly poisonous to man. However, *Adenia repanda* is also reported to be greedily eaten by livestock.

Ecology *Adenia digitata* occurs in savanna, bushland, dry rocky or grassy localities, on termite mounds and along forest fringes, on stony, sandy, or clayish soils from sea-level up to 1850 m altitude.

Genetic resources and breeding *Adenia*

digitata is widely distributed and hence not threatened with genetic erosion.

Prospects It seems likely that medicinal use of *Adenia digitata* will remain limited in Africa, because of the high toxicity. The chemotherapeutic properties of lectins such as modeccin in cancer treatment and in chemoprevention warrant further research on medicinal applications. The prospects for *Adenia digitata* as an ornamental seem promising because of the growing interest in unusual plants by specialized amateurs.

Major references Arnold & Gulumian, 1984; de Wilde, 1971; Neuwinger, 2000; van Wyk, van Heerden & van Oudtshoorn, 2002; Watt & Breyer-Brandwijk, 1962.

Other references Bokan, 2004; de Wilde, 1975; Gasperi-Campani et al., 1978; González de Mejía & Prisecaru, 2005; Muhammad Mansur, 2003; Pelosi et al., 2005.

Authors A. de Ruijter

ADENIA GLOBOSA Engl.

Protologue Bot. Jahrb. Syst. 14: 382, f. 8 (1891).

Family Passifloraceae

Vernacular names Mpaga (Sw).

Origin and geographic distribution *Adenia globosa* occurs in East Africa from Somalia south to northern Tanzania.

Uses In Tanzania a cold water extract of the stem is drunk to treat abdominal pain. An extract is used as a bath to treat itches. In Kenya the Maasai people use the tuberous stem as cattle medicine. *Adenia globosa* is grown for ornamental purposes in South Africa and in greenhouses in the temperate regions.

Production and international trade *Adenia globosa* is collected, grown and traded as an ornamental by plant amateurs.

Properties The aerial parts of *Adenia globosa* contain the cyanogenic glycosides deidaclin and its stereoisomer tetraphyllin A.

Botany Dioecious shrub or climber up to 8 m tall, with a swollen, warty globular trunk up to 2.5 m in diameter; stems erect or scandent, more or less succulent, with axillary, up to 8 cm long thorns. Leaves alternate, simple and entire to 3-lobed, soon falling; petiole 1–1.5 mm long; stipules narrowly triangular, c. 0.5 mm long, acute; blade triangular, 3–7 mm × 1.5–9 mm, base rounded, apex acute, with 1 kidney-shaped gland at base. Inflorescence an axillary cyme, 1–5-flowered; peduncle up to 1.5 mm long; bracts and bracteoles triangular. Flowers unisexual, regular, 5-merous, greenish white; pedicel up to 1(–1.5) cm long, jointed near base; calyx tube about as long as lobes; petals free, exserted, toothed; male flowers up to 2 cm long, filaments of stamens fused at base, anthers free, ovary rudimentary; female flowers up to 1 cm long, ovary superior, ovoid to ellipsoid, 3-ribbed, styles 3, fused at base, stigmas kidney-shaped, stamens rudimentary. Fruit a stalked globular to ovate-ellipsoid capsule 1–3 cm × 1–2 cm, leathery, smooth, green, many-seeded. Seeds broadly ovoid, flattened, 6–7 mm × 3–5.5 mm × 3 mm, pitted.

Adenia comprises about 95 species, with about 60 species on the African continent, 20 in Madagascar and 15 in Asia. The genus is subdivided in 6 sections. *Adenia globosa*, and several other species with medicinal uses belong to section *Adenia*. *Adenia venenata* Forssk. occurs from Nigeria east to Eritrea and south to Tanzania. In DR Congo *Adenia venenata* is cultivated near villages and is used to treat intestinal worms. In Kenya Turkana people use the leaves to treat cattle suffering from mange. In Madagascar the pounded stems of *Adenia subsessilifolia* Perr. are applied to wounds. The tubers are bitter and inedible.

Ecology *Adenia globosa* occurs in scrub savanna at 100–1800 m altitude.

Genetic resources and breeding *Adenia globosa* is widely distributed and hence not threatened with genetic erosion.

Prospects *Adenia globosa* is only locally used, and will remain of little importance unless pharmacological research shows new possibilities. The prospects of *Adenia globosa* as an ornamental seem promising because of the growing interest in unusual plants by specialized amateurs.

Major references de Wilde, 1971; Hedberg et al., 1983b; Neuwinger, 2000.

Other references de Wilde, 1975; Jaroszewski & Jensen, 1985; Ohto, 1984; Olafsdottir, Andersen & Jaroszewski, 1989; Sinei & Mwangi, 1995; Watt & Breyer-Brandwijk, 1962.

Authors A. de Ruijter

ADENIA LOBATA (Jacq.) Engl.

Protologue Bot. Jahrb. Syst. 14: 375 (1891).

Family Passifloraceae

Chromosome number $2n = 24, 48$

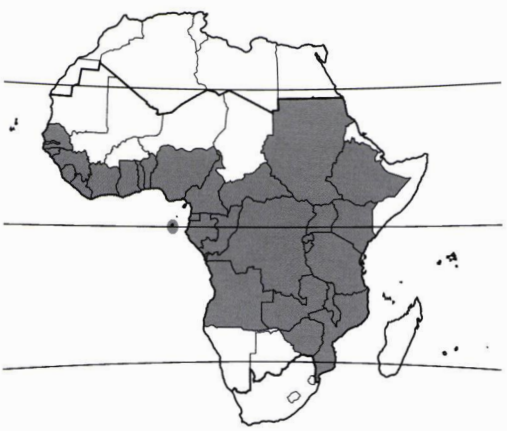
Synonyms *Adenia mannii* (Mast.) Engl.

(1871), *Adenia schweinfurthii* Engl. (1891), *Adenia rumicifolia* Engl. & Harms (1921).

Vernacular names Ngole (Sw).

Origin and geographic distribution *Adenia lobata* occurs from Senegal east to Ethiopia and south to Angola and Mozambique.

Uses *Adenia lobata* is widely used in traditional medicine. Young, lightly roasted leaves are applied and then covered with leaves to treat abscesses. In Senegal leafy stems are dry-heated and applied to Guinea worm sores to extract the worms. The Tenda people of Senegal prepare a soup from the leaves to treat fever in children and they also wash the patients with the leaf decoction. In Côte d'Ivoire and Congo the leaves are eaten with palm oil and salt to treat palpitations. The leaf sap is applied topically or as an enema against rheumatic, rib and abdominal pains and a macerate of leafy twigs in water is taken to treat cough, bronchitis and fever. Sap of leaves and stems is used to treat trypanosomiasis and is applied to insect bites. Pulped twigs administered as an enema are used as a diuretic and to treat jaundice and fainting. To facilitate childbirth, a root maceration or the stem sap is drunk. The stem sap is also taken to treat gastrointestinal problems; it is rubbed in to treat headache, a stiff neck and dropped in the ear to treat inflammation of the ear. A leaf extract as enema is used as a strong purgative. The Ebrié people of Côte d'Ivoire use a maceration of crushed leaves in water as an enema to treat fever attacks. In Ghana the leaves are locally applied to treat haemorrhoids. In Togo a twig decoction is drunk and used in a bath to treat malaria. In Nigeria and Côte d'Ivoire the stem pulp is used as an enema and taken orally as an aphrodisiac and to treat gonorrhoea. A leaf decoction is taken to treat cough, bronchitis and fever.



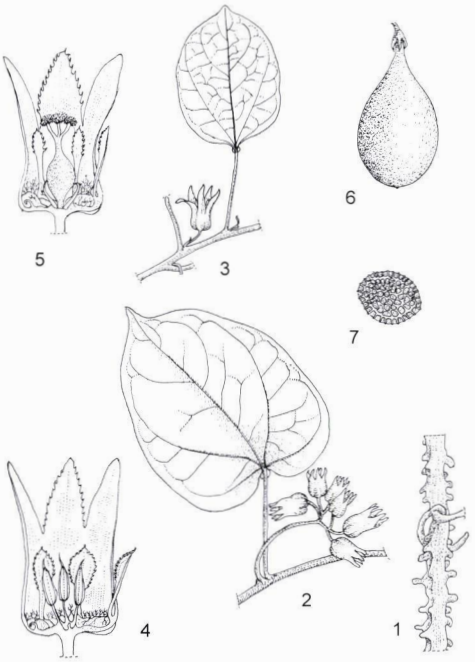
Adenia lobata – wild

In Gabon root powder, together with powdered *Capsicum annuum* L. and seeds of *Aframomum melegueta* K.Schum., is sniffed to treat nasal tumours. In DR Congo a leaf decoction is drunk to treat insanity and a twig extract is drunk or applied as an enema to treat gonorrhoea and abdominal pain. Bark scrapings are ground in water and massaged into the head to treat head lice, and root scrapings are applied to wounds. In Sierra Leone, Côte d'Ivoire and Gabon the sap of the stem is used as an arrow poison and to kill rats and street dogs. The stem, stem bark, fruit or sap are used for fish poisoning in West and Central Africa, and in Tanzania and Angola.

In DR Congo the finely cut and cooked leaves of *Adenia lobata* are eaten as a vegetable. The liquid from the stem can be drunk. In Príncipe Island a fibre is produced from the stem, and in DR Congo the stem serves as rope. In Cameroon sections of the stem are used as sponges.

Properties The stem and leaves of *Adenia lobata* contain cyanogenic glycosides. Gynocardin or a closely related substance was detected in *Adenia lobata*. Dried leaves from Cameroon contained the flavonoids 2"-xylosylvitexin, vitexin, violanthin, vicenin-2 and schaftoside.

Description Large liana, usually dioecious, with stem up to 45 m long and up to 12 cm in diameter, smooth or with tubercles; bark green to red-brown; sap clear, turning red; stems with simple or 3(–7)-fid tendrils up to 25 cm long. Leaves alternate, simple; stipules triangular, 0.5–1 mm long, soon falling; petiole up to 15 cm long; blade entire or sinuate to palmately 3–5(–7)-lobed, elliptical to ovate or orbicular in outline, 4–25 cm × 2–20 cm, base deeply cordate, apex acuminate, with 2 glands at base of blade and up to 16 glands on lower leaf surface. Inflorescence an axillary cyme, usually with 1–3 tendrils up to 20 cm long, up to 30-flowered in male, up to 10-flowered in female inflorescence; peduncle up to 12 cm long; bracts and bracteoles triangular to oblong, 1–2 mm long. Flowers unisexual, regular, 5-merous, yellowish; pedicel 5–40 mm long; calyx with tube (5–)7–15 mm long and triangular, 7–15 mm long lobes; petals free; corona consisting of a fringe of hairs; male flowers with spoon-shaped to elliptical-oblong petals, 4–13 mm long, margins fringed, filaments of stamens fused at base, included, ovary rudimentary; female flowers with linear to spoon-shaped petals, 5–9 mm long, acute, margins



Adenia lobata – 1, part of older stem; 2, part of male flowering stem; 3, part of female flowering stem; 4, male flower in longitudinal section; 5, female flower in longitudinal section; 6, fruit; 7, seed.
Redrawn and adapted by Iskak Syamsudin

fringed or entire, ovary superior, ovoid to ellipsoid, 4–8 mm long, styles 3, fused at base, arms up to 5 mm long, stigmas kidney-shaped, densely woolly papillate, stamens rudimentary. Fruit an obovoid to globular or ellipsoid capsule 3–8 cm long, leathery or fleshy, yellow, smooth or lumpy, 20–150-seeded. Seeds broadly ellipsoid to orbicular, c. 5 mm long, pitted.

Other botanical information *Adenia* comprises about 95 species, with about 60 species on the African continent, 20 in Madagascar and 15 in Asia. The genus is subdivided in 6 sections. *Adenia lobata* belongs to section *Blepharanthes*. A more robust type of *Adenia lobata* has been described as *Adenia miegei* Aké Assi, but this is now considered to be the tetraploid form.

Growth and development In West Africa *Adenia lobata* flowers throughout the year but fruits are mainly present from July to November. It regenerates rapidly after bush fires.

Ecology *Adenia lobata* occurs in rainforest, secondary forest, forest edges, gallery forest, periodically inundated and marshy forest and on rocky outcrops from sea-level up to 1800 m altitude.

Propagation and planting *Adenia lobata* can be grown from seeds or cuttings. The plant grows rapidly and can be trained to grow over a pergola in a similar fashion to passion fruit.

Management Because the plant is not common in the Mount Nimba area of Liberia, Mano people protect it for its fish-poisoning property.

Diseases and pests *Adenia lobata* is a host plant of passion fruit ring spot virus (PFRSV), to which *Passiflora edulis* Sims is very susceptible.

Handling after harvest The harvested parts are usually used fresh for medicinal purposes after collection from the wild.

Genetic resources *Adenia lobata* is widespread in a range of habitats, very common in its area of distribution and is not in danger of genetic erosion.

Prospects *Adenia lobata* is widely used in local medicine. Surprisingly little is known about the properties, and more research into the chemical composition and pharmacological activities of the compounds seems warranted.

Major references Burkill, 1997; de Wilde, 1971; Neuwinger, 2000; Neuwinger, 2004; Okpekon et al., 2004; Raponda-Walker & Sillans, 1961; Robyns, 1995; Ulubelen et al., 1982.

Other references Adjanohoun et al., 1986; Adjanohoun & Aké Assi, 1979; Aké Assi et al., 1985; Atindehou et al., 2002; Bouquet, 1969; Bouquet & Debray, 1974; de Wijs & Mobach, 1975; de Wilde, 1975; Fernandes & Fernandes, 1978; Gassita et al. (Editors), 1982; Getahun, 1976; Hulstaert, 1966; Kerharo & Bouquet, 1950; Kerharo, Guichard & Bouquet, 1961; Konda et al., 1992; Latham, 2004; Neuwinger, 1998.

Sources of illustration de Wilde, 1975.

Authors C. Zimudzi

ADENIA RACEMOSA W.J.de Wilde

Protologue Meded. Landbouwhogeschool. 71(18): 64 (1971).

Family Passifloraceae

Origin and geographic distribution *Adenia racemosa* is endemic to Tanzania.

Uses In Tanzania a bark decoction is drunk to treat menorrhagia. A leaf decoction is drunk to treat mental illness. The tubers are used to treat chickenpox. The flexible stems are used

as string. *Adenia racemosa* is also used for fodder and is grown for ornamental purposes in greenhouses in temperate regions.

Production and international trade *Adenia racemosa* is collected, traded and grown as an ornamental by plant amateurs.

Properties Few phytochemical analyses have been done on *Adenia racemosa*. The stem bark contains flavonoids, saponins and tannins, but no cyanoglycosides have been reported. Recently, ribosome-inactivating proteins have been isolated.

Botany Monoecious climber up to 8 m tall, with a swollen, globular trunk; stems with simple tendrils 8–12 cm long. Leaves alternate, deeply (3–)5(–7)-lobed; petiole 1.5–5.5 cm long; stipules broadly triangular, c. 1 mm long, acute; blade orbicular to broadly ovate in outline, 3–10 cm × 3–10 cm, base cordate to truncate, lobes triangular to elliptical, up to 5 cm long, acute to rounded. Inflorescence in the axils of much reduced leaves on short shoots, up to 7-flowered; peduncle 0.5–4 mm long; bracts and bracteoles triangular to oblong, c. 1 mm long. Flowers unisexual, regular, 5-merous, greenish to yellowish; pedicel up to 1 cm long, jointed near base; calyx tube much shorter than lobes; petals free, exserted, entire, corona consisting of lobes or a lobed rim present; male flowers c. 1 cm long, filaments of stamens fused at base, anthers free, ovary rudimentary; female flowers c. 0.5 cm long, ovary superior, ovoid, styles 3, free, stigmas globular to kidney-shaped, papillate, stamens rudimentary. Fruit a stalked ovoid-ellipsoid capsule 2–3 cm × 1.5–2 cm, woody to leathery, red, many-seeded. Seeds broadly ovoid, flattened, c. 6.5 mm × 5.5 mm × 3 mm, coarsely banded or pitted.

Adenia comprises about 95 species, with about 60 species on the African continent, 20 in Madagascar and 15 in Asia. The genus is subdivided in 6 sections. *Adenia racemosa* and some other species with medicinal uses belong to section *Microblepharis*. *Adenia aculeata* (Oliv.) Engl. occurs in Ethiopia, Somalia and north-eastern Kenya. In Somalia the fresh root of *Adenia aculeata* is boiled in water, the decoction is filtered and drunk to treat gastritis. Like *Adenia racemosa*, *Adenia aculeata* is collected, traded and grown as an ornamental.

Ecology *Adenia racemosa* occurs in regenerating bush at c. 1000 m altitude.

Genetic resources and breeding *Adenia racemosa* is a rare species and because of its limited area of distribution, it is liable to genetic erosion.

Prospects Because of its rarity it seems likely that *Adenia racemosa* will remain of limited use only. The wild population needs to be protected and care should be taken with uprooting plants for trade as ornamentals.

Major references Chhabra, Mahunnah & Mshiu, 1991; de Wilde, 1971; Neuwinger, 2000; Ruffo, Birnie & Tengnäs, 2002.

Other references Pelosi et al., 2005; Samuelsson et al., 1993.

Authors A. de Ruijter

ADENIA VOLKENSII Harms

Protologue Engl., Pflanzenw. Ost-Afrikas C: 281 (1895).

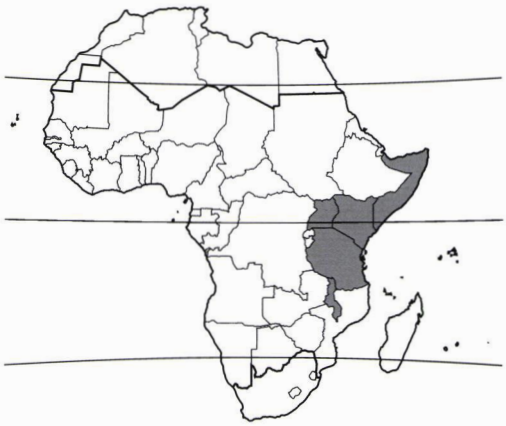
Family Passifloraceae

Vernacular names Kilyambiti plant (En).

Origin and geographic distribution *Adenia volkensii* occurs in eastern Africa from Somalia south to Malawi.

Uses In East Africa a leaf decoction is taken orally to treat bronchitis, coughs and fever, or is used as a purgative enema. Pounded seeds are given in enema form as a diuretic. A few drops of sap are sucked from a piece of twig or stem to treat gonorrhoea; larger amounts are very poisonous. Powder of the roasted rootstock is taken in Kenya to treat coughs, colds and pneumonia and with milk to treat stomachache and internal swellings. The rootstock is also used to cure trypanosomiasis and venereal diseases in livestock. The fruit and roots are used to poison hyenas.

Adenia volkensii is collected, grown and traded as an ornamental by enthusiasts.



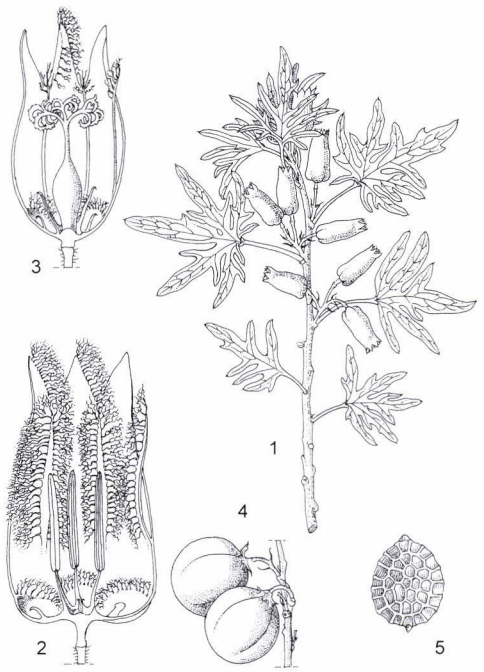
Adenia volkensii – wild

Production and international trade Leaves, rootstock and bark are sold for medicinal purposes in local markets, but *Adenia volkensii* is also commercially important because pharmaceutical products are produced industrially from the same plant parts.

Properties The most important active ingredient of *Adenia volkensii* is volkensin, a galactose-specific lectin (glycoprotein) consisting of an A and a B subunit, linked by disulfide and noncovalent bonds. Volkensin is a potent inhibitor of eukaryotic protein synthesis in whole cells as well as in cell-free systems. The inhibitory activity is a function of the A subunit; the B subunit has a lectin function and allows the protein to pass the intact cell membrane. Volkensin is one of the most lethal double-chain ribosome-inactivating and ricin-like toxins; in rats the LD_{50} is 50–60 µg/kg. Chemically, it resembles most closely modeccin, the toxin of *Adenia digitata* (Harv.) Engl. In a rat model volkensin could be used effectively to produce anatomically selective lesions in the brain. It causes neuron death not only at the injection site, but it is also transported between neurons. Possibilities have also been studied of selectively killing mononuclear macrophages, the cells in which the HIV virus survives and which transfer it to T-cells in which the virus is rapidly multiplied resulting in the development of Aids.

All parts of *Adenia volkensii*, even the flowers, contain cyanogenic glycosides, with the rootstock accounting for about 90% of the amount of these compounds. The cyanogenic glycosides isolated are tetraphyllin B (barterin) and its epimer epi-tetraphyllin B (volkenin).

Description Usually monoecious shrub or herb up to 1.5 m tall, with annual shoots of 20–50 cm long growing from a rootstock or caudiciform, succulent stem up to 100 cm long; tendrils absent. Leaves alternate, simple; stipules 0.5–1.5 mm long, triangular, acute; petiole 1.5–10 cm long; blade entire or more or less deeply 3–7-lobed, orbicular to ovate or rhomboid in outline, 3–16 cm long, base cordate to truncate, apex acute, mucronate, margin toothed or dissected, with 2 glands at base, 2–6 glands on lower leaf surface, and blackish glands on the teeth. Inflorescence an axillary cyme, 1–6-flowered in male, 1–2(–3)-flowered in bisexual and female inflorescences; peduncle up to 0.5 cm long; bracts and bracteoles lanceolate, 2.5–10 mm long, acute, toothed and gland-dotted. Flowers usually unisexual, regular, 5-merous, glabrous, pale greenish or cream; pedicel 5–25 mm long; calyx with long tube and shorter lobes, woolly hairy at margins; petals free, corona consisting of branched hairs 1.5–3 mm long; male flowers with calyx tube 12–20 mm long, lobes ovate-triangular, 3–9 mm long, obtuse, petals lanceolate-linear, 10–14 mm long, acute, with many branched hairs 3–5 mm long at margins, stamens free, ovary rudimentary; female flowers with calyx tube 7–10 mm long, lobes oblong, 5–8 mm long, obtuse, petals linear, 8–12 mm long, with few branched hairs, ovary superior, ellipsoid, 4–8 mm long, styles connate for 2–4 mm, the arms c. 1 mm long, stigmas c. 4 mm in diameter, much-branched, woolly-papillate, stamens rudimentary. Fruit a globose to ellipsoid capsule 3.5–5.5 cm × 3–4.5 cm, leathery, 15–30-seeded. Seeds ovoid, 8–9 mm × 7–7.5 mm × 3–4 mm, pitted.



Adenia volkensii – 1, branch with male inflorescences; 2, male flower in longitudinal section; 3, female flower in longitudinal section; 4, fruits; 5, seed.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Adenia* comprises about 95 species, with about 60 species on the African continent, 20 in Madagascar and 15 in Asia. The genus is subdivided in 6 sections. *Adenia volkensii* belongs to section

Blepharanthes. Several other species belonging to this section have medicinal properties. *Adenia ellenbeckii* Harms occurs in Ethiopia, Somalia, Kenya, Uganda and Tanzania. A decoction of its fruit is taken to treat wounds and fruit powder is applied to the wounds. The juice of the fruit added to meat is used to poison hyenas. In Ethiopia the leaves are eaten as a vegetable. *Adenia keramanthus* Harms occurs in Kenya and Tanzania. A stem extract is taken to treat syphilis and the leaves and roots are chewed to treat snakebites. *Adenia lanceolata* Engl. occurs from southern Sudan to Malawi and is poisonous. *Adenia ellenbeckii*, *Adenia keramanthus* and *Adenia lanceolata* contain cytotoxic lectins. The effect of the lectin from *Adenia lanceolata* is similar to the effect of volkensin on cell-free protein synthesis, but the former is more effective on whole cells, and is one of the most potent toxins of plant origin.

Growth and development *Adenia volkensii* is fast growing and flowers more profusely if growing in direct sunlight. It has the ability to store water in the rootstock.

Ecology *Adenia volkensii* occurs in scrubby vegetation in rocky localities on red soil or lava-dust at 1000–2000 m altitude. It regenerates quickly after damage by cutting and from light fires.

Propagation and planting *Adenia volkensii* can be propagated by seed and by stem cuttings. Cuttings taken from mature plants seem to flower more easily. The cuttings do not necessarily result in formation of a rootstock.

Harvesting The stem, rootstock and leaves of *Adenia volkensii* are collected from the wild whenever needed and can be used fresh or dried.

Genetic resources *Adenia volkensii* is fairly widespread in its distribution area and therefore not likely to be threatened by genetic erosion.

Prospects *Adenia volkensii* will remain important in East Africa both in human and in veterinary traditional medicine. The active ingredients of *Adenia volkensii* and related species, especially the ribosome-inactivating proteins, warrant further study. Large-scale cultivation for pharmaceutical products seems possible since other *Adenia* species are quite easily propagated for ornamental purposes.

Major references Chambery et al., 2004; de Wilde, 1971; de Wilde, 1975; Fernandes & Fernandes, 1978; Gondwe, Seigler & Dunn, 1978; Neuwinger, 2000.

Other references Barbiera, Falasca & Stirpe, 1984; Clausen et al., 2001; ITDG & IIRR, 1996; Kokwaro, 1993; Kraft et al., 2003; LaGrone, 1999; Morgan, 1981; Pangalos et al., 1991; Pelosi et al., 2005; Stirpe et al., 1985; Szalai et al., 2005.

Sources of illustration de Wilde, 1971.

Authors D.M. Modise

ADENIUM BOEHMIANUM Schinz

Protologue Verh. Bot. Vereins Prov. Brandenburg 30: 259 (1888).

Family Apocynaceae

Chromosome number $2n = 22$

Synonyms *Adenium obesum* (Forssk.) Roem. & Schult. subsp. *boehmianum* (Schinz) G.D.Rowley (1983).

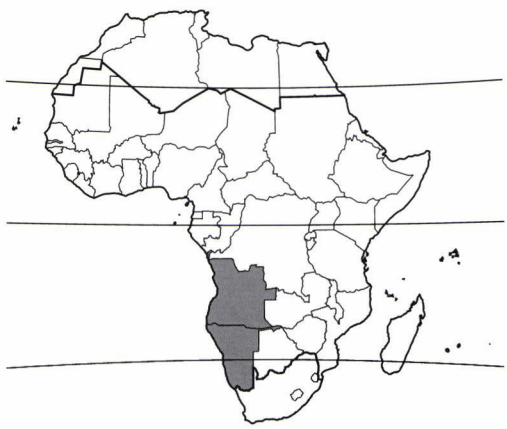
Vernacular names Bushman poison (En). Unguiu (Po).

Origin and geographic distribution *Adenium boehmianum* occurs naturally in Angola and Namibia.

Uses The extremely bitter root sap and latex are boiled to prepare arrow poison in Namibia and neighbouring parts of Angola. The arrow poison is used for hunting large game such as zebra and wildebeest. Plants are occasionally grown as ornamentals.

Production and international trade There is some international trade in seeds and plants of *Adenium boehmianum* for ornamental purposes.

Properties The arrow poison prepared from *Adenium boehmianum* has strong cardiotoxic effects. When an animal is hit it usually dies within a few hours and within a few hundred metres from where it was shot. The poisonous



Adenium boehmianum – wild

compounds in the root and stem latex have been identified as cardiac glycosides. The most important ones are: echujine (composed of the aglycone digitoxigenin, the sugars D-cymarose and 2 molecules of D-glucose), digitalinum verum (composed of gitoxigenin, D-digitalose and D-glucose), somaline (composed of digitoxigenin and D-cymarose) and abobioside (composed of abogenin and D-cymarose).

Description Succulent shrub up to 2.5(–3.5) m tall, with rootstock and white latex in all parts; stem swollen at base, up to 40(–60) cm in diameter; branches erect, sparingly hairy when young becoming scabrid, greyish white. Leaves arranged spirally, clustered at the end of branches, simple; stipules minute or absent; petiole 1–3(–7) mm long; blade obovate, 8–15 cm × 4.5–8 cm, often folded upwards along the midrib, base cuneate, apex usually emarginate, entire, glaucous or pale green, leathery, hairy at least when young, pinnately veined with distinct lateral veins. Inflorescence a dense terminal cyme; bracts narrowly oblong to narrowly ovate, 5–11 mm × 1–3 mm, acuminate, pubescent. Flowers bisexual, regular, 5-merous, showy, appearing before or with the leaves; pedicel 5–10 mm long; sepals lanceolate, 6–12 mm long, fused at base, acuminate, densely hairy; corolla with tube 0.7–1 cm long and obovate lobes, spreading, 2.5–3.5(–4.5) cm × 1–1.5 cm, slightly undulate, pink to mauve, darker in the throat, hairy outside; stamens inserted near base of corolla tube, included, anthers forming a cone covering the pistil, base sagittate, 5–7 mm long, with long apical appendices; ovary superior, composed of 2 free carpels, glabrous, styles fused, slender with well-developed clavuncula. Fruit consisting of 2 linear-oblong follicles, coherent at base, 10–18 cm long, tapering at both ends, spreading or recurved when mature, opening by a longitudinal slit, many-seeded. Seeds linear-oblong, 7–9 mm long, brown, striate, with tufts of long dirty white to pale brown hairs at both ends.



Adenium boehmianum – 1, flowering branch; 2, follicle; 3, seed.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Adenium* comprises 5 species, which are sometimes merged into a single one, *Adenium obesum* (Forssk.) Roem. & Schult. with 6 subspecies. *Adenium swazicum* Stapf may resemble *Adenium boehmianum*, but differs in its narrower leaves. It has a limited distribution in Swaziland and neighbouring parts of South Africa and southern Mozambique and is planted as an ornamental. Some selections are 'Boyce Thompson' with deep purplish pink flowers, and 'Perpetual Pink', which is robust, upright and with large pink flowers.

Growth and development Plants bear leaves for about 3 months only. This period cannot be extended by cultural practices in cultivation. They flower for a few weeks only.

Ecology In its natural range *Adenium boehmianum* is widespread in granitic rocky localities and occasionally at edges of swamps. The largest plants are found along the escarpment of the Mary river in Kaokoland in Namibia.

Propagation and planting As an ornamental *Adenium boehmianum* can probably be propagated like *Adenium obesum*, by seed, grafting or cuttings.

Management Plants used for making arrow poison are always collected from the wild. As a container plant *Adenium boehmianum* is handled in the same way as other large succulents.

Genetic resources Although the natural distribution of *Adenium boehmianum* is restricted, it seems not to be in danger of genetic erosion.

Prospects More research into the chemical composition and pharmacological activities of the compounds of *Adenium boehmianum* seems warranted. Its prospects as an ornamental seem limited because of the short flowering

period.

Major references Codd, 1963; Dimmitt & Hanson, 1992; Neuwinger, 1996; Plaizier, 1980; Rowley, 1983; Stapf, 1902–1904.

Other references von Koenen, 2001; van Wyk & Gericke, 2000.

Sources of illustration Plaizier, 1980.

Authors L.P.A. Oyen

ADENIUM MULTIFLORUM Klotzsch

Protologue Naturw. Reise Mossambique 6(1): 279, t. 44 (1861).

Family Apocynaceae

Chromosome number $2n = 22$

Synonyms *Adenium obesum* (Forssk.) Roem. & Schult. var. *multiflorum* (Klotzsch) L.E.Codd (1961), *Adenium obesum* (Forssk.) Roem. & Schult. subsp. *multiflorum* (Klotzsch) G.D.Rowley (1974).

Vernacular names Sabi star, impala lily (En). Megoza (Po).

Origin and geographic distribution *Adenium multiflorum* is widespread in Malawi, southeastern Zambia, Zimbabwe, Mozambique, Swaziland and north-eastern South Africa.

Uses The stem latex of *Adenium multiflorum* has long been used in Zimbabwe and Zambia to prepare arrow poison and fish poison. Usually, the poison is combined with that of other plants. In Zimbabwe the root and stem latex are used in veterinary medicine; an extract is given against diarrhoea and eye diseases in domestic birds.

Like other *Adenium* spp., *Adenium multiflorum* is grown as an ornamental for its curious habit and striking flowers. In Zimbabwe *Adenium multiflorum* is relished by cattle and also wild animals, which browse the plants down to ground level, indicating that plants with low toxicity exist.

Production and international trade There is some international trade of seeds and plants of *Adenium multiflorum* for ornamental purposes.

Properties *Adenium multiflorum* contains cardenolide glycosides similar to those found in *Adenium obesum* (Forssk.) Roem. & Schult. The glycosides identified include: 16-desacetyl-16-anhydrohonghelоside A (composed of 16-anhydrogitoxigenin and D-cymarose), 16-anhydrostrospeside (composed of 16-anhydrogitoxigenin and D-digitalose) and strospeside (composed of gitoxigenin and D-digitalose).

There may be chemical differences between *Adenium multiflorum* from different provenances, as the plant is relished by animals in Zimbabwe, but in other countries it is considered highly poisonous.

Botany Succulent shrub or small tree up to 3.5 m tall, with watery latex and with large thickened root, up to 1 m in diameter at stem base; bark shiny grey. Leaves arranged spirally, clustered at end of branchlets, simple; stipules minute or absent; petiole 3–7 mm long; blade obovate to oblong, 7.5–12.5 cm × 2–7.5 cm, base cuneate, apex acute to rounded or emarginate, apiculate or mucronate, entire, leathery, glabrous, pinnately veined with distinct lateral veins. Inflorescence a dense terminal cyme; bracts narrowly obovate, 4–6 mm × 1–3 mm. Flowers bisexual, regular, 5-merous, showy, usually appearing before the leaves; pedicel 2–4 mm long, densely hairy; sepals narrowly ovate, 6–10 mm × 2.5–3 mm, fused at base, hairy; corolla with funnel-shaped tube 2.2–4 cm × 1–1.3 cm and narrowly ovate to narrowly obovate, spreading lobes 1.3–3 cm × 1–2 cm, red, pink to white with deep pink to scarlet margins and red stripes inside the throat, hairy outside; stamens inserted near base of corolla tube, distinctly exserted, anthers forming a cone covering the pistil, base sagittate, 5–7 mm long, with long apical appendices; ovary superior, composed of 2 free carpels, glabrous, styles fused, slender, with well-developed clavuncula. Fruit consisting of 2 oblong follicles 10–18 cm long, eventually spreading at 180°, pale grey to pale grey-brown, opening by a longitudinal slit, many-seeded. Seeds linear, 10–15 mm long, very pale brown, with tufts of long dirty white to light brown hairs at both ends 2–3 cm long.

Adenium comprises 5 species, which are sometimes merged into a single one, *Adenium obesum* (Forssk.) Roem. & Schult. *Adenium multiflorum* crosses readily with *Adenium obesum* and with other *Adenium* spp.

Adenium multiflorum has long dormancy; regardless of growing conditions, leaves fall at the start of the cool season and growth will not resume for at least 4 months. It flowers profusely during the cool season. Leaves appear only after flowering. Plants rarely flower before they are 4–5 years old.

Ecology The natural habitat of *Adenium multiflorum* is savanna and occasionally open forest on sandy soil along marshes and rivers and also in much drier sandy and rocky localities; it occurs up to 700(–1200) m altitude.

Management In cultivation *Adenium multi-*

florum is propagated by seed, cuttings or grafting. Tip-cuttings dipped in a rooting hormone, planted in a coarse rooting medium and well-watered are most successful. Seeds germinate readily in about a week at 30°C, and seedlings grow through the first cool and dry period before obligate dormancy appears. After the first year, the plants should be kept dry during dormancy, to prevent the brittle root from rotting.

Genetic resources and breeding *Adenium multiflorum* is considered vulnerable in Zambia, Zimbabwe and Swaziland. It is threatened by collection for horticulture, medicinal uses and by heavy browsing by livestock.

Prospects *Adenium multiflorum* is an interesting ornamental, although its flowering period is shorter and growth rate is lower than that of *Adenium obesum*. It is unlikely that it will become important in medicine, while its importance as arrow poison has dwindled.

Major references Bester, 2004; Leeuwenberg et al., 1985; Neuwinger, 1996; Plaizier, 1980; Rowley, 1983.

Other references Dimmitt & Hanson, 1991; Hargreaves, 2002; van Wyk, van Heerden & van Oudtshoorn, 2002.

Authors L.P.A. Oyen

ADENIUM OBESUM (Forssk.) Roem. & Schult.

Protologue Syst. veg. 4: 411 (1819).

Family Apocynaceae

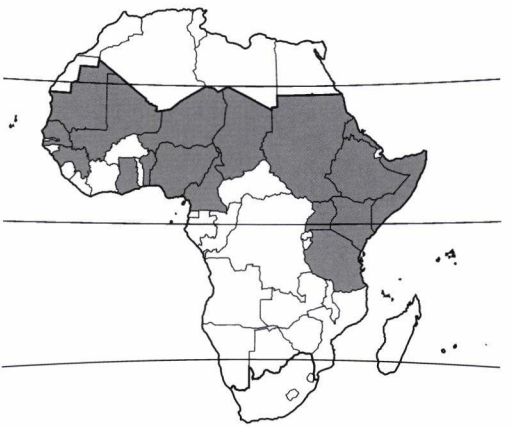
Chromosome number $2n = 22$

Synonyms *Adenium somalense* Balf.f. (1888), *Adenium socotranum* Vierh. (1904).

Vernacular names Desert rose, impala lily (En). Rose du désert, baobab chacal, faux baobab, lis des impalas, pied d'éléphant (Fr). Rosa do deserto, baobá exótica, djindje pété (Po). Mdagu, mdaguwande, mwanja (Sw).

Origin and geographic distribution *Adenium obesum* occurs from Senegal to Ethiopia and from Somalia to Tanzania. It also occurs in Egypt, Saudi Arabia, Oman and Yemen, including Socotra; it is uncertain whether it occurs naturally in West Africa or has been introduced and become naturalized. *Adenium obesum* is naturalized in Sri Lanka and parts of south-eastern Asia, e.g. Thailand. As an ornamental it is cultivated worldwide.

Uses In a wide area of Africa the root sap or sometimes the wood or stem latex of *Adenium obesum* is used to prepare arrow poison. The poison is popular for hunting large game as it kills quickly and the hunted animal dies within 2 km from the place where it was shot. The Hadza people of Tanzania use the sap by itself or sometimes in combination with poison from *Strophanthus eminii* Asch. & Pax, while the Duruma people of Kenya use the stem latex, sometimes in combination with the roots and wood of *Acokanthera schimperi* (A.DC.) Schweinf. or the latex of *Synadenium pereskiifolium* (Baill.) Guillaumin. The use of *Adenium obesum* arrow poison is also reported from Senegal, Nigeria and Cameroon. A decoction of the bark and leaves is widely used as fish poison. This use is reported from Nigeria, Cameroon and East Africa. In Mauritania and Senegal preparations from *Adenium obesum* are used as ordeal poison and for criminal purposes.



Adenium obesum – wild

Adenium obesum is important in traditional medicine. In the Sahel a decoction from the roots, alone or in combination with other plants, is used to treat venereal diseases; a root or bark extract is used as a bath or lotion to treat skin diseases and to kill lice, while latex is applied to decaying teeth and septic wounds. In Somalia a root decoction as nose drops is prescribed for rhinitis. In northern Kenya latex is rubbed on the head against lice and powdered stems are applied to kill skin parasites of camels and cattle. The bark is chewed as an abortifacient.

Adenium obesum is planted fairly frequently for its curious form and attractive flowers. Sometimes it is planted as a live fence. In Tanzania it is planted to mark the position of graves. The wood is sometimes used as fuel.

Production and international trade Seed

and plants of *Adenium obesum* are traded internationally for ornamental purposes.

Properties In *Adenium obesum* the presence of some 30 cardiotoxic glycosides has been demonstrated, which act in a similar way as digitalis from *Digitalis*. Digitalis acts upon the Na^+K^+-ATPase enzyme that regulates the concentrations of Na^+ and K^+ ions in body cells and so also modifies the Ca^{++} concentration. In low doses it is used to treat congestive heart failure (CHF) and heart rhythm problems (atrial arrhythmias), but in high doses it leads to systolic heart failure and death.

Several of the cardiac glycosides from *Adenium obesum* have oleandrigenin as aglycone moiety, e.g. hongheloside A (with D-cymarose), hongheloside C (with D-cymarose and D-glucose) and 16-acetylstrospeside (with D-digitalose). Other glycosides include: hongheline (composed of digitoxigenin with D-thevetose), somaline (composed of digitoxigenin with D-cymarose) and digitalinum verum (composed of gitoxigenin with D-digitalose and D-glucose). The roots and stems contain the same glycosides and in similar amounts. Oleandrigenin and some of the glycosides derived from it have cytotoxic effects and are being studied as potential components of anticancer drugs.

The ethanol extract of the roots slows down the growth of *Bacillus subtilis*, but has not shown activity against *Pseudomonas aeruginosa*, *Staphylococcus aureus* or *Candida albida*. Extracts from the root have shown a cytotoxic effect against several carcinoma cell lines. The aqueous stem bark extract is a potential acaricide as it shows high toxicity on all stadia of development of the ticks *Amblyomma* spp. and *Boophilus* spp.

Description Succulent shrub or small tree, up to 4(–6) m tall, sometimes with a fleshy taproot; stem swollen at base up to 1(–2) m in diameter; bark pale greyish-green, grey or brown, smooth, with sticky, clear or white latex; branchlets glabrescent, pubescent at apex. Leaves arranged spirally, clustered at the end of branchlets, simple; stipules minute or absent; petiole up to 4 mm long; blade linear to obovate, 3–12(–17) cm × 0.2–6 cm, base cuneate, apex acute to rounded or emarginate, entire, slightly glaucous, dull green or pale green, leathery, pinnately veined with distinct or indistinct lateral veins. Inflorescence a more or less dense terminal cyme; bracts linear to narrowly oblong, 3–8 mm long, acuminate, pubescent. Flowers bisexual, regular, 5-merous, showy, usually appearing before the leaves; pedicel 5–9 mm long; sepals narrowly oblong to narrowly ovate, 6–12 mm long, hairy; corolla with funnel-shaped tube 2–4.5 cm × 0.9–1.7 cm, reddish-pink to white suffused with pink, sometimes red-striped inside the throat, hairy to glabrous outside, glandular hairy on main veins inside, lobes 1–3 cm × 0.5–2.5 cm, spreading, pale pink to red with darker margins; stamens inserted near base of corolla tube, included or exserted, anthers forming a cone covering the pistil, base sagittate, 5–7 mm long, with long apical appendices; ovary superior, composed of 2 free carpels, glabrous, styles fused, slender, with well-developed clavuncula. Fruit consisting of 2 linear-oblong follicles, coherent at the base, 11–22 cm long, tapering at both ends, recurved, grey to pale grey-brown, opening by a longitudinal slit, many-seeded. Seeds linear-oblong, 10–14 mm long, pale brown, slightly rough, with tufts of long dirty white hairs at both ends.



Adenium obesum – 1, leafy branch; 2, inflorescence; 3, follicle; 4, seed.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Adenium* comprises 5 species, which are sometimes merged into a single one, *Adenium obesum* with 6 subspecies. *Adenium obesum* is the most widespread species in the wild and in cultiva-

tion. It crosses readily with *Adenium multiflorum* Klotzsch in cultivation, but the areas of natural distribution do not overlap. *Adenium* is closely related to *Pachypodium* and *Nerium*.

Growth and development The stem base of *Adenium obesum* becomes strongly thickened with age and sometimes spreads over rocks. In the wild the plant flowers during the first part of the dry season while leafless. Pollination is by insects with a long slender proboscis. The proboscis is inserted through one of the slits in the cone formed by the anthers and the pollen is placed on the stigma. When the proboscis is withdrawn, it is gummed by contact with the knob of the style and picks up fresh pollen from the anthers. Fruits mature 2–3 months after pollination. In cultivation in warm climates the plant can be semi-evergreen if kept warm and well-watered. Under such conditions plants undergo a short period of leaf-drop and dormancy in spring or early summer. They can also endure a drought or cold-induced dormancy of several months as occurs in the natural habitat. Under favourable conditions some clones flower for 2–4 months or even nearly year-round. Flowering stops when temperatures exceed 38°C. Plants grown from seed may flower within 1 year. Plants grown from cuttings also develop a thickened stem base and become indistinguishable from seed-grown plants.

Ecology *Adenium obesum* occurs in savanna, dry bushland or woodland, and wooded grassland up to 2100 m altitude, on rocky or sandy soil. In cultivation it requires full sunlight and warm temperatures with maximum temperatures preferably above 30°C. Although it originates from dry areas, it tolerates high air humidity well, which explains its popularity e.g. in Thailand and the Philippines. Branch tips are damaged at temperatures below 5°C and *Adenium obesum* cannot be grown in the open when temperatures are regularly close to 0°C. Waterlogging is not tolerated.

Propagation and planting As an ornamental *Adenium obesum* is propagated by seed, grafting or cuttings. Viability of seed from cultivated plants is sometimes poor because of pollination problems. Viable seed should be planted in a sandy free-draining medium after removal of the hairy tufts and treatment with a fungicide. It germinates within a week at temperatures of about 30°C. Seedlings are ready for transplanting within 1 month when they have developed 6 leaves. Tip-cuttings dipped in a rooting hormone, planted in a coarse rooting medium and well watered are most successful. Selected plants and valuable hybrids are often propagated by cleft grafting as this process is more reliable than propagation by cuttings, although it requires more skill. Grafting onto oleander (*Nerium oleander* L.) is possible and leads to rich flowering.

Management *Adenium obesum* thrives under conditions of ample rainfall or irrigation with temperatures above 27°C and in a perfectly draining soil. During cool weather it is prone to root rot and then requires drier soil. For fast growth fertilizer should be applied regularly.

Diseases and pests Bacterial and fungal root and stem rot are the most common diseases in cultivation. Avoiding wet cool conditions is the best control strategy. Spider mites, scale insects and mealy bugs occasionally cause damage. Caution is needed when using pesticides as *Adenium obesum* is sensitive to many formulations containing oil. Diseases and pests seem rare in the wild.

Genetic resources *Adenium obesum* occurs in a large area and does not seem to be in danger of genetic erosion.

Breeding Many ornamental cultivars of *Adenium obesum* have been developed as well as hybrids with other species. Well known selections are 'Singapore' which is deep pink and probably originally from Yemen, 'Red Everbloomer', 'Mombasa' which is a much-branched dwarf, 'Fritz Dederer' forming thick corky white bark, and 'Tom Grumbleys' with purely white flowers. Hybrids between *Adenium obesum* and *Adenium swazicum* Stapf include 'Asha', 'Endless Sunset', 'Perpetual Pink' and 'Volcanic Sunset'.

Prospects The chemical and pharmacological properties of *Adenium obesum* deserve more research attention although there are no immediate prospects for the development of heart or cancer medicines. Interest in *Adenium obesum* as an ornamental is likely to remain strong because of the striking habit and flowers.

Major references Dimmitt & Hanson, 1991; Leeuwenberg, 2003; Leeuwenberg et al., 1985; McLaughlin & Garofalo, 2002; Neuwinger, 1996; Omino, 2002; Plaizier, 1980; Rowley, 1983; Yamauchi & Abe, 1990.

Other references Arbonnier, 2000; Cepleanu et al., 1994; Eggli, 2002; Forster, 1998; Goyder, 2001; Hargreaves, 2002; Melero, Medarde & San Feliciano, 2000; Mgbojikwe & Okoye, 2000; Neuwinger, 2000; Singh, 2004;

Vethaviyasar & John, 1982.

Sources of illustration Plaizier, 1980.

Authors L.P.A. Oyen

ADENIUM OLEIFOLIUM Stapf

Protologue Kew Bull. 1907: 53 (1907).

Family Apocynaceae

Chromosome number $2n = 22$

Synonyms *Adenium obesum* (Forssk.) Roem. & Schult. subsp. *oleifolium* (Stapf) G.D.Rowley (1980).

Origin and geographic distribution *Adenium oleifolium* occurs naturally in south-eastern Namibia, Botswana and South Africa.

Uses An arrow poison is prepared from the latex, or from a decoction of the extremely bitter tuber. People living in the south-western Kalahari Desert prepare a salve from the plant, which is applied to snakebites and scorpion stings. Root sap is used to treat fever and colic. In larger doses it is purgative and toxic. *Adenium oleifolium* is occasionally grown as an ornamental.

Properties Several cardiac glycosides have been isolated from *Adenium oleifolium*: honghelosides A (composed of oleandrigenin and D-cymarose), echujine (composed of the digitoxigenin, D-cymarose and 2 molecules of D-glucose), somaline (composed of digitoxigenin and D-cymarose) and odorotrioside G (composed of digitoxigenin, D-digitalose and 2 molecules of D-glucose). Tests with guinea pigs, cats and rats, which were injected with an alcoholic extract of the tuber or given the extract orally, all resulted in restlessness, generalized tremor, rapid breathing, convulsions and death.

Botany Succulent, small shrub up to 40 cm tall, with thickened rootstock (tuber) 50–80 cm × 15–30 cm and white latex in all parts, soft pubescent on all parts; stem swollen at base. Leaves arranged spirally, clustered at the end of branchlets, simple, sessile; stipules minute or absent; blade linear, 4.5–14.5 cm × 0.3–1.4 cm, base cuneate, apex acute, entire, glaucous or pale green, leathery, hairy to glabrous. Inflorescence a terminal cyme; bracts narrowly oblong to narrowly ovate, 3–4 mm × 1–2 mm, acuminate, pubescent. Flowers bisexual, regular, 5-merous, showy, appearing with the leaves; pedicel 5–8 mm long, hairy; sepals lanceolate, 5–7 mm long, fused at base, white outside, hairy; corolla with tube 2.2–3.4 cm long, narrowly cylindrical at the base for 4–7 mm then campanulate to funnel-shaped, throat scales forming pockets between the lobes, lobes obovate, spreading, 1–1.3 cm long, acute, pale pink to red, more intense towards the margin, hairy outside, glabrous inside; stamens inserted at base of widened part of corolla tube, slightly exserted, anthers forming a cone covering the pistil, base sagittate, 5–7 mm long, with long apical appendices; ovary superior, composed of 2 free carpels, glabrous, styles fused, slender, with well-developed clavuncula. Fruit consisting of 2 cylindrical follicles, coherent at base, 8–11 cm long, long tapering at apex, spreading or recurved when mature, opening by a longitudinal slit, many-seeded. Seeds linear-oblong, 12–15 mm long, brown, striate, with tufts of long brownish hairs at both ends.

Adenium comprises 5 species, which are sometimes merged into a single one, *Adenium obesum* (Forssk.) Roem. & Schult. with 6 subspecies. *Adenium oleifolium* is characterized by its narrow leaves. The fruits take more than a year to mature. Seeds germinate readily, but the growth of the plants is slow.

Ecology *Adenium oleifolium* grows in grassland with bushes, on stony ridges and limestone rock outcrops or in loose sand.

Genetic resources and breeding Although the natural distribution of *Adenium oleifolium* is restricted, it seems not to be in immediate danger of genetic erosion. However, in Botswana it is rare and considered vulnerable.

Prospects More research into the chemical composition and pharmacological activities of the compounds of *Adenium oleifolium* seems warranted. Possibilities to develop *Adenium oleifolium* as an ornamental seem limited because of its slow growth.

Major references Dimmitt & Hanson, 1992; Neuwinger, 1996; Plaizier, 1980; Rowley, 1983; von Koenen, 2001.

Other references Codd, 1963.

Authors L.P.A. Oyen

AGAVE AMERICANA L.

Protologue Sp. pl. 1: 323 (1753).

Family Agavaceae

Chromosome number $2n = 60$

Vernacular names Century plant, American agave, American aloe (En). Agave d'Amérique (Fr). Piteira de boi, piteira brava (Po).

Origin and geographic distribution *Agave*

americana is a native of Mexico and the southern United States. It has been distributed throughout the world for its ornamental value. Its distribution in Africa is not reflected by collections in herbaria as it is introduced and not easy to collect. However, it is probably found throughout tropical Africa.

Uses In DR Congo and Mauritius the leaf sap of *Agave americana* is drunk for its laxative and diuretic properties and as an emmenagogue. It is applied to wounds and cuts to promote healing. A decoction of the roots is taken, mixed with honey, to cure syphilis and it also has diuretic properties. In South Africa the leaves are used to treat cardiac problems, high blood pressure and gastro-intestinal problems. The leaves are split, heated and applied externally to relieve rheumatic pain. The leaf sap is used as an insecticide, e.g. against termites in Tanzania.

As an ornamental, *Agave americana* is planted in private and public gardens and on roadsides. It is used as a hedge plant and planted along contours for erosion control and for reclamation of denuded and overgrazed land. The leaf fibres are used locally to make textiles.

Properties Two different derivatives of triacontanol, isolated from the leaves, were shown to have antibacterial activity against *Staphylococcus* spp., *Pseudomonas aeruginosa* and *Escherichia coli*. Leaf extracts showed molluscicidal and insecticidal properties. The leaves contain angiotensin-converting enzymes that are a potent medicine to treat hypertension. The leaves also contains several sapogenins, e.g. hecogenin, which can be used in the manufacture of semisynthetic corticosteroids, but only if they do not contain too much tigogenin, because this results in losses in product quality and yield. In Nigerian plants tigogenin was only found in trace amounts in the leaves. Tigogenin itself is a base material for the production of other steroids.

The leaves contain needle-like calcium oxalate crystals, called raphides, which can cause contact dermatitis and conjunctivitis.

Botany Robust, perennial herb up to 9 m tall when flowering, producing suckers; stem short and thick, up to 20 cm in diameter, with a dense rosette of leaves at apex. Leaves arranged spirally, succulent, sessile, lanceolate, 1–2 m × 15–25 cm, base fleshy, triangular in cross section, apex with sharp, dark brown spine up to 5 cm long, margin wavy to toothed with teeth up to 10 mm long, pale blue-grey to green, sometimes variegated. Inflorescence a very large, terminal, rather open panicle; peduncle 2–8 m long. Flowers bisexual, regular; perianth tubular, 8–20 mm long, 6-lobed, pale yellow; stamens 6, attached above the middle of the perianth tube, 6–9 cm long; ovary inferior, 3-celled, style 1, longer than the stamens, stigma 3-lobed. Fruit an oblong capsule 4–5 cm long, shortly beaked, many-seeded. Seeds flat, disk-shaped, 7–8 mm × 5–6 mm, curved, shiny black. Seedling with epigeal germination.

Agave americana follows the Crassulacean Acid Metabolism (CAM) pathway. CAM plants are able to fix CO_2 at night and photosynthesize with closed stomata during the day, thus minimizing water loss. *Agave* comprises 100–200 species, all native to Central America and Mexico.

Ecology *Agave americana* is adapted to a wide range of conditions. In East Africa it is found from sea-level to 2500 m altitude. It is found in both low and high rainfall areas. In many countries in southern Africa, including South Africa, it is considered a noxious invasive weed.

Management Multiplication of *Agave americana* is done by suckers or seeds. The hecogenin content of the leaves increases with age of the plant and is highest during dry periods.

Genetic resources and breeding As *Agave americana* is widely distributed and cultivated no threats are envisaged. Many ornamental cultivars have been developed, including a cultivar with pale yellow leaf margins, known as 'Marginata', which is widely planted. Breeding and selection for ornamental properties is ongoing.

Prospects As a source of medicine for hypertension, *Agave americana* is promising. Hypertension, often regarded as a disease of well-to-do populations, is on the increase in urban populations in Africa.

Major references Duncan, Jäger & van Staden, 1999; Edwards & Tesfaye, 1997; Gelfand et al., 1985; Gurib-Fakim, Guého & Bissoondoyal, 1995.

Other references Dahal, Utomo & Brink, 2003; Dharmshaktu, Prabhakaran & Menon, 1987; Gbolade et al., 1992; Lorenza-Salinas, Ogura & Soffchi, 2001; McDaniel, 1985; Nel et al., 2004; Parmar et al., 1992; Sukumaran, Parashar & Rao, 1994; Watt & Breyer-Brandwijk, 1962; Yang et al., 2006b.

Authors P. Oudhia

ALAFIA BARTERI Oliv.

Protologue Hook.f., Icon. pl. 20: t. 1992 (1890).

Family Apocynaceae

Origin and geographic distribution *Alafia barteri* occurs in the forests of West and Central Africa, from Guinea Bissau east to Cameroon and south to Congo.

Uses In Côte d'Ivoire a leaf infusion is used to treat malaria. In Nigeria a decoction is taken to treat rheumatic pains. The roots are used as chew sticks.

The fibre of the stems is used as binding material for roofs. The latex has been used to adulterate better latex.

Properties Ethanol and water extracts of the leaves of *Alafia barteri* showed antifungal activity against *Aspergillus flavus*, *Aspergillus fumigatus*, *Aspergillus niger*, *Candida albicans*, *Microsporum audoninii*, *Trichoderma viride* and *Trichophyton mentagrophytes*. The ethanol extracts were more effective than the water extracts.

Botany Liana up to 35 m long, with clear sap or sometimes with white latex; stem up to 3 cm in diameter; bark pale grey-brown with many lenticels. Leaves opposite, simple and entire; stipules in axil of petiole; petiole 2–5(–8) mm long; blade elliptical to narrowly elliptical, 4–16.5 cm × 2–6.5 cm, base obtuse to cordate, apex rounded to shortly acuminate, leathery, glabrous. Inflorescence a rather lax terminal dichasial cyme, many-flowered; peduncle 5–20 mm long; bracts sepal-like. Flowers bisexual, regular, 5-merous, fragrant; pedicel 2–6 mm long; sepals free, ovate, 1.5–2 mm long, rounded or obtuse; corolla white, often with greenish tube, tube 5–8 mm long, 1–2 mm wide above the base, widening near the insertion of the stamens and narrowed towards the throat, glabrous or slightly hairy outside, inside with hairy belt below insertion of stamens, lobes obliquely orbicular to elliptical or obovate, 4.5–8 mm long, at apex rounded and often wavy, spreading, glabrous outside, hairy with curled to rather straight hairs at the part of the lobes covered in the bud and hairy inside at the base and in the upper part of the throat; stamens inserted halfway the corolla tube, just included or exserted, anthers sessile, arrow-shaped; ovary superior, ovoid, consisting of 2 separate carpels, style narrowly obconical, 2.5–3 mm long, pistil head consisting of basal ring, cylindrical part and 2-lobed stigmoid apex. Fruit consisting of 2 separate, cylindrical, linear follicles 15–50 cm × 0.5–1 cm, dehiscent, dark brown, many-seeded. Seeds narrowly ellipsoid, c. 20 mm long, at the top with a tuft of hairs c. 2.5 cm long.



Alafia barteri – *1, flowering twig; 2, flower; 3, fruit.*
Source: Flore analytique du Bénin

Alafia comprises 23 species, 15 of which occur in continental Africa and 8 in Madagascar. *Alafia benthamii* (Baill.) Stapf is another species from West and Central Africa, usually found in periodically inundated riverine forest. In Sierra Leone a leaf infusion is used to treat fever.

Ecology *Alafia barteri* occurs in lowland forest up to 200 m altitude.

Genetic resources and breeding *Alafia barteri* is widespread and there are no indications that it is threatened by genetic erosion.

Prospects *Alafia barteri* is a useful medicinal plant in rural communities. More information is needed to assess the pharmacological possibilities.

Major references Burkill, 1985; Dalziel, 1937; Irvine, 1961; Leeuwenberg, 1997b.

Other references Adekunle & Okoli, 2002; Osemeobo & Ujor, 1999; Tra Bi, Kouamé & Traoré, 2005.

Sources of illustration Akoègninou, van

der Burg & van der Maesen, 2006.

Authors A. de Ruijter

ALAFIA LANDOLPHIOIDES (A.DC.) Benth. & Hook.f. ex K.Schum.

Protologue Engl. & Prantl, Nat. Pflanzenfam. 4, 2: 165 (1895).

Family Apocynaceae

Synonyms *Alafia scandens* (Thonn.) De Wild. (1903).

Origin and geographic distribution *Alafia landolphioides* occurs from Senegal east to the Central African Republic and northern DR Congo.

Uses In Côte d'Ivoire and Ghana a leaf decoction of *Alafia landolphioides* is taken to treat rheumatism, while scraps of the residue are rubbed in to treat rheumatic spots. In Ghana the latex is used as an adhesive ingredient in arrow poison; in the Central African Republic it is also used as an ingredient of arrow poison.

Botany Liana up to 20 m long, with white latex; stem up to 2.5 cm in diameter; bark dark brown, with pale brown lenticels. Leaves opposite, simple and entire; stipules in axil of petiole; petiole 3–7 mm long; blade elliptical to narrowly elliptical, 4–13 cm × 1.5–6.5 cm, base cuneate to rounded, apex acuminate, leathery, glabrous or hairy. Inflorescence a rather lax terminal dichasial cyme, many flowered; peduncle 3–40 mm long; bracts sepal-like. Flowers bisexual, regular, 5-merous, fragrant; pedicel 1–5 mm long; sepals free, ovate to broadly ovate, 1.5–2 mm long, obtuse or rounded; corolla white, dark red at the throat, tube 6–7 mm long, 1.5–2 mm wide above the base, slightly widening near the insertion of the stamens and narrowed towards the throat, glabrous outside, inside with hairy belt below insertion of stamens, lobes obliquely elliptical to oblong or obovate, 5.5–9 mm long, rounded, spreading, hairy near margin with long curled hairs at the part of the lobes covered in the bud; stamens inserted 1.5–3.5 mm from the base of the corolla tube, included, anthers sessile, arrowhead-shaped; ovary superior, globose, consisting of 2 separate carpels, style narrowly obconical, 2.5–3 mm long, pistil head consisting of a basal ring, cylindrical part and 2-lobed stigmoid apex. Fruit consisting of 2 separate, cylindrical, linear follicles 18–45 cm × 0.5–1.5 cm, dehiscent, dark brown, striate, glabrous, many-seeded. Seeds narrowly ellipsoid, 16–19 mm × 2–3 mm × 0.5–1 mm, with several longitudinal lines, with an acute wing 2 mm long at base, at the top with a tuft of hairs 3–5 cm long.

Alafia comprises 23 species, 15 of which occur in continental Africa and 8 in Madagascar. The seeds and roots of *Alafia erythrophthalma* (K.Schum.) Leeuwenb., occurring partly in the same region as *Alafia landolphioides*, i.e. from Nigeria east to Uganda and south to DR Congo, are used as an arrow poison ingredient in the Central African Republic and DR Congo.

Ecology *Alafia landolphioides* occurs in forest and savanna, up to 1000 m altitude.

Genetic resources and breeding Although *Alafia landolphioides* is fairly widespread, it is locally under much pressure because of habitat destruction, e.g. in Côte d'Ivoire.

Prospects Research is needed to assess the potential of *Alafia landolphioides* in the treatment of rheumatic pains. *Alafia landolphioides* produces large amounts of fragrant flowers, and may be a potential ornamental plant.

Major references Abbiw, 1990; Burkill, 1985; Irvine, 1961; Kerharo & Bouquet, 1950; Neuwinger, 2000.

Other references Avit, Pedia & Sankaré, 1999; Terashima & Ichikawa, 2003.

Authors A. de Ruijter

ALAFIA LUCIDA Stapf

Protologue Bull. Misc. Inform. Kew 1894: 122 (1894).

Family Apocynaceae

Origin and geographic distribution *Alafia lucida* occurs from Guinea east to Uganda and Tanzania, and south to northern Angola.

Uses In Côte d'Ivoire an extract of the aerial parts is taken to treat jaundice and swollen glands, whereas in Gabon it is dripped into the eye to cure eye problems. A leaf decoction is used in Congo to wash sores and is taken orally to treat stomach complaints. To promote the healing of wounds, a paste made from bark and plant sap is applied as a dressing. The latex, coagulated with sap from *Costus* sp., is used as arrow poison.

Properties The chemical constituents of *Alafia lucida* are not known, apart from the information that the seeds tested positive for alkaloids.

Botany Large liana up to 45(–70) m long, with white latex; stem up to 18 cm in diameter;

branches dark brown or pale grey, rough, deeply longitudinally fissured, glabrous. Leaves opposite, simple and entire; stipules in axil of petiole; petiole 2–6 mm long; blade elliptical to obovate, 4.5–15 cm × 2–7 cm, base cuneate, apex rounded or shortly acuminate, leathery, glabrous. Inflorescence a rather lax terminal, occasionally axillary dichasial cyme, many-flowered; peduncle 5–25 mm long; bracts sepal-like, persistent. Flowers bisexual, regular, 5-merous, sweet-scented; pedicel 4–7 mm long; sepals free, ovate to broadly ovate, 1–2 mm long, obtuse or rounded; corolla yellow or cream with a dark red throat, tube 4–7 mm long, 1–2 mm wide at base, slightly widening at or just below the middle, glabrous or hairy in longitudinal stripes outside, inside with hairy belt below insertion of stamens, lobes elliptical, 6–10 mm long, apex bluntly truncate, slightly toothed, hairy on the part covered in the bud; stamens inserted 1.5–5.5 mm from the base of the corolla tube, just included or exserted, anthers sessile, arrowhead-shaped; ovary superior, ovoid to globose, consisting of 2 separate carpels, style narrowly obconical, c. 2 mm long, pistil head consisting of a basal ring, cylindrical part and 2-lobed stigmoid apex. Fruit consisting of 2 separate, cylindrical, linear follicles 24–75 cm × 0.5–1.5 cm, dehiscent, dark brown, striate, glabrous, many-seeded. Seeds narrowly ellipsoid, c. 23 mm × 2 mm × 1 mm, with longitudinal ridges, at the top with a tuft of hairs c. 3 cm long.

Alafia comprises 23 species, 15 of which occur in continental Africa and 8 in Madagascar. *Alafia caudata* Stapf is also medicinally used in Gabon. It occurs from Gabon east to Kenya and south to Mozambique and Angola. In Gabon bark scrapings along with the fruit of *Capsicum annuum* L. are rubbed on the skin to treat kidney pain. *Alafia perrieri* Jum. is endemic to Madagascar and has similar uses as *Alafia lucida*. A decoction of the bark is taken to treat jaundice, measles and fever attacks. The latex of *Alafia perrieri* and three other endemic species in Madagascar, *Alafia fuscata* Pichon, *Alafia pauciflora* Radlk. and *Alafia thouarsii* Roem. & Schult., contain saponins and are used as a substitute for soap. The fibre of the stems of these last three species is used as binding material for roofs.

Ecology *Alafia lucida* occurs in primary and secondary rainforest up to 2000 m altitude.

Genetic resources and breeding *Alafia lucida* is widespread and there are no indications that it is threatened by genetic erosion.

Prospects As there are no published data on the chemical compounds or pharmacological effects of *Alafia lucida* it will probably remain of local importance only.

Major references Bouquet, 1969; Bouquet & Debray, 1974; Burkill, 1985; Neuwinger, 2000.

Other references Abisch & Reichstein, 1960; Boiteau, Boiteau & Allorge-Boiteau, 1999; Dalziel, 1937; Markgraf, 1976; Raponda-Walker & Sillans, 1961.

Authors A. de Ruijter

ALAFIA MULTIFLORA (Stapf) Stapf & Pichon

Protologue Bull. Misc. Inform. Kew 1908: 303 (1908).

Family Apocynaceae

Origin and geographic distribution *Alafia multiflora* occurs from Sierra Leone east to southern Sudan and south to northern DR Congo.

Uses *Alafia multiflora* is widely used in its area of distribution to treat wounds. Latex mixed with bark scrapings is applied to wounds and ulcers, and also to ulcers caused by syphilis. In Ghana the latex diluted with water is taken to cure stubborn wounds. In Cameroon fresh latex, either alone or mixed with *Oncinotis glabrata* (Baill.) Stapf ex Hiern, is also applied to treat yaws. Stem bark or fruits in decoction are taken to relieve abdominal pain. The seeds are an ingredient of arrow poison in DR Congo.

Properties The pyrrolizidine alkaloid alafine has been extracted from *Alafia multiflora* seeds. Vanillic acid isolated from an ether extract of the latex was found to be responsible for the antibacterial properties.

Botany Large liana up to 40(–80) m long, with clear sap or sometimes white latex; stem up to 18 cm in diameter; bark dark brown, rough, with or without scattered pale brown lenticels. Leaves opposite, simple and entire; stipules in axil of petiole; petiole 5–10 mm long; blade elliptical, 5–21 cm × 2.5–11.5 cm, base rounded to slightly cordate, apex shortly acuminate, leathery, glabrous on both sides. Inflorescence a dense terminal dichasial cyme, many-flowered; peduncle 3–27 mm long; bracts sepal-like. Flowers bisexual, regular, 5-merous, slightly fragrant; pedicel 5–15 mm long; sepals free, ovate to broadly ovate, 3–6 mm long, rounded or obtuse; corolla white, often greenish outside, tube 11–18 mm long, 1.5–3 mm wide

at base, widening near the insertion of the stamens and narrowed towards the throat, glabrous outside, inside with hairy belt below insertion of stamens, lobes broadly rounded, 10–20 mm long, at apex often wavy, spreading, hairy with long curled hairs at the part of the lobes covered in the bud and hairy inside in the upper part of the throat; stamens inserted halfway the corolla tube, included, anthers sessile, arrowhead-shaped; ovary superior, broadly ovoid, 2-celled, style cylindrical, 4.5–10 mm long, pistil head cylindrical with 2-lobed stigmoid apex. Fruit a cylindrical, linear capsule 70–110 cm × 2–2.5 cm, dehiscent, glabrous, many-seeded. Seeds narrowly ellipsoid, 20–26 mm × 4 mm × 2 mm, with a longitudinal raised line, at the base with an obtuse wing 0.5–1 mm long, at the top with a beak c. 5 mm long and tuft of hairs 4–7 cm long.

Alafia comprises 23 species, 15 of which occur in continental Africa and 8 in Madagascar. *Alafia multiflora* differs from the other species of the genus by the syncarpous fruit and the beak on the seed. The fruits of *Alafia multiflora* and those of *Alafia schumannii* Stapf are the longest in the entire family, measuring up to 1.1 m.

Alafia schumannii occurs in tropical forest from Sierra Leone east to Uganda and south to northern Angola. The latex is an effective medicine for treating wounds: it is dropped directly into the wound to improve healing.

Ecology *Alafia multiflora* occurs in periodically inundated riverine forest, up to 750 m altitude.

Management *Alafia multiflora* can be harvested at any time in the year. Harvesting is done by wounding a leafy stem, collecting the latex on a leaf or in a bottle and put it directly on and around the wound or ulcers. Bark is harvested by scratching it as powder from the stem; it is then mixed with the sap.

Genetic resources and breeding *Alafia multiflora* is widespread and there are no indications of genetic erosion.

Prospects *Alafia multiflora* is a widely used medicinal plant in rural communities. As there are few published data on the pharmacological effects of this plant, more information is needed to assess its qualities.

Major references Abbiw, 1990; Balansard et al., 1980; Leeuwenberg, 1997b; Neuwinger, 2000; Pais et al., 1971.

Other references Brisson, 1988; Mshana et al., 2000; N'goran et al., 1995.

Authors D.E. Tsala & T. Dimo

ALBERTISIA CORDIFOLIA (Mangenot & J.Miège) Forman

Protologue Kew Bull. 30(1): 83 (1975).

Family Menispermaceae

Synonyms *Epinetrum cordifolium* Mangenot & J.Miège (1951).

Origin and geographic distribution *Albertisia cordifolia* is endemic to the south-eastern coastal region of Côte d'Ivoire, where it occurs in a small area near Abidjan.

Uses In Côte d'Ivoire the root of *Albertisia cordifolia* is used to treat anaemia and oedema of the legs. Root pulp with some water is used as nose drops and administered as a sedative to agitated people, complementing treatment with the root of *Rauvolfia vomitoria* Afzel. Root pulp is inserted into the vagina to treat uterus complaints and applied externally as a haemostatic. Men suffering from gonorrhoea take an enema of root pulp. A root maceration is taken as an enema or in draught as aphrodisiac and stimulant.

Properties The roots of *Albertisia cordifolia* contain the bisbenzylisoquinoline alkaloids cycleanine, isochondrodendrine and norcycleanine. Cycleanine is a neuromuscular stimulant in small doses and paralyses at high doses. *Albertisia cordifolia* is considered poisonous to sheep.

Botany Dioecious scandent shrub or liana up to 15 m long; young branches yellowish hairy, old branches with greyish or brownish glabrous bark. Leaves alternate, simple and entire; stipules absent; petiole 3–12 cm long, thickened at both ends, white-hairy; blade ovate to elliptical, 8–25 cm × 5–17 cm, base cordate, apex acute or shortly acuminate, papery to thinly leathery, glabrous except for the veins, pinnately veined but with 5–7 basal veins. Inflorescence an axillary few-flowered cyme; male inflorescence 2–5-flowered, with peduncle up to 1.5 cm long, female inflorescence 1–2-flowered with peduncle up to 2 mm long. Flowers unisexual, regular, pedicel 2–4 mm long; sepals 9 in 3 whorls, greyish hairy outside, glabrous and blackish inside, 3 outer sepals triangular, c. 1 mm long, next 3 sepals triangular-ovate, 2–4 mm long, 3 inner ones elliptical-oblong, 6–9 mm long, yellowish; petals 6, kidney-shaped, c. 0.5 mm long; male flowers with c. 20 stamens fused into a staminal column 2–2.5 mm long, anthers fused into a conical head c. 2 mm long; female flowers with superior ovary consisting of 6 silky hairy carpels. Fruit composed of 4–6 sessile drupes,

each drupe ovoid to nearly globose, 2–3.5 cm × 2–2.5 cm, short-hairy, orange, 1-seeded. Seed ovoid to broadly ellipsoid, 2–3 cm × 2–2.5 cm. Seedling with hypogeal germination; epicotyl 4–7 cm long; cotyledons remaining within the fruit-stone.

Albertisia cordifolia flowers from April to June and fruits ripen about 2 months later. The seeds are probably dispersed by animals that feed on the fruit.

Albertisia comprises 18 species, 13 in Africa and 5 in tropical Asia. Other species occurring in Côte d'Ivoire are *Albertisia mangenotii* (Guillaumet & Debray) Forman in the south-western part of the country and *Albertisia scandens* (Mangenot & J.Miège) Forman in southern Côte d'Ivoire and Ghana. Leaf sap of both species is applied to treat toothache, and leaf sap of *Albertisia scandens* is also applied to skin affections.

Ecology *Albertisia cordifolia* occurs in secondary formations inside dense humid forest at low altitude.

Management *Albertisia cordifolia* roots are only collected from the wild.

Genetic resources and breeding The area of distribution of *Albertisia cordifolia* is small with an estimated width of 13 km and its habitat is shrinking which may bring it in danger of extinction.

Prospects *Albertisia cordifolia* will probably remain locally important as a medicinal plant.

Major references Burkill, 1997; de Koning, 1983; Holmgren et al., 2004; Neuwinger, 2000; Troupin, 1962.

Other references Bouquet & Debray, 1974; Debray, 1966; Debray, Plat & Le Men, 1966; Forman, 1975; Hawthorne & Jongkind, 2006; Oliver-Bever, 1986.

Authors A. de Ruijter

ALBERTISIA DELAGOENSIS (N.E.Br.) Forman

Protologue Kew Bull. 30(1): 83 (1975).

Family Menispermaceae

Synonyms *Epinetrum delagoense* (N.E.Br.) Diels (1910).

Origin and geographic distribution *Albertisia delagoensis* occurs in Mozambique and eastern South Africa.

Uses In Mozambique the root of *Albertisia delagoensis* is used to treat fever. In South Africa a root extract is taken to treat diarrhoea, vomiting, menstrual pain, chest problems, body pain caused by influenza, back pain and antenatal problems, and it is used as an anthelmintic, appetite stimulant and to improve sexual performance in men. A root and leaf extract is given orally to babies for cleansing the stomach. The ash of burnt roots is applied to heal sores.

Properties The stems and roots of *Albertisia delagoensis* contain as major compounds the bisbenzylisoquinoline alkaloids O-methylcocsoline and cissacapine, and small amounts of cocsoline, cocsuline, cycleanine and 2 unidentified alkaloids. The aporphine alkaloid dicentrine was also isolated as minor component. The leaves contain O-methylcocsoline and cycleanine and small amounts of the other alkaloids. The alkaloid yield of the roots is 1–2.2 mg/g dry weight, of the stems 0.3–0.8 mg/g and of the leaves 1.1–2.7 mg/g. The alkaloid composition varies between plants. The large amounts of alkaloids make the plant bitter, which explains its use as an appetite stimulant. Tested on chloroquine-resistant *Plasmodium falciparum*, methanol extracts of the leaves and roots exhibited antiplasmodial activities of IC_{50} 4.1 µg/ml and 1.6 µg/ml, respectively. Cocsoline showed strong antiplasmodial activity (IC_{50} = 1 µM) in vitro; cycleanine showed selective antiplasmodial and antiprotozoal activities as well as spasmolytic activity in vitro, and also antimicrobial, anti-inflammatory and analgesic activities. Dicentrine exhibited antibacterial and antifungal activities in vitro. In-vitro tests showed a low cytotoxicity against the Graham cell line for leaf extracts.

Botany Dioecious small shrub or liana; branches greyish hairy. Leaves alternate, simple and entire; stipules absent; petiole 1–1.5 cm long; blade oblong-elliptical to broadly elliptical, 4–9 cm × 2–5 cm, base cuneate, apex acute, mucronate, leathery, glabrous except on the veins above, short-hairy below, pinnately veined with 2–3 pairs of lateral veins, but also with 3–5 basal veins. Male inflorescence an axillary, 1–3-flowered cyme with short peduncle, female flowers solitary. Flowers unisexual, regular; pedicel 2–3.5 mm long; sepals 6 in 2 whorls, 3 outer sepals narrowly lanceolate or ovate, 1.5–2.5 mm × c. 1 mm, 3 inner sepals 4.5–6 mm × 2.5–3.5 mm; petals 6, kidney-shaped, 0.5–1 mm × 0.5–1 mm; male flowers with c. 20 stamens fused into a staminal column 3–4.5 mm long, anthers fused into a conical head c. 2 mm long; female flowers with superior ovary consisting of 6 silky hairy carpels. Fruit composed of 2–6 sessile drupes, each

drupe ellipsoid, c. 2.5 cm × 1.5 cm, short-hairy, orange, 1-seeded. Seed ovoid, curved, c. 1.5 cm × 1 cm.

Albertisia comprises 18 species, 13 in Africa and 5 in tropical Asia.

Ecology *Albertisia delagoensis* occurs on well drained littoral sand, in open grassy fields or in open spaces between trees.

Genetic resources and breeding Although the natural distribution of *Albertisia delagoensis* is restricted, it does not seem to be in danger of genetic erosion.

Prospects The low cytotoxicity of the leaf extract coupled to the significant antiplasmodial activity indicates that *Albertisia delagoensis* has potential as an antimalarial plant.

Major references de Wet, 2005; de Wet et al., 2007; Troupin, 1962.

Other references Jansen & Mendes, 1983; Marshall et al., 1994; Rondanelli et al., 1986a; Rondanelli et al., 1986b; Schiff, 1987; Schiff, 1991.

Authors A. de Ruijter

ALBERTISIA VILLOSA (Exell) Forman

Protologue Kew Bull. 30(1): 84 (1975).

Family Menispermaceae

Synonyms *Epinetrum villosum* (Exell) Troupin (1962).

Origin and geographic distribution *Albertisia villosa* occurs in Gabon, Congo, DR Congo and Cabinda (Angola).

Uses In DR Congo a root bark decoction is taken to treat malaria and a root decoction to treat diarrhoea and dysentery. The crushed leaves are applied to burned skin and ground leaves as a haemostatic to wounds. *Albertisia villosa* is considered to have abortive activity.

Production and international trade In DR Congo *Albertisia villosa* is commonly sold in local markets as a medicine.

Properties The root bark of *Albertisia villosa* contains the bisbenzylisoquinoline alkaloids cycleanine, cocsoline and norcycleanine, of which cycleanine is the most abundant (85%). Aqueous and methanol extracts of the root have shown strong antibacterial properties in in-vitro screening tests. The methanol extract was also effective against castor-oil-induced diarrhoea in mice. In-vitro tests of cycleanine and the alkaloidal extract of the root bark revealed potent antibacterial, antifungal, antiplasmodial, and cytotoxic activities. Cycleanine was found to cause inhibition of 12-O-tetradecanoyl-phorbol-13-acetate-induced ear tumours in rat. These results may partly explain and support the use of *Albertisia villosa* root bark for the treatment of malaria and other infectious diseases in traditional medicine in DR Congo.

Botany Dioecious liana; branches red-hairy. Leaves alternate, simple and entire; stipules absent; petiole 3–10 cm long, hairy; blade ovate, 9–20 cm × 6–18 cm, base cordate, apex long-acuminate, hairy at both sides, pinnately veined with 4–5 pairs of lateral veins but also with 5–7 basal veins. Male inflorescence an axillary 2–5-flowered cyme with short peduncle, female flowers solitary. Flowers unisexual, regular, nearly sessile; male flowers with 9 sepals, 6 outer sepals lanceolate, up to 10 mm long, very hairy, 3 inner sepals lanceolate to ovate, 6–10 mm × 2–4 mm, leathery, hairy, petals absent or 6 and very small, stamens up to 30, fused into a staminal column up to 1 mm long, anthers fused into a conical head 1.5–4 mm long; female flowers with 9–12 sepals, the outer 6–9 lanceolate, up to 10 mm long, very hairy, the 3 inner ones c. 7 mm long, petals 6, 1–2.5 mm × 1.5–3 mm, deeply cordate, with a tuft of red hairs at apex, ovary superior, consisting of 8–12 carpels 3–5 mm long, densely reddish hairy. Fruit composed of 2–6 ellipsoid drupes, each 3–4.5 cm × 2.5–3 cm, densely hairy, 1-seeded. Seeds ellipsoid, 2–2.5 cm × 1–1.5 cm.

Albertisia comprises 18 species, 13 in Africa and 5 in tropical Asia. Another species that occurs in Congo, DR Congo and Angola (and maybe also in Côte d'Ivoire and Tanzania) is *Albertisia undulata* (Hiern) Forman, which is also used as an abortifacient in DR Congo. Crushed leaves in palm oil are applied to treat wounds.

Ecology *Albertisia villosa* occurs in dense humid forest, also in secondary forest and in gallery forest at low to medium altitudes.

Genetic resources and breeding Although the habitat of *Albertisia villosa* is shrinking, there are no indications that it is threatened by genetic erosion.

Prospects Because of the potent antiplasmodial, bactericidal, cytotoxic and fungicidal activities of its main active ingredient cycleanine, further research on medicinal applications of *Albertisia villosa* is warranted.

Major references Lohombo-Ekomba et al., 2004; Longanga-Otshudi, Vercruysse & Foriers, 2000; Neuwinger, 2000; Troupin, 1951; Troupin, 1962.

Other references Burkill, 1997; Longanga-Otshudi et al., 2005; Longanga-Otshudi et al., 2000; Wome, 1985.

Authors A. de Ruijter

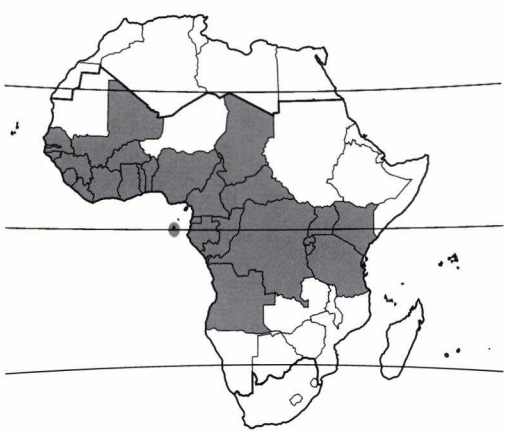
ALCHORNEA CORDIFOLIA (Schumach. & Thonn.) Müll.Arg.

Protologue Linnaea 34: 170 (1865).
Family Euphorbiaceae
Chromosome number $2n = 36$
Vernacular names Christmas bush, dovewood (En). Arbre de djeman (Fr). Bugi-bugi, bunce, pô d'arco (Po).

Origin and geographic distribution *Alchornea cordifolia* occurs from Senegal east to Kenya and Tanzania and south throughout Central Africa to Angola. It is cultivated in DR Congo for its medicinal use.

Uses *Alchornea cordifolia* is commonly used as a medicinal plant throughout its area of distribution. The leaves are mostly used, but also the stem bark, stem pith, leafy stems, root bark, roots and fruits enter in local medicine. The leaves or leafy stems, as an infusion or chewed fresh, are taken for their sedative and antispasmodic activities to treat a variety of respiratory problems including sore throat, cough and bronchitis, genital-urinary problems including venereal diseases and female sterility, and intestinal problems including gastric ulcers, diarrhoea, amoebic dysentery and worms. As a purgative, they are also taken as an enema; high doses taken orally are emetic. They are also taken as a blood purifier, as a tonic and to treat anaemia and epilepsy. In Senegal a leaf decoction is taken to treat tachycardia. Young stem pith is bitter and astringent and is chewed for the same use. The pith may also be rubbed on the chest to treat respiratory problems. The leaves are eaten in West Africa and Congo as an emmenagogue and to facilitate delivery, and in Gabon as an abortifacient. A cold infusion of the dried and crushed leaves acts as a diuretic. Leaf and root decoctions are widely used as mouth wash to treat ulcers of the mouth, toothache and caries, and twigs are chewed for the same purposes. Crushed fresh leaves or powdered dry leaves are applied externally as a cicatrisant to wounds, to relieve pain, e.g. backache and headache, to fractures to improve healing and to treat eye infections and numerous skin afflictions including venereal diseases, sores, abscesses, yaws and filariasis. A decoction or paste of leafy twigs is applied as a wash to treat fever, malaria, rheumatic pains, enlarged spleen and as a lotion or poultice to sore feet; vapour baths can also be taken. In Côte d'Ivoire and Ghana the leaves are applied as a haemostatic to stop prolonged menstruation and a decoction of roots or leaves is applied in the vagina to stop post-partum haemorrhage and to treat vaginitis. In Sierra Leone and Congo young leaves or pounded bark are made into a suppository to treat haemorrhoids. In DR Congo bruised leaves are applied as an enema to treat impotency. In West Africa pulped root is widely taken to treat venereal diseases. Dried leaves or roots, alone or with tobacco, are smoked to cure cough. The leaves and root bark are externally applied to treat leprosy and as an antidote to snake venom. In Gabon and Congo a root decoction or maceration is taken to treat amoebic dysentery and diarrhoea and used as eye drops to cure conjunctivitis. In Nigeria a decoction of bruised fruit is taken to prevent miscarriage. The sap of the fruit is applied to cure eye problems and skin diseases. In veterinary medicine a leaf or root infusion is given to livestock to treat trypanosomiasis. In Nigeria the stem bark is thrown in dammed streams as a fish poison.

Alchornea cordifolia is used for alley cropping for in-situ mulch production in banana or maize plantations in West and East Africa. In Burkina Faso the plant is used as a windbreak around crops. In West Africa the leaves are used as forage for small ruminants and poultry. Chicken produce egg yolks with a deeper yellow colour when fed regularly with the leaves. In West Africa the leaves are used for packing cola nuts and 'okpeye', a Nigerian con-



Alchornea cordifolia – wild

diment produced by fermenting seeds of *Prosopis africana* (Guill. & Perr.) Taub. Pipe stems are made from the branches with the pith removed. The Iwo people of Nigeria chew the leaves as an appetizer. Dried leaves are a tea substitute.

In West Africa mats and cloth are cooked with the fruits and natron to colour them black; the fruits are often combined with fermented *Parkia* pods or the bark of *Bridelia ferruginea* Benth. This dye is also used on pottery, calabashes and leather. The leaves are often added to indigo to darken its colour. In Nigeria fishermen use leaves and fruits for dyeing and preserving fishing nets; dried leaves give a darker colour than fresh ones. In Gabon bark and leaves are used to blacken cloth and pottery. The wood ash serves as a mordant. The wood is light, soft and perishable and is used for house construction, stakes and kitchen utensils, and also benches when large stems are available. The wood is also used as fuel. In DR Congo the split stems are used to line baskets. In Cameroon and Gabon the acidulous fruits are considered edible and are also used as bait to trap birds. The infructescences are used in decorations.

Alchornea cordifolia extract has been patented for various other applications: antifouling adjuvant in paints, coatings and polymers, and alchorneic acid was proposed as a raw material for hemi-synthesis of plastic.

Production and international trade In Ghana and Burkina Faso the leaves, root bark and fruits of *Alchornea cordifolia* are sold in local markets from November to January. The Centre National de Semences Forestières of Burkina Faso sells seeds at a price of US$ 10 per kg in the region and US$ 14 outside the region.

Properties The leaves, roots and stem bark contain terpenoids, steroid glycosides, flavonoids (2–3%), tannins (about 10%), saponins, carbohydrates and the imidazopyrimidine alkaloids alchorneine, alchornidine and several guanidine alkaloids. The leaves also contain a range of hydroxybenzoic acids: gallic acid and its ethyl ester, gentisic acid, anthranilic acid (vitamin L1) and protocatechuic acid, and also ellagic acid (alizarine yellow). A C_{20} homologue of vernolic acid, named alchornoic acid, was found in the seed oil.

Different leaf, stem bark and root extracts (macerations or decoctions and methanolic, ethanolic or acetonic extracts) have shown significant activities against a range of bacterial and fungal pathogens of humans. The root bark showed the strongest activity. The results of tests on anti-HIV activities of the seed extract are contradictory; in African tests, HIV-1 strains were sensitive to the seed extract, whereas American tests seemed inconclusive. Methanol or ethanol extracts of leaf and root at a concentration of 100 µg/ml did not show cytotoxic activity against 60 different tumour cell lines from 8 organs. The ethanol extracts of the leaf and fruit showed significant trypanocidal, anthelminthic and amoebicidal activities. The amoebicidal activity of the root bark was even much higher. The ethanol extract of the leaf exhibited mild in-vitro activity against *Plasmodium falciparum*, whereas chloroform and ether extracts were inactive. Ellagic acid was found to be the active constituent of the extract. Crude ethanol extracts of the leaves showed moderate in-vitro anthelmintic activity against *Haemonchus contortus*, a nematode pathogenic to small ruminants.

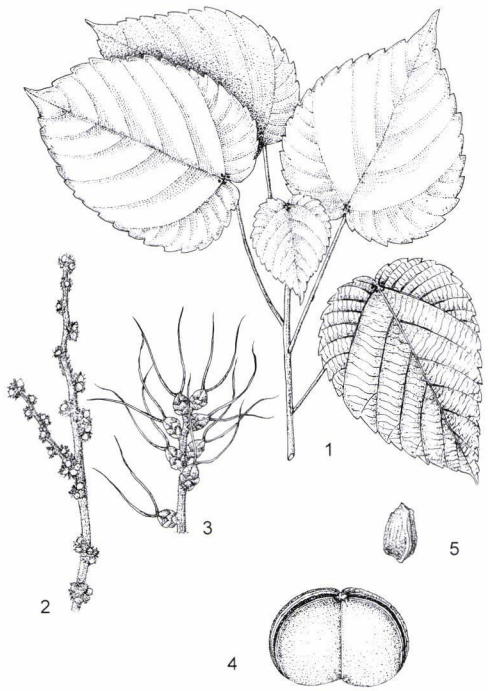
Different leaf extracts showed a significant anti-anaemic activity by increasing the level of haemoglobin and iron in the blood after oral administration to anaemic rats. Crude extracts of the leaves coagulated blood plasma in vitro. The high tannin content was thought to be responsible for this activity.

The ethanol extract of the leaf showed significant activity against castor oil-induced diarrhoea in mice. The presence of tannins and flavonoids may account for the increased colonic water and electrolyte reabsorption. The crude methanol extract of the leaf has a moderate relaxing effect on smooth muscles in vitro, which is attributed to the flavonoid quercetin and its derivatives. The ethanol extract of the root significantly delayed the effect of histamine-induced broncho-constriction characterized by shortness of breath in guinea pig. The crude methanol extract of the leaves and several fractions of it have shown anti-inflammatory activity in the croton oil-induced ear oedema test in mice and in the egg albumen-induced hind paw oedema test in rats. The cytotoxicity of the crude extract was very low. Alcohol extracts from root bark, stem bark, leaves, fruits and seeds disrupted mitotic cell division in onion (*Allium cepa* L.). A methanol extract of the seed has shown inhibition of vascularization in chicken embryos.

The approximate nutrient composition of leaf meal for use in chicken feed was per 100 g dry matter: energy 1930 kJ, crude protein 18.7 g and crude fibre 16.4 g. While the production of

leaves is high, their palatability to cattle, goats and sheep is rather low.

Description Straggling, laxly branched, evergreen dioecious shrub or small tree up to 8 m tall; young shoots erect, later becoming horizontal, hollow, glabrous. Leaves alternate, simple; stipules triangular, c. 1.5 mm long, acute, soon falling; petiole (3–)5–15 cm long; blade ovate to elliptical-ovate, (5–)10–25 cm × (3–)7–15 cm, base cordate, with basal lobes slightly auriculate and overlapping, apex acute to acuminate, margins toothed, shortly hairy when young, later almost glabrous, 3–5-veined at the base with 4 glandular patches in the angles of the veins. Male inflorescence an axillary panicle up to 30(–45) cm long, sparingly hairy, bracts minute; female inflorescence an axillary spike or lax panicle up to 30(–45) cm long, 1-several together, bracts broadly triangular-ovate, c. 1 mm long, acuminate. Flowers unisexual, sessile; male flowers with 2 cup-shaped sepals, petals absent, stamens 8, the united filaments forming a basal plate; female flowers with 2–4-lobed calyx, lobes obtuse, hairy, petals absent, ovary superior, conical, c. 2 mm × 2 mm, smooth, densely silky hairy, styles 2–3, 1–2 cm long, free or fused at base, dark red. Fruit a 2-lobed capsule c. 1.5 cm × 1.5 cm, lobes somewhat compressed, smooth, shortly hairy, green to red, 2-seeded. Seeds ovoid-ellipsoid, c. 6 mm long, smooth, bright red.



Alchornea cordifolia – 1, leafy branch; 2, part of young male inflorescence; 3, tip of female inflorescence; 4, fruit; 5, seed.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Alchornea* is pantropical and comprises about 60 species of which 6 occur in tropical Africa.

Growth and development In West Africa *Alchornea cordifolia* flowers at the start of the dry season, in October–November; in DR Congo flowering is from June to August. The nectar glands at the leaf base attract ants, which protect the plant from attacks from other insects.

Ecology *Alchornea cordifolia* is widespread in secondary forest and riverine forest, especially in marshy areas but sometimes in drier sites, from sea-level up to 1500 m altitude. It often forms thickets in disturbed, unburned localities. It is well adapted to acid soils. In DR Congo the tree is reported to improve soil fertility and is known to be effective in restoring calcium levels in acid soils. It is one of the first trees to appear in vegetation dominated by *Chromolaena odorata* (L.) R.M.King & H.Rob.

Propagation and planting *Alchornea cordifolia* is propagated by seed or stem cuttings. The weight of 1000 seeds is about 77 g. Plants are most easily propagated from stem cuttings, which root in 9 weeks. When grown from seed, germination takes 3–12 weeks when directly planted in moist soil.

Management Coppice regrowth of *Alchornea cordifolia* is vigorous. In Nigeria field tests with *Alchornea cordifolia* showed that it is a promising alley crop. As a mulch crop it has good potential for restoration of soil fertility considering its standing biomass, root distribution, nutrient content in the biomass, decomposition and nutrient release patterns, and association with mycorrhiza.

Diseases and pests *Alchornea cordifolia* is a preferred feed plant of the desert locust *Zonocerus variegatus*.

Harvesting For medicinal purposes *Alchornea cordifolia* is mainly harvested from the wild.

Yield The yearly biomass production of *Alchornea cordifolia* is 2000–3000 kg/ha.

Handling after harvest In traditional medicine, the leaves and root bark are used fresh or dried in the shade for later use.

Genetic resources *Alchornea cordifolia* is widespread and common in secondary forest

and produces much seed; it is therefore not threatened.

Prospects *Alchornea cordifolia* is an important medicinal plant in traditional medicine and much pharmacological research has been effected including its antibacterial, antifungal and antiprotozoal properties, as well as its anti-inflammatory activities, with significant positive results. However, the link between activity and particular compounds is often not clear, although the flavonoids and tannins seem to play a major role. More research is needed to elucidate these relations. It is probable that *Alchornea cordifolia* will remain a major medicinal plant. Its use as an alley-cropping component is promising, especially as a mulch crop for restoration of soil fertility, but other, especially leguminous, species are preferred in most situations.

Major references Agbor, Leopold & Jeanne, 2004; Aké-Assi, Guinko & Aya-Lazare, 1991; Burkill, 1994; Kapnang Jepang, 1997; Koné et al., 2005; Mavar-Manga et al., 2004; Neuwinger, 2000; Nia et al., 2005; Radcliffe-Smith, 1987; Stäuble, 1986.

Other references Adewunmi et al., 2001; Adjanohoun et al., 1989; Ayisi & Nyadedzor, 2003; Banzouzi et al., 2002; Boampong, 1992; Ebi, 2001; Iwu, 1993; Kamara et al., 2000; Kang et al., 1999; Kanmegne et al., 1999; Lamikanra, Ogundaini & Ogunbamila, 1990; Latham, 2004; Muanza et al., 1995; Nkum, 1997; Obadoni & Ochuko, 2002; Ogungbamila & Samuelsson, 1990; Okeke et al., 1999; Osadebe & Okoye, 2003; Ruhigwa et al., 1994; Tona et al., 2000.

Sources of illustration Radcliffe-Smith, 1987.

Authors H. Mavar-Manga, J. Lejoly, J. Quetin-Leclercq & G.H. Schmelzer

ALCHORNEA FLORIBUNDA Müll.Arg.

Protologue Flora 47: 435 (1864).

Family Euphorbiaceae

Chromosome number $2n = 18$

Vernacular names Niando (En). Alchornée fleurie, niando (Fr). Ilondo (Po).

Origin and geographic distribution *Alchornea floribunda* occurs from Guinea east through the forest zone of West and Central Africa to Sudan and Uganda. In DR Congo it is cultivated in home gardens for its medicinal use.

Uses In West and Central Africa, especially in Côte d'Ivoire, Gabon and DR Congo, the root of *Alchornea floribunda* has a great reputation as a stimulating intoxicant and aphrodisiac. The powdered dried roots or root bark scrapings are either mixed with food or macerated for several days in palm wine, banana beer or other local beers and consumed as a tonic to provide energy during festivals and, formerly, for warfare. It provides a state of intense excitement followed by a deep, sometimes fatal, depression depending on dosage, individual temperament and habit. Similar effects have been observed in gorillas and chimpanzees that had eaten the root. In Gabon the roots are sometimes mixed with or used as a substitute for those of *Tabernanthe iboga* Baill. and taken in water as an aphrodisiac and stimulant in initiation ceremonies.

In Côte d'Ivoire, Congo and DR Congo leaf or root sap is rubbed over the affected area to treat wounds, circumcision wounds, ringworm and eczema. A leaf decoction is drunk or the leaves are eaten as a vegetable to treat ovarian problems, stomach problems and intestinal disorders. In Nigeria and Gabon the root sap is used as eye drops to treat ophthalmia and conjunctivitis. In Cameroon the ash of burnt roots mixed with palm oil is applied to scarifications to treat chest pain and headache. One teaspoon of root bark powder is eaten daily to cure impotence. In Equatorial Guinea the leaf pulp is applied to wounds. In Congo the leaves are eaten as a vegetable with meat or fish as an antidote to poison. The roots and fruits are taken for urinary, respiratory and intestinal problems. In DR Congo a leaf maceration is taken against pains in the heart. A decoction of the young leaves is taken to treat diarrhoea.

In DR Congo the thin branches are used to make the framework of round huts. The root scrapings or dried leaves are smoked as a substitute of tobacco.

Production and international trade Dried root bark of *Alchornea floribunda* is traded on the internet for its stimulating (and supposedly hallucinogenic) properties at c. US$ 15 per 100 g, but its trade name 'niando' is confused with that of the South American *Alchornea castaneifolia* (Humb. & Bonpl. ex Willd.) A.Juss., mainly known as 'iporuru', which has similar properties.

Properties The stem bark contains 0.1 mg/g crude alkaloids, the root bark 1.9 mg/g and the leaves 4.8 mg/g. The imidazopyrimidine alkaloid alchorneine is the major alkaloid present in the stem bark and root bark. The root bark

and leaves also contain isoalchorneine, and the leaves also alchorneinone. Some reports have mentioned the presence of yohimbine, an indole alkaloid present in *Tabernanthe iboga*. However, more recent evaluations did not confirm the presence of this compound in *Alchornea floribunda*. The leaves and bark contain about 10% tannins.

The root extract has sympatholytic action and increases significantly the sensitivity of the nervous system to adrenalin. In dogs, small doses produced slight hypotension followed by hypertension; larger doses produced an increase of blood pressure followed by a strong decrease with only slow recovery. A patent has been obtained for the use of the leaf alkaloid as a spasmolytic. Positive results have been reported in clinical experiments with root and leafy stem extracts in the treatment of hepatitis.

Botany Laxly branched monoecious shrub or small tree up to 4.5(–7) m tall; young shoots shortly hairy. Leaves alternate, simple, crowded at the end of shoots; stipules 3–9 mm long, shortly hairy; petiole 0.5–2.5 cm long; blade oblanceolate to oblong-lanceolate, 14–37 cm × 6–13.5 cm, base cuneate, apex shortly acuminate to obtuse, margins remotely and shallowly glandular-toothed, glandular at base, glabrous above, minutely hairy beneath, pinnately veined. Male inflorescence an axillary panicle up to 20 cm long, bracts minute; female inflorescence a terminal spike or lax panicle, up to 25 cm long; bracts 2–3 mm long, acuminate, with 2 sessile glands at the base. Flowers unisexual, sessile; male flowers with 3 almost orbicular sepals, petals absent, stamens 8; female flowers with 5 triangular-ovate sepals, c. 1.5 mm long, acute, glandular-toothed, shortly hairy, petals absent, ovary superior, 3-lobed, 1–1.5 mm × 1.5–2 mm, smooth, densely silky hairy, styles 3, 1–2.5 cm long, free, dark red. Fruit a 3-lobed capsule c. 6 mm × 10 mm, smooth, shortly hairy, 3-seeded. Seeds almost globose, c. 4 mm long, smooth, shiny, pale brown.

Alchornea is pantropical and comprises about 50 species, of which 6 occur in tropical Africa.

Ecology *Alchornea floribunda* grows in the understorey and clearings of rainforest and swamp forest, from sea-level up to 1200 m altitude.

Management The roots and leaves are harvested from the wild or home gardens, and can be used fresh or dried and powdered for future use.

Genetic resources and breeding *Alchornea floribunda* is widespread and common in the forest understorey and therefore not in danger of genetic erosion.

Prospects *Alchornea floribunda* has quite a reputation as a stimulating intoxicant and aphrodisiac. The presence of the alkaloid alchorneine seems partly responsible for these activities, but more research is needed to corroborate the findings.

Major references Burkill, 1994; Neuwinger, 2000; Radcliffe-Smith, 1987; Raymond-Hamet, 1952; Raymond-Hamet, 1954.

Other references Betti, 2004; Bouquet, 1969; Bouquet & Debray, 1974; Cousins & Huffman, 2002; De Smet, 1996; Kawukpa & Angoyo, 1994; Nyakabwa & Dibaluka, 1990; Oliver-Bever, 1986; Raponda-Walker & Sillans, 1961; Terashima & Ichikawa, 2003.

Authors D.M. Mosango

ALCHORNEA HIRTELLA Benth.

Protologue Hook., Niger fl.: 507 (1849).

Family Euphorbiaceae

Chromosome number $n = 9$

Origin and geographic distribution *Alchornea hirtella* is widespread in tropical Africa and occurs from Senegal east to Kenya and Tanzania and south to South Africa.

Uses In Senegal and Congo the leaf sap is inhaled through the nose or applied to scarifications on the temples to treat headache. A decoction of the aerial parts is taken to treat ovarian trouble and gastro-intestinal afflictions. In Guinea an infusion of the leaves and stem pith is taken as an anti-cough agent and is locally applied as an antiseptic. In Sierra Leone the leaves are chewed to treat toothache, and the leaf sap is swallowed to treat diarrhoea. Bark scrapings ground with white lime are applied to treat river blindness. In Côte d'Ivoire a root decoction is taken as a sedative to treat pain; the sap is also topically applied. A root decoction is taken to treat stomach-ache and as a purgative. In DR Congo root scrapings are chewed to treat tiredness after intoxication. Dried and powdered leaves soaked in water are applied as a poultice to broken limbs. In southern Uganda an infusion of the inflorescences is taken to expel worms.

In Uganda *Alchornea hirtella* is one of the most favoured sources of bean stakes and branches are used in house construction. A branch split in 2 or 3 is used as a rim in basketry. Some-

times the wood is used as firewood.

Properties The dried root bark of *Alchornea hirtella* yields 1.5 mg/g crude alkaloids and the dried stem bark 0.15 mg/g, both with the imidazopyrimidine alkaloid alchorneine as major component. Alchorneine causes parasympathic paralysis of autonomous ganglions because of its strong inhibition of both the vagus nerve and intestinal peristalsis in anaesthetized dogs.

Botany Spindly, scandent to straggling shrub or small tree up to 9(–12) m tall, usually dioecious; bark smooth, pale grey; young shoots long hairy to shortly appressed hairy. Leaves alternate, simple; stipules 2–5 mm long, bristly hairy; petiole 0.5–2(–3.5) cm long, thickened at base, bent at top; blade elliptical to oblanceolate, 5–20(–25) cm × 2–8.5 cm, base cuneate, apex shortly acuminate, margins remotely and shallowly glandular-toothed, glandular at base, glabrous to roughly hairy, pinnately veined. Male inflorescence a usual terminal panicle up to 30 cm long, bracts minute; female inflorescence a terminal, lax spike up to 10 cm long, few-flowered, bracts c. 2 mm long, glandular at base. Flowers unisexual, sessile; male flowers with 2 cup-shaped, reflexed, reddish sepals, petals absent, stamens 8, filaments united into a basal plate; female flowers with 5 lanceolate, c. 1.5 mm long, acute, slightly toothed sepals, petals absent, ovary superior, 3-lobed, c. 1 mm × 1.5 mm, smooth, shortly hairy, styles 3, up to 2 cm long, united at base, red. Fruit a 3-lobed capsule 5–9 mm × 7–8 mm, smooth, dark green, slightly shortly hairy, 3-seeded. Seeds ovoid to almost globose, c. 4.5 mm × 4 mm, smooth, shiny, pale brown and mottled.
Alchornea is pantropical and comprises about 50 species, of which 6 occur in tropical Africa. Another *Alchornea* species with medicinal uses in DR Congo is *Alchornea yambuyaensis* De Wild. A leaf decoction, together with leaves of *Psidium guajava* L., is taken as an enema to treat fever.

Ecology *Alchornea hirtella* occurs often gregariously in the understorey of evergreen forest, also in secondary forest and riverine forest, sometimes also in associated bushland, at 400–2500 m altitude.

Management *Alchornea hirtella* is fast growing, and sticks used for bean support root quickly.

Genetic resources and breeding *Alchornea hirtella* is common throughout its very wide distribution area and therefore not threatened by genetic erosion.

Prospects *Alchornea hirtella* has several interesting medicinal uses, e.g. for pain relief and as a purgative. Very little is known about its phytochemistry and pharmacology, besides the presence of the alkaloid alchorneine, and more research is warranted.

Major references Burkill, 1994; Neuwinger, 2000; Radcliffe-Smith, 1996a.

Other references Berhaut, 1975a; Chifundera, 2001; De Smet, 1996; Hamill et al., 2000; Radcliffe-Smith, 1987; Wome, 1985; Yamada, 1999.

Authors G.H. Schmelzer

ALCHORNEA LAXIFLORA (Benth.) Pax & K.Hoffm.

Protologue Engl., Pflanzenr. IV, 147, 7: 245 (1914).

Family Euphorbiaceae

Chromosome number $2n = 18$

Origin and geographic distribution *Alchornea laxiflora* occurs from Nigeria east to Ethiopia and south to DR Congo and through East Africa to Zimbabwe, Mozambique, north-eastern South Africa and Swaziland.

Uses In Nigeria a decoction of the leaves is taken to treat inflammatory and infectious diseases. It is also a common ingredient in herbal antimalarial preparations. In Tanzania the ground leaves are taken in water to treat hernia. The leaf sap and root decoction are drunk to treat pain in neck and shoulders. The ash of the stem pith is applied to a stiff neck.
In Nigeria the leaves are used as packing and preservation material for kola nuts. Small branches are used as chew sticks. Straight stems are used as fence poles.

Properties Preliminary phytochemical screening revealed the presence of alkaloids, cardiac glycosides, saponins and phenolic compounds in the roots, and in lower amounts, in the leaves. From the ethyl acetate soluble fraction of the crude methanolic leaf extract the flavonoids quercetin and the quercetin-related compounds rutin and quercitrin were isolated. These compounds showed significant antimicrobial activity against several gram-positive and gram-negative bacteria and fungi. The anti-oxidant activity of the root and leaf extracts have been compared with that of the standard anti-oxidant butylated hydroxyanisole. The crude hexane and methanol extracts of *Alchornea laxiflora* showed 65–75% activity for root extracts, and ca. 40% activity for leaf

extracts in comparison to the standard antioxidant compound.

Botany Deciduous, erect to straggling shrub or small tree up to 7(–10) m tall, monoecious with male and female inflorescences on separate branches; bark smooth, pale grey, flaking; young shoots shortly hairy to almost glabrous. Leaves alternate, simple; stipules linear, 2–8 mm long; petiole 1–7(–9) cm long, thickened at both ends with 2 filiform, 1–3 mm long stipels at top; blade elliptical-lanceolate to oblong-oblanceolate, 5–18 cm × 3–8 cm, base rounded or cuneate, apex acuminate, margins shallowly toothed, glandular at base, sparingly shortly hairy on the veins, base 3-veined, reddish when young. Male inflorescence an axillary spike or raceme up to 12 cm long, developing on older twigs just before new leaf flush, bracts ovate, 1.5–5 mm long; female inflorescence a terminal, lax spike up to 10 cm long, few-flowered, bracts ovate-lanceolate, 2–3 mm long, glandular at base. Flowers unisexual, sessile; male flowers with 2–4(–5), almost round to ovate, reflexed, yellowish green or white sepals, petals absent, stamens 8–9, filaments united into a basal plate; female flowers with 5–6, almost round to ovate, acute, unequal, slightly toothed sepals, petals absent, ovary superior, almost globose, c. 1 mm × 1.5 mm, scarcely 3-lobed, smooth, shortly hairy, styles (2–)3, up to 1.5 cm long, united at base, red. Fruit a 3-lobed capsule 5–7 mm × 7–8 mm, smooth, dark green, brown or black, slightly shortly hairy, 3-seeded. Seeds ovoid to almost globose, c. 4 mm × 3 mm, smooth or slightly rough, slightly shiny, pale brown or greyish.

Alchornea is pantropical and comprises about 50 species, of which 6 occur in tropical Africa.

Ecology *Alchornea laxiflora* occurs in evergreen forest and associated bushland, in riverine thickets, from sea-level up to 1600 m altitude.

Genetic resources and breeding *Alchornea laxiflora* is locally common throughout its wide distribution area, and is probably not threatened by genetic erosion.

Prospects *Alchornea laxiflora* has interesting antibacterial and pain-suppressing activities, which merit further research. The antioxidant activities of the leaves are interesting as well, and more research is needed to elucidate the effectiveness under different conditions.

Major references Farombi et al., 2003; Neuwinger, 2000; Ogundipe et al., 2001; Radcliffe-Smith, 1996a.

Other references Burkill, 1994; Kokwaro, 1993; Ogundipe et al., 2001; Radcliffe-Smith, 1987.

Authors G.H. Schmelzer

ALOE ARBORESCENS Mill.

Protologue Gard. dict. ed. 8: Aloe n.3 (1768).

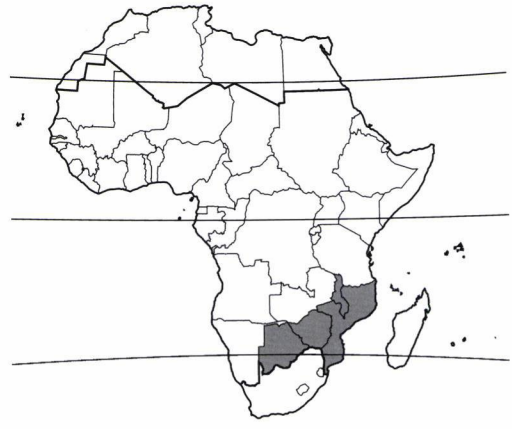
Family Asphodelaceae

Chromosome number $2n = 14$

Vernacular names Krantz aloe, Kidachi aloe, mountain bush aloe, candelabra aloe, octopus plant, torch plant (En). Aloès arborescent (Fr).

Origin and geographic distribution *Aloe arborescens* is native to southern Africa and occurs in Malawi, Botswana, Zimbabwe and Mozambique as well as South Africa. It has been imported in many countries in the tropics and subtropics as an ornamental and medicinal plant. In Italy it is commercially grown for its medicinal and cosmetic uses and in Japan for both medicine and food. In Japan, where it was first introduced in the 17th century, it has become naturalized. Commercial growing of *Aloe arborescens* has started recently in Israel and China.

Uses The split or crushed fresh leaves of *Aloe arborescens* are widely used to treat burns and wounds. In South Africa a leaf decoction is given to women to ease childbirth. In Japan the leaves are used as a vegetable and as a health food because they are thought to overcome constipation. Parts of the stem with a number of leaves attached are marketed as a vegetable. Preparations are sold as over-the-counter drugs for acceleration of gastric secre-



Aloe arborescens – wild

tion, as a purgative and for dermatological use. *Aloe arborescens* is an important ingredient of 'Kidachi aloe candies' popular in Japan for their tangy yoghurt flavour. Worldwide attention was drawn to the possible value of gel prepared from *Aloe arborescens* after the second World War, when skin burns of victims of the nuclear bombs on Japan were successfully treated with this gel. In southern Africa *Aloe arborescens* is planted as a living fence. Homesteads that have been abandoned for over a century can still be traced thanks to surviving fences. *Aloe arborescens* is grown widely as an ornamental in the subtropics and is especially popular in the Mediterranean region.

Production and international trade There are no statistics available on the production of *Aloe arborescens*. Japan is probably the largest producer, but for the national market only.

Properties As in most *Aloe* species, the leaf exudate of *Aloe arborescens* contains anthrone 10-C-glucosides (anthraquinone derivatives) such as aloin and hydroxyaloins. Aloin is a mixture of the stereoisomers aloin A (barbaloin) and aloin B (isobarbaloin). Furthermore, the exudate contains the pyrone derivative aloenin and free and glucosylated 2-acetonyl-7-hydroxy-5-methylchromones (e.g. aloesone, furoaloesone, aloeresin A, aloeresin B (aloesin) and aloeresin C). The compound responsible for the laxative properties is aloin, which itself is inactive as a laxative, but is activated by *Eubacterium* sp. to aloe-emodin anthrone. Although some observations indicate that in diarrhoea induced by aloin, increased water content might be more important than stimulated peristalsis, the side effects of prolonged use point to a griping effect on the colon. Anthraquinone laxatives should not be used for longer than 8–10 days, or by children younger than 12 years. Contra-indications include pregnancy, breastfeeding, intestinal inflammations and haemorrhoids. It has been claimed that aloin is responsible for antihistamine and anti-inflammatory activity. Aloin should be administered preferably in combination with an antispasmodic to moderate its griping action. Possible side effects of aloin include congestion and irritation of the pelvic organs. Anthraquinone laxatives may play a role in development of colorectal cancer as they have genotoxic potential and also tumorigenic potential in rodents. Both aloin and aloeresin B have skin-whitening activity. In 2002 the United States Food and Drug Administration withdrew the 'generally recognized as safe and effective (GRASE)' status for over-the-counter drugs based on aloe exudates.

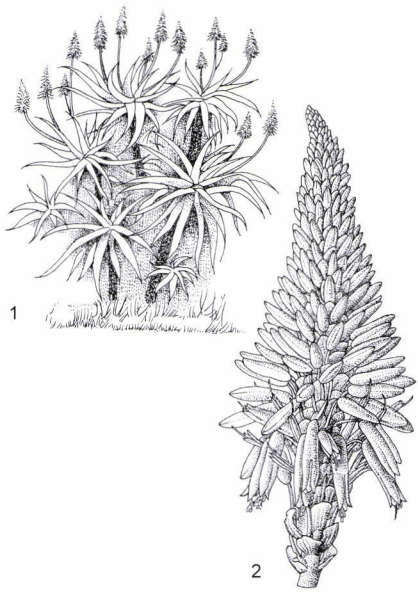
The gel contains polysaccharides and glycoproteins. Apart from mannan and glucomannan, arboran A and arboran B have been identified, which have hypoglycaemic effects. The structure–function relationship of polysaccharides from gel from different *Aloe* species is still subject to research. Biological activity is thought to be, at least partly, due to immunomodulating effects of these polysaccharides.

The leaf epidermis contains lectins (aloctin A and aloctin B) that inhibit the growth of fibrosarcoma in animals. *Aloe arborescens* leaf powder showed protective effects on mouse skin injury induced by soft X-irradiation. It also showed protective effects against human carcinogenesis. *Aloe arborescens* gel works as a synergist of neomycin sulfate in eye drops; they are useful in the treatment of inflammation and infections of the eye.

Freeze-dried leaves have shown a 70% growth inhibition of *Trichophyton mentagrophytes* (one of the fungi causing athlete's foot in humans), induced in guinea-pigs feet in vivo.

Adulterations and substitutes Psyllium (*Plantago* spp.), which is a natural bulk laxative, is one of the substitutes for anthraquinone-containing laxative drugs such as aloe that may cause dependency and/or cathartic colon. Anthraquinone-containing preparations from *Senna alata* (L.) Roxb. and other *Senna* and *Cassia* species are sometimes recommended as substitutes for *Aloe* products. *Centella asiatica* (L.) Urb. is recommended as a substitute for *Aloe vera* gels in wound treatments; its triterpenes have exhibited both wound healing and antibacterial activities.

Description Succulent shrub up to 5 m tall; stems solitary, branching at or near the base, with persistent dead leaves. Leaves in a dense rosette, spreading, becoming recurved; stipules absent; petiole absent; blade lanceolate, up to 60 cm × 7 cm, apex long-acuminate, margin with firm, deltoid, forward-pointing, yellow teeth, c. 4 mm long, 1–1.5 cm apart, blade greyish green, reddish tinged in dry conditions. Inflorescence a terminal raceme, 20–40 cm long, 1–4 per rosette, erect, cylindrical-acuminate, very densely flowered; peduncle up to 60 cm long, simple or rarely with 1 short branch; bracts broadly ovate, 2–5 mm long. Flowers bisexual, regular, 3-merous; pedicel 1–1.5 cm long; perianth tubular, 3.5–4 cm long, c. 7 mm in diameter, lobes 6, free to the base, bright orange to scarlet; stamens 6, exserted;



Aloe arborescens – 1, plant habit; 2, part of inflorescence.
Redrawn and adapted by Achmad Satiri Nurhaman

ovary superior, 3-celled, style filiform, stigma head-shaped, exserted. Fruit an oblong-ovoid capsule up to 18 mm × 7 mm, yellowish brown, dehiscing loculicidally, many-seeded. Seeds c. 3.5 mm long, with very narrow wings.

Other botanical information *Aloe* comprises about 450 species in Africa and Arabia, of which c. 315 occur in mainland Africa, c. 100 are endemic to Madagascar or the Indian Ocean islands (including the former *Lomatophyllum*) and c. 50 occur in Arabia. The taxonomy is complicated by the occurrence of interspecific hybrids both in the wild and in cultivation. *Aloe arborescens* is a morphologically very variable species.

Growth and development In southern Africa *Aloe arborescens* flowers in June–July.

Ecology *Aloe arborescens* occurs in montane grassland among rocks, in open evergreen forest and in coastal forests from sea-level to 2100(–2800) m altitude.

Propagation and planting *Aloe arborescens* can be propagated by seed and by stem cuttings of 3–10 cm long. It can also be multiplied by tissue culture methods.

Yield The contents of aloin, aloeresin and aloenin are highest in the leaves that grow high on the branch. Repeated pruning increases the content of these compounds in the dry exudate of the regrown parts from 10% to 85%.

Genetic resources In Zimbabwe *Aloe arborescens* has a protected status. As it is widely cultivated for ornamental purposes there are no major threats. All *Aloe* species, except *Aloe vera* (L.) Burm.f., are listed by CITES and all international trade of plants and products should be regulated.

Breeding In the wild, hybrids of *Aloe arborescens* with a number of other species occur. Hybrids with *Aloe ferox* Mill. are common and are of interest as garden ornamentals. There are no indications that breeding is actively undertaken, although there is discussion in the literature of Japanese cultivars. Once gel production becomes important, selection for larger leaf size and low anthraquinone content would be indicated.

Prospects *Aloe arborescens* is, surprisingly, little used as a medicinal in its native range and surprisingly highly esteemed in Asia and the Mediterranean. The chemistry is subject of intensive study but husbandry aspects have not yet been published in an accessible form. Future developments will depend on competitive advantages of *Aloe arborescens* over *Aloe vera*.

Major references Coates Palgrave, 1983; Kuzuya, Shimpo & Beppu, 2004; Newton, 2001; Yagi, 2004.

Other references Beppu et al., 2004; Carter, 2001; Chauser-Volfson & Gutterman, 2004; Furukawa et al., 2002; Gutterman & Volfson, 2000; Kawai et al., 1998; Kodym et al., 2002; van Wyk & Gericke, 2000; Umano et al., 1999.

Sources of illustration Coates Palgrave, 1983.

Authors C.H. Bosch

ALOE BUETTNERI A.Berger

Protologue Bot. Jahrb. Syst. 36: 60 (1905).
Family Asphodelaceae
Chromosome number $2n = 14$
Synonyms *Aloe barteri* Baker (1860) p.p.

Origin and geographic distribution *Aloe buettneri* is restricted to West Africa, where it occurs from Senegal to Nigeria. In this region it is locally cultivated.

Uses *Aloe buettneri* is widely used as a medicinal plant. The leaves are applied externally for all kinds of skin trouble: burns, wounds,

insect bites, Guinea worm sores and vitiligo. Internally, the leaf sap is taken to treat intestinal and uro-genital problems. In Burkina Faso the dried powdered leaves are taken to treat malaria, while in Côte d'Ivoire and Togo the roots are used for this purpose. Throughout West Africa, decoctions of bulbs and roots are taken to cure liver problems, especially jaundice. Decoctions of leaves, roots and whole plants are taken as a laxative, to treat stomach-ache and to get rid of internal parasites. Rheumatism is treated with leaf ash. A leaf decoction is drunk to cure cough. A decoction of the chopped whole plant is taken to treat venereal diseases and infertility in women. A leaf decoction is applied for treating cancer. In Senegal a leaf decoction is added to the drinking water of poultry to prevent avian cholera. In Nigeria leaf sap is given to cattle as an anthelmintic.

Properties The methanol extract of the dried leaf exudate of *Aloe buettneri* or the related *Aloe schweinfurthii* Baker showed significant in-vivo activity against helminthiasis caused by *Nippostrongylus* sp. in rats.

Botany Succulent perennial herb up to 80 cm tall, without stem, usually solitary, rarely suckering, with a bulb. Leaves about 16 in a rosette, erect to spreading; stipules absent; petiole absent; blade triangular, 30–50 cm × 10 cm, apex acuminate, margin hard and tough, with firm white to pale pink sharp teeth 3–4 mm long, 1–1.5 cm apart, blade with scattered whitish spots. Inflorescence consisting of cylindrical-conical to almost head-like racemes 15 cm × 7 cm, peduncle 70–90 cm long, with 3–5 branches; bracts deltoid-acute or lanceolate-acuminate, 10–15 mm × 6–8 mm. Flowers bisexual, regular, 3-merous; pedicel 2–2.5 cm long; perianth tubular, up to 4 cm × 1 cm, inflated around the ovary, lobes 6, c. 12 mm long, greenish yellow to dull red; stamens 6, slightly exserted; ovary superior, 3-celled, style filiform, stigma head-shaped, exserted. Fruit an ovoid capsule up to 4 cm long, dehiscing loculicidally, many-seeded.

Aloe comprises about 450 species in Africa and Arabia, of which c. 315 occur in mainland Africa, c. 100 are endemic to Madagascar or the Indian Ocean islands (including the former *Lomatophyllum*) and c. 50 occur in Arabia.

In West Africa 3 indigenous *Aloe* species are distinguished: *Aloe buettneri*, *Aloe schweinfurthii* Baker and *Aloe macrocarpa* Tod. The name *Aloe barteri* Baker has long been used as a name for all West African *Aloe*, but the name was based on a mixture of plant parts of *Aloe buettneri* and *Aloe schweinfurthii*. In West Africa, the distribution of *Aloe schweinfurthii* largely overlaps with that of *Aloe buettneri*, but the former species also occurs in DR Congo, Sudan and Uganda. *Aloe schweinfurthii* differs from *Aloe buettneri* in lacking a bulb, its smaller fruits and the presence of suckers. *Aloe schweinfurthii* is cultivated locally for its medicinal uses. It has the same uses as *Aloe buettneri*. *Aloe macrocarpa* is widely distributed in West Africa and extends east to Eritrea and Djibouti. In Eritrea the leaf exudate is used medicinally and the plant is planted on contours for soil conservation. In West Africa the flowers are eaten as a vegetable. In western DR Congo the leaf sap of *Aloe congolensis* De Wild. & T.Durand is traditionally used to cure sores, wounds, burns, pain in the joints, inflammation of the breast and as a laxative, whereas dried and powdered leaves are said to prevent cancer of the colon and rectum. *Aloe congolensis* appears closely related to *Aloe buettneri* and is possibly synonymous.

Ecology *Aloe buettneri* occurs in grassland and woodland at 250–900 m altitude.

Management Although *Aloe buettneri* is sometimes cultivated, no details of its husbandry have been published. Most harvesting is done from wild plants.

Genetic resources and breeding Like all *Aloe* species except *Aloe vera* (L.) Burm.f., *Aloe buettneri* is listed by CITES and trade in plants and plant parts is restricted, although there must be numerous plants in botanical gardens and private succulent collections and there are no indications that the species is threatened in the wild.

Prospects *Aloe buettneri* will probably remain locally important as a medicinal plant. Pharmacological work on West African *Aloe* species has been limited so far and further work is warranted. Related *Aloe* species of Central Africa are in need of taxonomic study.

Major references Baerts & Lehmann, 2005a; Burkill, 1995; Newton, 2001; von Koenen, 2001.

Other references Berhaut, 1967; Carter, 2001; Hammond, Fielding & Bishop, 1997; Kibungo Kembelo, 2004; Latham, 2004; Newton, 2004.

Authors C.H. Bosch

ALOE DIVARICATA A.Berger

Protologue Bot. Jahrb. Syst. 36: 64 (1905).
Family Asphodelaceae
Chromosome number $2n = 14$
Origin and geographic distribution *Aloe divaricata* is an endemic of Madagascar and is widespread in the western and southern parts of the island.

Uses A leaf decoction of *Aloe divaricata* is used as a purgative. A decoction of the leaves or the leaf sap is applied internally and externally to improve healing of bone fractures. The dehydrated exudate, known as 'Madagascar Aloes', has been an important article in local and international trade.

Production and international trade Export of 'Madagascar Aloes' by the East India Company dates back to 1630, and prices then were higher than those for 'Socotrine aloe', from *Aloe perryi* Baker. The present production is unclear and there are no export figures.

Properties The internationally traded product 'Madagascar Aloes' contains 15–40% anthrone 10-C-glucosides (anthraquinone derivatives) such as aloin, hydroxyaloins and sometimes aloinoside. Aloin and aloinoside are both mixtures of stereoisomers. Aloin is responsible for the laxative properties. On a dry weight basis the exudate of *Aloe divaricata* contains 18.5% aloin, and the leaf 3%. *Aloe divaricata* is reported to induce labour by stimulating contractions of the uterine muscles.

Botany Succulent shrub, stem 2–3(–6) m tall, usually sparsely branching from the base or low down, dead leaves persistent over 50–100 cm. Leaves about 30 in a rosette, erect-spreading; stipules absent; petiole absent; blade lanceolate, up to 65 cm × 7 cm, apex obtuse, margin cartilaginous, with deltoid teeth, 5–6 mm long, reddish brown, 15–20 mm apart, blade dull grey-green tinged reddish, exudate drying yellow. Inflorescence heavily branched, consisting of 60–80 terminal, erect racemes, 15–20 cm long, lax, apex acuminate; peduncle up to 1 m long; bracts deltoid, 4 mm long. Flowers bisexual, regular, 3-merous; pedicel 6 mm long; perianth tubular, 2.5–3 cm long, up to 7 mm in diameter, lobes 6, free to base, scarlet or pale pink; stamens 6, exserted; ovary superior, 3-celled, style filiform, stigma head-like, exserted. Fruit an oblong capsule, 25–30 mm × 12 mm long, dehiscing loculicidally, many-seeded. Seeds c. 1.5 cm long, wings 4 mm wide.

Aloe comprises about 450 species in Africa and Arabia, of which c. 315 occur in mainland Africa, c. 100 are endemic to Madagascar or the Indian Ocean islands (including the former *Lomatophyllum*) and c. 50 occur in Arabia. The taxonomy is complicated by the occurrence of interspecific hybrids both in the wild and in cultivation. Based on genome size, most species from Madagascar are considered closely related (with the exception of those formerly placed in *Lomatophyllum*) although the many different growth forms would suggest otherwise. The species from Madagascar were obviously isolated long ago from the mainland African species.

Apart from *Aloe divaricata*, a number of other Madagascan *Aloe* species have recorded medicinal uses. A number of unspecified species are used for sun creams and dandruff lotions. *Aloe vaombe* Decorse & Poiss. (orthographic variant *'vahombe'*) is a small tree with an unbranched trunk up to 5 m tall. Skin lesions are treated with leaf juice, and the leaves are boiled in water and drunk to cure yellow fever. Extracts of *Aloe vaombe* leaves have shown anti-infectious activity when mice were injected with them but no bactericidal activity was detected. In another test with mice, administration of a gel extract called 'Alva' reduced the growth rate of fibrosarcoma and melanoma tumours. *Aloe macroclada* Baker, locally called 'vahona', is a solitary plant without stem. The leaves are used to cure ascites, while the leaf pulp is rubbed on the head to treat dandruff. It has a reputation as a traditional anti-carcinogenic. On internet 'vahona' gel products are offered for sale with similar properties as for *Aloe vera* (L.) Burm.f. The leaf sap of *Aloe capitata* Baker is used as a cathartic and purgative; the whole plant is used to cure dropsy.

Ecology *Aloe divaricata* is mostly found in arid bush vegetation on sandy soils and in coastal thickets, up to 800 m altitude. In dense bush it can grow with a simple stem up to 6 m long.

Management All Madagascan *Aloe* species used as medicine are collected from the wild. *Aloe divaricata* is considered the Madagascan species with the highest exudate production.

Genetic resources and breeding All *Aloe* species except *Aloe vera* are listed by CITES, and quite a number of Madagascan species appear in Appendix 1. Harvesting from the wild for medicinal and ornamental uses and habitat destruction are major threats to *Aloe*

divaricata.

Prospects The *Aloe* species from Madagascar have not been the subject of systematic ethnobotanical research. It is therefore difficult to determine their potential. Species such as *Aloe divaricata*, *Aloe macroclada* and *Aloe vaombe* could possibly play a role in the worldwide trade of medicinal and cosmetic products and could compete with *Aloe vera* if they can be cultivated and produced on a large scale.

Major references CITES, 2003; Debray, Jacquemin & Razafindrambao, 1971; Groom & Reynolds, 1987; Newton, 2001; Perrier de la Bâthie, 1938; Rasolondraibe, 2003.

Other references Radjabi-Nassab et al., 1984; Ralamboranto et al., 1982; Rasoanaivo, 1990; Ravohitraniaina, 2003; Reynolds, 1966; Stiles, 1998; Tizard & Ramamoorthy, 2004; Strickland & Pelley, 2004; Zonneveld, 2002.

Authors C.H. Bosch

ALOE FEROX Mill.

Protologue Gard. dict. ed. 8: *Aloe* n. 22 (1768).

Family Asphodelaceae

Chromosome number $2n = 14$

Synonyms *Aloe candelabrum* A.Berger (1906).

Vernacular names Cape aloe, bitter aloe, red aloe (En). Aloès du Cap (Fr).

Origin and geographic distribution *Aloe ferox* is indigenous in South Africa. From the Dutch East India Company's garden in the Cape it was distributed throughout the tropics and subtropics, where it is grown as an ornamental and medicinal plant. Although not treated or mentioned in regional floras, its occurrence in several countries of tropical Africa is probable.

Uses In southern Africa the thickened, red leaf exudate, called 'Cape aloe', is used as a purgative in human and veterinary medicine and fresh exudate is applied in cases of ophthalmia and syphilis. The gel from the core of the leaves has a similar use as the gel from the leaves of *Aloe vera* (L.) Burm.f. and is used to treat skin afflictions (burns, wounds, abrasions, irritations), and is applied as a poultice on contusions or as a general refrigerant. It is furthermore used as a hair wash to promote hair growth and against dandruff and as a cosmetic to improve the complexion and to smooth the skin. Aloe gel is also widely used as a hydrating and skin-protecting agent in creams and liquids such as sun lotion, shaving cream, lip balm and healing ointments. An infusion of crushed leaves in water is given to cattle to treat jaundice and redwater and to expel worms. The gel has been used in South Africa to make a jam that tastes like watermelon jam; it is also gaining importance as a refreshing and nutritive ingredient in food and drinks. The gel, leaf powder and drinks are produced in South Africa for both domestic and international markets. Dry leaves are harvested and crushed, after which a decoction is used to make a herbal tea. The leaf ash is used as an insect repellent. In South Africa *Aloe ferox* is planted as a live fence. It is readily browsed by goats.

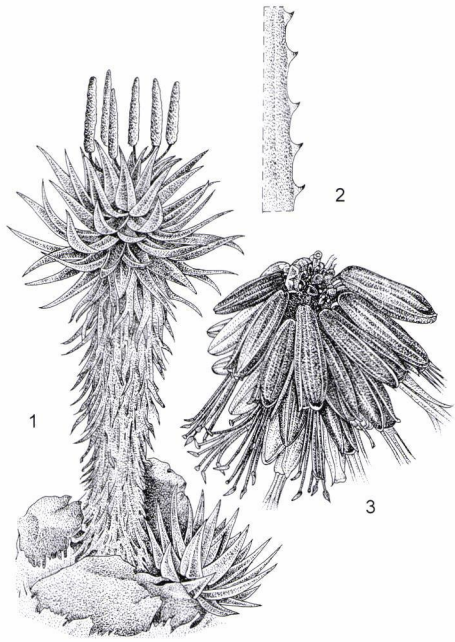
Production and international trade Though considerable quantities of 'Cape aloe' are marketed and used locally, most of the exudate produced in South Africa is exported. Total legal harvest is approximately 400 t/year, although an additional 300 t is presumed to go undocumented. Exports are destined for Europe, Asia and North America, with the main importing countries being the United States, Japan and Germany. Production of *Aloe ferox* gel has been hampered by lack of processing facilities in South Africa. Most gel is bought by the cosmetic industry, which demands high quality.

Properties The exudate of *Aloe ferox* contains 15–40% anthrone 10-C-glucosides (anthraquinone derivatives) such as aloin and hydroxyaloins. Aloin is a mixture of the stereoisomers aloin A (barbaloin) and aloin B (isobarbaloin). Furthermore, the exudate contains the pyrone derivative aloenin and free and glucosylated 2-acetonyl-7-hydroxy-5-methylchromones (e.g. aloesone, furoaloesone, aloeresin A, aloeresin B (aloesin) and aloeresin C). *Aloe ferox* also contains free or glycosylated feroxidin (a tetralin) and feralolide (a dihydroisocoumarin). 'Cape aloe' drugs should contain at least 18% hydroxy-anthraquinone derivatives, not more than 12% moisture and 2% ash, and a water-soluble fraction of at least 45%. The compound responsible for the laxative properties is aloin, which itself is inactive as a laxative, but is activated to aloe-emodin anthrone, by *Eubacterium* sp. Although some observations indicate that in diarrhoea induced by aloin, increased water content might be more important than stimulated peristalsis, the side effects of prolonged use point to a griping effect on the colon. Anthraquinone laxatives should not be used for longer than 8–10 days, or by children

younger than 12 years. Contra-indications include pregnancy, breastfeeding, intestinal inflammations and haemorrhoids. In 2002 the United States Food and Drug Administration withdrew the 'generally recognized as safe and effective (GRASE)' status for over-the-counter drugs based on aloe exudates. Aloin should be administered preferably in combination with an antispasmodic to moderate its griping action. Possible side effects of aloin include congestion and irritation of the pelvic organs. Anthraquinone containing laxatives such as aloe may play a role in colorectal cancer as they have genotoxic potential, and tumorigenic potential in rodents. Aloe-emodin, chrysophanol and aloin A, all isolated from *Aloe ferox* leaf extract, have significant antibacterial activity in vitro. Aloeresin A and B both reduce the oedematous response induced by croton oil in the mouse ear by 40%. Aloeresin B also modulates melanogenesis via competitive inhibition of tyrosinase, thus showing promise as a pigmentation-altering agent for cosmetic or therapeutic applications.

Adulterations and substitutes Psyllium (*Plantago* spp.), which is a natural bulk laxative, is one of the substitutes for anthraquinone-containing laxative drugs such as *Aloe*, and has the advantage that it does not cause dependency and/or cathartic colon. Anthraquinone-containing preparations from *Senna alata* (L.) Roxb. and other *Senna* and *Cassia* species are also sometimes recommended as substitutes for aloe. *Centella asiatica* (L.) Urb. is recommended as a substitute for aloe gels in wound treatments; its triterpenes have exhibited both wound healing and antibacterial activities.

Description Succulent shrub up to 3(–5 m) tall; stem solitary, up to 30 cm in diameter, rarely branching from above the base, with persistent dead leaves. Leaves 50–60 in a dense rosette, spreading or recurved; stipules absent; petiole absent; blade lanceolate-oblong, up to 100 cm × 15 cm, apex long-acuminate, margin with sharp, reddish(-brown) teeth c. 6 mm long, 1–2 cm apart, blade dull green, sometimes reddish tinged; exudate yellow, drying red. Inflorescence consisting of large, dense, elongated racemes 50–80 cm long; peduncle with 5–8 spreading branches; bracts broadly ovate, 2–5 mm × 2–4 mm. Flowers bisexual, regular, 3-merous; pedicel 1–1.5 cm long; perianth tubular, 2.5–3.5 cm long, lobes 6, 12–17 mm long, red or deep orange, sometimes white or yellow; stamens 6, exserted; ovary superior, 3-celled, style filiform, stigma head-shaped, exserted. Fruit an ovoid capsule up to 3 cm long, dehiscing loculicidally, many-seeded. Seeds c. 9 mm long, broadly winged.



Aloe ferox – 1, plant habit; 2, leaf margin; 3, top of inflorescence.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Aloe* comprises about 450 species in Africa and Arabia, of which c. 315 occur in mainland Africa, c. 100 are endemic to Madagascar or the Indian Ocean islands (including the former *Lomatophyllum*) and c. 50 occur in Arabia.

Another South African species with medicinal uses is *Aloe maculata* All. (synonym: *Aloe saponaria* (Aiton) Haw.). It has been planted in the drier parts of Mauritius, Rodrigues and Comoros as an ornamental, but is also used medicinally. An infusion of the leaves is used as eye drops to treat conjunctivitis, and rubbed on boils, sores, bruises and rheumatic joints. It is also taken to treat stomach-ache and headache. In South Africa a leaf infusion is taken to treat cardiac problems and as an anthelmintic. The pulverized flower infusion is drunk or given as an enema to treat colds with fever in children. The leaves contain anthraquinones, as well as aloesaponarin I and II, and aloin. The leaves yield a yellow dye. The plant is

readily browsed by goats.

Growth and development *Aloe* species follow the Crassulacean acid metabolism (CAM). CAM plants are able to fix CO_2 at night and to photosynthesize with closed stomata during the day, thus minimizing water loss. This, plus their succulent leaves and stems and the presence of a thick cuticle, makes them well adapted to dry conditions. Severe drought, though, stops exudate production. *Aloe ferox* has a stem surrounded with a persistent layer of dead leaves that insulate the stem in the case of bush fires. Harvesting of *Aloe ferox* leaves for medicinal purposes could thus result in significant mortality due to fires. The flower morphology of *Aloe ferox* suggests pollination by birds. However, honey bees also play a role in the pollination. *Aloe ferox* is self-incompatible and only a few flowers per raceme flower simultaneously. The stamens produce pollen in the morning and wither in the afternoon, whereas the style is exserted on the second day of anthesis.

Ecology *Aloe ferox* is one of the dominant species in the 'succulent bushland' vegetation in South Africa. It grows in a wide range of climatic conditions. It is especially abundant on arid rocky hillsides up to 1000 m altitude, where mean temperatures range from 27–31°C. Annual rainfall ranges from 50–300 mm. Though the root system is shallow, the plant can grow under such dry conditions. Waterlogging should be avoided and *Aloe ferox* thrives on well-drained, rich soils. It withstands light frost, although the flowers may be damaged.

Propagation and planting *Aloe ferox* does not produce suckers but can be propagated by seed and planting of the tops of old plants. Plant regeneration from root and embryo tissue is successful as well.

Management Commercial cultivation becomes a profitable option now that not only the exudate but also the gel has become interesting. Details on cultivation have not been published.

Diseases and pests A leaf-mining insect affects yields of natural populations of *Aloe ferox*.

Harvesting Harvesting of leaves from wild plants of *Aloe ferox* is thought to be sustainable. Rural populations have been harvesting for generations and a fee is paid to the landowner. *Aloe ferox* exudate is often collected by cutting off the leaves transversely close to the stem and positioning them in such a way that the exudate drains into pots, tubs, vessels or even a simple canvas placed over a depression in the ground. The exudate may also be obtained by squeezing the leaves or by warm or cold water retting. In South Africa *Aloe ferox* is preferably tapped during the rainy season, because then the exudate is more abundant, but tapping is also carried out in other periods of the year, except for the driest months. The leaves are usually cut in the morning and it takes 4–5 hours for the exudate to drain from a pile of leaves. Only older leaves are cut; younger ones and growing tips are spared.

Yield Two tonnes of *Aloe ferox* leaves yield about 1 kg of gel powder, which is a higher ratio than for *Aloe vera*.

Handling after harvest Collected exudate is usually concentrated by boiling and then cooling. On cooling, a solid, amorphous extract is formed and this constitutes the drug. Its appearance varies with the concentration process used. If the exudate has been concentrated slowly, in the sun or over a low fire, the cooled extract is opaque, waxy and liver-coloured ('hepatic aloe') and aloin crystals are visible under the microscope. If, on the other hand, the juice has been concentrated rapidly, for instance over a fierce fire, the cooled extract is semi-transparent ('glassy aloe') and no aloin crystals are visible under the microscope.

An option for adding value is to produce dried and ground leaf powder. After the leaf exudate is extracted, the leaves are pulped and squeezed dry under high pressure. The liquid is settled and treated with chemicals to flocculate the jelly fraction.

The gel can be obtained by removing the outer tissues of the leaf. In Aruba, gel is obtained by cutting open the leaves lengthwise and scraping the gel from the leaf blade. The youngest leaves (< 25 cm) are not suitable because of the small amount of gel, but the leaves should not be too old, because gel quantity and quality may decline.

Genetic resources Because of their popularity as a garden and greenhouse plant, various *Aloe* species are potentially at risk of extinction as a result of plant collection from the wild. *Aloe ferox* is cultivated widely as an ornamental. Harvesting from the wild is still considered sustainable but warrants monitoring. An export permit is compulsory because apart from *Aloe vera*, all *Aloe* species are listed in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendices.

Breeding No breeding programmes are

known to exist for *Aloe ferox*. High-yielding plants may be selected and propagated for commercial cultivation. In *Aloe ferox* in South Africa, the aloin content of the leaf exudate was found to differ markedly between provenances. Many *Aloe* species hybridize in the wild if their area of distribution and period of flowering overlap, and it is easy to produce hybrids in cultivation. The scope for breeding and selection is therefore enormous.

Prospects *Aloe ferox* is a potential crop in arid regions. It will remain beneficial as a household remedy: fresh gel can easily be prepared and applied to wounds. In its use as a laxative, however, there is a tendency for the drug to be replaced by other laxatives such as those from *Plantago* spp. The gel industry has a bright future. Other *Aloe* species producing suckers, such as *Aloe turkanensis* Christian and *Aloe flexilifolia* Christian from East Africa, may prove better candidates for commercial cultivation.

Major references Aguilar & Brink, 1999; CITES, 2003; Coates Palgrave, 1983; Glen & Hardy, 2000; Gurib-Fakim, Guého & Bissoondoyal, 1996; Kambizi, Sultana & Afolayan, 2004; Newton, 2001; Newton & Vaughan, 1996; van Zyl, Mander & Antrobus, 2001.

Other references Baerts & Lehmann, 2005b; Bayne, 2002; Bond, 1983; Grierson & Afolayan, 1999; Jones et al., 2002; Kleinschmidt, 2004; Latham, 2004; Mascolo et al., 2004; Neuwinger, 2000; Newton, 2004; Speranza et al., 1993; Speranza et al., 2005; van Wyk & Gericke, 2000; van Wyk, van Oudtshoorn & Gericke, 1997; Watt & Breyer-Brandwijk, 1962.

Sources of illustration Hobson et al., 1975; Jeppe, 1969.

Authors C.H. Bosch

ALOE FLEXILIFOLIA Christian

Protologue Journ. S. African Bot. 8(2): 167 (1942).

Family Asphodelaceae

Origin and geographic distribution *Aloe flexilifolia* is endemic to the Usambara Mountains of north-east Tanzania.

Uses Sap from crushed roots and leaves of *Aloe flexilifolia* is applied by the Shambaa people of Tanzania to reduce swelling of the testicles and scrotum.

Properties The distinctive constituents in *Aloe* are phenolic compounds, notably chromone, anthraquinone or anthrone derivatives. The exudate of *Aloe flexilifolia* is known to be caustic, and is rich in aloin. Aloin is the active ingredient and has purgative properties. Other compounds of interest for their medicinal activity in this and other *Aloe* species are the polysaccharides contained in the gel from the core of the leaves, and lectins found in several plant parts.

Botany Succulent perennial shrub; stem stout, erect and up to 1 m tall or slender, pendulous and up to 2 m long, much branched from the base forming large clumps. Leaves laxly crowded at top of branches, hanging down; stipules absent; petiole absent; blade narrowly lanceolate, up to 50 cm × 7 cm, apex long-acuminate, margin hard and tough, with pale brown sharp teeth 1–2 mm long, 1–2 cm apart, blade pale bluish green with a few white spots when young; exudate drying brown. Inflorescence consisting of erect, cylindrical racemes, 10–15(–30) cm × 8 cm, densely flowered; peduncle horizontal to down-curved, 50–65 cm long, with 6–8 branches, lowest branches occasionally rebranched; bracts ovate-lanceolate, 5–6 mm long. Flowers bisexual, regular, 3-merous; pedicel 12–18 mm long; perianth tubular, up to 3.5 cm long × c. 8 mm, lobes 6, 10–12 mm long, bright red or brownish red, sometimes yellow; stamens 6, exserted; ovary superior, 3-celled, style filiform, stigma head-shaped, exserted. Fruit unknown.

Aloe comprises about 450 species in Africa and Arabia, of which c. 315 occur in mainland Africa, c. 100 are endemic to Madagascar or the Indian Ocean islands (including the former *Lomatophyllum*) and c. 50 occur in Arabia. *Aloe flexilifolia* belongs to a group of species with decumbent, sprawling or pendulous stems. Several other East African species in this group have medicinal uses. The leaf sap of *Aloe carolineae* L.E.Newton is used in Kenya to cure eye disorders. *Aloe pulcherrima* M.G.Gilbert & Sebsebe, which is endemic to central Ethiopia, is used medicinally and has become scarce in the wild due to harvesting, but is increasingly cultivated in gardens. According to CITES, *Aloe scabrifolia* L.E.Newton & Lavranos from Kenya is threatened as a result of overexploitation for medicinal use and exudate extraction; the leaf exudate is brown and contains much aloin A. The So people of Uganda use the exudate of *Aloe wilsonii* Reynolds from north-western Kenya and north-eastern Uganda externally to cure eye infections, headache and body pains, while an infusion of the whole

plant is taken as an emetic; pounded roots and leaves are applied to aching teeth. The leaf exudate is yellow and turns brownish when drying.

Ecology *Aloe flexilifolia* occurs on rocky slopes and cliff-faces at 1000–1250 m altitude.

Management *Aloe flexilifolia* can easily be propagated by suckers and stem cuttings.

Genetic resources and breeding Harvesting from the wild for medicinal and ornamental uses and habitat destruction are major threats to many *Aloe* species. All *Aloe* species, except *Aloe vera* (L.) Burm.f. are listed by CITES. The status of *Aloe flexilifolia* is classified as 'Undetermined'. However, in view of its restricted range and a general decline in Tanzania of populations of medicinally used *Aloe* species, 'Vulnerable' would probably be a more appropriate classification.

Prospects Research into the chemical composition and affinities of *Aloe* species is well underway. However, the ethnobotanical aspects of less important species such as *Aloe flexilifolia* are poorly documented. The high aloin content makes *Aloe flexilifolia* a potential crop plant. Growing *Aloe* as a commercial crop might take the pressure off wild populations but more research is needed to identify the species best suited for domestication and their requirements in cultivation.

Major references Carter, 1994; CITES, 2003; Morgan, 1981; Newton, 2001; Reynolds, 1996.

Other references Demissew Sebsebe & Gilbert, 1997; Groom & Reynolds, 1987; Heine & König, 1988; Kokwaro, 1993; Newton & Lavranos, 1990; Reynolds, 1997.

Authors C.H. Bosch

ALOE LATERITIA Engl.

Protologue Pflanzenw. Ost-Afrikas: 140 (1895).

Family Asphodelaceae

Chromosome number $2n = 14$

Vernacular names Mlalangao (Sw).

Origin and geographic distribution *Aloe lateritia* is restricted to East Africa, and occurs naturally in southern Ethiopia, Kenya and Tanzania. It has not been domesticated, and is only occasionally cultivated as an ornamental. Records of *Aloe lateritia* for DR Congo, Rwanda, Burundi and Uganda refer to *Aloe wollastonii* Rendle.

Uses In Kenya the leaf exudate of *Aloe lateritia* is used locally for treating colds and malaria. A decoction of the leaves is taken to treat hepatitis. In some areas leaves are applied to wounds and are used to treat chicken diseases. A liquid obtained by pounding the leaves is drunk to relieve stomach-ache. A decoction of the roots together with *Solanum incanum* L. roots is taken to treat anaemia. The roots are pounded, boiled and added to beer, reputedly to increase fermentation.



Aloe lateritia – wild

Two products from leaves of *Aloe* spp. can be used commercially in the manufacture of medicinal and cosmetic preparations. One is the gel from the centre of the leaf, the other the exudate (usually yellow) from the longitudinal vessels situated at the outer poles of the vascular bundles of the leaves. In Kenya only the exudate is harvested, as it can be processed easily into a solid material suitable for trading, and known as 'bitters'.

The roots have been used as a dye in Kenya, giving yellow to pink-brown colours. *Aloe lateritia* is sometimes grown as a garden ornamental in the tropics and subtropics.

Production and international trade In 1986 the President of Kenya announced that all *Aloe* species were to be protected in Kenya, and that commercial exploitation must be from plantations and not from wild plants. Although this was not formalised into law, the CITES Licensing Office in Kenya has refused since then to give export permits for *Aloe* plants and *Aloe* products. Therefore, all international trade from Kenya is illegal and no official trade figures are available. The Kenya Aloes Working Group, inaugurated in 2004, has initiated arrangements for registration of plantations

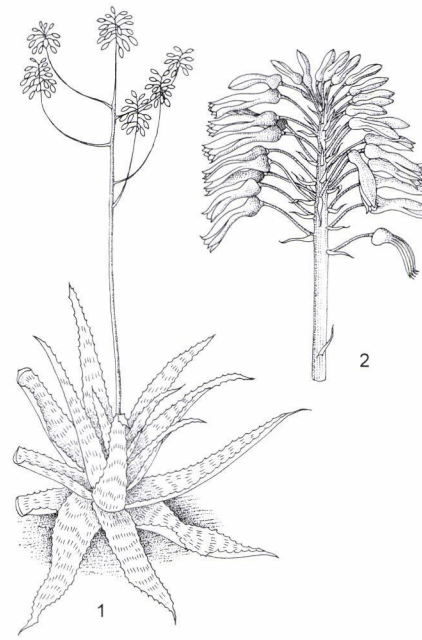
developed with propagated material, and legal trading in *Aloe* products.

Aloe lateritia is one of the *Aloe* species in Kenya harvested illegally from the wild. It appears that there is substantial international trade in processed exudate, but the exported product is probably a mixture of exudate from several species. Informal figures for 2003 suggest that up to 85,000 kg of solid 'bitters' with a market value of about US$ 840,000 are exported from Kenya per year. Main importers are China and Saudi Arabia.

Properties Distinctive constituents in *Aloe* leaves are phenolic compounds, notably chromone, anthraquinone or anthrone derivatives, but the chemistry varies considerably among species. Some of the compounds are found in many species, while others occur in only a few. From the exudate of *Aloe lateritia* the anthrone-C-glucosides homonataloin and aloin were isolated, both as 2 stereoisomers. Aloin is the active ingredient in the exudate and has purgative properties. Chrysophanol, asphodelin, chrysophanol-8-methyl ether, aloesaponol I, II and III and aloesaponarin I and II have been isolated from the roots. No information is available on the polysaccharides in the gel.

Adulterations and substitutes As harvesting from the wild is uncontrolled, exudates are collected indiscriminately from many *Aloe* species in Kenya. Dealers buying from the collectors have not developed any method of quality control, and rely on visual assessment only.

Description Succulent, perennial herb, without stem or with stem up to 50 cm long, usually solitary or suckering to form small groups. Leaves 16–20 in a dense rosette; stipules absent; petiole absent; blade lanceolate, 25–50 cm × 5–10 cm, apex long-acuminate, margin with firm, brown, sharp teeth 3–4 mm long, 1–1.5 cm apart, blade fleshy, surface smooth, bright green, usually with elongated white spots in irregular transverse bands; exudate yellow. Inflorescence consisting of terminal head-like racemes 4–12 cm × 8 cm, densely flowered, sometimes to 20 cm long and more laxly flowered; peduncle up to 125 cm long, with 3–8 branches, lowest branches occasionally rebranched; bracts linear-lanceolate, 10–20(–25) mm × 4 mm. Flowers bisexual, regular, 3-merous; pedicel 2–3 cm long; perianth tubular, 3–4 cm long, inflated around the ovary, c. 5 mm diameter at the mouth, lobes 6, 10–13 mm long, orange-red, sometimes yellow, usually glossy; stamens 6, exserted; ovary superior, 3-celled, style filiform, stigma head-shaped, exserted. Fruit an ovoid capsule up to 28 mm long, pale brown, dehiscing loculicidally, many-seeded. Seeds c. 5 mm long, blackish brown, with speckled wings.



Aloe lateritia – 1, plant habit; 2, part of inflorescence.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Aloe* comprises about 450 species in Africa and Arabia, of which c. 315 occur in mainland Africa, c. 100 are endemic to Madagascar or the Indian Ocean islands (including the former *Lomatophyllum*) and c. 50 occur in Arabia. The taxonomy is complicated by the occurrence of interspecific hybrids both in the wild and in cultivation. Two varieties of *Aloe lateritia* are recognized: var. *lateritia* and var. *graminicola* (Reynolds) S.Carter. Var. *graminicola* differs from the poorly suckering and strictly acaulescent var. *lateritia* by often having a decumbent stem up to 50 cm long, usually suckering to form dense clumps. Var. *graminicola* also has sharper teeth and always head-like racemes. The cuticular wax of the two taxa are indistinguishable in their chemistry and there is mention of intergrades. Var. *graminicola* is the more abundant of the 2 in Kenya.

Several other species that resemble *Aloe la-*

teritia in forming groups by suckering and having branched inflorescence stalks also have medicinal uses. The Topnaar people in Namibia drink an infusion of the leaves of *Aloe asperifolia* A.Berger to treat arteriosclerosis, kidney problems, asthma, colds and epilepsy. A decoction is taken by humans and livestock to expel the placenta, and given to donkeys when they have eaten poisonous plants. The leaves are chewed or the decoction is drunk to treat stomach-ache and chest pains. The leaf exudate is added to drinking water of chickens to treat various diseases. An infusion of the leaves of *Aloe chabaudii* Schönland, native of DR Congo, Tanzania and southern Africa, is taken as an abortifacient. Fatal casualties have been reported, although the abortifacient activity of the infusion could not be demonstrated in tests with rats. A decoction of the leaves is taken orally as a purgative. An infusion of the roots is taken to overcome nausea. A root decoction is drunk to treat blood in the urine. Leaf sap is rubbed into scarifications on the ankle to reduce swelling. Poultry are dipped in an infusion of the leaves to kill external parasites and the leaf juice is mixed with drinking water as a cure for poultry with blood in their faeces. Cattle are drenched with the leaf infusion to cure diarrhoea. *Aloe duckeri* Christian from southern Tanzania, Malawi and Zambia has been confused with *Aloe lateritia* but has unspotted or lightly spotted leaves and dull orange-red flowers. The leaf sap is used in southern Tanzania to help childbirth. *Aloe esculenta* L.C.Leach is a native of the western part of southern Africa. The leaf sap is applied to burns and cuts. The pulverized, dried root is made into a paste by adding water and is massaged into painful and swollen body parts. *Aloe globuligemma* Pole-Evans from Botswana, Zimbabwe and South Africa is known to have caused fatal poisoning. Plants differ in toxicity. Toxic plants smell of rats which indicate the presence of the hemlock alkaloid γ-coniceine. A leaf infusion is taken traditionally in Zimbabwe to relieve stomach-ache, as a cure for venereal diseases and as an abortifacient, although abortifacient activity of the infusion could not be demonstrated in tests with rats. *Aloe hendrickxii* Reynolds, an endemic of DR Congo, is used externally for healing wounds of cattle and the diluted leaf sap is applied orally to calves to cure ear problems.

Growth and development All *Aloe* spp. can survive dry periods well, thus making them a useful crop for semi-arid areas; they need water though in order to develop new leaves. Seedlings take a few years before they are large enough for harvesting.

Ecology *Aloe lateritia* is found in grassland and open bushland, often on rocky slopes, at 250–2100 m altitude.

Propagation and planting *Aloe lateritia* can be propagated by seed or by suckers. Tissue culture techniques can be used to produce large numbers of plants for establishing plantations.

Management Harvesting of wild *Aloe lateritia* is generally destructive. Development of properly managed plantations will lead to conservation of the wild populations and to substantial production. As the establishment of plantations of *Aloe lateritia* is just starting, there are no data on optimum spacing and general management of plantations.

Diseases and pests *Aloe* spp. grown in gardens in Kenya for decorative purposes are susceptible to fungal attack, as well as scale insects and mealy bug infestation. Newly established plantations will need to be closely monitored to watch for signs of diseases and pests.

Harvesting In order to harvest the exudate from *Aloe lateritia* leaves, a hole is dug in the ground and lined with a container, which may be a skin bag, polythene bag or plastic bowl. Leaves are cut and immediately arranged around the edge of the hole at an angle allowing the exudate to drain into the container. When no more sap is seen to be dripping from the leaves, the exudate is transferred to bottles or jerry cans for sale to a dealer.

Yield Harvesting of exudate of *Aloe lateritia* takes place throughout the year, though it has been observed that the yield is higher during rainy seasons. On average one mature plant can produce 80–100 ml of exudate. In some areas of Kenya dealers obtain up to 1700 l/day from collectors.

Handling after harvest Dealers only visually inspect the quality of the exudate. The usual reason for rejection of the exudates is that the liquid is too thin or 'watery', as seen from the ease with which a small sample will soak into the ground. The dealer will store the exudate until at least 200 l has accumulated before further processing. The liquid is placed in a large drum and boiled over a controlled fire for a period of 5–11 hours, depending on the quality. Eventually the exudate becomes black and very viscous. It is then removed from the fire and transferred from the drum to sacks, in which it is left to cool and harden.

After a day the material is solid and black, called 'bitters', and is ready for sale to a middleman, who will sell it on to an exporter. Because of the illegality in Kenya, the whole marketing chain is shrouded in secrecy.

Genetic resources *Aloe lateritia* is collected indiscriminately from the wild, with no selection factors involved. The few plantations now being established are stocked with plants (probably from various species) collected in the wild. All *Aloe*, except *Aloe vera* (L.) Burm.f., are protected by CITES and all international trade of plants and products should be regulated.

Breeding So far there has been no attempt to improve the stock of *Aloe lateritia* by breeding but there is ample scope for selection in this highly variable species.

Prospects The yield of exudate of *Aloe lateritia* is not as high as in other species currently being harvested, and it is possible that other species will be preferred when plantations are developed.

Major references Carter, 1994; Gelfand et al., 1985; Kihara et al., 2003; Newton, 2001; Reynolds (Editor), 2004.

Other references Baerts & Lehmann, 2005c; Byavu et al., 2000; Cribb & Leedal, 1982; Dagne et al., 2000; Demissew Sebsebe & Gilbert, 1997; Ermias Dagne et al., 1994; Gachathi, 1989; Herbin & Robins, 1968; Hindmarsh, 1982; Kokwaro, 1993; Lukwa et al., 2001; Neuwinger, 1996; Newton, 1995; Parry & Matambo, 1992; Rauwald & Niyonzima, 1991; Reynolds, 1966; Reynolds, 1985; Van Damme & Van den Eynden, 2000; von Koenen, 2001.

Sources of illustration Carter, 1994.

Authors L.E. Newton

ALOE LOMATOPHYLLOIDES Balf.f.

Protologue Journ. Linn. Soc. Bot. 16: 22 (1877).

Family Asphodelaceae

Synonyms *Lomatophyllum lomatophylloides* (Balf.f.) Marais (1975).

Vernacular names Ananas marron (Fr).

Origin and geographic distribution *Aloe lomatophylloides* is endemic to Rodrigues (Republic of Mauritius), where it is restricted to the Grande Montagne Reserve, but was formerly widespread.

Uses The crushed leaves of *Aloe lomatophylloides* are applied as a poultice to relieve muscle pain. A decoction of the leaves is taken to increase the menstrual flow. The plant is widely grown as an ornamental.

Properties All *Aloe* spp. in the section *Lomatophyllum*, to which *Aloe lomatophylloides* belongs, have a common phytochemical profile and contain flavones, anthrones and chromones. In *Aloe lomatophylloides* the flavone isovitexin (apigenin 6-C-glucoside) occurs together with the anthrone aloin.

Botany Succulent herb up to 40 cm tall; stem short, decumbent, unbranched. Leaves in a lax rosette, erect to spreading; stipules absent; petiole absent; blade lanceolate, up to 75 cm × 8 cm, apex attenuate, margin with short deltoid teeth, 5–15 mm apart. Inflorescence consisting of few cylindrical racemes, 15–20 cm long, lax, with acuminate apex; peduncle up to 12 cm long, with 2–3 branches; bracts lanceolate, up to 4 mm long. Flowers bisexual, regular, 3-merous; pedicel c. 2 cm long; perianth tubular, 1.5–2 cm long, lobes 6, free to base, pale reddish orange; stamens 6, exserted; ovary superior, 3-celled, style filiform, stigma head-shaped, exserted. Fruit a berry 15–20 mm long, many-seeded. Seeds c. 3 mm long.

Aloe comprises about 450 species in Africa and Arabia, of which c. 315 occur in mainland Africa, c. 100 are endemic to Madagascar or the Indian Ocean islands (including the former *Lomatophyllum*) and c. 50 occur in Arabia. Based on genome size, the species of *Aloe* in the section *Lomatophyllum* are not closely related to the other *Aloe* species of the Indian Ocean Islands. Therefore, and because of the difference in fruits (berries versus capsules) some authors maintain 2 separate genera.

Another *Aloe* species endemic to Mauritius and with medicinal uses is *Aloe purpurea* Lam. (synonym: *Lomatophyllum purpureum* (Lam.) T.Durand & Schinz). Its leaf sap is applied to the nipples to wean children. The leaves contain the flavone isovitexin and its aglucon apigenin, the anthrone homonataloin, and the chromone aloeresin A. The leaf sap of *Aloe mayottensis* A.Berger, endemic to Mayotte, is applied as eye drops to cure conjunctivitis, and to nipples to wean children. A poultice of the leaves is used to treat wounds and burns.

Ecology There is no information on the ecological requirements of *Aloe lomatophylloides*, but probably it occurs on open, dry localities.

Management All *Aloe* species used as medicine in Mauritius are collected from the wild.

Genetic resources and breeding Harvesting from the wild for medicinal and ornamental uses and habitat destruction have devastated the population of *Aloe lomatophylloides*.

Whereas it was common in the 19th century, its natural range is now restricted to a single reserve on Rodrigues where just 30 plants remain. It is however widely planted in botanical gardens and is grown widely as an ornamental and is therefore not immediately threatened with extinction. All *Aloe* species with the exception of *Aloe vera* are listed by CITES.

Prospects The *Aloe* species from Mauritius have not been the subject of systematic ethnobotanical research, and little has been published. Proper protection of the remaining plants seems in place and cultivation will take the pressure off wild populations.

Major references Groom & Reynolds, 1987; Gurib-Fakim & Brendler, 2004; Gurib-Fakim et al., 1994; Marais & Coode, 1978; Newton, 2001.

Other references Baker, 1877; Dagne et al., 2000; Gurib-Fakim, 2004; Pascal, 2002; Rowley, 1997; Viljoen, van Wyk & van Heerden, 1998; Zonneveld, 2002.

Authors C.H. Bosch

ALOE NUTTII Baker

Protologue Dyer, Hooker's Icon. pl. 26: t. 2513 (1897).

Family Asphodelaceae

Vernacular names Kisimamleo, mshubili, msubili (Sw).

Origin and geographic distribution *Aloe nuttii* occurs from DR Congo and Tanzania south to Malawi, Zambia, Angola and Mozambique.

Uses *Aloe nuttii* is medicinally used in Tanzania. The leaf sap is rubbed on the skin to treat ringworm. A decoction of the roots is drunk to cure kidney problems and as an aphrodisiac. A decoction of the leaves is drunk to cure diarrhoea. In Malawi *Aloe nuttii* is used in veterinary medicine to prevent Newcastle disease in chickens, for deworming and to ease parturition. Mature flowers are boiled and eaten as a vegetable in Tanzania. *Aloe nuttii* is grown as a garden ornamental in the tropics and subtropics, and as a pot plant.

Botany Succulent perennial herb up to 1 m tall; stem 5 cm in diameter, solitary or suckering to produce a cluster of up to 12 plants. Leaves 16–20 in a rosette, erect; stipules absent; petiole absent; blade linear, 40–50 cm × 1.5–2(–4) cm, grass-like, apex acute, margin white, hard and tough, with soft teeth, c. 1 mm long, crowded at base, almost absent towards tip, blade with scattered whitish spots towards the base on lower surface. Inflorescence a terminal cylindrical-acuminate raceme 15–25 cm × 8–9 cm, dense; peduncle erect, unbranched, 60–80 cm long; bracts ovate, 15–20 mm long, apex acute, imbricate in bud. Flowers bisexual, regular, 3-merous; pedicel 3–3.5 cm long; perianth tubular, c. 4 cm × 1 cm, lobes 6, up to 30 mm long, coral-pink to orange-red, green-tipped; stamens 6, slightly exserted; ovary superior, 3-celled, style filiform, stigma head-shaped, slightly exserted. Fruit an ovoid capsule up to 4 cm long, dehiscing loculicidally, pale brown, many-seeded.

Aloe comprises about 450 species in Africa and Arabia, of which c. 315 occur in mainland Africa, c. 100 are endemic to Madagascar or the Indian Ocean islands (including the former *Lomatophyllum*) and c. 50 occur in Arabia. Several other *Aloe* species have medicinal uses in southern Africa. A flower decoction of *Aloe cooperi* Baker from Mozambique and South Africa is taken by the Zulu people to ease childbirth. In Swaziland the young shoots and flowers are cooked and eaten as a vegetable. *Aloe cooperi* is planted as an ornamental in South Africa. In Zimbabwe leaf sap of *Aloe greatheadii* Schönland is used as eye drops to cure chronic conjunctivitis. An infusion or decoction of the leaves is drunk to treat gonorrhoea. An infusion of the leaves is used as a malaria prophylactic and is taken as a purgative and put in drinking water of poultry to cure diseases. In South Africa the leaf sap is applied externally to bruises, burns and skin irritations. Leaf pulp is used to treat snakebites. Flower buds are considered a delicacy. Large concentrated populations of *Aloe greatheadii* are an indication of overgrazing. Seedlings are planted in land reclamation trials; they need partial shade for survival. Probably *Aloe ortholopha* Christian & Milne-Redh., which is endemic to Zimbabwe and resembles *Aloe greatheadii*, has similar medicinal uses. In Namibia a leaf infusion of *Aloe hereroensis* Engl. is taken to treat digestive problems, chest and heart pains, urinary incontinence and venereal diseases. Both leaf sap and roots are used to treat gonorrhoea. The leaf sap is used to cure eye problems. *Aloe swynnertonii* Rendle is used in Malawi as fish poison, and in South Africa, it is used in a mixture with other plants to kill pests in vegetable crops. In Namibia the Topnaar people drink a decoction of the roots of *Aloe dichotoma* Masson to treat asthma and tuberculosis. In the past, the hol-

low branches were used as quivers for arrows. The Nama people use the porous inner fibre of the trunk as cooling material. Sheep eat the dry leaves. *Aloe dichotoma* is planted as an ornamental in South Africa.

Ecology *Aloe nuttii* occurs in moist grassland ('dambos') and often on rocky slopes, at 1600–2650 m altitude.

Management *Aloe nuttii* is collected from the wild and leaves can be harvested throughout the year. Flowers can be collected at the end of the rainy season.

Genetic resources and breeding *Aloe nuttii* is not uncommon and probably not in danger of genetic erosion. However, all *Aloe* species except *Aloe vera* (L.) Burm.f. are listed by CITES, and trade in plants and plant parts is restricted.

Prospects *Aloe nuttii* is not suitable for large scale exploitation or domestication because of the small plant size and narrow leaves; it will therefore remain of local importance only.

Major references Carter, 2001; Gelfand et al., 1985; Newton, 2001; Ruffo, Birnie & Tengnäs, 2002; van Wyk, van Oudtshoorn & Gericke, 1997.

Other references Dlamini, 1981; Glen & Hardy, 2000; Kambewa et al., 1999; Lukwa et al., 2001; Neuwinger, 2000; SEPASAL, 2005; Smith & de Correia, 1992; Tredgold, 1986; Van Damme & Van den Eynden, 2000; von Koenen, 2001.

Authors C.H. Bosch

ALOE RABAIENSIS Rendle

Protologue Journ. Linn. Soc. Bot. 30: 410 (1895).

Family Asphodelaceae

Chromosome number $2n = 14$

Origin and geographic distribution *Aloe rabaiensis* occurs in Somalia, Kenya and Tanzania.

Uses In Kenya and Tanzania a leaf decoction of *Aloe rabaiensis* is taken to cure an enlarged spleen. It causes vomiting and diarrhoea. Together with *Acokanthera schimperi* (A.DC.) Schweinf., the exudate is part of an arrow poison made by the Giriama people of the coast of Kenya. The Digo people of Tanzania apply the heated and pounded leaves to swellings. Small portions of the root are taken as a purgative. The exudate is harvested as it can be concentrated easily into a solid material suitable for trading, called 'bitters'.

Production and international trade *Aloe rabaiensis* is one of the *Aloe* species in Kenya harvested illegally from the wild. It appears that there is a substantial international trade in concentrated exudate, but the exported product is probably a mixture of exudate from several *Aloe* species.

Properties The distinctive constituents in *Aloe* leaves are phenolic compounds, including chromone, anthraquinone or anthrone derivatives. Some of the compounds are found in many species, whereas others occur in only a few. The widespread anthrone glucoside aloin A (barbaloin) is present in the exudate of *Aloe rabaiensis*. The exudate also contains aloeresin-D. Aloin is the active ingredient in the 'bitters' and has purgative properties. Other compounds of interest for their medicinal activity in this and other *Aloe* species are the lectins and the polysaccharides contained in the gel.

Botany Succulent perennial shrub up to 2 m tall; stem branching from base, erect or sprawling, often supported by surrounding shrubs. Leaves in a lax rosette, persistent; stipules absent; petiole absent; blade lanceolate, 30–45 cm × 3–8 cm, apex long-acuminate, margin with firm, brown-tipped teeth 2–3 mm long, 1–1.5 cm apart, blade fleshy, greyish green often tinged reddish with few scattered whitish spots on leaves of young shoots; exudate yellow. Inflorescence consisting of head-like racemes up to 8 cm × 8 cm, densely flowered; peduncle up to 60 cm long, with 5–9 branches, lower branch sometimes rebranched; bracts lanceolate, 10–12 mm × 3 mm. Flowers bisexual, regular, 3-merous; pedicel 1–1.5(–2) cm long; perianth tubular, 2–2.5 cm long, slightly inflated around the ovary, lobes 6, 1–1.5 cm long, orange-red, yellow at the mouth, sometimes entirely yellow; stamens 6, exserted; ovary superior, 3-celled, style filiform, stigma head-shaped, exserted. Fruit unknown.

Aloe comprises about 450 species in Africa and Arabia, of which c. 315 occur in mainland Africa, c. 100 are endemic to Madagascar or the Indian Ocean islands (including the former *Lomatophyllum*) and c. 50 occur in Arabia. The taxonomy is complicated by the occurrence of interspecific hybrids both in the wild and in cultivation. *Aloe rabaiensis* belongs to a group of species with obvious stems that grow into shrubs of over 2 m tall. Several other species in this group have medicinal uses. In Rwanda the leaf extract of *Aloe dawei* A.Berger is drunk to cure malaria and leaf sap is used as drops to

treat inflammation of the ear. In the highlands of Kenya the leaves of *Aloe kedongensis* Reynolds are used to treat colds, fever, diarrhoea and malaria. Veterinary use comprises treatment of poultry diseases and East Coast fever in cattle. *Aloe kedongensis* is planted to form live fences and is used as a dye. The roots are added to honey beer to promote fermentation. *Aloe ngongensis* Christian occurs in the highlands of Kenya and Tanzania and has long been considered as conspecific with *Aloe rabaiensis*. It has the same medicinal uses as *Aloe rabaiensis*, and is also harvested from the wild for exudate extraction. The leaf sap of *Aloe nyeriensis* Christian from the Central Province of Kenya is locally used by women to clear up pimples and blemishes on the face. The leaf exudate contains aloin A (barbaloin) and homonataloin. Natural hybrids of *Aloe rabaiensis* with some other species have been reported.

Ecology *Aloe rabaiensis* grows in sandy soil in open bushland up to 500 m altitude.

Management *Aloe rabaiensis* can be propagated by cuttings or by seed. It is possible to use tissue culture techniques to produce large numbers of plants for establishing plantations. Although harvesting from wild plants is illegal, exudate is collected from many *Aloe* species in Kenya. In order to harvest the exudate from *Aloe rabaiensis*, a hole is dug in the ground and lined with a container. Cut leaves are arranged around the edge of the hole at an angle allowing the exudate to drain into the container. The exudate is transferred to bottles or jerry cans for sale to a dealer. The exudate is placed in a large drum and boiled down so that it becomes reddish black and very viscous. It is then transferred from the drum to sacks, in which it is left to cool and harden. After a day of cooling the material is solid and black, called 'bitters', and is ready for sale to a middle man, who will sell it on to an exporter. Because of the illegality in Kenya the whole marketing chain is shrouded in secrecy. Harvesting from wild plants is generally destructive. Development of properly managed *Aloe* plantations will lead to conservation of the wild plants and substantial yields from the plantations.

Aloe species grown in Kenyan gardens for decorative purposes are susceptible to fungal attack, scale insect and mealy bug infestation. Newly established plantations will need to be closely monitored to watch for signs of diseases and pests.

Genetic resources and breeding *Aloe rabaiensis* is collected indiscriminately from the wild, with no selection factors involved. The few plantations now being established are stocked using plants collected from the wild and probably from several species.

Prospects Once the legislation is in place and enforced, and once plantations are established, *Aloe rabaiensis* should be a valuable crop for marginal areas where low rainfall makes it difficult to gain good yields from conventional crops. Borrowing technology from better-studied *Aloe* species such as *Aloe vera* (L.) Burm.f. will make progress in management fast and could lead to the production of leaf gel in addition to 'bitters'. The Kenya Aloes Working Group intends to look for ways of improving the processing and quality control of the *Aloe* products.

Major references Carter, 1994; Kihara et al., 2003; Maundu et al., 2001; Newton, 2001; Reynolds (Editor), 2004.

Other references CITES, 2003; Conner et al., 1989; Cutler, 1980; Gachathi, 1989; Lavranos, 1995; Newton, 1994; Newton, 1995; Pakia & Cooke, 2003b; Reynolds, 1966; Reynolds, 1986.

Authors L.E. Newton

ALOE SECUNDIFLORA Engl.

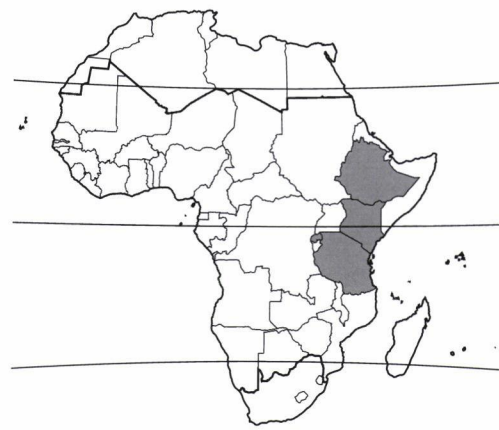
Protologue Pflanzenw. Ost-Afrikas: 140 (1895).

Family Asphodelaceae

Chromosome number $2n = 14$

Origin and geographic distribution *Aloe secundiflora* occurs in Rwanda, southern Ethiopia, Kenya and Tanzania.

Uses The leaves of *Aloe secundiflora* are



Aloe secundiflora – wild

applied to wounds to assist healing. The leaf sap is drunk as an appetizer and anti-emetic. Diluted leaf sap is drunk as a cure for malaria, typhoid fever, diarrhoea, oedema, swollen diaphragm, nosebleed, headache, pneumonia, chest pain and as a disinfectant. The exudate is applied into the eyes, to cure conjunctivitis. The bitter exudate is applied to nipples to wean children. The basal parts of the leaves are used in the fermentation of local beer by several tribes in East Africa. The leaves are pounded and added to drinking water for preventing or treating coccidiosis and Newcastle disease in poultry. The plant is sometimes added as an ingredient to *Acokanthera schimperi* (A.DC.) Schweinf. or *Adenium obesum* (Forssk.) Roem. & Schult. for arrow poison in Kenya.

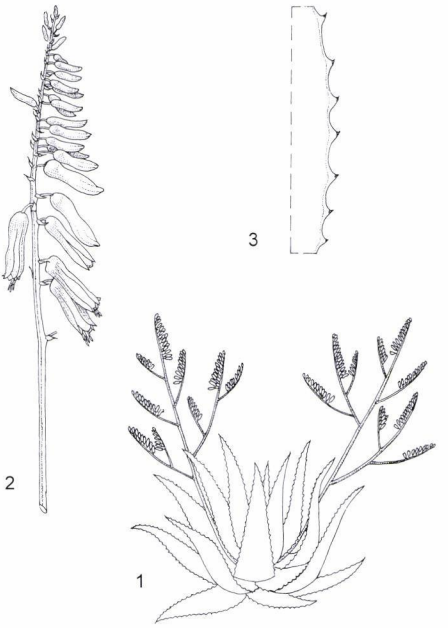
Two products from *Aloe secundiflora* can be used commercially in the manufacture of medicinal and cosmetic preparations. One is the gel from the centre of the leaf, and the other is the exudate from longitudinal vessels situated at the outer sides of the vascular bundles of the leaves. In Kenya only the exudate is harvested, as it can be processed easily into a solid material suitable for trading, known as 'bitters'. Most of the material harvested in Kenya is exported. One small factory in Kenya uses *Aloe* in the manufacture of bathing soap and a crude medicine for abdominal pain. Large-scale Kenyan producers of cosmetic products import gel of *Aloe vera* (L.) Burm.f. *Aloe secundiflora* is planted as a garden ornamental in tropics and subtropics. In East Africa farmers sometimes plant *Aloe secundiflora* as a live fence.

Production and international trade In 1986 the President of Kenya announced that all *Aloe* species were to be protected in Kenya, and that commercial exploitation must be from plantations and not from wild plants. Although this was not formalised into law, the CITES Licensing Office in Kenya has refused since then to give export permits for *Aloe* plants and *Aloe* products. Therefore, all international trade from Kenya is illegal and no official trade figures are available. The Kenya Aloes Working Group, inaugurated in 2004, has initiated arrangements for registration of plantations developed with propagated material, and legal trading in *Aloe* products.

Aloe secundiflora is one of the *Aloe* species in Kenya harvested illegally from the wild. It appears that there is a substantial international trade in dried exudate, but the exported product is probably a mixture of exudate from several species. Informal figures for 2003 suggest that up to 85,000 kg of solid 'bitters' with a market value of about US$ 840,000 are exported from Kenya per year. Main importers are China and Saudi Arabia.

Properties Distinctive constituents in *Aloe* leaves are phenolic compounds, notably chromone, anthraquinone or anthrone derivatives, but the chemistry varies considerably among species. Some of the compounds are found in many species, whereas others occur in only a few. The major components of the leaf exudate of *Aloe secundiflora* are the anthrones aloenin, aloenin B, aloin A (barbaloin) and other aloin-derivatives. The exudate also contains chromones and phenylpyrones, and the phenylethylamine alkaloid N-methyltyramine. No information is available on the polysaccharides in the gel. In a field experiment, the leaf extract was found to be significantly active against fowl typhoid caused by *Salmonella gallinarum* and against Newcastle disease virus (NDV) in chickens.

Adulterations and substitutes As harvesting from the wild is uncontrolled, exudates are collected indiscriminately from many *Aloe* spp. now in Kenya. Only the 3 species known to



Aloe secundiflora – 1, plant habit; 2, part of inflorescence; 3, leaf margin.
Redrawn and adapted by Achmad Satiri Nurhaman

be poisonous are avoided. Dealers buying from the collectors have not developed any method of quality control and rely on visual assessment only.

Description Succulent, perennial herb, without stem or with stem up to 30 cm long, usually solitary, sometimes suckering to form small groups. Leaves about 20 in a dense rosette; stipules absent; petiole absent; blade ovate-lanceolate, 30–75 cm × 8–30 cm, apex long-acuminate, margin with dark brown, sharp teeth, 3–6 mm long, 1–2 cm apart, surface smooth, dull green, often with horny margin; exudate yellow. Inflorescence consisting of racemes, 15–20 cm long, lax, flowers arranged at one side; peduncle 1–1.5 m long, with up to 12 branches, the lower branches rebranched; bracts ovate-acute, 3–7 mm long, pale brown, papery. Flowers bisexual, regular, 3-merous; pedicel 5–10 mm long; perianth tubular, 2.5–3.5 cm long, inflated around the ovary, lobes 6, 12–17 mm long, rose-pink to dull scarlet, paler at mouth; stamens 6, exserted; ovary superior, 3-celled, style filiform, stigma head-shaped, exserted. Fruit an oblong-ovoid capsule up to 25 mm × 14 mm, pale brown, dehiscing loculicidally, many-seeded. Seeds c. 8.5 mm long, blackish brown, with speckled wings.

Other botanical information *Aloe* comprises about 450 species in Africa and Arabia, of which c. 315 occur in mainland Africa, c. 100 are endemic to Madagascar or the Indian Ocean islands (including the former *Lomatophyllum*) and c. 50 occur in Arabia. The taxonomy is complicated by the occurrence of interspecific hybrids both in the wild and in cultivation. Two varieties of *Aloe secundiflora* are recognized: var. *secundiflora* and the suckering var. *sobolifera* S.Carter; the latter is only known from Tanzania. Natural hybrids with several other species have been reported. Apart from *Aloe secundiflora*, there are several other East African species with similar growth habit and with medicinal use or use as poison. *Aloe macrosiphon* Baker is used medicinally and has very similar chemical properties to *Aloe vera*. *Aloe ruspoliana* Baker is poisonous to sheep and camels and is used in Somalia and Kenya to poison hyenas.

Growth and development Seedlings take a couple of years before they are large enough for harvesting. Although *Aloe secundiflora* is drought tolerant it needs water to develop new leaves.

Ecology Like all *Aloe* species, *Aloe secundiflora* is well adapted to dry semi-arid conditions. It occurs in grassland and open woodland on sandy soil at 600–2000 m altitude.

Propagation and planting With the exception of the relatively rare var. *sobolifera*, *Aloe secundiflora* plants have solitary or few (up to 3) rosettes. Therefore they are usually propagated from seed. There are plans to use tissue culture techniques to produce large numbers of plants for establishing plantations.

Management To protect wild populations and increase production, plantations of *Aloe secundiflora* are being established. As establishment is just starting, there are no data yet on management techniques.

Diseases and pests *Aloe* species grown in gardens in Kenya for decorative purposes are susceptible to fungal attack, scale insects and mealy bug infestation. Newly established plantations will need to be closely monitored for signs of diseases and pests.

Harvesting In some areas, wild plants of *Aloe secundiflora* are harvested on a sustainable basis and the same plants can be used for many years. In areas where there is no established tradition of harvesting, wild plants are frequently destroyed while collecting the exudate. To harvest the exudate from *Aloe secundiflora*, a hole is dug in the ground and lined with a container. Cut leaves are arranged around the edge of the hole at an angle allowing the exudate to drain into the container. The exudate is transferred to bottles or jerry cans for sale to a dealer.

Yield Harvesting of exudate takes place throughout the year, though it has been observed that the yield is higher during rainy seasons. On average one mature plant can produce 80–100 ml of exudate. In some areas of Kenya the dealers obtain up to 1700 l/day from collectors.

Handling after harvest Dealers only visually inspect the quality of the exudate. The usual reason for rejection of the exudates is that the liquid is too thin, or 'watery', as seen from the ease with which a small sample will soak into the ground. To concentrate the exudate it is placed in a large drum and boiled so that it becomes reddish black and very viscous. It is then transferred from the drum to sacks, in which it is left to cool and harden. After a day of cooling the material is solid and black, called 'bitters', and is ready for sale to a middleman, who will sell on to an exporter. Because of the illegality in Kenya the whole marketing chain is shrouded in secrecy.

Genetic resources *Aloe secundiflora* is col-

lected indiscriminately from the wild, with no selection factors involved. The few plantations now being established are stocked with plants (probably from various species) collected in the wild. All *Aloe* species, except *Aloe vera*, are protected by CITES and all international trade of plants and products should be regulated.

Breeding So far, there has been no attempt to improve the stock of *Aloe secundiflora* by breeding.

Prospects Once legislation is in place and plantations are established, *Aloe secundiflora* will be a valuable crop for marginal areas where low rainfall makes it difficult to obtain good yields from conventional crops. The Kenya Aloes Working Group intends to look for ways of improving the processing and quality control of the product.

Major references Carter, 1994; Kihara et al., 2003; Mascolo et al., 2004; Newton, 2001; Newton, 2004.

Other references Atiti, 2004; Baerts & Lehmann, 2005d; CITES, 2003; Ermias Dagne et al., 1994; Demissew Sebsebe & Gilbert, 1997; Gachathi, 1989; Kokwaro, 1993; Musila, Kisangau & Muema, 2004; Neuwinger, 1996; Newton, 1994; Newton, 1995; Oketch-Rabah, 1996; Oketch-Rabah, Dossaji & Mberu, 1999; Waihenya, Mtambo & Nkwengulila, 2002; Waihenya, 2002; Waihenya et al., 2003.

Sources of illustration Agnew & Agnew, 1994; Carter, 1994.

Authors L.E. Newton

ALOE TURKANENSIS Christian

Protologue Journ. S. African Bot. 8(2): 173 (1942).

Family Asphodelaceae

Chromosome number $2n = 14$

Origin and geographic distribution *Aloe turkanensis* occurs in north-western Kenya and in the Karamoja District of Uganda.

Uses The Turkana people of Kenya apply the leaf sap of *Aloe turkanensis* to wounds and as a cure for eye diseases. The juice from boiled roots is added to a drink to induce vomiting, which is said to relieve persistent headaches. The roots are used to flavour beer.

Production and international trade The trade of *Aloe* extract from East Africa is illegal. The dried exudate, marketed under the name 'Kenya aloes' or 'bitters', is usually a mixture of the exudate of several species. In Kenya *Aloe turkanensis* is harvested from the wild at a large scale.

Properties The main components of leaf exudate of *Aloe turkanensis* are aloin A, aloin B and aloesone. From about 70 *Aloe* species checked, *Aloe turkanensis* had the highest aloin content, both in the exudate and in the leaf (31% and 6.6% of dry weight, respectively). Aloin is a mixture of the stereoisomers aloin A (barbaloin) and aloin B (isobarbaloin), and is responsible for the laxative properties.

Botany Succulent sprawling shrub; stem ascending, becoming decumbent, up to 70 cm long, branching from the base and forming large clumps. Leaves 14–18 in a dense rosette, erect to spreading; stipules absent; petiole absent; blade lanceolate, up to 70 cm × 9 cm, apex long-acuminate, margin with sharp deltoid teeth, 2 mm long, whitish, brown-tipped, 12–18 mm apart, blade pale bluish green with elongated white spots on both surfaces; exudate drying yellow. Inflorescence consisting of cylindrical racemes 15–26 cm long; peduncle up to 1 m long, with up to 8 branches; bracts ovate, 5–7 mm long. Flowers bisexual, regular, 3-merous; pedicel 8–10 mm long; perianth tubular, c. 2.5 cm long, lobes 6, c. 12 mm long, bright coral-pink, paler at mouth; stamens 6, exserted; ovary superior, 3-celled, style filiform, stigma head-shaped, exserted. Fruit an oblong-ovoid capsule c. 2 cm × 1 cm, dehiscing loculicidally, yellowish brown, many-seeded. Seeds blackish with whitish, sparsely black-speckled wings.

Aloe comprises about 450 species in Africa and Arabia, of which c. 315 occur in mainland Africa, c. 100 are endemic to Madagascar or the Indian Ocean islands (including the former *Lomatophyllum*) and c. 50 occur in Arabia. *Aloe turkanensis* belongs to a group of East African species forming large clumps, with leaves wider than 2 cm. Several other species in this group have medicinal uses and are considered by CITES to be under threat because of the risk of overexploitation. *Aloe calidophila* Reynolds from Ethiopia and Kenya has become rare due to harvesting for medicinal purposes. *Aloe camperi* Schweinf. (synonym: *Aloe eru* A.Berger) is one of the most important medicinal plants in Eritrea. In Egypt it is widely cultivated for its exudate. The main components of the exudate are emodin and aloenin. The exudate has significant antifungal properties. *Aloe elgonica* Bullock, from Kenya, has become vulnerable due to harvesting. The leaf exudate contains aloe-emodin, aloenin, aloesin, aloeresin B and homonataloin. In Somalia the exu-

date of *Aloe microdonta* Chiov. is dissolved in water and drunk to treat jaundice. The leaf juice is applied topically to cure skin diseases. The leaf exudate contains aloin A and B, and microdontin A and B.

Ecology *Aloe turkanensis* grows on stony, sandy soil or lava, usually in the shade of shrubs in arid areas at 600–1250 m altitude.

Management To harvest the exudate from *Aloe turkanensis* and other *Aloe* species, a hole is dug in the ground and lined with a container. Cut leaves are arranged around the edge of the hole at an angle allowing the exudate to drain into the container. The exudate is transferred to bottles or jerry cans for sale to a dealer. It is placed in a large drum and boiled down until it becomes reddish black and very viscous. It is then transferred from the drum to sacks, in which it is left to cool and harden. After a day of cooling the material is solid and black, called 'bitters', and is ready for sale to a middle man, who will sell it to an exporter. Harvesting from wild plants is generally destructive. Development of properly managed plantations will lead to conservation of the wild plants and substantial yields from the plantations. *Aloe turkanensis* can easily be propagated by suckers. It is being cultivated on a small scale in Kenya for exudate production, but no details are available on its management.

Genetic resources and breeding Harvesting from the wild for medicinal and ornamental uses and habitat destruction are major threats to many *Aloe* species. All *Aloe* species are listed by CITES, except *Aloe vera* (L.) Burm.f. As *Aloe turkanensis* is still being harvested on a large scale from the wild, it is certainly threatened.

Prospects Research into the chemical composition and affinities of *Aloe* species is well underway. However, the ethnobotanical aspects of less important *Aloe* species are poorly documented. Growing *Aloe* species as a commercial crop might take the pressure off wild populations, but more research is needed to identify the species best suited for domestication and their requirements in cultivation. *Aloe turkanensis* and other species that develop many suckers seem good candidates for domestication. The high aloin content of *Aloe turkanensis* makes it even more interesting as a potential crop plant.

Major references Carter, 1994; CITES, 2003; Morgan, 1981; Newton, 2001; Newton & Lavranos, 1990.

Other references Ali et al., 1999a; Conner et al., 1990, 1990; Ermias Dagne et al., 1994; Demissew Sebsebe & Gilbert, 1997; Farah, Andersson & Samuelsson, 1992; Groom & Reynolds, 1987; Neuwinger, 2000; Reynolds, 1996; Reynolds & Nicholls, 1986; Tawfik, Sheteawi & El-Gawad, 2001.

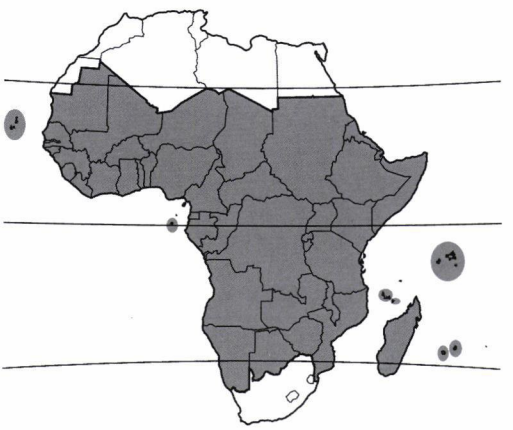
Authors C.H. Bosch

ALOE VERA (L.) Burm.f.

Protologue Fl. ind.: 83 (1768).
Family Asphodelaceae
Chromosome number $2n = 14$
Synonyms *Aloe barbadensis* Mill. (1768).

Vernacular names Aloe vera, Barbados aloe, coastal aloe, Curaçao aloe, Indian aloe, medicinal aloe, Mediterranean aloe, true aloe, West Indian aloe (En). Aloès, aloès vulgaire, aloe vera (Fr). Aloés, aloé vera, aloés de Barbados, caraguatá, erva-babosa, azebre vegetal (Po).

Origin and geographic distribution *Aloe vera* is only known as a cultivated or naturalized plant. It is generally presumed that the origin is Arabia, Somalia or Sudan and a recently discovered stand of *Aloe vera* in Oman could well prove to be the only wild population in the world. A Mediterranean origin is often quoted but probably wrong. At present *Aloe vera* is widely distributed throughout the tropics and subtropics. It is widely grown as a cash crop in dry regions in the Americas, Asia and Australia. *Aloe vera* was already used as a drug by the Greeks as early as 400 B.C. and later by Arabian physicians. It is probably present as a cultivated plant in all countries of tropical Africa, although its presence is largely undocu-



Aloe vera – planted and naturalized

mented.

Uses *Aloe vera* is a well-known medicinal plant widely used in modern herbal practice and often available in proprietary herbal preparations. The exudate, called 'aloe', 'aloes' or 'bitter aloes', is contained in the pericycle cells of the vascular bundles in the leaf, and is used either fresh or dried. The dried exudate is used as a laxative, purgative and vermifuge. The fresh leaf exudate is also taken as a laxative or purgative, and is externally applied as a refrigerant, to treat acne or cuts. Mixed with other ingredients to mask its bitter taste, it is taken against asthma and to treat coughs. Similar mixtures are taken to cure dysentery, kidney problems or against dyspepsia. The exudate is used as a bittering agent for food and beer.

Aloe gel, the mucilage from the central part of the leaf, has a multitude of medicinal applications. The gel or peeled leaves are generally applied to treat skin afflictions (burns, wounds, abrasions, skin diseases, irritations), as a poultice on contusions or as a general refrigerant. The gel is also applied externally to cure haemorrhoids. It is furthermore used as a hair wash to promote hair growth and against dandruff, and as a general cosmetic to improve the complexion and to smooth the skin. The peeled leaves are eaten to relieve sore throat and coughs and as a mild laxative. As a food supplement, *Aloe vera* gel is said to facilitate digestion, and to improve blood and lymphatic circulation, as well as kidney, liver and gall bladder functions. There are claims of beneficial activity of *Aloe vera* products in cases of AIDS, arthritis, or other chronic and debilitating conditions. However, these claims have not been substantiated by scientific studies. There is also no evidence that topical *Aloe vera* gel is effective in preventing or minimizing radiation-induced skin reactions in cancer patients. In large amounts, the gel has anti-irritant properties.

For tropical Africa there are reports from countries including Nigeria, DR Congo and Uganda of medicinal use of *Aloe vera*, in particular to treat skin problems. Identification of the species however is doubtful as many *Aloe* species have identical uses. In Mauritius *Aloe vera* gel is used for treating sprains, muscle pain and callosities of the feet. Leaves and seeds are cooked and eaten as a vegetable. The gel is used in the manufacture of commercial jellies, drinks and ice-cream. A novel application of gel powder is as a 1% addition to concrete, which gives the reinforcing steel better resistance against corrosion. *Aloe vera* gel used in a coating on grapes lengthens the shelf life considerably and this patented method could also be applicable in other high-value fruits and vegetables. *Aloe vera* is often grown as an ornamental in gardens or pots.

Production and international trade The global annual turnover of fresh *Aloe vera* gel products amounted to approximately US$ 125 million in 2004 and was expected to grow at a rate of 35% over the next five years. The American continent supplies about 60% of the gel to the world market, with Mexico, the Dominican Republic and Venezuela as the main producers. Asia and Australia produce the remainder of the internationally traded product, with China and Thailand as the most important producers. In Nigeria *Aloe vera* is commercially grown for the local market.

Properties Dried exudate contains 15–40% anthrone 10-C-glucosides (anthraquinone derivatives) such as aloin and hydroxyaloins. Aloin is a mixture of the stereoisomers aloin A (barbaloin) and aloin B (isobarbaloin). Furthermore, the exudate contains the pyrone derivative aloenin and free and glucosylated 2-acetonyl-7-hydroxy-5-methylchromones (e.g. aloesone, furoaloesone, aloeresin A, aloeresin B (aloesin) and aloeresin C). 'Curaçao aloe' should contain at least 28% hydroxyanthraquinone derivatives; it is almost entirely soluble in 60% alcohol and for more than 70% in water. It should not contain more than 12% moisture and 3% ash. The compound responsible for the laxative properties is aloin, which itself is inactive as a laxative, but is activated to aloe-emodin anthrone, by *Eubacterium* sp. Although some observations indicate that in diarrhoea induced by aloin increased water content might be more important than stimulated peristalsis, the side effects of prolonged use point to a griping effect on the colon. Anthraquinone laxatives should not be used longer than 8–10 days, or by children younger than 12 years. Contra-indications include pregnancy, breastfeeding, intestinal inflammations and haemorrhoids. It has been claimed that aloin is responsible for antihistamine and anti-inflammatory activity. Aloin should be administered preferably in combination with an antispasmodic to moderate its griping action. Possible side effects of aloin include congestion and irritation of the pelvic organs. Anthraquinone laxatives may play a role in development of colorectal cancer as they have

genotoxic potential, and tumorigenic potential in rodents. Both aloin and aloeresin B have skin-whitening activity. Large variations in aloin content have been found in *Aloe vera*, with the highest concentration in exudates from younger mature leaves. In 2002 the United States Food and Drug Administration withdrew the 'generally recognized as safe and effective (GRASE)' status for over-the-counter drugs based on aloe exudates.

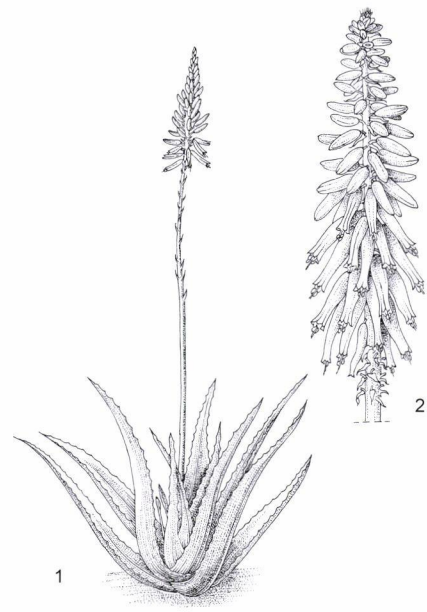
Aloe vera gel has earned a reputation as a miracle drug. It is effective in burn treatment, because of its anti-inflammatory and wound-healing properties. Its healing properties may be due to rehydrating, insulating and protective activities resulting from the high water content. The major constituents are polysaccharides (mainly acemannan), lectins, sterols and enzymes, and the effect is assumed to be a synergy between the polysaccharide base and various components. In addition, acemannan has shown immune stimulating, anticancer and antiviral effects. The use of the gel has been approved in the United States for treatment of leukaemia in cats, of fibrosarcoma in dogs, for wound healing in humans and to prevent dry socket ('alveolar osteitis') in humans.

In several experiments with rats (including diabetic rats) both topical and oral treatments with *Aloe vera* gel had a positive influence on the synthesis of glycosamino glycans, thereby facilitating wound healing. A placebo-controlled, double-blind study showed that a topically applied *Aloe vera* gel of 0.5% in a hydrophylic cream is beneficial for patients suffering from psoriasis. It did not show toxic or other side-effects. A clinical test with patients with advanced solid tumours, for whom no standard effective therapy was available, suggested that *Aloe vera* gel in combination with the immunomodulating neurohormone melatonin may produce some therapeutic benefits, at least in terms of stabilization of disease and survival.

Contradicting results of clinical tests with *Aloe vera* products are common. A problem is that the identity of the tested plants is not always certain. A second problem is that the products are not of standard composition, but depend on cultivar, growing conditions and handling after harvest. Therefore, commercial products may vary enormously in composition. Also, contamination of the gel with exudate can turn a harmless product into a purgative. It is therefore imperative that products of well-defined composition are used for clinical trials, that the identity of the plant is confirmed by a taxonomist and that a specimen is deposited in a herbarium for future reference.

Adulterations and substitutes The enormous increase in demand in the 1990s and the lack of regulation has led to cases of deliberate manipulation of the quality of *Aloe vera* gel. Samples of *Aloe vera* gel powder have been found that contained up to 90% maltodextrin, a polysaccharide made from cornstarch. In the United States certification of *Aloe vera* products is in place. The commercial drug 'Cape aloe' is produced from *Aloe ferox* Miller and 'Socotrine aloe', from *Aloe perryi* Baker. Their exudates are used as substitutes for 'bitter aloes'.

Psyllium (*Plantago* spp.), which is a natural bulk laxative, is one of the substitutes for anthraquinone-containing laxative drugs such as *Aloe* and has the advantage that it does not cause dependency and/or cathartic colon. Anthraquinone-containing preparations from *Senna alata* (L.) Roxb. and other *Senna* and *Cassia* species are sometimes recommended as substitutes for *Aloe* products. *Centella asiatica* (L.) Urb. is recommended as a substitute for *Aloe vera* gels in wound treatments; its triterpenes have exhibited both wound healing and



Aloe vera – 1, plant habit; 2, part of inflorescence. Redrawn and adapted by Achmad Satiri Nurhaman

antibacterial activities.

Description Succulent perennial herb up to 160 cm tall, without stem or with a short stem up to 30 cm long, freely suckering and forming dense groups. Leaves 16–20 in a dense rosette, erect to slightly spreading; stipules absent; petiole absent; blade linear-lanceolate, 40–50 cm × 6–7 cm, apex acuminate, margins slightly pinkish, with deltoid, firm teeth 2 mm long, pale, 1–2 cm apart, fleshy, upper surface rather flat, grey-green to pale green, lower surface convex; leaf sap yellowish. Inflorescence a terminal dense raceme 30–40 cm × 5–6 cm; peduncle simple or sometimes 1–2-branched above the middle, 60–90 cm tall; bracts ovate-acute, deflexed, up to 1 cm long. Flowers bisexual, regular, 3-merous; pedicel c. 5 mm long; perianth tubular, up to 3 cm long, inflated around the ovary, lobes 6, 3 outer lobes acute, 3 inner lobes obtuse, yellow, orange or red; stamens 6, exserted; ovary superior, 3-celled, 6-grooved, style filiform, stigma head-shaped, exserted. Fruit a capsule, dehiscing loculicidally, many-seeded. Seeds c. 7 mm long, dark brown, winged.

Other botanical information *Aloe* comprises about 450 species in Africa and Arabia, of which c. 315 occur in mainland Africa, c. 100 are endemic to Madagascar or the Indian Ocean islands (including the former *Lomatophyllum*) and c. 50 occur in Arabia. The taxonomy is complicated by the occurrence of interspecific hybrids both in the wild and in cultivation. The long history of cultivation has led to various selections that are sometimes given formal botanical ranking. The names *Aloe vera* and *Aloe barbadensis* have long been contentious among specialists. While taxonomists now agree that *Aloe vera* is the correct name, both pharmacologists and medical researchers still use both names, probably also due to patent-related problems. To confuse matters further many pharmacologists apply the name 'aloe vera' to products derived from other *Aloe* species.

The group of *Aloe* species to which *Aloe vera* belongs is characterized by the production of suckers and a simple or sparsely branched inflorescence. *Aloe officinalis* Forssk. has the same growth habit and is cultivated for medicinal use of the leaves in Somalia. It is native to Yemen and it is often incorrectly considered conspecific with *Aloe vera*.

Growth and development *Aloe* species follow the Crassulacean acid metabolism (CAM). CAM plants can fix CO_2 at night and photosynthesize with closed stomata during the day, thus minimizing water loss. This, plus their succulent leaves and stems, and the presence of a thick cuticle, makes them well adapted to dry conditions. Birds are the most important pollinators of *Aloe* but in Africa honeybees also play a role. In Africa *Aloe vera* flowers and fruits normally, but elsewhere fruit formation is rare. Failure to set fruit is presumed to be caused by pollen sterility and self-incompatibility.

Ecology *Aloe vera* grows in a wide range of climatic conditions. It prefers sandy or loamy, well-drained soils and can grow in nutritionally poor soil, but thrives on rich soils. It is tolerant of salinity. Established plants will survive drought quite well even though the root system is relatively shallow. *Aloe vera* is not very frost-hardy, but will survive a temperature of –3°C with only slight injury. It should be planted in full sun or light shade. During the winter months in the subtropics, the plant becomes dormant and utilizes very little moisture.

Propagation and planting In *Aloe vera* cultivation, vegetative propagation is usually preferred above propagation by seed, because of poor seedling emergence and faster initial growth of suckers. Water deficiency may lead to decreased sucker formation. Suckers can be cut from the mother plant when they are 15–20 cm long. They may be grown in a nursery during the first year. Micropropagation through in-vitro culture of vegetative meristems, as well as in-vitro regeneration of leaf base explants is possible.

Management Management practices for *Aloe vera* vary widely. Where grown extensively, for example in the Dominican Republic, goats are used for weeding. Greenhouse cultivation is practised in Ohio, United States. Use of chemical fertilizers is not common, probably because it would spoil the reputation of this organic health product. Nitrogen is the most important nutrient. Plant densities used are variable. Densities of 60,000 plants/ha have given the highest yields of gel and exudate, but in large-scale plantations the distances between and within rows are usually at least 50 cm. Densities of about 15,000 plants/ha are considered optimal for intensive cultivation with drip irrigation and polythene ground cover. Lower densities will give larger leaves but lower gel yields per ha.

Diseases and pests In Africa no serious diseases affect *Aloe vera*. In India *Alternaria*

alternata and *Fusarium solani* are causes of leaf spot disease. In Aruba leaf rot caused by *Erwinia chrysanthemi* occurs occasionally. *Aloe vera* has few pests as the tough outer skin provides excellent resistance. It is likely that the bitter anthraquinones contained in the outer layer of the leaf make the plant unattractive.

Harvesting *Aloe vera* plants take about 3 years to attain harvestable size, and then leaves can be harvested for about seven years. The exudate is collected by cutting off the leaves transversely close to the stem and positioning them in such a way that the juice drains into pots, tubs, vessels or even a simple canvas placed over a depression in the ground. The exudate may also be obtained by squeezing the leaves or by warm or cold water retting. The leaves are usually cut in the morning and it takes 4–5 hours for the juice to drain from a pile of leaves. Only older leaves are cut; younger ones and growing tips are spared.

For gel production, the leaves are cut at intervals of about 3 months. The youngest leaves (< 25 cm) are not suitable because of their low gel content, but the leaves should not be too old because gel quantity and quality may decline. Individual *Aloe vera* leaves in Aruba reach their maximum fresh weight after about 40 weeks of growth. Leaves with tip necrosis or that are otherwise damaged, should be discarded to avoid contamination of the gel with bacteria. In a system where only selected leaves are cut, the possibilities for mechanical harvesting are limited.

Yield In Aruba *Aloe vera* plants can produce 16–20 leaves per year under optimal moisture supply and sufficient nitrogen fertilization. With a plant density of 50,000 plants/ha and an average fresh leaf weight of 0.2 kg, this implies a gel yield of about 180 t/ha. Leaves of the cultivar 'Rio Grande Valley' can weigh up to 1.3 kg when grown under optimal conditions.

Handling after harvest The exudate collected is concentrated by boiling and subsequent cooling or by vacuum evaporation. The resulting amorphous extract constitutes the drug 'Curaçao aloe'. The extract is opaque, waxy and often liver-coloured ('hepatic') and aloin crystals are visible under the microscope. Other compounds found in dried exudate may well be artefacts of boiling the exudate.

For gel production the cut leaves are transferred to water baths where debris is washed off. The leaves are then taken into the factory for filleting. To separate the gel-containing parts, each leaf is topped and tailed and the sides are cut off using a very sharp knife. Then the outer tissues of the leaf are removed the same way. The remaining gel must be processed as quickly as possible to avoid degradation of the polysaccharides. In an alternative method used e.g. in Aruba, gel is obtained by cutting the leaves lengthwise and scraping the gel from the leaf blade. The gel is further cut into small pieces to produce a free flowing liquid, followed by refining and filtration. Purification is done by centrifugal removal of cell wall material, and the liquid pure gel is stabilized chemically. Subsequently the gel may be concentrated and dehydrated. So-called 'whole leaf aloe vera' products are produced in the same way as the gel products but the outer tissues are extracted separately, the aloins are removed by mixing with fine charcoal, and the extract is subsequently sieved and added to the gel. In Asia the whole dried fillet is marketed, and in several West African markets and in supermarkets in the United States whole fresh leaves are sold.

Genetic resources *Aloe vera* is widely cultivated because of its commercial value. It is also present in many botanical gardens, and is therefore not endangered. *Aloe vera* is the only *Aloe* species not listed by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendices and is therefore the only species that can be traded legally.

As a result of the continuous vegetative propagation, the genetic variation within *Aloe vera* in cultivation seems to be rather small but this variation has never been studied. Populations in India and China for example have been isolated for centuries and may harbour characteristics that could be useful elsewhere.

Breeding High-yielding plants may be selected and propagated for commercial cultivation. For gel production cultivars with low aloin content would be preferred and seem to exist. Many *Aloe* species hybridize in the wild if their area of distribution and period of flowering overlap, and it is easy to produce hybrids in cultivation. The scope for breeding and selection is therefore enormous.

Prospects *Aloe vera* is of particular interest for the use of its gel in burn and wound care. It will remain beneficial as a household remedy: fresh gel can easily be prepared and applied to wounds. In its use as a laxative, however, the drug tends to be replaced by other laxatives such as those from *Plantago* spp. Even so, there is still considerable demand, also for vet-

erinary use, worldwide. For gel production *Aloe vera* has potential as a commercial crop in arid regions as the demand is enormous and increasing; in Kenya plantations of *Aloe vera* have started on a small scale. Growing *Aloe vera* for gel requires however considerable investment in processing equipment.

In the Western World the medicinal use of *Aloe vera* extracts will be gradually replaced by that of purified drugs. The number of scientific and pseudo-scientific publications on medicinal and pharmacological aspects is overwhelming and new insights are likely to contribute to the demystification of now contentious claims about the beneficial effects of *Aloe vera*. The identification of active ingredients and mechanisms of action are critical for production of effective and safe drugs based on *Aloe vera* and other *Aloe* species.

Major references Abe & Talmadge (Editors), 2004; Aguilar & Brink, 1999; Dagne et al., 2000; Das & Chattopadhay, 2004; Eshun & He, 2004; Grindlay & Reynolds, 1986; Newton, 2001; Reynolds, 2004; Reynolds & Dweck, 1999; Strickland & Pelley, 2004.

Other references Cerqueira et al., 1999; Chow et al., 2005; Diehl & Teichmuller, 1998; Duke & duCellier, 1993; Dweck, undated; Ekpendu, 2004; Facciola, 1990; Gurib-Fakim, Guého & Bissoondoyal, 1996; Liao et al., 2004; Richardson et al., 2005; Ross, 2003; Tanaka,, 1976; Torres-Acosta et al., 2005; Valverde et al., 2005; Usher, 1974; Yeh et al., 2003; WHO, 1999.

Sources of illustration Baillon, 1886.

Authors A.J. Afolayan & P.O. Adebola

ALOE VOLKENSII Engl.

Protologue Pflanzenw. Ost-Afrikas: 141 (1895).

Family Asphodelaceae

Chromosome number $2n = 14$

Origin and geographic distribution *Aloe volkensii* occurs in Rwanda, southern and coastal Kenya, southern Uganda, and northern and coastal Tanzania, including Zanzibar.

Uses In eastern Africa the leaf sap of *Aloe volkensii* is applied to burns, wounds and sores and as a lotion to eyes. The bitter exudate is applied to nipples to wean children and is rubbed on the forehead to treat headache. In Rwanda it is taken as a purgative. The leaf sap is taken to expel a retained placenta. The leaves are used to deworm livestock. Small amounts of leaf sap are added to butter to increase its shelf life. *Aloe volkensii* is planted as a live fence. Roots are used to accelerate the fermentation of honey beer and to impart a slightly bitter taste.

Properties Exudate of *Aloe volkensii* contains a mixture of the stereoisomers aloin A (barbaloin) and aloin B (isobarbaloin), which are responsible for the laxative properties.

Botany Succulent shrub or small tree up to 3(–9) m tall; stem solitary or clustered, up to 30 cm in diameter, simple or branching from above the base, with persistent dead leaves. Leaves in a rosette, erect, later spreading and recurved; stipules absent; petiole absent; blade narrowly lanceolate, up to 1 m × 10 cm, margin with forward pointing, brown-tipped teeth 2–4 mm long, 1–2.5 cm mm apart, blade dull olive-green; exudate yellow, drying red. Inflorescence consisting of head-like racemes c. 8 cm long, becoming cylindrical-conical; peduncle 50–60(–85) cm long, with 8 or more spreading branches, lowest with secondary branches; bracts broadly ovate, 2–5 mm long. Flowers bisexual, regular, 3-merous; pedicel 1–1.5 cm long; perianth tubular, 2.5–3.5 cm long, 6–8 mm in diameter, lobes 6, 12–17 mm long, red with yellow tips; stamens 6, exserted; ovary superior, 3-celled, style filiform, stigma head-shaped, exserted. Fruit an ovoid capsule c. 3 cm × 1.5 cm, dehiscing loculicidally, many-seeded. Seeds c. 9 mm long, broadly winged.

Aloe comprises about 450 species in Africa and Arabia, of which c. 315 occur in mainland Africa, c. 100 are endemic to Madagascar or the Indian Ocean islands (including the former *Lomatophyllum*) and c. 50 occur in Arabia. *Aloe volkensii* belongs to a group of species, which are often small trees with usually unbranched trunks (sometimes branching at base) or suckering shrubs. Several other species in this group have medicinal uses. *Aloe ballyi* Reynolds is a rare species from Kenya and Tanzania. Leaf sap is taken as a purgative but this is dangerous as it contains poisonous alkaloids. It is planted as an ornamental in the streets of Nairobi, Kenya. *Aloe christianii* Reynolds occurs in DR Congo, Tanzania and a large part of southern Africa. A leaf infusion is taken to induce abortion, but is considered too poisonous in Zimbabwe. *Aloe excelsa* A.Berger occurs in a large part of southern Africa. An infusion made of the leaves is taken as a malaria prophylactic and to cure stomach-ache, asthma and jaundice and is put in drinking water of chickens to prevent diseases. The leaves con-

tain aloesin, anthraquinones and a C-glucoside. In Namibia the leaf sap of *Aloe littoralis* Baker is applied to cure eye problems and to arrest progress of venereal disease. Powdered leaves are an effective anti-inflammatory. Daily use of leaf extract is said to be effective as a malaria prophylaxis. Chopped leaves, boiled in water are purgative both for humans and livestock. Chopped leaves added to drinking water protect cattle against ticks and ear lice and chickens against lice. *Aloe marlothii* A.Berger occurs in Botswana, Mozambique, Swaziland and northern South Africa. A leaf decoction is taken with porridge to treat stomach-ache and intestinal worms. The leaf pulp is rubbed on nipples to wean children. The burned dried leaves are mixed with snuff. *Aloe marlothii* is planted as a live fence. The leaves show strong in-vitro anthelminthic activity. Ash from the leaves, mixed with maize, effectively protects the latter from storage pests. The dried exudate was formerly traded under the name 'Natal aloe'. *Aloe marlothii* is an important bee plant.

Ecology *Aloe volkensii* occurs in dry, riverine forest and bush on rocky localities from sea-level to 2100 m altitude.

Management Cuttings are used to establish live fences of *Aloe volkensii*. For medicinal use leaves are primarily harvested from wild plants in a non-destructive way.

Genetic resources and breeding There is no indication of over-utilisation of *Aloe volkensii* in its natural range.

Prospects *Aloe volkensii* has not drawn much interest so far. It is likely to remain important only for local use. Its habit does not make it a likely candidate for domestication.

Major references Carter, 1994; Gelfand et al., 1985; Kokwaro, 1993; Maundu et al., 2001; van Wyk & Gericke, 2000.

Other references Abegaz et al., 1999; Baerts & Lehmann, 2005e; Carter, 2001; CITES, 2003; Clarkson et al., 2004; Lukwa et al., 2001; Neuwinger, 2000; Newton, 2004; Pakia & Cooke, 2003b; von Koenen, 2001.

Authors C.H. Bosch

ALOE WOLLASTONII Rendle

Protologue Journ. Linn. Soc. Bot. 38: 238 (1908).

Family Asphodelaceae

Vernacular names Mlalangao (Sw).

Origin and geographic distribution *Aloe wollastonii* is distributed from north-eastern DR Congo to western Kenya and Tanzania.

Uses In DR Congo and Burundi exudate, crushed leaves and dried leaves are applied topically to cure haemorrhoids. In Uganda itchy skin rash is treated by bathing in an infusion of *Aloe wollastonii* leaves or by using the crushed leaves as a sponge. Uterine inflammation is treated by drinking an infusion of the leaves. A decoction of roots and leaves is drunk to cure jaundice. Veterinary applications of the leaves are multiple in DR Congo, Rwanda and Burundi. Anthrax, piles, burns, parasites and retention of the afterbirth are ailments that are treated with fresh leaves or dried leaf powder, as is East Coast fever in cattle.

Properties *Aloe* species contain a variety of phenolic compounds, including chromone, anthraquinone or anthrone derivatives. The leaf exudate of *Aloe wollastonii* contains about 15% aloin.

Botany Succulent perennial herb up to 1.5 m tall, without stem, usually solitary. Leaves 12–15 in a dense rosette, erect to spreading; stipules absent; petiole absent; blade lanceolate, up to 50 cm × 10 cm, apex long-acuminate, margin with sharp white-horny to red-brown teeth 4–6 mm long, 1–2 cm apart, blade dull green with elongated white blotches in transverse bands; exudate drying yellow. Inflorescence consisting of cylindrical-conical racemes 10–25(–30) cm long, laxly flowered; peduncle up to 1.2 m long, with 4–6 branches, lower branches sometimes rebranched; bracts linear–lanceolate, (10–)15–20 mm long. Flowers bisexual, regular, 3-merous; pedicel 1.5–2 cm long; perianth tubular, 3–3.5 cm long, c. 9 mm in diameter at base, lobes 6, c. 11 mm long, pinkish to orange-red, rarely yellow; stamens 6, exserted; ovary superior, 3-celled, style filiform, stigma head-shaped, exserted. Fruit an ovoid capsule c. 20 mm × 12 mm, dehiscing loculicidally, many-seeded. Seeds c. 3 mm × 5 mm, blackish brown with broad, speckled wings.

Aloe comprises about 450 species in Africa and Arabia, of which c. 315 occur in mainland Africa, c. 100 are endemic to Madagascar or the Indian Ocean islands (including the former *Lomatophyllum*) and c. 50 occur in Arabia. *Aloe wollastonii* has been confused in the literature with *Aloe lateritia* Engl., a species with a more eastern distribution and more densely flowered racemes. *Aloe wollastonii* belongs to a group of *Aloe* species with solitary rosettes or forming small groups, with leaves wider than 2 cm and

inflorescences with at least 2 branches. Several other species in this group have medicinal uses. The exudate of *Aloe citrina* S.Carter & Brandham is used in Somalia to cure ophthalmia. The leaf juice of *Aloe cryptopoda* Baker is used in Zimbabwe to treat constipation, venereal diseases and as abortifacient, although the abortifacient activity of the infusion could not be demonstrated in tests with rats. The sap from roasted leaves of *Aloe kilifiensis* Christian from coastal Kenya is applied to the skin to reduce swelling. A decoction of the leaves is taken to cure an enlarged spleen. The exudate is used externally to treat headache. *Aloe rivae* Baker from Ethiopia and Kenya is threatened because of overexploitation for undocumented medicinal uses. In Sudan both the leaves and leaf exudate of *Aloe sinkatana* Reynolds are valued for treating a variety of ailments, including skin diseases, constipation, fever, tonsillitis, haemorrhoids and inflamed colon. *Aloe sinkatana* is valued as an ornamental. It is depleted in the wild and propagation and conservation measures are urgently needed.

Ecology *Aloe wollastonii* is found in grassland and woodland at 1100–2300 m altitude.

Genetic resources and breeding *Aloe wollastonii* is widespread and probably not under direct threat of genetic erosion or extinction, although it is included in CITES lists like all *Aloe* spp. except *Aloe vera* (L.) Burm.f.

Prospects As *Aloe wollastonii* produces few or no suckers it is not an obvious choice for commercial cultivation. Confusion with *Aloe lateritia* warrants review of the literature on chemistry and ethnobotany of both species.

Major references Carter, 1994; Kokwaro, 1993; Marshall, 1998; Tabuti, Lye & Dhillion, 2003.

Other references Baerts & Lehmann, 2005c; Champluvier & Maquet, 1988; CITES, 2003; Newton, 2001; Pakia & Cooke, 2003b; Parry & Matambo, 1992.

Authors C.H. Bosch

ANDRACHNE ASPERA Spreng.

Protologue Syst. veg. 3: 884 (1826).

Family Euphorbiaceae (APG: Phyllanthaceae)

Origin and geographic distribution *Andrachne aspera* occurs throughout northern Africa east through the Arabian peninsula to Turkey, Pakistan and India. In tropical Africa it occurs in Cape Verde and from Cameroon east to Somalia and Kenya.

Uses In Ethiopia the roots are eaten as an anti-emetic. An extract of the aerial parts is drunk as a poison antidote, and to treat headache and stomach-ache. In Pakistan and India a decoction of the bitter root is used as eye drops to treat eye infections and improve eyesight.

Properties From the aerial parts a number of piperidine alkaloids were isolated: aspertine A–D, andrachcinine, andrachcinidine, andrachamine, andrachcine, as well as the alkaloids (+)-allosedridine, (–)-8-epi-8-ethylnorlobelol I and (–)-8-epihalosaline. Terpenes isolated from the aerial parts are lupeol acetate, α-amyrin, β-amyrin, α-taraxerol, stigmasterol, β-stigmasterol, lupeol, oleanolic acid and germanicol. In preliminary laboratory tests, an alcoholic extract of the aerial parts showed stimulatory activity on respiration and blood pressure of dogs and cats. It also showed spasmolytic activity on isolated guinea-pig ileum and rat ileum, as well as antihistaminic activity on guinea-pig ileum. Root extracts showed significant antibacterial activity against several human pathogens, but methanol extracts of the aerial parts were inactive. Toxicity studies with rats showed low toxicity.

Botany Monoecious, prostrate or decumbent perennial herb up to 35 cm tall; stems hairy. Leaves alternate, simple and entire; stipules oblong to lanceolate, c. 1 mm long; petiole 1–10(–15) mm long; blade broadly ovate to almost kidney-shaped, 0.5–1.5(–2.5) cm in diameter, base rounded to shallowly cordate, apex rounded to notched, glabrous to sparingly short-hairy above, short-hairy beneath. Inflorescence axillary; male inflorescence a few-flowered fascicle, female flowers solitary. Flowers unisexual, regular, 5(–6)-merous; male flowers with pedicel 1.5–2 mm long, sepals oblanceolate-oblong, c. 1.5 mm long, slightly toothed at apex, yellowish green with membranaceous margins, petals rhombic-elliptical, c. 1 mm long, acute, white, disk glands kidney-shaped, flattened, stamens c. 1 mm long, free or fused in the lower third; female flowers with pedicel c. 2 mm long, extending to 4–8 mm in fruit, sepals lanceolate, c. 2 mm long, almost acute, green with narrow membranaceous margins, petals subulate, c. 1 mm long, acute, whitish, disk glands free, fleshy, ovary superior, c. 1 mm in diameter, shallowly 6-lobed, densely short-hairy, styles 3, c. 0.5 mm long, apex 2-fid. Fruit a deeply 3-lobed capsule 2–2.5 mm × c. 3.5 mm, sparingly short-hairy, dull green or purplish tinged, 6-seeded. Seeds ir-

regularly compressed-trigonous, c. 2 mm × 1.5 mm, greyish brown, minutely whitish warty.
Andrachne comprises about 45 species and occurs throughout the tropics and subtropics; 2 species occur in Madagascar and 6 in continental Africa, 2 of which extend their distribution area to Pakistan.

Ecology *Andrachne aspera* occurs in open dry woodland or bushland and in dry, sandy or stony river beds, from sea-level up to 2000(–2400) m altitude.

Genetic resources and breeding *Andrachne aspera* is extremely widespread and there are no signs that it is threatened by genetic erosion.

Prospects Although the roots of *Andrachne aspera* are used medicinally, nothing is known about their chemistry and pharmacology. The aerial parts were active in preliminary pharmacological tests, but it is not known whether the alkaloids and terpenes in the aerial parts are associated with these activities. Further research is justified on both the roots and aerial parts of the species.

Major references Geyid et al., 2005; Jansen, 1981; Mill & Hootelé, 2000; Radcliffe-Smith, 1987.

Other references Ikram & Haq, 1980; Kamal, 2001.

Authors G.H. Schmelzer

ANDRACHNE OVALIS (E.Mey. ex Sond.) Müll.Arg.

Protologue Linnaea 32: 78 (1863).

Family Euphorbiaceae (APG: Phyllanthaceae)

Vernacular names False lightning bush (En).

Origin and geographic distribution *Andrachne ovalis* occurs in Zimbabwe, South Africa and Swaziland.

Uses The strong-smelling roots of *Andrachne ovalis* are used in medicine. A decoction of the root is given orally to humans and animals as an anthelmintic by the Swazi people, whilst an infusion of the root is externally applied as a wash by the Zulu people to treat head lice and fleas. Burned roots are sniffed to treat headache or taken as an emetic to treat chest complaints. Snakebites are treated with an emetic prepared from burned roots, or with powdered root bark applied to incisions in the skin. Powdered stem bark is reported to be effective against epilepsy. The roots are inserted in holes to repel snakes. Powdered root bark in milk is used to trap flies, which are said to die soon after eating the mixture.

Properties Methanol extracts of the bark and leaves showed strong molluscicidal activity against the snail *Bulinus africanus*, and some antibacterial activity against the bacterial wilt disease *Ralstonia solanacearum* (synonym: *Pseudonomas solanacearum*). Bioactivity has been attributed to anthraquinones and their glycosides, saponins, flavonoids and steroids.

Botany Monoecious or dioecious, rather lax, slender, almost glabrous shrub or small tree up to 3(–6) m tall; bark grey, smooth; young twigs terete, greenish. Leaves alternate, simple and entire; stipules triangular-ovate, c. 1 mm long; petiole 2–5(–7) mm long, slender, sparingly pubescent when young; blade ovate to elliptical-ovate, 1–4(–6) cm × 0.5–2(–3) cm, base cuneate to rounded, apex obtuse to almost acute, deep glossy green above, paler beneath, smelling of cyanide when crushed. Inflorescence axillary; male inflorescence a few-flowered fascicle, female flowers solitary. Flowers unisexual, regular, 5(–6)-merous; male flowers with pedicel 2–3(–5) mm long, sepals almost orbicular to obovate, c. 1.5 mm × 1.5 mm, fused at base, obtuse, greenish yellow, petals almost orbicular, c. 1 mm long, white, disk cup-shaped, c. 1.5 mm in diameter, with 10 triangular teeth, stamens c. 1.5 mm long, fused in the lower third; female flowers with pedicel 4–8 mm long, extending up to 1.5 cm in fruit, apically enlarged, sepals ovate, c. 2 mm long, greenish, becoming hardened and persistent in fruit, petals almost orbicular to obovate, c. 1 mm long, disk cup-shaped, 1–2 mm in diameter, margin irregularly lobed or toothed, orange, ovary superior, c. 1 mm in diameter, globose, sparingly hairy, styles 3, c. 0.5 mm long, apex 2-fid. Fruit a rounded, 3-lobed capsule, 5–6 mm × 8–10 mm, reticulately veined, short-hairy at apex, green, 6-seeded. Seeds irregularly compressed-trigonous, c. 3.5 mm × 3 mm × 1.5 mm, dorsally irregularly ridged, dark greyish brown.
Andrachne comprises about 45 species and occurs throughout the tropics and subtropics; 2 species occur in Madagascar and 6 in continental Africa, 2 of which extend their distribution area to Pakistan. *Clutia pulchella* L. is found in a similar habitat and may be confused with *Andrachne ovalis*.

Ecology *Andrachne ovalis* occurs in evergreen forest, forest margins, grassy and stony slopes and ravines, at 650–1700 m altitude.

Andrachne ovalis flowers from November–January and fruits from January–March.

Genetic resources and breeding There are no signs that *Andrachne ovalis* is threatened by genetic erosion.

Prospects The roots and stem bark of *Andrachne ovalis* have several medicinal uses, but their chemistry or pharmacology are not well documented. Additional research is therefore warranted.

Major references Amusan, Msonthi & Makhubu, 1995; Radcliffe-Smith, 1996a; Watt & Breyer-Brandwijk, 1962.

Other references Amusan et al., 1994; Coates Palgrave, 1983; Govaerts, Frodin & Radcliffe-Smith, 2000; Hoffmann, 2000; Hutchings et al., 1996.

Authors O.M. Grace

ANDROSIPHONIA ADENOSTEGIA Stapf

Protologue Journ. Linn. Soc., Bot. 37: 101 (1905).

Family Passifloraceae

Origin and geographic distribution *Androsiphonia adenostegia* occurs in West Africa from Sierra Leone east to Ghana.

Uses In Liberia and Ghana the leaves are mixed with palm oil and applied to the head to kill lice. The leaves are mixed with lime juice (*Citrus aurantifolia* (Christm. & Panzer) Swingle) and used to treat crab louse. In Liberia twigs are used as chew sticks.

Properties *Androsiphonia adenostegia* contains the cyanogenic glycosides tetraphyllin B, volkenin and their possible biosynthetic precursor the nonprotein amino acid L-cyclopentenylglycine, a potent inhibitor of valine and isoleucine utilization in bacteria. *Androsiphonia adenostegia* also contains saponin derivates.

Botany Shrub or small tree up to 6 m tall. Leaves alternate, simple; stipules absent; petiole 8–25 mm long; blade oblong to elliptical, 12–25 cm × 4–7 cm, base with two large black glands, one at each side of the midrib, apex acuminate to acute, margin toothed, papery, slightly hairy when young, later glabrous. Inflorescence a terminal panicle, sometimes also axillary, few- to many-flowered; bracts leafy, glandular. Flowers bisexual, regular, 5-merous, c. 2.5 cm in diameter; sepals fused at base, ovate to elliptical, hairy; petals inserted at the base of the sepals, similar to the sepals, greyish green; corona emerging from the base of the calyx, deeply divided, segments broadly linear; stamens inserted at the base of the ovary, forming an ovoid tube up to 3 mm long, filaments c. 5 mm long, anthers oblong; ovary superior, ellipsoid, c. 1 mm long, 1-celled, styles 3, slender, c. 6 mm long, stigmas head-shaped. Fruit a leathery, globose berry 2–3 cm long, apex acuminate, yellow to orange when ripe, several-seeded. Seeds with pitted wall, surrounded by pulpy aril.

Androsiphonia comprises a single species.

Ecology *Androsiphonia adenostegia* occurs in dense evergreen humid forest.

Genetic resources and breeding As *Androsiphonia adenostegia* only occurs in evergreen forest, it might be threatened by genetic erosion because of habitat loss, although it does not seem to be endangered yet.

Prospects In view of the biological importance of the active substances found in *Androsiphonia adenostegia*, further research into the properties may prove worthwhile, although these substances also occur in several better-known *Passiflora* spp.

Major references Abbiw, 1990; Andersen, Nielsen & Jaroszewski, 2000; Bernhard, 1999; Burkill, 1997; Clausen et al., 2001.

Other references Hedberg, 1979; Keay, 1954a; Neuwinger, 2000.

Authors A. de Ruijter

ANISOCYCLA CYMOSA Troupin

Protologue Bull. Jard. Bot. Etat 19: 416 (1949).

Family Menispermaceae

Origin and geographic distribution *Anisocycla cymosa* is endemic to DR Congo.

Uses An aqueous extract of the leaves and roots is used in DR Congo as a tonic and analgesic, e.g. against rheumatic pains and stomach-ache.

Properties From the roots the bisbenzylisoquinoline alkaloids 2'-norcocsoline, cocsoline-N-oxide and 12-O-methylcocsoline-N-oxide have been isolated, as well as a number of alkaloids of various structures, including anisocycline, palmatine, liriodenine, remrefidine, 1,2-dehydroapateline, 1,2-dehydrotelobine and trilobine. The bisbenzylisoquinoline alkaloids 2-norobaberine-2'-β-N-oxide, 2-norobaberine, daphnandrine, coclobine, anisocycline, palmatine, and remrefidine have been isolated from seeds. Their role in neurochemistry is being studied. The leaves contain N-O-

dimethylthaicanine, N-methylthaicanine, N-methyltetrahydropalmatine, anisocycline, palmatine, and stephenanthrine.

Botany Dioecious liana; stem up to 5 cm in diameter; bark with circular leaf scars. Leaves arranged spirally, simple and entire; petiole up to 6 cm long, thin, grooved; blade broadly ovate to elliptical, 6–10 cm × 3–6.5 cm, base rounded to slightly cordate, apex acuminate, glabrous, pinnately veined with 3–5 pairs of lateral veins. Inflorescence an axillary, many-flowered cyme, single or paired, 2–8 cm long, reddish hairy. Flowers unisexual, small; pedicel short; sepals 9 in 3 whorls, yellowish hairy, sepals of outer and middle whorls 0.5–1.5 mm long, 3 inner sepals 2–3 mm × 1–1.5 mm; petals broadly ovate, c. 1.5 mm long, narrowing to the base, glabrous; male flowers with 9–18 stamens c. 3 mm long, filaments fused; female flowers with superior ovary composed of 3 free carpels 2–4 mm long, styles cylindrical, glabrous. Fruit composed of 1–3 drupes; stone bony.

Anisocycla comprises 6 species, 4 in continental Africa and 2 in Madagascar.

Anisocycla grandidieri Baill. is endemic to northern Madagascar, where it occurs below 500 m altitude. A very bitter decoction of its yellow roots is used to cure diseases of the kidneys and the bladder. Sap from the roots is used as a coagulant. The roots contain the bisbenzylisoquinoline alkaloids epistephanine, stebisimine, trilobine and 12'-O-demethyltrilobine. Epistephanine and stebisimine have shown spasmolytic activity in isolated guinea-pig ileum. *Anisocycla jollyana* (Pierre) Diels is a climbing shrub occurring in fringing forest from Equatorial Guinea to western DR Congo. It does not have recorded medicinal uses, but its chemistry was researched because its close relative *Anisocycla cymosa* contains many interesting alkaloids. The roots of *Anisocycla jollyana* contain a great variety of bisbenzylisoquinoline alkaloids and dioxine alkaloids, including cycleanine, limacusine, apateline and isochondrodendrine and its derivatives fastrine and jollyanine. From the leaves the secodibenzylisoquinolines secojollyanine and secohomoaromaline have been isolated, as have several bisbenzylisoquinoline alkaloids.

Ecology *Anisocycla cymosa* occurs on sandy riversides and in fringing forest around open vegetation in the humid forest belt.

Genetic resources and breeding Too little is known about *Anisocycla cymosa* to assess its genetic vulnerability.

Prospects Additional research on the phytochemistry and pharmacology of *Anisocycla cymosa* and the other *Anisocycla* species seems warranted in view of the uses and the numerous bioactive constituents.

Major references Kanyinda et al., 1989; Kanyinda, Vanhaelen-Fastre & Vanhaelen, 1993; Kanyinda et al., 1992; Kanyinda, 1993; Troupin, 1962.

Other references Boissier et al., 1975; Boiteau, Boiteau & Allorge-Boiteau, 1999; Kanyinda, Vanhaelen-Fastre & Vanhaelen,, 1995; Kanyinda et al., 1996; Kanyinda et al., 1997; Schlittler & Weber, 1972a; Thanikaimoni, 1986; Vauquelin et al., 1989.

Authors L.P.A. Oyen

ANTHOCLEISTA AMPLEXICAULIS Baker

Protologue Journ. Linn. Soc., Bot. 22: 506 (1887).

Family Loganiaceae (APG: Gentianaceae)

Origin and geographic distribution *Anthocleista amplexicaulis* is endemic to eastern and central Madagascar.

Uses In Madagascar a decoction of the aerial parts or stem bark is taken to treat malaria. *Anthocleista amplexicaulis* is also used to treat constipation and nervousness.

Properties *Anthocleista amplexicaulis* contains the secoiridoid glycosides swertiamarin, grandifloroside, methylgrandifloroside, amplexine and amplexine-1-glucoside. The leaves contain the cyclitol (+)-bornesitol.

Botany Small tree up to 15 m tall; bole up to 20 cm in diameter. Leaves opposite, simple and entire, sessile; blade obovate to oblanceolate, 7.5–90 cm × 3.5–35 cm, base usually auricled, apex rounded, papery to leathery, brittle, conspicuously pinnately veined. Inflorescence an erect terminal dichasial cyme 15–30 cm long, many-flowered; peduncle and branches greenish white. Flowers bisexual, regular; sepals 4, free, orbicular, the outer ones orbicular or broadly ovate, 4–10 mm long, the inner ones emarginate, whitish green; corolla with cylindrical tube 5–9 mm long, lobes 8–12, orbicular, broadly ovate or elliptical, 5–10 mm long, apex obtuse or rounded, spreading, violet or mauve; stamens as many as corolla lobes and alternating with them, exserted, filaments fused, anthers with a sterile acute apex; ovary superior, ovoid or oblong-ovoid, 5–6 mm × 2.5–3 mm, 4-celled, style short, stigma globose or obovoid, apically slightly notched. Fruit a globose to

ovoid berry 2–3 cm × 1–2 cm, smooth and shining, acuminate, thick-walled, green, many-seeded. Seeds obliquely ovoid-globose, 2–2.5 mm × 1.5–3 mm, brown.

Anthocleista comprises 14 species and occurs in tropical Africa, including Comoros and Madagascar.

Ecology *Anthocleista amplexicaulis* occurs in swamp forest, from sea-level up to 1200 m altitude.

Genetic resources and breeding *Anthocleista amplexicaulis* is fairly widespread in Madagascar, but there is insufficient information available to make any pertinent conclusions or recommendations concerning its genetic erosion and possible conservation measures.

Prospects The use of *Anthocleista amplexicaulis* appears to be limited and only occasional in Madagascar. In view of the limited chemical and pharmacological data available and the many uses of other *Anthocleista* species in Africa, research into the pharmacological properties of *Anthocleista amplexicaulis* may prove worthwhile.

Major references Debray, Jacquemin & Razafindrambao, 1971; Jensen & Schripsema, 2002; Leeuwenberg, 1961b; Leeuwenberg, 1980.

Other references Leeuwenberg, 1984; Neuwinger, 2000; Rasoanaivo et al., 1994a; Weber, 1974.

Authors A. de Ruijter

ANTHOCLEISTA DJALONENSIS A.Chev.

Protologue Bull. Soc. Bot. France 54: 47 (1908).

Family Loganiaceae (APG: Gentianaceae)

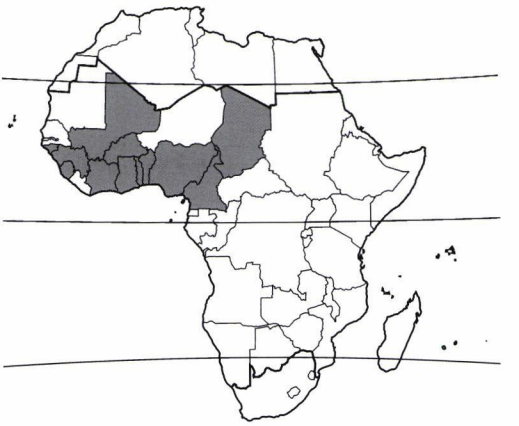
Chromosome number $2n = 60$

Synonyms *Anthocleista kerstingii* Gilg ex Volkens (1909).

Vernacular names Cabbage tree (En).

Origin and geographic distribution *Anthocleista djalonensis* occurs from Guinea Bissau east to Cameroon.

Uses *Anthocleista djalonensis* is widely used throughout its distribution area as a strong purgative and diuretic. A root decoction is commonly taken to treat constipation, to regulate menstruation and as an abortifacient. It is used as a wash or bath or as a vapour bath to treat leprosy, venereal diseases, oedema and scrotal elephantiasis. A root infusion is taken to treat intestinal problems, acute inflammations and boils on the skin. In Mali a root maceration is taken alone or with honey to treat malaria and a root decoction or root powder in porridge is taken to treat abdominal pain. A root decoction is also taken to treat hernia of the groin. In southern Nigeria a decoction of the roots with potash is taken to treat fungal skin infections and filarial worm infections, including loa loa filariasis. A tea made from the chopped soft root bark soaked in water is taken to treat thrush. An alcoholic leaf extract is taken to treat diarrhoea and dysentery. In Sierra Leone a decoction of dry fallen leaves is drunk to treat jaundice. In Guinea Bissau a bark infusion is used to treat broken bones in women. In Côte d'Ivoire the Attié people use an extract of twig bark as eye drops to treat diarrhoea in babies. Powdered stem bark mixed with the roots of *Aloe buettneri* A.Berger is taken to treat hepatitis, jaundice and cirrhosis.



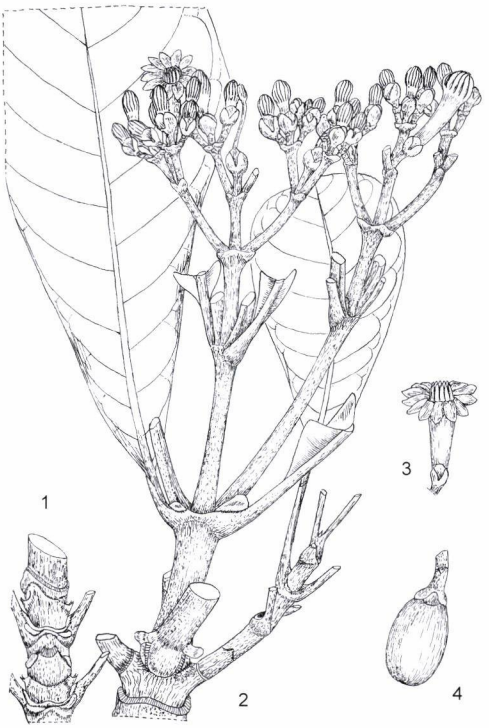
Anthocleista djalonensis – wild

Properties The bark of *Anthocleista djalonensis* contains the quinoline alkaloid brucine and the monoterpene glycoside loganoside (loganine). Brucine is a strychnine derivative. In chemistry, brucine and strychnine are commonly used as agents for chiral resolution. Loganoside plays an important role in the partial synthesis of alkaloids such as quinine, reserpine and strychnine. The root bark contains irlbacholine, which tested positive for antifungal activity against the pathogens *Candida albicans*, *Cryptococcus neoformans*, *Aspergillus fumigatus* and *Trichophyton rubrum*. Irlbacholine has been synthesized chemically. The plant also contains triterpenes, the monoterpene-diol djalonenol, the dibenzopyrone djalonensone, the iridoid glycosides sweroside (djalonenoside) and amplexine and

the xanthone lichexanthone. The stem bark contains the phthalide djalonensin. The cold water and ethanol extracts of the roots have antibacterial activities against *Staphylococcus aureus* and *Escherichia coli*. An aqueous extract of *Anthocleista djalonensis* showed a hypertensive effect in cats and increases the tone and amplitude of rabbit duodenal movement. An alcoholic leaf extract showed in-vitro antispasmodic and smooth muscle relaxant activities.

Adulterations and substitutes Several *Anthocleista* species are used for similar medicinal purposes and may be used as a substitute for *Anthocleista djalonensis*. When sold on the market it is very difficult to differentiate between the dried bark of the different species.

Description Small tree up to 15 m tall; bole up to 40 cm in diameter; twigs sometimes with 2 erect spines or small cushions above the leaf axils. Leaves opposite, simple and entire; petiole 1–9 cm long, auricled; blade oblong-elliptical to obovate-elliptical, 9–35 cm × 5–17 cm, in young plants up to 115 cm × 50 cm, base cordate, rounded or cuneate, apex rounded.



Anthocleista djalonensis – 1, portion of branch; 2, part of flowering branch; 3, flower; 4, fruit. Redrawn and adapted by Iskak Syamsudin

Inflorescence an erect terminal dichasial cyme, 15–50 cm long, many-flowered; peduncle and branches greenish white or pale green and with darker green dots, thickened at the nodes. Flowers bisexual, regular; sepals 4, free, orbicular, 6–10 mm long; corolla with cylindrical tube 20–32 mm long, lobes 11–14, oblong-lanceolate, 10–18 mm long, spreading, white or creamy; stamens as many as corolla lobes and alternating with them, exserted, filaments fused into a ring, anthers creamy or pale yellow; ovary superior, obovoid, 6–7 mm × 3–4 mm, 4-celled, stigma obovoid-cylindrical, apically 2-lobed. Fruit an ellipsoid berry 3.5–5 cm × 2–3.5 cm, rounded at the apex, thick-walled, dark green, many-seeded. Seeds obliquely ovoid, 2.5 mm × 1.5–2 mm × 1 mm, brown.

Other botanical information *Anthocleista* comprises 14 species and occurs in tropical Africa, including Comoros and Madagascar. The 4 West African species have the same vernacular names and are used by local practitioners for the same medicinal purposes.

Growth and development In Ghana *Anthocleista djalonensis* flowers in April and May, in Nigeria from March to May. Fruits occur in Nigeria in October and November.

Ecology *Anthocleista djalonensis* occurs in rather dry localities, in savanna or thickets, from sea-level up to 500 m altitude.

Harvesting The leaves are collected from young trees or by climbing older ones. The bark is obtained by slashing or peeling with a cutlass. The roots are dug up when the soil is workable.

Handling after harvest The collected material is dried in the sun and kept in wrappers or is pounded and made into balls. Sometimes, the plant material is powdered when dry.

Genetic resources *Anthocleista djalonensis* grows sparsely in savanna areas and care should be taken to protect it from overexploitation. In Mali and Burkina Faso *Anthocleista djalonensis* is threatened because of uncontrolled harvesting for use in local medicine and a concerted effort is being undertaken to conserve the species. It is rare in Cameroon where its niche is occupied by *Anthocleista schweinfurthii* Gilg.

Prospects In view of the medicinal uses on record, more research into the chemical composition and pharmacological activities of the compounds of *Anthocleista djalonensis* seems warranted. In areas where *Anthocleista djalonensis* is rare, measures should be taken to propagate and protect the species.

Major references Adjanohoun et al., 1979; Akubue, Mittal & Aguwa, 1983; Bierer et al., 1995; Jensen & Schripsema, 2002; Leeuwenberg, 1961b; Neuwinger, 2000; Okoli & Iroegbu, 2004; Okorie, 1976; Onocha et al., 2003a; Togola et al., 2005.

Other references Arbonnier, 2002; Berhaut, 1979; Bouquet, 1969; Irvine, 1961; Keay, 1989; Leeuwenberg, 1980; Onocha et al., 1995.

Sources of illustration Leeuwenberg, 1961b.

Authors A. de Ruijter

ANTHOCLEISTA LIEBRECHTSIANA De Wild. & T.Durand

Protologue Bull. Soc. Roy. Bot. Belg. 38(2): 96 (1899).

Family Loganiaceae (APG: Gentianaceae)

Chromosome number $2n = 60$

Vernacular names Lesser forest fever tree (En).

Origin and geographic distribution *Anthocleista liebrechtsiana* occurs from Ghana east to the Central African Republic and south to Zambia and Namibia.

Uses In Congo a stem bark decoction of *Anthocleista liebrechtsiana* is taken to treat hernia and a root decoction is taken to treat stomach-ache in women, ovarian problems, venereal diseases, hernia, bronchitis and fever and also to induce labour and as a purgative. Sap of young leaves, root powder and bark pulp are used to treat sores, abscesses, as a haemostatic and for cicatrization. Sap is applied topically to treat otitis or ophthalmia.

Properties *Anthocleista liebrechtsiana* contains the secoiridoid glycoside swertiamarin (swertiamaroside), a compound used in Asian medicine. Patent applications have been submitted for its use in hair-growth products and hepatitis medicines.

Botany Few-stemmed shrub or small tree up to 12 m tall; bole up to 30 cm in diameter; twigs without spines. Leaves opposite, simple and entire; petiole 1–9 cm long, auricled; blade very narrowly obovate to linear, 15–40 cm × 3–8 cm, in young plants up to 75 cm × 15 cm, base long-decurrent into the petiole, apex rounded. Inflorescence an erect terminal dichasial cyme 10–35 cm long, many-flowered. Flowers bisexual, regular; sepals 4, free, broadly ovate or orbicular, 4–8 mm long; corolla with narrowly cylindrical tube 22–34 mm long, contracted at base, greenish white, lobes 10–12, oblong-lanceolate, 10–18 mm long, apex obtuse, spreading, white; stamens as many as corolla lobes and alternating with them, exserted, filaments fused; ovary superior, obovoid, 5–7 mm × 3–4 mm, stigma obovoid-cylindrical, notched at apex. Fruit a globose to ovoid berry 1.5–2.5 cm × 1–2 cm, rounded at apex, thin-walled, green or pale yellow, many-seeded. Seeds obliquely ovoid, 1.5–2.5 mm × 1–1.5 mm, brown.

Anthocleista comprises 14 species and occurs in tropical Africa, including Comoros and Madagascar.

Ecology *Anthocleista liebrechtsiana* occurs in open localities in swamps and periodically inundated forests from sea-level up to 400 m altitude.

Genetic resources and breeding *Anthocleista liebrechtsiana* is widespread and not under pressure from genetic erosion, although it is uncommon in West Africa.

Prospects In view of the medicinal uses on record, the limited chemical and pharmacological data available and the many medicinal uses of other *Anthocleista* species, research into the properties of *Anthocleista liebrechtsiana* is recommended.

Major references Burkill, 1995; Jensen & Schripsema, 2002; Leeuwenberg, 1961b; Leeuwenberg, 1983; Neuwinger, 2000.

Other references Bouquet, 1969; Kanemura, 2006; Keay, 1989; Leeuwenberg, 1980; Tchouto, 2004; Zhang, 2005.

Authors A. de Ruijter

ANTHOCLEISTA MADAGASCARIENSIS Baker

Protologue Journ. Bot. 20: 173 (1882).

Family Loganiaceae (APG: Gentianaceae)

Synonyms *Anthocleista rhizophoroides* Baker (1887), *Anthocleista hildebrandtii* Gilg (1893).

Origin and geographic distribution *Anthocleista madagascariensis* is endemic to Madagascar, where it is widespread.

Uses In Madagascar a decoction of the leaves and roots is taken to treat cough, malaria, fever, dysentery and as an emetic, tonic and bitter. A bark decoction is taken to treat gonorrhoea, as a diuretic and antiseptic of the urinary tract. A decoction of the plant is used as a steam bath to treat common cold. A leaf decoction is taken to induce labour. *Anthocleista madagascariensis* is also used to treat constipation and nervousness. The wood is used locally for construction work.

Properties *Anthocleista madagascariensis* contains the monoterpene alkaloid gentianine. In *Anthocleista procera* Lepr. ex Bureau this compound arises as an artifact in the isolation of swertiamarin, but the presence of swertiamarin in *Anthocleista madagascariensis* has not been established. Different extracts were shown to have a strong effect on the nervous system and on the heart, lowering the rhythm and diminishing the amplitude of the contractions.

Botany Small tree up to 15 m tall; bole up to 30 cm in diameter; twigs without spines. Leaves opposite, simple and entire; petiole 1–2.5(–4) cm long, slightly auricled; blade oblong-obovate or oblanceolate, 5–17 cm × 2–9 cm, in young plants up to 24 cm × 11 cm, base decurrent into the petiole, apex rounded, margin revolute when dry. Inflorescence an erect terminal dichasial cyme, 5–20 cm long, many-flowered; peduncle and branches creamy or pale green. Flowers bisexual, regular; sepals 4, free, orbicular or broadly ovate, 5–9 mm long; corolla with cylindrical tube 8–12 mm long, lobes 10, orbicular or elliptical, 7–10 mm long, apex obtuse or rounded, spreading, violet; stamens as many as corolla lobes and alternating with them, exserted, filaments fused, anthers brownish white with an often large petal-like sterile acute apex; ovary superior, obovoid, 5–6 mm × 2.5–3 mm, 4-celled, stigma obovoid, apically slightly notched. Fruit a globose to ovoid berry 2.5–4 cm × 1.5–2.5 cm, smooth and shining, apiculate, thick-walled, many-seeded. Seeds obliquely ovoid to ellipsoid, 2–2.5 mm × 1.5–2.5 mm, medium brown, usually surrounded by a narrow ridge.

Birds often visit the nectar-rich flowers. The seeds of *Anthocleista madagascariensis* are probably dispersed by bats, which eat the fruits.

Anthocleista comprises 14 species and occurs in tropical Africa, including Comoros and Madagascar.

Ecology *Anthocleista madagascariensis* occurs in open moist localities, mostly in rainforest, at 450–1700 m altitude.

Genetic resources and breeding *Anthocleista madagascariensis* is widespread in Madagascar, but there is insufficient information to draw pertinent conclusions or make recommendations concerning its genetic erosion and possible conservation measures.

Prospects The use of *Anthocleista madagascariensis* appears to be limited and only occasional in Madagascar. In view of the limited chemical and pharmacological data available and the many uses of other *Anthocleista* species in Africa, research into the pharmacological properties of *Anthocleista madagascariensis* may prove worthwhile.

Major references Boiteau & Allorge-Boiteau, 1993; Debray, Jacquemin & Razafindrambao, 1971; Leeuwenberg, 1961b; Leeuwenberg, 1984; Neuwinger, 2000.

Other references Bollen, Van Elsacker & Ganzhorn, 2004; Leeuwenberg, 1980; Randriamantsoa, 1996; Rasoanaivo & Ratsimamanga-Urverg, 1992; Razafindramanana, 1996.

Authors A. de Ruijter

ANTHOCLEISTA NOBILIS G.Don

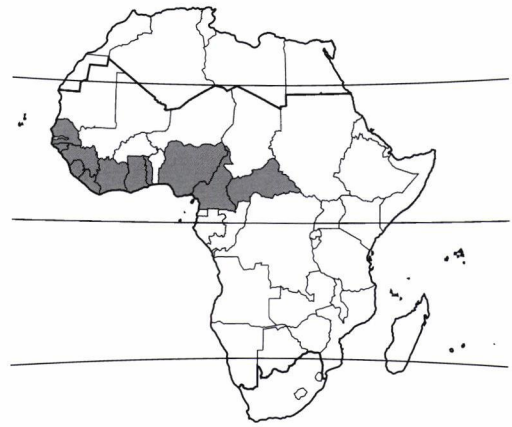
Protologue Gen. hist. 4: 68 (1838).

Family Loganiaceae (APG: Gentianaceae)

Vernacular names Cabbage tree, cabbage palm (En). Anthocleista majestueux, arbre chou (Fr).

Origin and geographic distribution *Anthocleista nobilis* occurs from Senegal east to the Central African Republic. It possibly also occurs in Benin, Gabon and Congo.

Uses *Anthocleista nobilis* is widely used throughout its distribution area as a strong purgative and diuretic. A root decoction is commonly taken to treat constipation, to regulate menstruation and as an abortifacient. It is used as a wash, bath or vapour bath to treat leprosy, venereal diseases, oedema and scrotal elephantiasis. In Sierra Leone a decoction of the roots with lemon is taken to treat hepatitis. Bark pulp is used as an enema to treat intestinal parasites. A bark decoction is taken or used



Anthocleista nobilis – wild

as vapour bath to treat fever, stomach-ache, leprosy, gonorrhoea and dysmenorrhoea. In Senegal, Liberia and Ghana stem bark or powdered young green twigs are applied fresh or as a paste on wounds, abscesses or ulcerous wounds. In Côte d'Ivoire the Oubi people use a decoction of twig bark and leaves together with those of *Thaumatococcus daniellii* (Bennet) Benth. as nose drops to treat headache. Twig bark of *Anthocleista nobilis* and *Zanthoxylum gilletii* (De Wild.) P.G.Waterman made into a paste is applied locally to treat rheumatism. In Liberia a bark infusion is given to dogs with diarrhoea.

A poultice obtained by grinding young leaves with soil from a fireplace and water is believed to promote closure of the fontanelle in babies. A decoction of the leaves is taken to treat abdominal pain of uterine origin.

The wood is used for general carpentry, small implements and plywood. The spiny logs are used in Liberia to make falling traps for animals. In Ghana potash from the wood is used to make soap.

In the northern region of Côte d'Ivoire *Anthocleista nobilis* is planted to protect the soil against erosion.

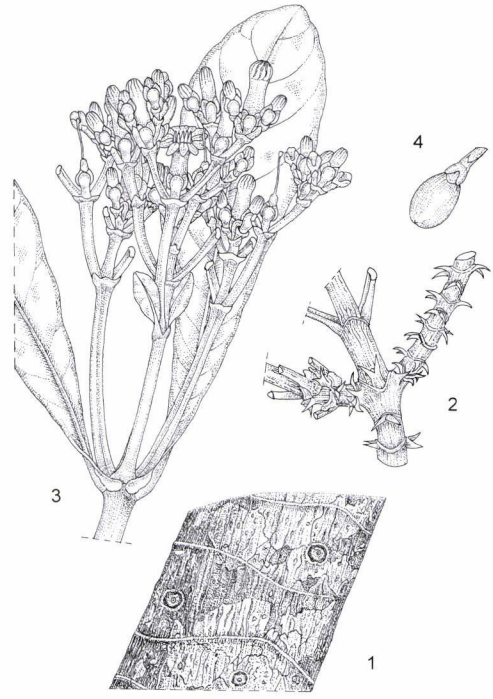
Production and international trade Dried bark and roots are sold in local markets. The timber is of some economic value. The seed and bark are exported from Ghana to industrial countries.

Properties *Anthocleista nobilis* contains xanthones and secoiridoids such as anthocleistol. The bark contains the quinoline alkaloid brucine and the monoterpene glycoside loganoside (loganine). Brucine is a strychnine derivative. In chemistry, brucine and strychnine are commonly used as agents for chiral resolution. Loganoside plays an important role in the partial synthesis of alkaloids such as quinine, reserpine and strychnine. An alcoholic extract from the root bark has shown a hypoglycaemic effect. Hypotensive and hypoglycaemic activities in the treatment of obese adult diabetics with hypertension have been reported. The bark has antimicrobial and anti-inflammatory properties. The ethanol extract of the bark showed a relaxant effect on isolated guinea-pig ileum and antihepatotoxic activity in mice. Accidental poisoning has occurred with the following symptoms: colic, obstinate constipation, weakening of the stomach or spasm of the pylorus, fibrillary trembling, pronounced paleness of the skin and heart weakness.

The wood is creamy or yellowish white, somewhat lustrous, light weight and soft but firm, easy to cut and finishing smoothly; it is not resistant to decay. The grain is straight or irregular, texture moderately coarse.

Adulterations and substitutes Several *Anthocleista* species are used for similar medicinal purposes and other West African *Anthocleista* species may be used as substitutes for *Anthocleista nobilis*. The dried bark of the different species is very difficult to differentiate when sold in the market.

Description Small to medium-sized tree up to 18(–30) m tall; bole branchless for up to 15 m long, up to 45(–90) cm in diameter; bark smooth, pale grey, inner bark cream-yellow and granular; twigs with 2 spines above the leaf axils. Leaves opposite, crowded at the end of branchlets, simple; petiole 1–6 cm long, auricled; blade oblong-elliptical, obovate-elliptical to oblanceolate, 7–35 cm × 4–12 cm, in young plants up to 150 cm × 25 cm, base long-decurrent, apex rounded, margin wavy and recurved. Inflorescence an erect terminal dichasial cyme 12–60 cm long, many-flowered;



Anthocleista nobilis – 1, portion of bole; 2, portion of branch; 3, part of flowering branch; 4, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

peduncle and branches creamy or green, thickened at the nodes. Flowers bisexual, regular; sepals 4, free, orbicular to ovate-elliptical, 7–10 mm long; corolla with cylindrical tube 30–45 mm long, fleshy, lobes 11–14, oblong-lanceolate, 9–12 mm long, obtuse to rounded, spreading, white; stamens as many as corolla lobes and alternating with them, exserted, filaments fused; ovary superior, obovoid, 6–7 mm × 3–4 mm, 4-celled. Fruit an ellipsoid berry 3–4 cm × 2–2.5 cm, thick-walled, green, many-seeded. Seeds obliquely ovoid-globose, 2–2.5 mm × 1.5–2 mm, dark brown.

Other botanical information *Anthocleista* comprises 14 species and occurs in tropical Africa, including Comoros and Madagascar.

Growth and development *Anthocleista nobilis* flowers throughout the year.

Ecology *Anthocleista nobilis* is a lower canopy tree of tropical rainforest and semi-deciduous forest. It is common in forest clearings, up to 1200 m altitude. It grows on well-drained soils with 1100–2000 mm annual rainfall, in regions where temperatures do not exceed 35°C.

Management *Anthocleista nobilis* is only rarely cultivated. However, in West Africa it is often left standing near houses for medicinal purposes.

Harvesting The leaves are collected from young trees or by climbing older ones. The bark is obtained by slashing or peeling with a cutlass. The roots are dug up when the soil is workable.

Handling after harvest The collected material is dried in the sun and kept in wrappers, or is pounded and made into balls. Sometimes, the plant material is powdered when dry.

Genetic resources *Anthocleista nobilis* is a common constituent of disturbed forest in large parts of West Africa and is not threatened by genetic erosion.

Prospects So far, no attempt has been made to cultivate *Anthocleista nobilis* for medicinal purposes. Improvement of the productivity of the plant and the development of management systems for its sustainable use are desirable. More research into the chemical composition and pharmacological activities of the compounds of *Anthocleista nobilis* seems warranted.

Major references Abbiw, 1990; FAO, 1986; Jensen, 1992; Jensen & Schripsema, 2002; Leeuwenberg, 1961b; Leeuwenberg, 1980; Neuwinger, 2000; Madubunyi & Asuzu, 1995.

Other references Berhaut, 1979; Bouquet & Debray, 1974; Dalziel, 1937; Kerharo, 1971; Oliver-Bever, 1986.

Sources of illustration Leeuwenberg, 1961b.

Authors D.M. Mosango

ANTHOCLEISTA PROCERA Lepr. ex Bureau

Protologue Fam. Logan.: 74–77, f. 60–62 (1856).

Family Loganiaceae (APG: Gentianaceae)

Vernacular names Cabbage tree, candelabrum tree (En). Arbre chou (Fr). Papae um eve (Po).

Origin and geographic distribution *Anthocleista procera* occurs from Senegal east to Nigeria.

Uses *Anthocleista procera* is widely used throughout its distribution area as a strong purgative and diuretic. A root decoction is commonly taken to treat constipation, to regulate menstruation and as an abortifacient. It is used as a wash or bath, or as a vapour bath to treat leprosy, venereal diseases, oedema and scrotal elephantiasis. A decoction of the bark is used against fever and as a stomachic. A seed or bark decoction is a strong purgative and should be used with caution and only if a strong effect is desired. Pulp of sun-dried bark mixed with palm oil is taken to treat constipation. In Senegal leaf sap is applied to the nostrils to provoke sneezing as a treatment of common cold. A leaf decoction is used as a face wash to treat dizziness.

The leaves are used as wrapping material.

Properties *Anthocleista procera* contains the secoiridoid glycoside swertiamarin. Swertiamarin is used in traditional Asian medicine, e.g. in hepatitis medicines. The fruits of *Anthocleista procera* contain c. 4.7% of the triterpene acid anthocleistin. Bark extracts have been tested for activity on avian malaria, but only the chloroform extract gave a slight response.

Botany Small to medium-sized tree up to 20 m tall; bole up to 50 cm in diameter; twigs without spines. Leaves opposite, simple, sessile; blade oblong-obovate to oblanceolate, 40–45 cm × c. 20 cm, in young plants up to 145 cm × 45 cm, base cuneate, auricled, apex rounded, margin entire or minutely crenate, brittle, leathery or papery. Inflorescence an erect terminal dichasial cyme 30–60 cm long, many-flowered; peduncle and branches pale green, thickened at the nodes. Flowers bisexual, regular; sepals 4, free, orbicular or broadly ovate, 9–10 mm × 7–8 mm; corolla with cylindrical

tube 35–55 mm long, lobes c. 9, oblong, 10–15 mm long, obtuse, white; stamens as many as corolla lobes and alternating with them, exserted, filaments fused; ovary superior, obovoid to cylindrical, c. 7 mm × 3.5 mm, 4-celled, stigma obovoid-cylindrical, apically slightly notched. Fruit an ellipsoid berry c. 3 cm × 2 cm, pale green, shining, rounded at the apex, thick-walled, many-seeded. Seeds obliquely ovoid-globular, 1.5–2 mm × 1–1.5 mm, dark brown.

Anthocleista comprises 14 species and occurs in tropical Africa, including Comoros and Madagascar. The 4 West African species have the same vernacular names and are used by local practitioners for the same medicinal purposes.

Ecology *Anthocleista procera* occurs in open, usually swampy localities at low elevations.

Genetic resources and breeding *Anthocleista procera* occurs in a large area of West Africa and there are no signs that the species is in danger, except for some areas where the population pressure is high. In Senegal *Anthocleista procera* has almost disappeared from the Dakar area but for 1 relic population. In Mali *Anthocleista procera* has been listed as a species in need of special attention. Care should be taken to protect the species from overexploitation.

Prospects In view of the medicinal uses on record, more research into the chemical composition and pharmacological activities of the compounds of *Anthocleista procera* seems warranted.

Major references Berhaut, 1979; Burkill, 1995; Claude & Claude, 1947; Dalziel, 1937; Jensen & Schripsema, 2002; Leeuwenberg, 1961b; Neuwinger, 2000.

Other references Carrière, 1994; Keay, 1989; Leeuwenberg, 1980; Plat et al., 1963.

Authors A. de Ruijter

ANTHOCLEISTA SCHWEINFURTHII Gilg

Protologue Engl., Bot. Jahrb. 17: 579 (1893).

Family Loganiaceae (APG: Gentianaceae)

Vernacular names Mkungu maji, mtambuu mwitu (Sw).

Origin and geographic distribution *Anthocleista schweinfurthii* occurs from Nigeria east to Ethiopia and south to Tanzania, Zambia and Angola.

Uses In Gabon the Bapunu people use *Anthocleista schweinfurthii* as a galactogenic. In Congo a stem bark decoction of *Anthocleista schweinfurthii* is taken to treat hernia and female sterility. A root decoction is taken to treat stomach-ache in women, ovarian problems, venereal diseases, hernia, bronchitis and fever, and also as a purgative and to induce labour. In Tanzania a root decoction is taken to treat malaria, hard abscesses and as an anthelminthic.

Sap of young leaves, root powder or bark pulp is used to treat sores, abscesses, as a haemostatic and for cicatrization. Sap is applied topically to treat otitis and ophthalmia. In Central Africa a decoction of leaves and roots is used as an enema to treat pain in the side. A bath is taken in a leaf decoction to treat vaginal prolapse. A decoction of twig bark and leaves or the sap is taken to treat fever, or used as an enema.

In the Central African Republic *Anthocleista schweinfurthii* is used to prepare arrow poison. The wood is very soft and is used in Tanzania for firewood. The tree is planted for amenity purposes and shade in Tanzania. In Cameroon pole-cuttings are used to establish hedges or living fences.

Properties *Anthocleista schweinfurthii* contains the secoiridoid glycoside swertiamarin. The bark contains traces of alkaloids and the roots contain up to 3% alkaloids. The leaves, bark and roots contain steroids and terpenes.

Botany Medium-sized tree up to 30 m tall; bole up to 70 cm in diameter; twigs often with small broadly conical cushions. Leaves opposite, simple and entire; petiole up to 10 cm long, auricled; blade oblong-obovate to oblanceolate, 7–45 cm × 3.5–18 cm, in young plants up to 100 cm × 30 cm, base cuneate, apex rounded, sometimes acute, margin revolute, papery to leathery. Inflorescence an erect terminal dichasial cyme 12–30 cm long, many-flowered; peduncle and branches thickened at the nodes. Flowers bisexual, regular; sepals 4, free, orbicular, 8–13 mm long; corolla with cylindrical tube 25–37 mm long, contracted at base when young, lobes 10–11, lanceolate, 21–28 mm long, reflexed, obtuse, greenish white to creamy; stamens as many as corolla lobes and alternating with them, exserted, filaments fused; ovary superior, ovoid, 5–7 mm × 3–4 mm, 4-celled, stigma obovoid-cylindrical, notched at apex. Fruit a globose to ellipsoid berry 2.5–4.5 cm × 2–3 cm, rounded or apiculate at apex, smooth, thick-walled, green or yellow, many-seeded. Seeds obliquely ovoid-globose, c. 2 mm × 1.5 mm, brown.

Anthocleista comprises 14 species and occurs in tropical Africa, including Comoros and Madagascar.

Ecology *Anthocleista schweinfurthii* occurs in secondary forest, gallery forest, in thickets and sometimes in savanna or rainforest, usually not in moist localities, at 400–1800 m altitude.

Genetic resources and breeding *Anthocleista schweinfurthii* is widespread and not under pressure from genetic erosion. It is common in Central and southern Africa, but rare in Nigeria.

Prospects In view of the medicinal uses on record, the limited chemical and pharmacological data available and the many uses of other *Anthocleista* species, research into the properties of *Anthocleista schweinfurthii* may prove worthwhile.

Major references Burkill, 1995; Leeuwenberg, 1961b; Leeuwenberg, 1980; Leeuwenberg, 1983; Neuwinger, 2000.

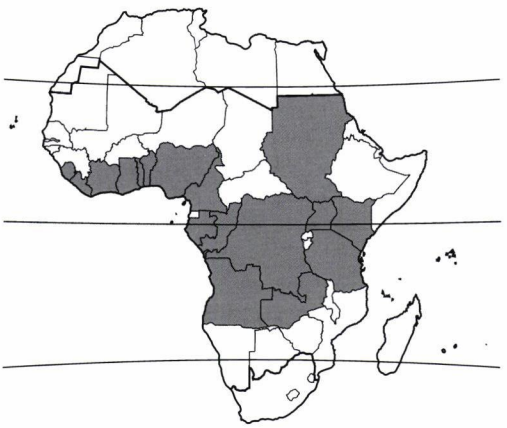
Other references Bouquet, 1969; Bouquet, 1972; Bourobou Bourobou et al., 1996; Gautier, 1995; Haerdi, 1964; Keay, 1989; Latham, 2004; Moundipa et al., 2005; Nkounkou-Loumpangou et al., 2005; Tchouto, 2004.

Authors A. de Ruijter

ANTHOCLEISTA VOGELII Planch.

Protologue Hook., Icon. pl. 8: t. 793 (1848).
Family Loganiaceae (APG: Gentianaceae)
Chromosome number $2n = 60$
Vernacular names Cabbage tree (En).

Origin and geographic distribution *Anthocleista vogelii* occurs from Sierra Leone east to Kenya, and south to Zambia and Angola.



Anthocleista vogelii – wild

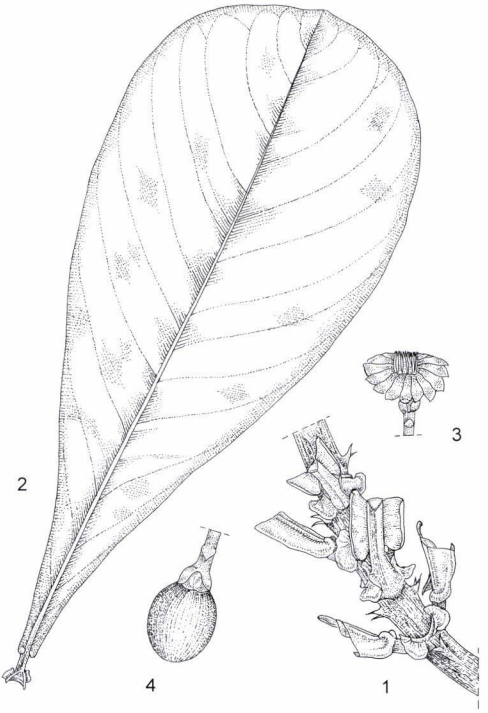
Uses *Anthocleista vogelii* is widely used in West Africa as a strong purgative and diuretic. A root decoction is commonly taken to treat constipation, to regulate menstruation and as an abortifacient. It is used as a wash, bath or vapour bath to treat leprosy, venereal diseases, oedema and scrotal elephantiasis. In Sierra Leone a decoction of the roots with lemon is taken to treat hepatitis, while a decoction of dry fallen leaves is taken to treat jaundice. In Ghana a root decoction of *Anthocleista vogelii* and *Combretum mucronatum* Schumach. & Thonn. with pepper and ashes is taken to treat chest pain. In Nigeria the bark and seed are used as an antipyretic and tonic. The seed is also used as a purgative. In Congo fresh twig bark with manioc is eaten raw to treat aspermia. A stem bark decoction is taken to treat hernia and a root decoction is taken to treat stomach-ache in women, ovarian problems, venereal diseases, hernia, bronchitis and fever, and also as purgative and to induce labour. Sap of young leaves, root powder or bark pulp is used to treat sores, abscesses, as a haemostatic and for cicatrization. Sap is applied topically to treat otitis or ophthalmia. A plaster of pulp of terminal buds is used to draw out thorns or splinters and is applied to snakebites.
In Ghana the wood-ash is used as a mordant to fix colours. The wood is used to make crates. In Nigeria stems are hollowed out to make quivers. In Zambia trunks are cut for dugout canoes. In Ghana potash of the wood is used in making soap. In Congo the leaves are placed between tobacco leaves during drying to make the tobacco stronger.

Properties *Anthocleista vogelii* contains the closely related secoiridoid glycosides secologanic acid, vogeloside, and sweroside. The stem bark contains the alkaloid fagaramide, the stem bark and wood several xanthones. The major xanthone of *Anthocleista vogelii* is decussatin and it contains the minor compounds 1,7-dihydroxy-3,8-dimethoxy-xanthone and 1,8-dihydroxy-3,7-dimethoxy-xanthone. The latter compound showed antimalarial activity in vivo against *Plasmodium berghei*. Tests with aqueous, hexane, acetone and methanol extracts of the stem bark in rats showed potent anti-ulcer properties, which could explain the traditional use in the treatment of stomach-ache.
The wood is whitish, soft and perishable.

Adulterations and substitutes Several *Anthocleista* species are used for similar medicinal purposes and may be used as substi-

tutes for each other. When sold on the market it is difficult to differentiate the dried bark of the different species.

Description Small to medium-sized tree up to 20 m tall; bole up to 55 cm in diameter, sometimes with stilt roots; twigs with 2(–4) divergent spines confluent at base. Leaves opposite, simple and entire, almost sessile; blade oblong-ovate to oblanceolate, 15–45 cm × 6–24 cm, in young plants up to 150 cm × 45 cm, base cuneate, auricled, apex rounded, margin recurved, papery or leathery. Inflorescence an erect terminal dichasial cyme 30–50 cm long, many-flowered; peduncle and branches yellowish green or orange, thickened at the nodes. Flowers bisexual, regular; sepals 4, free, orbicular or broader than long, outer ones 4–12 mm long, inner ones about twice as long; corolla with cylindrical tube, 12–18 mm long, lobes 13–16, oblong-lanceolate, 12–19 mm long, spreading, creamy to pale yellow; stamens as many as corolla lobes and alternating with them, exserted, filaments partly or entirely fused, anthers whitish green; ovary superior, ovoid-cylindrical to ovoid-conical, 5–7 mm × 3–6 mm, 4-celled, stigma obovoid-cylindrical, apically 2-lobed. Fruit an ellipsoid berry 2.5–4.5 cm × 2–3.5 cm, rounded at apex, thick-walled, green or yellowish, many-seeded. Seeds obliquely ovoid-globose, 2–2.5 mm × 1.5–2 mm, dark brown.



Anthocleista vogelii – 1, part of branch; 2, leaf; 3, flower; 4, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Anthocleista* comprises 14 species and occurs in tropical Africa, including Comoros and Madagascar. The 4 species occurring in West Africa have the same vernacular names and are used by local practitioners for the same medicinal purposes.

Growth and development In Nigeria *Anthocleista vogelii* flowers from October to February and from March to May; it fruits from November to March.

Ecology *Anthocleista vogelii* occurs in moist localities, in swamps, in *Raphia* groves, on river banks, in primary rainforest or secondary forest, from sea-level up to 1500 m altitude.

Harvesting The leaves are collected from young trees or by climbing older ones. The bark is obtained by slashing or peeling with a cutlass. The roots are dug up when the soil is workable.

Handling after harvest The collected material is dried in the sun and kept in wrappers or it is pounded and made into balls. Sometimes, the plant material is powdered when dry.

Genetic resources *Anthocleista vogelii* occurs rather sparsely, but it is widely distributed. It is not in danger of genetic erosion.

Prospects In view of the recorded medicinal uses, more research into the chemical composition and pharmacological activities of *Anthocleista vogelii* is warranted.

Major references Abbiw, 1990; Adjanohoun et al. (Editors), 1988; Ateufack et al., 2006; Jensen & Schripsema, 2002; Leeuwenberg, 1961b; Leeuwenberg, 1980; Neuwinger, 2000; Okorie, 1976; Olukoya, Idika & Odugbemi, 1993.

Other references Abuh et al., 1990; Bouquet, 1969; Chapelle, 1976; Karan et al., 2005; Keay, 1989; Rai, Wambebe & Abuh, 1989.

Sources of illustration Leeuwenberg, 1961b.

Authors A. de Ruijter

ANTHOSTEMA SENEGALENSE A.Juss.

Protologue Euphorb. gen.: 117 (1824).

Family Euphorbiaceae

Origin and geographic distribution *Anthostema senegalense* occurs from Senegal east

to Benin.

Uses The latex is toxic, acrid and vesicant, and can cause blindness. In spite of its toxicity, it is used, with suitable precautions, as a strong purgative. It is used to treat leprosy, menstrual problems and help with the expulsion of the afterbirth. For these purposes, small amounts of latex or pulped roots are added to food. The latex is also used as an antidote for poison, the latex diluted in water being drunk till vomiting occurs. A bark maceration is drunk to treat intestinal parasites, kidney problems, oedema, impotence and mental illness. In Sierra Leone young leaves are ground with flour and the dried paste is taken as a laxative. In Senegal the chopped up whole plant is thrown in pools as fish poison to catch small fish.

The wood is white and lightweight and is easy to work. It is used for local building purposes, poles for temporary fences, light carpentry work and boxes. In Sierra Leone the sticky latex is used as bird lime.

Properties The crude water extract of the stem bark of *Anthostema senegalense* showed strong anthelmintic activity against the larvae of *Haemonchus contortus* in vitro. A crude stem bark extract exhibited significant activity against *Leishmania donovani* with IC_{50} of 9.1 µg/ml, as well as moderate antibacterial and antifungal activities. Another *Anthostema* species, *Anthostema aubryanum* Baill., contains phorbol esters, and the presence of these compounds is consistent with the uses and properties as described above.

Botany Monoecious shrub or small to medium-sized tree up to 25 m tall; bole straight, up to 65 cm in diameter; twigs glabrous, with abundant latex. Leaves alternate, simple and entire; stipules absent; petiole 7–10 mm long; blade elliptical-oblong to lanceolate, 7–13 cm × 3–4.5 cm, base cuneate, apex acuminate, glabrous, pinnately veined with numerous pairs of lateral veins. Inflorescence an axillary, dense, much-branched sessile cyme with at apex of each cyme-branch a common involucre composed of 4 small partly fused bracts with glandular margins, enclosing 4 involucres each containing c. 8 male flowers and sometimes 1 female flower in the centre. Flowers unisexual; male flowers with short pedicel, 3–4-toothed perianth and a single stamen; female flowers with short pedicel, 3–4-lobed perianth with lobes c. 1.5 mm long, ovary superior, 3-celled, glabrous, styles stout, short, spreading. Fruit a deeply 3-lobed capsule c. 2.5 cm in diameter, 3-seeded. Seeds ellipsoid to almost globose, smooth.

Anthostema comprises 3 species, 2 in mainland Africa and 1 in Madagascar. It seems related to *Dichostemma*, which has a similar structure composed of cyathia (involucral bracts enclosing male flowers reduced to a single stamen and a female flower), but differs in the terminal position of the inflorescence and 4-lobed fruits.

Ecology *Anthostema senegalense* occurs in evergreen forest, wooded savanna and coastal savanna, usually in damp, swampy or flooded localities.

Genetic resources and breeding *Anthostema senegalense* is fairly widespread in its distribution area and does not seem to be threatened by genetic erosion.

Prospects *Anthostema senegalense* shows anthelmintic and antileishmanial activities in vitro, but virtually nothing is known concerning its active compounds, although phorbol esters with phytochemical activity have been identified in *Anthostema aubryanum*. Therefore more chemical and pharmacological analyses are needed to evaluate its potential.

Major references Abreu et al., 1999; Brown, Hutchinson & Prain, 1909–1913; Burkill, 1994; Koné et al., 2005; Neuwinger, 2000.

Other references Beutler, Alvarado Lindner & McCloud, 1996; Hawthorne & Jongkind, 2006; Keay, 1958a.

Authors G.H. Schmelzer

ANTIDESMA LACINIATUM Müll.Arg.

Protologue Flora 47: 520 (1864).

Family Euphorbiaceae (APG: Phyllanthaceae)

Chromosome number $2n = 26$

Origin and geographic distribution *Antidesma laciniatum* occurs from Sierra Leone east to southern Sudan and south to DR Congo and Uganda.

Uses In Liberia a leaf decoction is taken as a bath to prevent miscarriage. In Côte d'Ivoire powdered bark is taken in water or palm wine as an aphrodisiac. In Congo a bark decoction is taken orally or as an enema to treat intestinal complaints. In Central Africa meat is served on the aromatic leaves.

The wood is yellowish white to pinkish and hard and does not work well. It is used to make poles for house construction and tool handles, as firewood and for charcoal production. The

fruits are not palatable, unlike those of several other *Antidesma* spp.

Properties Leaves from Cameroon yield an essential oil (1.8% on a dry weight basis), which contains mainly terpenoids (72%) with a relatively high amount of esters (41%). The two major constituents are the esters benzyl benzoate (19%), responsible for the sweet balsamic odour of the oil, and geranyl acetate (15%). Other constituents isolated from the essential oil are the terpenoid squalene, used in cosmetics as an oil-free moisturizer, and the biflavonoid amentoflavone, which has shown antiviral and anticancer activity and is a potent antioxidant. The essential oil showed significant activity against *Plasmodium falciparum* in vitro, but no important radical scavenging activity.

Botany Dioecious, small tree up to 8(–15) m tall; branches spreading, young parts densely short-hairy. Leaves alternate, simple and entire; stipules with 3–9 lanceolate, linear or branched segments, 1–1.5 cm long, fairly persistent; petiole up to 5(–8) mm long; blade elliptical-oblanceolate to elliptical-oblong, 7.5–20 cm × 3–7 cm, base rounded to shallowly cordate, apex acuminate, variably hairy on veins. Inflorescence an axillary or terminal spike, sometimes with 1–2 lateral spikes at base, up to 10 cm long, in fruit up to 20 cm long. Flowers unisexual, regular, sessile or almost sessile, petals absent, disk annular; male flowers with cup-shaped calyx up to 1 mm long, 3-toothed, ciliate, reddish pink to reddish purple, stamens 3, 1.5–2 mm long; female flowers with cup-shaped calyx up to 1.5 mm long, 3-toothed, brownish, ovary superior, ellipsoid, c. 3 mm long, glabrous or hairy, 1(–2)-celled, styles 3, 2-fid or 2, 3-fid. Fruit a compressed ellipsoid to ovoid drupe up to 1 cm long, glabrous or hairy, brownish or yellowish to orange-red, 1-seeded. Seed ellipsoid.

Antidesma comprises about 155 species and occurs in the Old World tropics from tropical Africa and the Indian Ocean islands through Asia to Australia and the Pacific islands. In continental Africa 7 species occur and in the Indian Ocean islands 1 species. *Antidesma laciniatum* is rather variable and 2 varieties or subspecies are distinguished.

Ecology *Antidesma laciniatum* occurs in the understorey of dense forest, including secondary forest, and at forest edges, from sea-level up to 1200 m altitude.

Genetic resources and breeding *Antidesma laciniatum* is widespread and not likely to be threatened by genetic erosion.

Prospects The essential oil from the leaves contains several compounds with interesting activities. The bark is also used medicinally, but nothing is known about its chemistry or pharmacology. More research is therefore needed to assess the potential of *Antidesma laciniatum* as a medicinal plant.

Major references Boyom et al., 2003a; Boyom et al., 2003b; Burkill, 1994; Léonard, 1988; Neuwinger, 2000.

Other references Akoègninou, van der Burg & van der Maesen, 2006; Carter & Radcliffe-Smith, 1988; Tchinda et al., 2006; Wurdack et al., 2004; Yamada, 1999.

Authors G.H. Schmelzer

ANTIDESMA MEMBRANACEUM Müll.Arg.

Protologue Linnaea 34: 68 (1865).

Family Euphorbiaceae (APG: Phyllanthaceae)

Synonyms *Antidesma venosum* E.Mey. ex Tul. subsp. *membranaceum* (Müll.Arg) Lye (1998).

Vernacular names Pink tassle-berry (En). Mziwaziwa (Sw).

Origin and geographic distribution *Antidesma membranaceum* occurs from Senegal east to Sudan and south to northern South Africa.

Uses In Liberia a leaf decoction is used as a bath to prevent miscarriage. In Côte d'Ivoire a bark extract is widely taken as an aphrodisiac. In DR Congo a root decoction is taken to treat stomach-ache, colic, cough and snakebites. In Tanzania the Digo people drink a decoction of the roots to treat kwashiorkor and pneumonia. Scrapings of the roots are chewed to treat mouth ulcers in children. The powdered stem bark is sprinkled on wounds. The powdered seeds are eaten to expel roundworms. In Zimbabwe an infusion of leaves and roots is drunk to treat cough and chest problems.

The wood is white and hard and used in construction, and for making tool handles, knife sheaths and spoons. It is also used as firewood. The tree is planted for shade in home gardens. Edible caterpillars (*Imbrasia petiveri*) feed on the leaves.

Properties From different extracts of the root, leaves and stem bark several 2-alkylated benzopyranones, several amide derivatives of ferulic acid (4-hydroxy-3-methoxy-benzoic acid), a diferuloyate and syringaresinol were isolated. Antidesmone, an unusual hydroqui-

nolone or glycine-derived alkaloid was isolated from the leaves and bark. A butanol extract of the leaves and bark also yielded several alkaloidal, megastigmane and lignan glucosides. Antidesmone has potent and highly selective antitrypanosomal activity against *Trypanosoma cruzi*, the pathogenic agent of Chagas' disease.

Botany Dioecious shrub or small tree up to 8(–20) m tall; crown dense, branches drooping; bark smooth, pale yellowish brown to dark grey; young parts densely short-hairy. Leaves alternate, simple and entire; stipules lanceolate, 2–8(–15) mm long, fairly persistent; petiole up to 1 cm long; blade elliptical-oblong, 2–12(–20) cm × 1–7 cm, base rounded to cuneate, apex acuminate, glossy and dark green above, sparsely hairy and yellowish beneath. Inflorescence a terminal spike on a short lateral shoot, 4–10(–25) cm long, with 1–4 lateral spikes at base. Flowers unisexual, regular, sessile, petals absent, with unpleasant smell; male flowers with 4-lobed calyx, lobes c. 1 mm long, unequal, rounded, short-hairy, yellowish green, disk irregular, stamens mostly 4, c. 2.5 mm long; female flowers with cup-shaped calyx, 3–4-lobed, lobes c. 1 mm long, unequal, rounded, short-hairy, yellowish green, disk cup-shaped, ovary superior, compressed-ellipsoid, c. 1 mm long, glabrous, 1(–2)-celled, styles 2–4, short, 2-fid, strongly recurved. Fruit a laterally compressed ellipsoid to ovoid drupe up to 8 mm long, green becoming pink, purple or black, 1-seeded. Seed ellipsoid.

Antidesma comprises about 155 species and occurs in the Old World tropics, from tropical Africa and the Indian Ocean islands through Asia to Australia and the Pacific islands. In continental Africa 7 species occur and in the Indian Ocean islands 1 species. *Antidesma membranaceum* is often confused with *Antidesma venosum* E.Mey. ex Tul., which is used medicinally as well, but is better known for its edible fruits, which taste of mulberries. Compared to *Antidesma venosum*, the leaves of *Antidesma membranaceum* are more narrowly elliptical-oblong and more acutely acuminate, the female inflorescence never galled. In Namibia an extract of the crushed fruit, leaves and twigs of *Antidesma rufescens* Tul. is taken to treat abdominal pain. A root extract is added to a bath as an analgesic in case of body pain. In southern Nigeria a root decoction of *Antidesma vogeliana* Müll.Arg. with or without the seeds of *Aframomum melegueta* K.Schum. is taken as an aphrodisiac. In DR Congo a root decoction is drunk to treat worm infections and other intestinal problems, and it is gargled as a mouthwash to treat toothache. The crushed stem is used as fuel in lamps.

Ecology *Antidesma membranaceum* occurs in mixed woodland, humid woodland and evergreen forest, also in riverine vegetation and ravines, along lakeshores and in coastal forest, from sea-level up to 1850 m altitude.

Genetic resources and breeding *Antidesma membranaceum* is common in its large distribution area and therefore not threatened by genetic erosion.

Prospects *Antidesma membranaceum* is locally used against a range of bacterial diseases. Chemical analyses have yielded several complex chemical constituents of the roots, leaves and bark, the unusual alkaloid antidesmone being the most important compound. It exhibits potent antitrypanosomal activity and deserves further testing. More research is needed to elucidate the pharmacology of the other isolated compounds to evaluate the potential of the plant.

Major references Bringmann et al., 2000a; Bringmann et al., 2001; Burkill, 1994; Léonard, 1988; Neuwinger, 2000.

Other references Bringmann et al., 2000b; Buske et al., 1999.; Buske et al., 1997; Buske et al., 2001; Chhabra, Mahunnah & Mshiu, 1993; Latham, 2004; Lovett et al., 2006; Radcliffe-Smith, 1996a; von Koenen, 2001; Wurdack et al., 2004.

Authors G.H. Schmelzer

ANTIZOMA ANGUSTIFOLIA (Burch.) Miers ex Harv.

Protologue Fl. cap. 1: 11 (1860).

Family Menispermaceae

Synonyms *Cissampelos angustifolius* Burch. (1822).

Origin and geographic distribution *Antizoma angustifolia* occurs in Zimbabwe, Namibia, Botswana and northern South Africa.

Uses A root infusion is drunk as an emetic and purgative, to purify the blood in the treatment of boils, and also to treat stomach-ache, stomach ulcers, colic, diarrhoea and dysentery, kidney stones, liver, gallbladder and bladder complaints, general pain and cough. Women drink a root decoction during pregnancy to keep the foetus mobile and to facilitate childbirth as well as the expulsion of the afterbirth. A decoction from the leaves or roots is drunk or

leaves and roots are chewed to treat digestive problems, against general malaise and AIDS.

Properties *Antizoma angustifolia* contains large amounts of alkaloids, in the leaves 4.7–10.5 mg/g dry weight. The diversity of alkaloids present is remarkable. The leaves contain the proaporphines crotsparine, pronuciferine and traces of glaziovine and the bisbenzylisoquinoline dioxines cissacapine and insularine. The stem contains crotsparine and glaziovine. The root contains crotsparine, glaziovine, pronuciferine, the aporphine bulbocapnine and the morphinane salutaridine. Traces of other alkaloids were also found, but could not be identified. Crotsparine seems to be the main alkaloid in the leaves, accounting for 72% of the total alkaloids. Populations from different provenances vary considerably in their alkaloid content; salutaridine was found in only one sample plant from Pretoria (South Africa).

Botany Dioecious evergreen shrub up to 3 m tall, sometimes with long, rambling branches; young stems longitudinally striped, glabrous to densely hairy. Leaves alternate, simple and entire, grey-green; stipules absent; petiole up to 5 mm long, glabrous or hairy, with a dorsal spine on the stem just below the insertion; blade oblong to obovate, up to 8 cm × 2 cm, base obtuse to truncate, apex rounded to slightly notched, with mucro, leathery, hairy, palmately veined in broader leaves, pinnately in narrow leaves. Male inflorescence a condensed axillary fascicle, sometimes strongly branched; female inflorescence a few-flowered axillary fascicle on short side-branches or flowers solitary. Flowers small; pedicel up to 2.5 mm long, with joint at base; male flowers with (3–)4(–5) fused sepals, broadly obovate to spatulate, 1–2.5 mm × 0.5–2 mm, pale green or pale brown, glabrous or slightly short-hairy outside, petals 4, fused into a cup or saucer 0.5–2 mm in diameter, stamens (2–)4–5(–7), fused into a column 0.5–1 mm long; female flowers with 2(–4) sepals, rhomboid to obovate, 1–2 mm × 1–1.5 mm, slightly hairy outside, petals 2(–4), broadly oblanceolate to broadly obovate, 0.5–1.5 mm long, staminodes sometimes present, ovary superior, c. 1 mm long, glabrous or hairy, transversely grooved, style short, stigma lobed. Fruit an ovoid drupe; stone horseshoe-shaped, 1-seeded. Seed horseshoe-shaped, cotyledons appressed.

Antizoma angustifolia flowers from October to April. It is frost tender.

Antizoma is closely related to *Cissampelos* and comprises 3 species, which all occur in southern Africa. *Antizoma angolensis* Exell & Mendonça is endemic to Angola. *Antizoma miersiana* Harv. is endemic to southern Namibia and western South Africa; a root decoction is drunk to treat stomach ulcers. *Antizoma miersiana* is similar to *Antizoma angustifolia* in its rich diversity of isoquinoline alkaloids.

Ecology *Antizoma angustifolia* occurs in dry bushland, usually associated with *Acacia* species, at 750–1700 m altitude.

Management *Antizoma angustifolia* is only collected from the wild.

Genetic resources and breeding *Antizoma angustifolia* is fairly widely distributed and does not seem to be in danger of genetic erosion.

Prospects The diversity of traditional uses and of the alkaloids present in *Antizoma angustifolia* warrants further pharmacological research.

Major references de Wet, 2005; de Wet, van Heerden & van Wyk, 2004; de Wet & van Wyk, 2008; von Koenen, 2001; Watt & Breyer-Brandwijk, 1962.

Other references Dekker et al., 1988; de Wet, van Heerden & van Wyk, 2005; Leistner, 2000; Neuwinger, 2000; SEPASAL, 2008a.

Authors L.P.A. Oyen

ARGEMONE MEXICANA L.

Protologue Sp. pl. 1: 508 (1753).

Family Papaveraceae

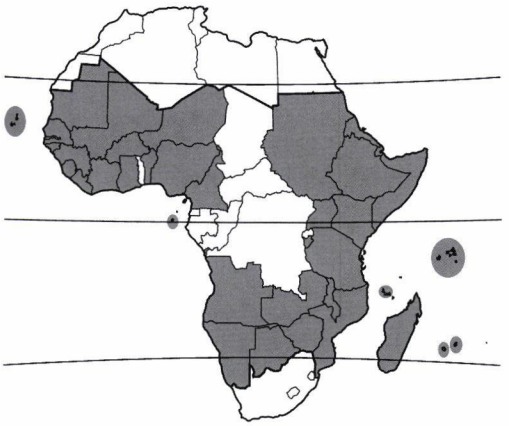
Chromosome number $2n = 28, 42, 56$

Synonyms *Argemone ochroleuca* Sweet (1828).

Vernacular names Mexican poppy, prickly poppy, yellow thistle, Mexican thistle (En). Argémone, pavot épineux, pavot du Mexique, tache de l'œil, chardon du pays (Fr). Papoila mexicana, papoula do México, cardo santo (Po). Mtunguja bonde (Sw).

Origin and geographic distribution *Argemone mexicana* is native in Mexico and the West Indies, but has become pantropical after accidental introduction or introduction as an ornamental. It is naturalized in most African countries, from Cape Verde east to Somalia, and south to South Africa.

Uses Throughout the tropics *Argemone mexicana* is widely used as a medicinal plant. It is considered a painkiller, diuretic, cholagogue and anti-inflammatory. The seed oil is used as a purgative and as a pomade. Both the seed oil



Argemone mexicana – naturalized

and leaf infusions are drunk to relieve cough. Root and leaf decoctions are applied to the skin to cure oedema, inflammation, muscle pain, ulcers, yaws, to remove warts, to kill Guinea worm and to promote wound healing. A root decoction is used as a mouthwash and eye bath to treat infections. Leaf sap is used as eardrops to cure ear inflammation. Flowers, leaves and seeds are used in alcoholic and non-alcoholic drinks for their psycho-active properties.

In Nigeria the seed oil is applied to protect wood from termite attack, whereas in India, Mexico and the West Indies the seed oil is sometimes used to make soap, for greasing and for illumination. The seed oil of *Argemone mexicana*, called 'argemone oil' or 'katkar oil', is sometimes added to mustard oil in India to increase the pungency. Larger amounts are sometimes used to adulterate mustard oil or sesame oil, which may lead to oedema and glaucoma in people who consume the oil.

Cattle do not graze the plant as it is spiny, but they can be poisoned if they consume it in hay or the chaff. Sheep and goats eat it when other vegetation is in short supply, while ostriches relish it. The value of wool decreases when it is contaminated by the prickly fruits.

Argemone mexicana is sometimes cultivated as an ornamental.

Production and international trade *Argemone mexicana* is only used locally and is not traded internationally. In Africa cultivation for its oil for the domestic market has been reported from Mali and Eritrea.

Properties *Argemone mexicana* contains numerous isoquinoline alkaloids of the protoberberine type and related types, including sanguinarine. The total alkaloid fraction in the dried roots and stems is 0.25%, mainly consisting of protopine and berberine. The alkaloid 6-acetonyldihydrochelerythrine has recently been isolated from whole plant extracts and was found to have significant anti-HIV activity. The alkaloids berberine, protopine, protopine hydrochloride, sanguinarine and dihydrosanguinarine have been isolated from the seeds. Protopine is considered a narcotic and it reduces morphine-withdrawal effects significantly. Protopine and sanguinarine showed molluscicidal properties against *Lymnaea acuminata* and *Biomphalaria glabrata*. Berberine has improving effects on the circulation in small doses and also has hallucinogenic properties. An overdose, however, produces death by paralysis of the central nervous system. Other pharmacological effects of berberine include spasmolytic, antibacterial and to some degree antifungal and antiprotozoal activities. Most berberine is formed in the flowers. The alkaloid fraction from the roots showed anti-inflammatory activity in rabbits and rats. Leaf extracts showed in-vitro anti-plasmodial activity.

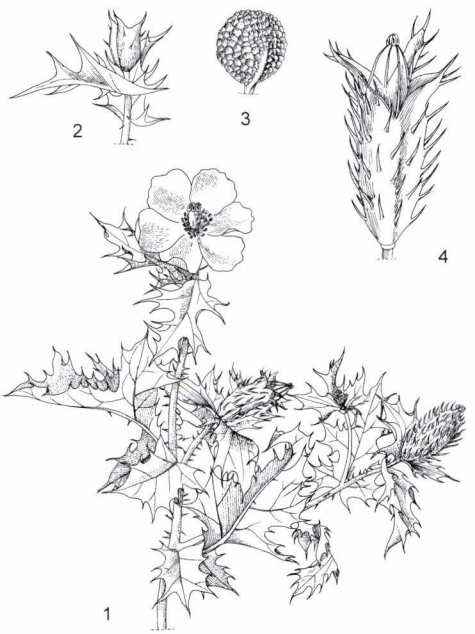
The seeds of *Argemone mexicana* contain 35–40% of an orange-yellow oil which consists mainly of linoleic acid (54–61%) and oleic acid (21–33%). It also contains poisonous sanguinarine in concentrations as high as 10 g/l. Accidental mixing of *Argemone mexicana* seed with grain and oil seeds has caused deaths in several countries, including South Africa. The seed oil has a significant nematicidal effect on larvae of the genus *Meloidogyne*. An aqueous mixture of the oil (0.2%) applied to the soil of okra (*Abelmoschus esculentus* (L.) Moench) significantly reduced nematode infection and nematode concentrations in roots and soil, thereby increasing okra growth. When sprayed on the leaves the effect was even more striking, showing the systemic effect of the spray.

Leaf extracts show antifeedant activity against insects, including the large cabbage-heart caterpillar (*Crocidolomia binotalis*), the cluster caterpillar (*Spodoptera litura*), the cotton aphid (*Aphis gossypii*) and also larvae of the southern house mosquito (*Culex quinquefasciatus*). Dried plant extracts significantly reduced nematode damage on seedlings of tomato and eggplant. Tomatoes treated with a leaf extract showed significantly less fruit rot caused by *Aspergillus niger*. A flower extract induced a high level of resistance to tomato virus × in *Chenopodium album* L. Extracts also showed antibacterial activity in vitro against *Bacillus*

subtilis, *Escherichia coli* and *Streptococcus faecalis*.

Aqueous leaf and flower extracts inhibit the germination and growth of many cultivated crops, such as tomato, cucumber, mustard, radish and pearl millet. Allelopathic effects of the residues on Bambara groundnut and sorghum have been observed in the field.

Description Erect, branched, annual herb up to 50(–100) cm tall, glabrous, containing yellow latex; taproot firm; stem with scattered prickles. Lower leaves in a rosette and with short petiole, stem leaves alternate, sessile, auricled, obovate in outline, 5–22 cm × 3–7 cm, margin wavy to more or less deeply lobed, sharply toothed, lobes curled upwards, white variegated along the main veins, bluish green elsewhere, prickles scattered along the margin and on the veins below. Flowers solitary, regular, 3-merous; bracts 3, leafy; sepals vaulted, terete, with few prickles, horn just below apex, caducous; petals 6, obovate, 1.5–3 cm long, pale to bright yellow; stamens many, 7–12 mm long, free; ovary superior, ovoid, 8–10 mm long, with long soft bristles, style very short, stigma 3–6-lobed, dark red. Fruit an ellipsoid, 3–6-lobed capsule 2.5–4 cm long, valves 3–6, dehiscing from the apex to about 1/3, covered with sharp prickles, many-seeded. Seeds globular, 1.5–2 mm in diameter, finely net-veined, black-brown, hilum prominent, pale. Seedling with epigeal germination; cotyledons linear, up to 2 cm long.



Argemone mexicana – 1, flowering and fruiting stem; 2, flower bud; 3, seed; 4, dehisced fruit. Source: PROSEA

Other botanical information *Argemone* comprises 6–9 species all from tropical America. Some authors consider *Argemone ochroleuca* Sweet a distinct species that can be distinguished by paler petals, thicker leaves and narrower fruits. However, it is widely accepted that it is the tetraploid form (or sometimes triploid form) of *Argemone mexicana*.

Growth and development In the tropics, *Argemone mexicana* flowers and fruits throughout the year. The flowers open early in the morning, and last for 2–3 days. Small stingless bees are the main pollinators, but *Argemone mexicana* is predominantly self-pollinated. Most seeds fall around the base of the parent plant where they may form a carpet of seedlings. The seed is light, has a waxy coat and is pitted, and may be dispersed by wind and water and is known to spread quickly in irrigation schemes. Dispersal also occurs by soil adhering to farm machinery and by man and livestock. Seeds can remain dormant for many years.

Ecology *Argemone mexicana* occurs mainly in regions with a pronounced dry season, on open waste ground, along roadsides and railways, in fields as a weed, mostly at sea-level, but sometimes up to 3000 m altitude. It is locally abundant, but on the whole scattered. It tends to grow well in soils of low fertility.

Propagation and planting *Argemone mexicana* is propagated by seed. Seed production can be 18,000–36,000 seeds per plant. Seeds germinate best in moist soil with a temperature of up to 25°C. In some regions they germinate throughout the year if enough moisture is available.

Management *Argemone mexicana* is hardly cultivated and generally considered a weed. As a weed in cultivated land it is generally not an aggressive competitor. It is reported as a weed in pulses, cereals, tobacco, tea, sugarcane, tomatoes, cotton and Irish potato. Hand harvesting of field crops can be painful in the presence of *Argemone mexicana*. In areas were it was introduced fairly recently its potential impact as a weed is often underestimated. A biological control programme has been initiated in Australia. In Mexico several predatory insects were identified including an extremely damaging species of root-breeding and leaf-feeding

weevil.

Diseases and pests In some areas *Argemone mexicana* is attacked by leafspot caused by *Xanthomonas campestris* pv. *papavericola*. *Argemone mexicana* is a host of collar rot (*Aspergillus niger*), the reniform nematode (*Rotylenchulus reniformis*) and the tobacco budworm (*Helicoverpa assulta*).

Harvesting The desired plant parts of *Argemone mexicana* are harvested whenever the need arises.

Yield Under favourable conditions, *Argemone mexicana* can produce a fresh weight of 6–9 t/ha.

Handling after harvest Harvested material of *Argemone mexicana* is used fresh or is dried for later use.

Genetic resources *Argemone mexicana* is not at risk of genetic erosion as it is a widely distributed weed.

Prospects Several compounds of *Argemone mexicana* display interesting pharmacological effects as purified compounds, making further research desirable. *Argemone mexicana* might be of interest as a natural source of berberine. The toxic effects of seed oil, flowers and to a lesser extent leaf sap make their use for medicinal purposes hazardous, but they will probably continue to be used extensively.

Major references Abebe & Hagos, 1991; Burkill, 1997; CAB International, 2007; Hyde & Wursten, 2002; Neuwinger, 2000; Seegeler, 1983; Tran Cong Khanh, 2001a.

Other references Boiteau & Allorge-Boiteau, 1993; Capasso et al., 2006; Carrillo-Rosario & Díaz de Ramirez, 2005; Chang et al., 2003; Chaturvedi, Datta & Pal, 1999; Das & Khanna, 1997; Diallo et al., 2005; Freiburghaus et al., 1996a; Gupta, Dixit & Dobhal, 1990; Gurib-Fakim et al., 1993; Sharma & Nathawat, 1987; Upreti, Das & Khanna, 1991; van Wyk, van Heerden & van Oudtshoorn, 2002.

Sources of illustration Tran Cong Khanh, 2001a.

Authors C.H. Bosch

Based on PROSEA 12(2): Medicinal and poisonous plants 2.

ARGOMUELLERA MACROPHYLLA Pax

Protologue Bot. Jahrb. Syst. 19: 90 (1894).

Family Euphorbiaceae

Origin and geographic distribution *Argomuellera macrophylla* occurs from Guinea east to Ethiopia and south throughout Central Africa to Angola, Zimbabwe and Mozambique.

Uses In Côte d'Ivoire the leaf sap is taken as a purgative and emetic in the treatment of poisoning and ascites. Powdered dried leaves are sometimes taken as an aphrodisiac. In Kenya the honey from the flowers is considered to be poisonous, causing joint problems.

Botany Monoecious, unbranched shrub or small tree up to 4(–9) m tall; young twigs densely short-hairy. Leaves alternate, crowded at twig ends, simple; stipules linear to lanceolate, 3–4(–15) mm long, rough hairy; petiole up to 1.5 cm long, densely hairy; blade elliptical-oblanceolate to oblong-elliptical, (10–)25–40 cm × 5–12 cm, base cuneate, apex acuminate, margins toothed, leathery, sparingly short-hairy above, densely hairy beneath, later often glabrescent, pinnately veined with 20–25(–30) pairs of lateral veins. Inflorescence an axillary raceme up to 25 cm long, with flowers in interrupted clusters, usually each cluster consisting of 1 female and several male flowers; axis densely hairy; bracts triangular-ovate, c. 2 mm long, short-hairy. Flowers unisexual, sweet-scented; pedicel (3–)5–6 mm long; petals absent; male flowers with 2–4, ovate to lanceolate sepals, 4–5 mm long, hairy outside, greenish to white, disk glands numerous, bright orange, stamens 30–120, free, 5–7 mm long; female flowers with 5–9, triangular-ovate sepals 3–4 mm long, hairy outside, disk annular, ovary superior, c. 2 mm in diameter, slightly 3-lobed, 3-celled, densely hairy, styles 3, c. 3 mm long, recurved, stout, fused at base, yellow. Fruit a 3-lobed capsule c. 7 mm × 13 mm, smooth, evenly short-hairy, green, 3-seeded. Seeds nearly globose, c. 5 mm × 4 mm, smooth, brown-marbled.

Argomuellera comprises 11 species, 5 of which occur in continental tropical Africa and 6 in Madagascar and the Comoros. *Argomuellera macrophylla* is the only species with a wide distribution area.

Ecology *Argomuellera macrophylla* occurs in the forest undergrowth, in West Africa often in drier types of forest, in East Africa often in riverine forest and dry evergreen lakeshore forest up to 1300(–1850) m altitude.

Genetic resources and breeding *Argomuellera macrophylla* has a very wide distribution in tropical Africa, and does not seem to be threatened by genetic erosion.

Prospects *Argomuellera macrophylla* has only few medicinal uses and nothing is known on its phytochemistry and pharmacology; it is

therefore likely to remain of local importance only.

Major references Burkill, 1994; Radcliffe-Smith, 1996a.

Other references Ichikawa, 1987; Radcliffe-Smith, 1987.

Authors G.H. Schmelzer

AZIMA TETRACANTHA Lam.

Protologue Encycl. 1(1): 343 (1783).

Family Salvadoraceae

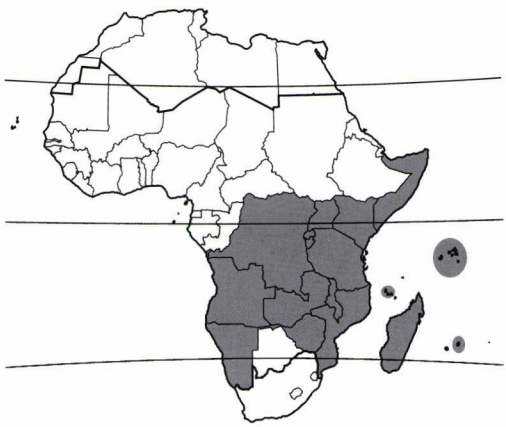
Chromosome number $2n = 22$

Synonyms *Azima spinosissima* Engl. (1894).

Vernacular names Bee sting bush, fire thorn, needle bush (En). Mdunga ndewe, mswaki ndume, mpilipili tawa (Sw).

Origin and geographic distribution *Azima tetracantha* occurs naturally in central, eastern and southern Africa as well as in the Indian Ocean islands, and extends through Arabia to tropical Asia.

Uses In East Africa the pounded roots of *Azima tetracantha* are applied directly to snakebites and an infusion is taken orally as a treatment for them, while in Zimbabwe a mixture of roots and leaves is used similarly. The Bajun people of the Kenyan coast use a root decoction to treat stomach disorders. In Madagascar an infusion of the leaves is used to treat venereal diseases. In the Cape Province of South Africa the juice of the berries is applied directly into the ear to treat earache and the dried root is ground, put in cold water and given to cows to facilitate difficult parturition. The Zulu people of South Africa apply the sap of the plant directly to treat toothache and bleeding gums after tooth extraction and also as a disinfectant. In India and Sri Lanka the root, root bark and leaves are added to food as a remedy for rheumatism. The plant is considered diuretic and is also used to treat dropsy, dyspepsia, chronic diarrhoea and as a stimulant tonic. In western India juice of the leaves is applied as eardrops against earache and crushed leaves are placed on painful teeth.



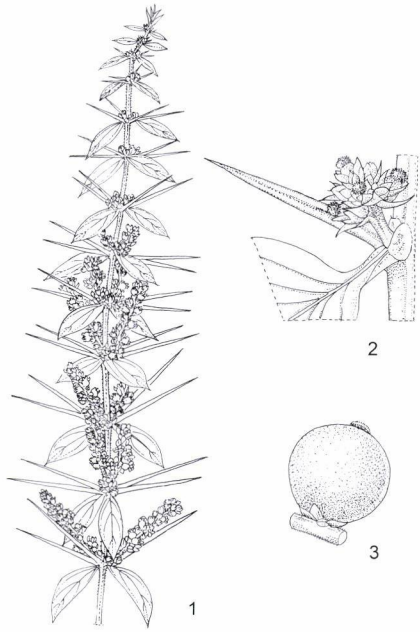
Azima tetracantha – *wild*

The fruit is edible. *Azima tetracantha* is browsed by livestock. It is planted as live fence in Bangalore (India). In Malaysia pickled leaves are used as an appetizer and against colds. The plant is promoted as an ornamental in the United States.

Properties The dimeric piperidine alkaloids azimine, azcarpine and carpaine have been isolated from all plant parts. Terpenoids are present in the roots and the leaves, while the seeds contain a complex mixture of about 25 flavonoids, predominantly as glycosides and acyl-glycosides, the most important being quercetin, isorhamnetin, rhamnetin and rhamnazin. All parts contain glucosinolates. These are hydrolyzed into thiocyanates and isothiocyanates, and the resulting compounds have anti-oxidant and sometimes anticarcinogenic activities. The seed and roots of *Azima tetracantha* contain high concentrations of N-methoxy-3-indolylmethyl-glucosinolate, whereas the stem and young leaves contain lower concentrations. Seed oil contains the fatty acids myristic acid 0.2%, palmitic acid 5%, stearic acid 15%, arachidic acid 7%, behenic acid 2%, oleic acid 32%, linoleic acid 18% and eicosenoic acid 21%, indicating that the oil could be suitable as an edible oil. Despite the traditional uses, the leaves of *Azima tetracantha* have tested negative in antibacterial and antifungal tests. The anti-inflammatory activity of leaf powder has been confirmed in tests on oedema in rats, and the wound-healing activity of a methanol extract was confirmed both as ointment and when injected in rats.

When *Azima tetracantha* is eaten by domestic stock, it imparts a very pronounced flavour to milk and butter. Pricks from thorns produce unpleasant burning sensations comparable to bee stings. The wood is avoided as fuel wood because the smoke is considered poisonous.

Description Dioecious, erect shrub up to 90 cm tall with (1–)2 spines 0.5–5 cm long in each leaf axil, sometimes scandent with stems up to 8 m long; branchlets terete or quadrangular, glabrous to densely hairy. Leaves decussately opposite, simple and entire; stipules absent or



Azima tetracantha – 1, male flowering branch; 2, female inflorescence; 3, fruit.
Redrawn and adapted by Iskak Syamsudin

rudimentary; petiole short; blade elliptical-oblong to ovate-oblong or orbicular, 1.5–5.5 cm × 0.5–4.5 cm, base rounded or somewhat narrowed, apex mucronate, pinnately veined with one pair of lateral veins from near the base. Inflorescence an axillary, sometimes terminal spike or cyme up to 3 cm long or flowers solitary; bracts ovate, often with long and spinous mucro. Flowers unisexual, regular, 4-merous, usually sessile; calyx campanulate, 2–4 mm long, with triangular lobes; petals linear-oblong to oblong, greenish to yellowish, the upper part reflexed over the calyx, 2–5 mm long; male flowers with stamens inserted at the base of the rudimentary ovary, exserted; female flowers with staminodes and superior ovary, up to 4.5 mm long with a broad sessile stigma. Fruit a globose berry, 0.5–1 cm in diameter, 1–2-seeded, green turning white, with persistent stigma. Seeds disk-like, brown to black.

Other botanical information *Azima* comprises about 4 species in mainland Africa, Madagascar and Asia and is characterized by long axillary spines. Over the range of its distribution *Azima tetracantha* varies considerably, yet it is an easily recognizable and distinct species. In southern Africa the male plants lack spines, or have poorly developed ones, while female specimens have long spines.

Growth and development The scandent, straggling growth habit and its spines make *Azima tetracantha* a useful species for hedges. The hedge tends to open up underneath but pruning will keep it in shape. It coppices readily and spreads through underground runners.

Ecology *Azima tetracantha* is found in bush, scrub and forest, along rivers and at the coast, up to 1100 m altitude. In East Africa it is common along banks of seasonal rivers where the soil is saline, notably in the edges of mangrove. In South Africa *Azima tetracantha* occurs on hillsides, in shrub savanna, often on termitaria, and at the coast.

Propagation and planting A few specialist nurseries in the United States offer seeds of *Azima tetracantha* for sale for ornamental purposes. Multiplication through cuttings is possible.

Management The South African Department of Agriculture considers *Azima tetracantha* an indicator of bush encroachment. Land users in certain areas are required to control the species to prevent deterioration and maintain the productivity of pastoral land. Overgrazing is the main reason for encroachment. When used as a hedge or barrier plant, it needs to be pruned regularly to keep a compact shape.

Genetic resources *Azima tetracantha* is a common, widespread pioneer and thus there is no immediate risk of overharvesting for human use.

Prospects The use of *Azima tetracantha* appears to be limited and only occasional in Africa. As all parts contain glucosinolates, further research on medicinal applications is warranted.

Major references Dold & Cocks, 2000; Dold & Cocks, 2001; Fox & Norwood Young, 1988; Hutchings et al., 1996; Ismail et al., 1997; Kokwaro, 1993; Verdoorn, 1963; Vickery, 1983b; Watt & Breyer-Brandwijk, 1962.

Other references Beentje, 1994; Bennett, Mellon & Kroon, 2004; Bennett et al., 2004; Brown et al., 2003; Carlquist, 2002; Coates Palgrave, 1983; Dahir, 1999; Dale & Greenway, 1961; den Outer & van Veenendaal, 1981; Friis, 1992; Guerra dos Santos, 1989; Hebbar et al., 2004; Henderson, 1987; Jaswanth et al., 2001; Perrier de la Bâthie, 1946; Ramaswamy & Razi, 1973; Rodman et al., 1996; Schatz, 2001; Vonshak et al., 2003.

Sources of illustration Vickery, 1983b.

Authors A.P. Dold

BAISSEA AXILLARIS (Benth.) Hua

Protologue Compt. Rend. Hebd. Séances Acad. Sci. 134: 857 (1902).

Family Apocynaceae

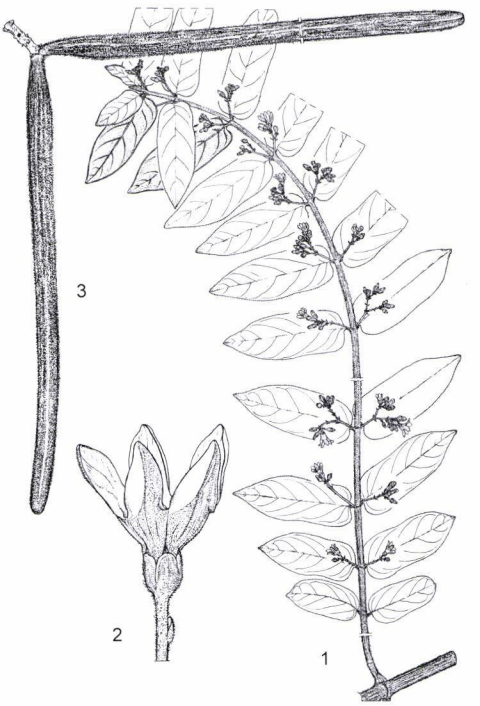
Chromosome number $2n = 22$

Origin and geographic distribution *Baissea axillaris* occurs from Senegal east to the Central African Republic, and south to northern Angola. There is one collection from eastern Tanzania.

Uses In Congo a decoction of the leafy twigs is taken to treat kidney problems. In DR Congo a maceration of the root is used as eye drops to treat psychosis. A decoction of the roots and stem bark is taken to treat colic; it causes no diarrhoea. A decoction of the leafy twigs is taken as a diuretic. The Yoruba people in Nigeria add the latex to palm wine to increase the intoxicating effect. The bark in decoction is applied to the skin of dogs to cure mange. The bark is used to make a powerful hunting poison. In DR Congo the root sap is dripped into the nostrils of hunting dogs to improve their ability to scent.

Properties No chemical analyses have been carried out on *Baissea axillaris*. It belongs to the subfamily *Echitoideae*, whose representatives often contain cardiac glycosides, especially in the seeds and roots.

Botany Liana up to 15 m long, with white latex; stem up to 12 cm in diameter; bark rough or smooth, greyish; branchlets densely hairy. Leaves opposite, simple and entire; stipules absent; petiole 1–8 mm long, densely hairy; blade ovate to oblong, often violin-shaped, sometimes deltoid, 1–8 cm × 0.5–3 cm, base rounded to cordate, apex obtuse to acute, glabrous to hairy on both sides, pinnately veined with 3–10 pairs of lateral veins. Inflorescence an axillary cyme, sometimes terminal, lax or congested, 1–20-flowered; peduncle 1–15 mm long. Flowers bisexual, regular, 5-merous; pedicel 1.5–5 mm long; sepals connate at base, broadly ovate, 1–2 mm long, apex rounded to obtuse, brown hairy outside; corolla tube funnel-shaped, (2–)3–5 mm long, variably hairy outside, with tufts of hairs and small scales inside, yellow, orange or white, sometimes with red spots or stripes inside, lobes elliptical, 1.5–6 mm × 1–2 mm, apex obtuse, variably hairy outside, glabrous inside; stamens inserted near the base of the corolla tube, anthers almost sessile, forming a cone over the pistil head; ovary half-inferior, globose to cylindrical, consisting of 2 carpels connate at the very base, style 0.5–1 mm long, pistil head c. 1 mm long. Fruit consisting of 2 almost free, narrowly cylindrical follicles 11–39 cm × 0.5–3 cm, apex rounded, pendulous, densely hairy, many-seeded. Seeds narrowly ellipsoid, laterally compressed, 17–27 mm long, apex truncate, with a tuft of hairs 15–45 mm long.



Baissea axillaris – *1, flowering twig; 2, flower; 3, fruit.*
Source: Flore analytique du Bénin

Baissea is confined to continental Africa and comprises 18 species. *Baissea axillaris* flowers and fruits throughout the year. *Baissea leonensis* Benth. has about the same distribution area as *Baissea axillaris*, occurring from Senegal to western Uganda, and south to DR Congo. In Senegal the latex is applied to mumps, and the latex together with the powdered bark of *Zanthoxylum leprieurii* Guill. & Perr. is applied to tumours. In Côte d'Ivoire the latex is dropped in water to stupefy fish. The strong stems are used as ropes. The leaves contain the coumarin glycoside baisseoside.

Ecology *Baissea axillaris* occurs in riverine forest, coastal forest and secondary forest, up to 1000 m altitude.

Genetic resources and breeding *Baissea axillaris* is relatively common throughout its

distribution area and grows well in disturbed forest. It is therefore not threatened by genetic erosion.

Prospects *Baissea axillaris* will remain of local importance only, unless chemical and pharmacological research reveals possibilities for modern medicine.

Major references Burkill, 1985; Neuwinger, 1996; Neuwinger, 2000; van Dilst, 1995.

Other references Bouquet, 1969; Oliver-Bever, 1986; Terashima & Ichikawa, 2003; Tra Bi, Kouamé & Traoré, 2005.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors G.H. Schmelzer

BAISSEA MULTIFLORA A.DC.

Protologue Prodr. 8: 424 (1844).

Family Apocynaceae

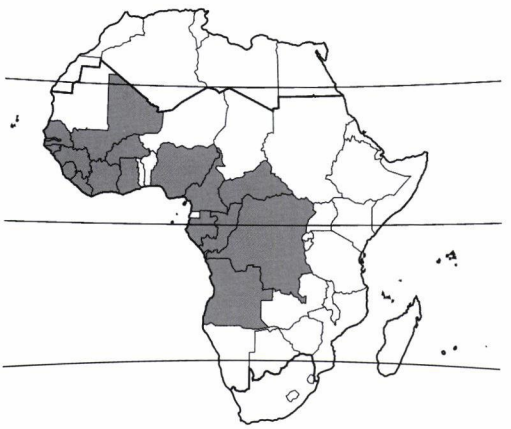
Synonyms *Baissea laxiflora* Stapf (1894).

Vernacular names Liane étoilée (Fr).

Origin and geographic distribution *Baissea multiflora* occurs from Senegal east to the Central African Republic and DR Congo, and south to northern Angola.

Uses In Senegal roots and bark decoctions are widely used to treat colic and stomach-ache without causing diarrhoea, and to treat sterility in women. A decoction of the leafy twigs or bark is considered diuretic and taken to treat rheumatism, arthritis, kidney problems, haemorrhoids, lumbago, oedema caused by deficiencies and as a stimulant to treat general fatigue. The decoction is also externally used in friction or bathing. Root powder in water is dripped into the eye to treat conjunctivitis or cataract and mixed with food or drink to treat appendicitis. It is also applied to snakebites. The Tenda people of Senegal give a few drops of the sap to children with fever. Ash of the plant is rubbed on the back to treat backache. Tenda hunters consider the plant a charm. In Gambia a decoction of the leafy twigs is taken to treat diarrhoea. In northern Côte d'Ivoire the roots in decoction are taken to treat dry cough, and are used as a wash to treat gonorrhoea.

The strong stems are used in Sierra Leone to tie roofs of houses. In Gambia the bark is made into rope. The plants contain white latex, which has been collected in the past in Ghana to produce a good quality rubber. Cattle in Senegal browse on the leaves and stems are pulled to the ground to make the leaves available. *Baissea multiflora* produces masses of small flowers, which are sweet-scented, and have ornamental value. It is listed as a rare ornamental plant on a gardener's website.



Baissea multiflora – *wild*

Properties No chemical analyses have been carried out on *Baissea multiflora*. It belongs to the subfamily *Echitoideae*, whose representatives often contain cardiac glycosides, especially in the seeds and roots. A leaf extract showed significant molluscicidal activity against *Biomphalaria glabrata*. An ethanol extract of the root or bark did not show any antibacterial, antitrypanosomal or antiplasmodial activities.

Description Shrub up to 6 m tall or liana up to 30 m long, with white latex; stem up to 12 cm in diameter; bark with small grooves, dark grey or brown; branches smooth, grey- or red-brown, branchlets hairy. Leaves opposite, simple and entire; stipules absent; petiole 1–5 mm long, hairy; blade obovate to oblong, 1.5–9.5 cm × 1–4.5 cm, base cuneate to rounded, apex acute to acuminate, glabrous on both sides, pinnately veined with 5–10 pairs of lateral veins. Inflorescence an axillary or terminal cyme, lax or congested, few- to many-flowered; peduncle 0.5–4.5 cm long, hairy. Flowers bisexual, regular, 5-merous, fragrant; pedicel 2.5–30 mm long; sepals free or nearly so, broadly ovate to oblong, 1–4 mm long, apex obtuse to acute, red-brown or greenish, minutely hairy; corolla tube cylindrical to cup-shaped, 3–5.5 mm long, minutely hairy, with tufts of hairs and distinct scales inside, white, pink or orange, lobes narrowly ovate or strap-shaped, 5–21 mm × 1–2 mm, apex acuminate, white or yellow, sometimes red striped, variably hairy outside, glabrous inside; stamens inserted near the base of the corolla tube, in-



Baissea multiflora – 1, flowering twig; 2, flower; 3, fruit.
Redrawn and adapted by Iskak Syamsudin

cluded, anthers almost sessile, forming a cone over the pistil head; ovary half-inferior, globose to cylindrical, consisting of 2 carpels connate at the very base, style 0.5–1.5 mm long, pistil head c. 1 mm long. Fruit consisting of 2 almost free, narrowly cylindrical follicles 30–45 cm × 0.5–1 cm, pendulous, hairy, many-seeded. Seeds narrowly ellipsoid, laterally compressed, 14–19 mm long, black, with a tuft of hairs 35–50 mm long at apex.

Other botanical information *Baissea* is confined to continental Africa and comprises 18 species. The hairiness of the flowers in most species is extremely variable, as is the size of the corolla lobes.

Baissea myrtifolia (Benth.) Pichon from Kenya and Tanzania has similar uses as *Baissea multiflora*. In Kenya a root decoction is taken to treat stomach and kidney problems, colic and dysentery.

Growth and development In West Africa *Baissea multiflora* flowers from July to May, and fruits from September to June. In Central Africa it can be found flowering and fruiting throughout the year.

Ecology *Baissea multiflora* occurs in primary as well as secondary forest, and in riverine forest, at 150–1400 m altitude.

Harvesting The bark, roots and leaves of *Baissea multiflora* are harvested from the wild whenever the need arises.

Handling after harvest The plant parts harvested are usually used fresh.

Genetic resources As *Baissea multiflora* is only used at a local scale, it is not likely to become threatened by genetic erosion.

Prospects Despite the multiple uses in local medicine, very little is known about the chemistry and pharmacological activities of *Baissea multiflora*. Several antibacterial tests had negative results, although it showed significant molluscicidal activity. More research is necessary to determine the value of *Baissea multiflora* as a medicinal plant. The profusion of small and fragrant flowers makes it an ornamental worth cultivating.

Major references Arbonnier, 2002; Burkill, 1985; Neuwinger, 2000; van Dilst, 1995.

Other references Atindehou et al., 2004; Burkill, 2000; Duret & Paris, 1972; Kerharo & Adam, 1974; Koné et al., 2004.

Sources of illustration van Dilst, 1995.

Authors G.H. Schmelzer

BARTERIA FISTULOSA Mast.

Protologue Oliv., Fl. trop. Afr. 2: 511 (1871).

Family Passifloraceae

Synonyms *Barteria nigritana* Hook.f. subsp. *fistulosa* (Mast.) Sleumer (1974).

Vernacular names Arbre à fourmis (Fr).

Origin and geographic distribution *Barteria fistulosa* occurs from western Nigeria east to the Central African Republic and south to DR Congo.

Uses The stem bark, roots and leaves of *Barteria fistulosa* are widely used in baths and embrocation to treat pain, e.g. fever pains, headache, intestinal and lumbar pains and rheumatism. In Gabon a bark decoction is gargled to treat toothache, and in the Central African Republic a decoction is used as nose drops to treat headache. Young shoots are eaten as an aphrodisiac, and the powdered root is widely taken as an invigorator for men. A bark decoction is taken to treat venereal diseases and madness. In Congo *Barteria fistulosa* is used in many formulations to treat epilepsy and snakebites. A bark decoction makes a wash to treat smallpox and ulcerous sores. A

mixture of dried ground twig bark, rock salt and maize meal is eaten as a purgative. Powdered bark is used to stop the coughing of blood and uterine haemorrhage, while the leaf powder is rubbed into scarifications. In DR Congo the bark sap is used to treat wounds.

Properties The stem bark of *Barteria fistulosa* contains large amounts of flavones, while the leaves and roots contain traces. The bark furthermore contains a trace of saponins, the bark and root contain tannins and the leaves, bark and root contain traces of hydrocyanic acid. The cyanogenic glycoside barterioside has been isolated from the root bark.

Botany Small tree up to 13 m tall with deep taproot; branches horizontal, hollow over their full length, smooth or with lenticels, greyish. Leaves distichously alternate, simple, almost entire; stipules absent; petiole short, thickened; blade oblong to obovate-oblong, 20–42 cm × 6–19 cm, base decurrent into the petiole, forming a raised line on both sides of the stem, apex apiculate, leathery, glabrous. Inflorescence an axillary fascicle, often horseshoe-shaped, (2–)6–9-flowered; bracts numerous, oblong, apex rounded to obtuse, overlapping, shiny, chestnut-coloured, increasing in size from below upwards. Flowers bisexual, regular, 5-merous; sessile; sepals fused at base, oblong to lanceolate, c. 3 cm × 1 cm, overlapping, wavy at the margins, silky and downy outside, white; petals similar to the sepals, but slightly larger and glabrous; corona double, the outer membranous, about half the length of the petals, jagged at the edge, inner much smaller, consisting of a ring of thick, fleshy tubercles; stamens numerous, c. 3 cm long, filaments fused at base, anthers linear-oblong; ovary superior, globose, 1-celled, style thick, stigma large, mushroom-shaped. Fruit a leathery, ellipsoid indehiscent berry 3–3.5 cm × 2–2.5 cm, many-seeded. Seeds ovoid, compressed, coarsely pitted, with pulpy aril.

Barteria comprises 4 species, which all occur in tropical Africa. *Barteria fistulosa* houses large, aggressive ants (*Tetraponera* spp.). *Barteria nigritana* Hook.f. and *Barteria dewevrei* De Wild. & T.Durand house small ants in their hollow branches, while *Barteria solida* Breteler does not house any ants. In Nigeria *Barteria fistulosa* fruits in March on trees more than 8 m tall (more than 10 years old). The seeds are dispersed by birds and small mammals. Seedlings occur in heavy shade and produce the first hollow, horizontal branches when 1–1.5 m tall; these are colonized by ants. The growth rate is 50–100 cm per year, and the tree dies after 15–30 reproductive seasons, at which time the crown is high enough to be exposed to broken sunlight.

In Cameroon the Baka people use *Barteria nigritiana* to treat anaemia and toothache and in Congo the Kouilou and Mayombe people use the bark to treat wounds, scabies and itch. After a wash with the decoction, the affected area is dusted with powdered bark.

Ecology *Barteria fistulosa* occurs in lowland rainforest and gallery forest, also in secondary forest, often in clearings or along rivers.

Genetic resources and breeding *Barteria fistulosa* is widespread and hence not threatened with genetic erosion.

Prospects In view of the many medicinal uses and the limited chemical and pharmacological data, research into the properties of *Barteria fistulosa* may prove worthwhile.

Major references Breteler, 1999; Burkill, 1997; Janzen, 1972; Keay, 1954a; Neuwinger, 2000; Waterman, Ross & McKey, 1984.

Other references Adjanohoun et al. (Editors), 1988; Akendengué & Louis, 1994; Betti, 2004; Bouquet, 1969; Gassita et al. (Editors), 1982; Hulstaert, 1966; Paris, Bouquet & Paris, 1969; Raponda-Walker, 1952; Sandberg & Cronlund, 1982; Tanno, 1981.

Authors A. de Ruijter

BASANANTHE SANDERSONII (Harv.) W.J.de Wilde

Protologue Blumea 21(2): 339 (1973).

Family Passifloraceae

Synonyms *Tryphostemma longifolium* Harms (1891).

Origin and geographic distribution *Basananthe sandersonii* occurs from Tanzania south to Zimbabwe, Mozambique, South Africa and Swaziland.

Uses In Tanzania the roots are chewed and the juice taken internally to treat snakebites.

Botany Perennial herb up to 60 cm tall, with woody rootstock; stems erect or prostrate at base. Leaves alternate, simple; stipules linear, 1.5–5 mm long; petiole 0–5 mm long; blade orbicular, broadly ovate, obovate or elliptical, 2–16 cm × 1–4 cm, base rounded or cuneate, apex rounded or obtuse, margins toothed, glaucous beneath. Inflorescence an axillary cyme, 1–3-flowered, often with a tendril 0.5–2(–5) cm long; peduncle up to 4.5 cm long; bracts 1–4 mm long. Flowers bisexual, regular, campanu-

late; pedicel 3–17 mm long, pale yellow; hypanthium 2–4 mm wide; sepals 5(–7), 4.5–8.5 mm long, apex obtuse; petals absent or rarely 2; outer corona blue, with tube 1–2 mm high and threads 0.5–1.5 mm long, inner corona 1–1.5 mm high, cup-shaped; stamens 5, inserted at the inner corona, filaments 1.5–4 mm long; ovary superior, obovoid, 1–1.5 mm long, 1-celled, styles 3(–4), free, 3–4 mm long, stigma head-shaped. Fruit an obovoid capsule 1.5–2 cm long, pendulous, 1–4-seeded. Seeds 6–10 mm long.

Basananthe comprises about 25 species in continental Africa. *Basananthe heterophylla* Schinz is an annual or occasionally short-lived perennial herb up to 50 cm tall, occurring in Namibia and Botswana at 900–1500 m altitude. A root decoction from it is used in Namibia to treat coughs.

Ecology *Basananthe sandersonii* occurs in grassland, open scrub vegetation and forest edges on sandy and rocky soils, up to 1700 m altitude.

Genetic resources and breeding *Basananthe sandersonii* is a widespread pioneer plant and thus not at risk of genetic erosion.

Prospects In view of the medicinal use on record and the complete lack of chemical and pharmacological data, research into the properties of *Basananthe sandersonii* may prove worthwhile.

Major references de Wilde, 1973; Kokwaro, 1993; Neuwinger, 2000.

Other references Bernhard, 1999; von Koenen, 2001.

Authors A. de Ruijter

BAUHINIA KALANTHA Harms

Protologue Bot. Jahrb. Syst. 28: 398 (1900).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Vernacular names Mchekwa (Sw).

Origin and geographic distribution *Bauhinia kalantha* is endemic to Tanzania where it is restricted to the Dodoma, Morogoro and Iringa Regions.

Uses In the area around Dodoma (Tanzania), the sliced roots of *Bauhinia kalantha* are boiled together with chicken and eaten as a treatment for schistosomiasis. Young, tender leaves are cooked alone or with other leaves as a vegetable. *Bauhinia kalantha* produces good firewood and a dye used in basketry. Ropes are made from the bark fibre.

Properties Active compounds have not been reported for *Bauhinia kalantha*, but other *Bauhinia* species are known to contain glucosides of flavones and flavonols.

Botany Shrub up to 3 m tall, glabrous except stamens and ovary. Leaves alternate, simple; blade 1–4.5 cm × 1.5–4 cm, deeply 2-lobed to one-fifth from base, lobes rounded at the apex. Flowers solitary, bisexual, almost regular, 5-merous; hypanthium 3–4 mm long; sepals narrowly ovate to lanceolate, 13–17 mm long; petals obovate, 2.5–3.5 cm × 1–2 cm, yellow; stamens 10, all fertile, hairy; ovary superior, hairy, stigma c. 3 mm in diameter. Fruit an oblong pod c. 1.5 cm wide, woody, dehiscent, few-seeded. Seeds 7–8 mm × 6–7 mm, deep brown.

Bauhinia is a widespread tropical genus with about 250 species. *Bauhinia urbaniana* Schinz is also used in traditional medicine. It is restricted to Zambia, Angola, Namibia and Botswana on Kalahari sands in woodland at around 1000 m altitude. In Namibia the cut fresh roots are cooked in water and the decoction is taken as a strengthening tonic for adults in case of any serious sickness. The dried, powdered roots are mixed with vaseline and babies are rubbed with the mixture as a protection against sickness.

Ecology *Bauhinia kalantha* occurs in deciduous woodland and thickets, often on stony soils, at 600–1000 m altitude.

Management For all uses, plant material is only collected from the wild. The edible leaves are collected from November till April.

Genetic resources and breeding Although it has a limited distribution, *Bauhinia kalantha* apparently is common in its range.

Prospects The chemical and pharmacological properties of *Bauhinia kalantha* have not been analysed and it is therefore impossible to judge its value as a medicinal plant and vegetable.

Major references Brenan, 1967; Kokwaro, 1993; Ruffo, Birnie & Tengnäs, 2002.

Other references Blomley & Mbogo, 1992; Brummitt et al., 2007; Dale & Greenway, 1961; Leger, 1997; Vihan, Kumar & Arora, 2007.

Authors C.H. Bosch

BERSAMA ABYSSINICA Fresen.

Protologue Mus. Senckenberg. 2: 281 (1837).
Family Melianthaceae
Synonyms *Bersama engleriana* Gürke (1892).
Vernacular names Winged bersama, bitter bark (En). Mwangwakwao, mtata (Sw).
Origin and geographic distribution *Bersama abyssinica* is distributed from Guinea Bissau through the coastal countries of West Africa except Benin, east to Eritrea and Ethiopia and south to Angola, Zambia, Zimbabwe and Mozambique.
Uses All parts of *Bersama abyssinica* are poisonous and have been implicated in killing humans and livestock. For internal use the dosage is therefore critical. Bark, leaf and root decoctions are widely taken as a purgative to treat a range of stomach disorders, such as abdominal pain, colic, diarrhoea, cholera, intestinal worms, amoebiasis and dysentery. Rabies, syphilis, gonorrhoea and malaria are also treated with these decoctions. A stem bark decoction is drunk to cure cancer and rheumatism. As an aphrodisiac, powdered bark is added to beer or leaves are chewed. A bark poultice is applied to the back, a leaf decoction is drunk or a root decoction is used as a wash to cure lumbago. Stem bark and leaves are used to treat diabetes mellitus. Leaf decoctions are also taken to treat feverish pains, loss of appetite, debility, jaundice and leprosy. Extracts of growing shoots are used for external treatment of burns, ulcers and to clean wounds. To treat convulsions and snakebites, leaves are pounded and mixed with water, and the mixture is drunk and applied the body. A root bark infusion is drunk, stem bark powder is sniffed, leaf sap is applied as eye drops or leaf powder is sniffed to treat migraine, headache and colds. A root decoction is used to treat haemorrhoids and epilepsy. Shoots and leaves are pounded and used to control stalk borers in maize.
The wood is used for poles in house building, as firewood and for making charcoal. Branches are used in living fences. *Bersama abyssinica* is further valued as an ornamental shade tree, for bee forage and in agroforestry. Seeds are used as a substitute for soap.
Properties The stem bark of *Bersama abyssinica* collected in Kenya and Uganda contained 2 bufadienolides, which are cardiac glycosides with anti-tumour activity, as well as sterols and the xanthone mangiferin. Differences between provenances were detected in the glycoside fractions. Two hellebrigenin derivatives identified in an ethanol extract of the bark have shown inhibitory activity against human carcinoma of the nasopharynx in cell cultures. Cardiac glycosides and unsaturated sterols were identified in tests in Ethiopia on stem bark and root bark. Leaf extracts have cardiogenic, spasmolytic and hypoglycaemic activities. Crude bark extracts slow down growth of *Bacillus cereus*, *Staphylococcus aureus*, *Shigella flexineri* and *Shigella dysenteria*, a root bark extract slows down that of *Bacillus subtilis*. An aqueous stem bark extract showed antispasmodic effects on isolated guinea-pig ileum. A methanolic leaf extract had an inhibitory effect on HIV-1 replication.
From the roots the bufadienolide abyssinin (an insect antifeedant against *Helicoverpa zea)*, 3 other bufadienolides, bersenogenin, berscillogenin, and 3-epiberscillogenin, all with in-vitro cytotoxicity, and glucuronide triterpene saponins have been isolated.
Methanol fractions of the leaves of *Bersama abyssinica* showed significant free radical scavenging capacity. Phytochemical investigation resulted in the isolation of five flavonol glycosides and the xanthone mangiferin. The last compound also has cytoprotective properties.
The wood is white to brownish grey without differentiation between sapwood and heartwood; the texture is moderately coarse. The wood is hard and works easily. The density is about 800 kg/m^3 at 12% moisture content.
Botany Evergreen shrub to small tree up to 12(–25) m tall; bark grey, brown or mottled, scaly. Leaves alternate, imparipinnately compound with up to 12 opposite pairs of leaflets, up to 1 m long; stipules 0.5–5 cm long; rachis usually with wide wings; leaflets nearly sessile, lanceolate to oblong or ovate-oblong, 3.5–22 cm × 1–8 cm, base cuneate to rounded, apex acuminate, margin entire to sharply and conspicuously toothed, glabrous to hairy, with 10–12 pairs of lateral veins. Inflorescence an upright, dense, axillary raceme up to 35 cm long. Flowers bisexual or often functionally unisexual, zygomorphic, 4–5(–6)-merous, scented; sepals 4–5, c. 6 mm long, 2 anterior ones fused; petals 5, free, narrowly oblong, 10–20 mm long, white, yellowish or purple-pink, stamens 4–6, free or fused at base; ovary superior, densely hairy, 4–5-celled, style simple. Fruit a woody capsule 1–3 cm in diameter, 4–5-lobed, yellowish to reddish, 4–5-seeded. Seed up to 11 mm × 8 mm, bright red with cup-shaped yellow or orange

aril.

Bersama comprises about 8 species, all occurring in Africa. The large variation in *Bersama abyssinica* has led to the naming of numerous species, subspecies and varieties. *Bersama lucens* (Hochst.) Szyszyl. occurs in Mozambique and South Africa, and in South Africa powder from its stem bark is sniffed to cure headache and a stem bark maceration is drunk to treat menstrual pain, nervousness, venereal diseases and impotence. The stem bark extract is also used to kill lice. An aqueous stem bark extract showed significant antifungal activity against *Candida albicans*. A stem bark extract of *Bersama tysoniana* Oliv., a South African endemic, is drunk to treat fever and hysteria; the bark is probably overharvested.

Ecology *Bersama abyssinica* grows in lowland bush savanna, gallery forests and montane forests, from sea-level up to 2700 m altitude. It behaves as a pioneer species and is considered a weed in forest plantations.

Management *Bersama abyssinica* can be propagated by seed, cuttings, wildlings or root suckers. There are about 1200 seeds in a kg. Seeds can be stored after removal of the aril and retain viability for 2 months at room temperature. They are sensitive to freezing. Management practices may include coppicing, lopping and pollarding. *Bersama abyssinica* produces root suckers.

The only important disease recorded is tar spot, caused by the fungus *Phyllachora bersamae*; it affects the leaves.

Genetic resources and breeding *Bersama abyssinica* is widespread, but nowhere abundant. Increased use especially of roots and stem bark could pose a threat in the future.

Prospects The taxonomy of *Bersama* is still far from clear. The large morphological variation in *Bersama abyssinica* is fairly well described, but variation in chemical properties is poorly understood. The medicinal properties warrant further research.

Major references Burkill, 1997; Maundu & Tengnäs, 2005; Neuwinger, 2000; Tapondjou, Miyamoto & Lacaille-Dubois, 2006; Verdcourt, 1989.

Other references Asres et al., 2001; Asres, Gibbons & Bucar, 2006; Buwa & Van Staden, 2006; Dharani, 2002; Geyid et al., 2005; Kitula, 2007; Latham, 2007; Makonnen & Hagos, 1993; Mikkelsen & Seberg, 2001; Njike et al., 2005.

Authors C.H. Bosch

BOERHAVIA DIFFUSA L.

Protologue Sp. pl. 1: 3 (1753).

Family Nyctaginaceae

Chromosome number $2n = 26, 52, 54, 116$

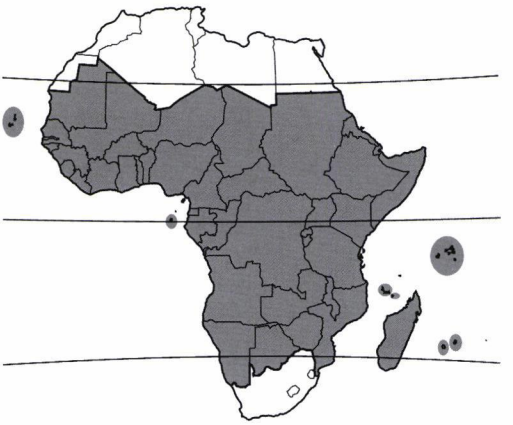
Synonyms *Boerhavia africana* Lour. (1790).

Vernacular names Spreading hogweed, red hogweed, tar vine, red spiderling (En). Agarra pinto, tangara, bredo de porco, erva tostão (Po). Mkwakwara, mkwayakwaya (Sw).

Origin and geographic distribution *Boerhavia diffusa* has a pantropical distribution, and possibly originates from the Old World tropics. It occurs throughout tropical Africa.

Uses In India *Boerhavia diffusa* is a very popular medicinal plant, called 'Punarnava'; especially the roots, leaves and seeds are used and the root is listed in the Indian Pharmacopoeia. Plant parts are applied as a stomachic, cardiotonic, hepatoprotective, laxative, diuretic, anthelmintic, febrifuge, expectorant and, in higher doses, as an emetic and purgative. As a diuretic it is useful in strangury, jaundice, enlarged spleen, gonorrhoea and other internal inflammations. In moderate doses it is successful in asthma. A decoction of the roots is also applied to corneal ulcers and to treat night blindness. Similar uses have been reported for Central America and South-East Asia.

In tropical Africa the boiled roots are applied to ulcers, abscesses and to assist in the extraction of Guinea worm. The boiled roots and leaves are considered expectorant and febrifuge, and in large doses emetic. A decoction of the aerial parts is also taken to treat gastro-intestinal pains, convulsions, intestinal worms and to regulate menstruation. In Mauritania the seeds are ground and made into cakes which



Boerhavia diffusa – wild

are cooked and eaten as a remedy for dysentery. In Côte d'Ivoire the powdered leaves are made into a paste and are applied to the chest to relieve asthma. The leaves are applied to the forehead to treat violent headache and around the ears against earache. Root sap as a lotion for friction is used to treat kidney troubles, rheumatism, generalised pain and sprains. In Ghana the root decoction is also taken to treat anaemia and applied externally to yaws, while the powdered root can be mixed with butter or oil to treat abdominal tumours. A decoction of the root is also taken to treat heart troubles, palpitations and jaundice. In Congo root sap is rubbed on the neck and throat to treat mumps, laryngitis and burns. In water or palm oil, or in a decoction, it is taken to treat spleen troubles, diarrhoea, dysentery, haematuria and gonorrhoea. The root is also considered abortifacient and used to hasten parturition. The roots are also applied as a snakebite antidote, and as an aphrodisiac. A decoction of the leaves is used in DR Congo to treat gonorrhoea and to calm pain. A decoction of the root is taken in Angola to treat jaundice. In Namibia the Bergdamara people chew or boil the root to treat gastro-enteritic problems, while the Damara people take a tea made from the root to treat a prolapsed uterus.

In West and East Africa the leaves are sometimes prepared in a sauce as a vegetable, while the seeds are added to cereals in Senegal and Mali. The leaves are cooked as a vegetable in curries and soups in India as well, and the roots and seeds are added to curries and bread. The leafy stems are widely eaten by sheep and cattle, and may also be cut as a fodder.

Production and international trade *Boerhavia diffusa* is mainly used at a local scale, except in India where especially the roots enter in popular medicinal formulations. Indian products are traded worldwide.

Properties The chemistry of the bioactive compounds of *Boerhavia diffusa* and their pharmacological properties are poorly studied. Most research has focused on extracts. Compounds isolated from the roots of *Boerhavia diffusa* include the alkaloid punarnavine, punarnavoside (a glucopyranoside), ursolic acid, and the rotenoids boeravinones A1, B1, C2, D, E and F, as well as several minor components.

In India *Boerhavia diffusa* is included in the Pharmacopoeia as a diuretic, and this action has since been confirmed. The diuretic activity is probably due to depression of tubular excretion, inhibiting kidney succinic dehydrogenase and stimulating D-amino oxidase. An aqueous extract of the dry or fresh plant is useful in cases of oedema and ascites. In India an intravenous injection of punarnavine in cats produced a distinct and persistent rise of blood pressure and a marked diuresis. The high amounts of potassium salts present in the whole plant increase the action of punarnavine. In a clinical trial for treatment of nephrotic syndrome, the extract was found to improve diuresis, to relieve oedema, and to cause an overall improvement of the patient, including a decrease in albuminuria, rise in serum protein and fall in serum cholesterol level.

A decoction of the leaves and the fresh juice both produced a significant analgesic effect in tests with rats, but the fresh juice raised the pain threshold for much longer than the leaf decoction. The alcoholic extract showed anti-inflammatory effects against carrageenan-induced paw oedema and also increased urinary output in rats.

In tests with mice, the alkaloidal fraction of the roots inhibited hypersensitivity reactions. Extracts of the whole plant exhibited various pharmacological effects including hepatoprotective, anticonvulsant, hypotensive, myocardial depressant, and skeleton and smooth muscle stimulant activities in rats. No teratogenic effects have been detected in pregnant rats. The root extract showed noticeable reduction of the duration of menstrual flow and iron loss in monkeys. The results of tests with rats suggest that a leaf extract has significant antidiabetic activity. The ethanolic extract of the aerial parts showed protection of guinea pigs with histamine-induced asthma. An ethanolic extract of the roots showed in-vitro and in-vivo antitumour activity. Additionally, extracts showed antiviral, antifungal and allelopathic activities.

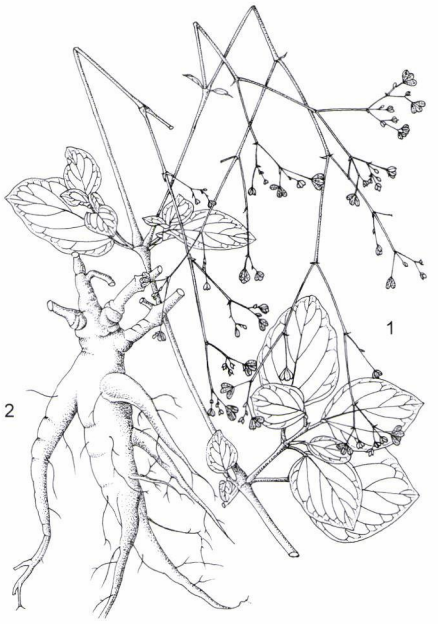
In-vitro root cultures were established from leaf segments of *Boerhavia diffusa*. Roots formed with 0.5 µM IAA contained 15% punarnavine on dry weight basis, while roots formed with higher concentrations of IAA contained less of the compound. In the presence of 2,4-D, leaf segments produced callus with regenerated roots, containing traces of punarnavine.

The nutritional composition of the leaves per 100 g edible portion is: water 82 g, energy 217 kJ (52 kcal), protein 4.5 g, fat 0.5 g, carbohydrate 10.3 g, fibre 2.2 g.

Adulterations and substitutes Other species of *Boerhavia*, and also *Trianthema portu-*

lacastrum L. (*Aizoaceae*) are sometimes used as a diuretic in the same way as *Boerhavia diffusa*.

Description Annual to perennial herb up to 1 m tall, sometimes with thick taproot; stem branching mainly from the base, prostrate when young, ascending to erect when flowering, fleshy, green, often flushed with red, glabrescent to short or long hairy with multicellular hairs, often glandular, especially around the swollen nodes. Leaves opposite, simple, unequal; stipules absent; petiole 1–2.5(–3.5) cm long; blade broadly ovate to elliptical, 1.5–6 cm × 0.5–5 cm, base obtuse, cordate or truncate, apex acute to obtuse, margins sinuate, pale green to whitish beneath, sometimes with red marginal glands. Inflorescence an axillary, small, often congested irregular umbel, (1–)3–5(–7)-flowered, aggregated in a large diffuse panicle up to 40(–60) cm long, by reduction of leaves appearing terminal, elongating greatly after start of flowering; bracts and bracteoles small, fimbriate, caducous. Flowers bisexual, regular; pedicel up to 1 mm long; perianth tubular-campanulate, distinctly constricted halfway, lower part obconical, surrounding the ovary, 5-ribbed, green, upper part 5-lobed, 0.5–1.5 mm × 2 mm, red or purple, soon falling; stamens 1(–3), slightly exserted; ovary superior, seemingly inferior, 1-celled, style slightly exserted, stigma head-shaped. Fruit an achene enclosed by the thickened lower part of perianth (collectively called anthocarp); anthocarp obconical or club-shaped, (2.5–)3–3.5 mm × 1–1.5 mm, apex rounded, 5-ribbed, with rounded ribs, with glandular hairs, 1-seeded. Seed obovoid, pale brown. Seedling with epigeal germination; hypocotyl well developed; cotyledons rounded, with distinct midvein; first leaves alternate, shortly hairy, purplish beneath.



Boerhavia diffusa – 1, flowering and fruiting stem; 2, root.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Boerhavia* comprises 5–20 species, depending on the species concept, and includes several variable pantropical weeds with complex nomenclatural histories. Two views have been taken on the application of the name *Boerhavia diffusa*: a broad view regarding several *Boerhavia* taxa (including *Boerhavia repens* L. and *Boerhavia coccinea* Mill.) as a single very variable species, and a restricted concept in which *Boerhavia diffusa* is applied to the taxon with an apparently terminal panicle. This last view is followed here, but this implies that some of the literature in which the name *Boerhavia diffusa* is used may refer to other species.

Growth and development *Boerhavia diffusa* can be found flowering and fruiting throughout the year, when sufficient water is available. The first flowers may appear 4 weeks after germination of the seeds.

Ecology *Boerhavia diffusa* occurs in ruderal localities and along roadsides, preferring sunny sites and a slightly seasonal climate, from sea-level up to 1200 m altitude. It is often a weed in cultivated land, usually on sandy soils, and is also found in lawns and grazing pasture.

Propagation and planting *Boerhavia diffusa* is propagated by seed, which germinates with the start of the first rains and continues to germinate throughout the rainy season. When the soil of arable fields is turned, pieces of root can sprout as well. Well-drained soils and sunny conditions are required. The mucous coat of the anthocarp shows a distinct sticky swelling when ripe, with which it clings to mammals and birds. *Boerhavia diffusa* has been successfully propagated by in-vitro induction of adventitious roots on stem explants, leaf or shoot tip cultures.

Management *Boerhavia diffusa* is a weed of cultivated land and wasteland, often in lawns in drier areas. Although common, it is not a weed of importance. After mechanical cultiva-

tion the plant resprouts from its roots but relatively few cultivations are needed to exhaust it.

Diseases and pests In India several host-specific diseases have been identified on *Boerhavia diffusa*, i.e. *Cercospora diffusa* causing chlorotic leaf spots, and *Colletotrichum boerhaviae* causing brown necrotic spots. Also in India *Boerhavia diffusa* is recorded as a host for the virus causing aubergine mosaic disease (EMV), and in Costa Rica as a host of zucchini yellow mosaic potyvirus (ZYMV). In Cameroon *Boerhavia diffusa* is an alternative host for the cotton aphid (*Aphis gossypii*), and in Nigeria caterpillars of *Aegocera rectilinea* and *Hippotion celerio* were found feeding almost solely on *Boerhavia diffusa*.

Handling after harvest The harvested parts of *Boerhavia diffusa* are often used fresh, except for the roots, which may be dried in the sun for later use.

Genetic resources *Boerhavia diffusa* has a large area of distribution, often as a weed, and is not at risk of genetic erosion. There seems to be a geographical variation in the composition of pharmacological compounds, and more research is needed in order to evaluate the most promising populations. There are no known breeding programmes of *Boerhavia diffusa*.

Prospects Various extracts and purified compounds from *Boerhavia diffusa* show a range of pharmacological effects (in vitro and in vivo), e.g. diuretic, anti-inflammatory and hepatoprotective activities. Few clinical data, however, are available and this merits further research in order to fully evaluate its potential for future medicinal use.

Major references Burkill, 1997; Chandan, Sharma & Anand, 2004; Gilbert, 2000a; Hiruma-Lima et al., 2000; Neuwinger, 2000; Noba & Ba, 1992; Rawat et al., 1997; Satheesh & Pari, 2004; Slamet Sutanti Budi Rahayu, 2001a; Whitehouse, 1996.

Other references Abo & Ashidi, 1999; Agrawal et al., 2004; Amoako, 1991; Berhaut, 1979; Edeoga & Ikem, 2002; Gupta & Ali, 1998; Kibungo Kembelo, 2004; Lami, Kadota & Kikuchi, 1991; Latham, 2004; Leung, Busson & Jardin, 1968; Mehrotra et al., 2002a; Mehrotra et al., 2002b; Mungantiwar et al., 1999; Pari & Amarnath, 2004a; Pari & Amarnath, 2004b; Shrivastava & Padhya, 1995; Singh et al., 1991; Smith et al., 1996; Thulin, 1993c; von Koenen, 2001.

Sources of illustration Adjanohoun et al. (Editors), 1982.

Authors M. Muzila

BOERHAVIA ERECTA L.

Protologue Sp. pl. 1: 3 (1753).

Family Nyctaginaceae

Chromosome number $2n = 52$

Vernacular names Tar vine, erect spiderling (En). Mkwakwara (Sw).

Origin and geographic distribution *Boerhavia erecta* originates from the New World but now has a pantropical distribution. It occurs throughout the regions of tropical Africa with a distinct dry season, from West Africa east to Somalia and south to South Africa. It is a recent introduction in Réunion.

Uses *Boerhavia erecta* has similar properties to *Boerhavia diffusa* L., and the root is applied in India especially as a diuretic, but also as a stomachic, cardiotonic, hepatoprotective, laxative, anthelmintic, febrifuge, expectorant and, in higher doses, as an emetic and purgative. As a diuretic it is useful in cases of strangury, jaundice, enlarged spleen, gonorrhoea and other internal inflammations. In moderate doses it is successful in treatment of asthma. In Mali a decoction of the whole plant is taken to treat gastro-intestinal, liver and infertility problems, while a paste of the roots is rubbed on abscesses and ulcers to ripen them. In Niger ash of the whole plant is rubbed on the skin of the head against fungal infections. In Benin a decoction of the whole plant is taken to treat convulsions in children. In southern Sudan the roots are used in a preparation for treating the stump of a newly severed umbilical cord. Neonatal tetanus is relatively prevalent in that area and this plant is suspected of being a vehicle for the infection. In Kenya the leaves are crushed in water and the extract taken to treat diarrhoea. In Tanzania the ash of the entire plant is mixed with oil and rubbed on to treat rheumatism and scabies. The dried root is powdered and added to local beer as an aphrodisiac. Sap from the leaves is squeezed into the eye to treat conjunctivitis.

In West and East Africa the leaves are sometimes eaten as a vegetable or used for the preparation of sauces. Cattle in the Sahel graze the plant before the inflorescences have developed. At this stage it can be made into silage as well. In Benin *Boerhavia erecta* was found to be very palatable for rabbits.

Production and international trade *Boerhavia erecta* is used at a local scale, except in India where especially the roots enter in popular medicinal formulations.

Properties Despite the common medicinal

uses of *Boerhavia erecta* throughout its distribution area, information on its properties is scarce. As it is credited with similar medicinal uses to *Boerhavia diffusa*, it is likely to contain similar compounds such as the alkaloid punarnavine. The ethanol extract of the aerial parts showed strong larvicidal effect on the tick *Boophilus microplus*.

Botany Annual to short-lived perennial herb up 1 m tall, sometimes with a thick taproot; stem branching mainly from the base, ascending to erect, fleshy, green, often flushed with red, lower parts thinly hairy, upper parts glabrous, nodes swollen. Leaves opposite, simple, about equal; stipules absent; petiole 1–3.5(–4) cm long; blade broadly lanceolate to ovate, 2.5–4.5(–8) cm × 1.5–2.5(–6.5) cm, base rounded to truncate, apex rounded to acute, margins sinuate, pale green to whitish beneath, sometimes with red marginal glands. Inflorescence an axillary, small, often congested umbel, (1–)4–5(–6)-flowered, aggregated in a diffuse panicle up to 30 cm × 20 cm, by reduction of leaves appearing terminal, elongating after start of flowering; bracts and bracteoles small, caducous. Flowers bisexual, regular; pedicel 1–3 mm long; perianth tubular-campanulate, distinctly constricted halfway, lower part obconical, surrounding the ovary, 5-ribbed, green, upper part 5-lobed, 1–1.5 mm × 2 mm, lobes emarginate, white to pale pink or dotted with red, soon falling; stamens 2(–3), slightly exserted; ovary superior, seemingly inferior, 1-celled, style slightly exserted, stigma head-shaped. Fruit an achene enclosed by the thickened lower part of perianth (collectively called anthocarp); anthocarp obconical or club-shaped, 3–4 mm × 1.5–2 mm apex truncate, sharply 5-ribbed, with glabrous ribs, 1-seeded. Seed obovoid, pale brown. Seedling with epigeal germination; hypocotyl well developed, shortly hairy; cotyledons rounded, with distinct midvein; first leaves alternate, shortly hairy, purplish beneath.

Boerhavia comprises 5–20 species depending on the species concept, and includes several variable pantropical weeds with complex nomenclatural histories. *Boerhavia erecta* is propagated by seed. The mucous coat of the anthocarp shows a distinct sticky swelling when ripe, with which it clings to mammals and birds for wide dispersal. *Boerhavia erecta* can be found flowering and fruiting throughout the year, when sufficient water is available. Under favourable conditions, flowering starts 2 weeks after germination and the first seeds ripen 2 weeks later. A well-developed *Boerhavia erecta* plant can form 20,000–30,000 seeds per year.

Ecology *Boerhavia erecta* occurs in open bushland, on waste ground, in agricultural land and along roadsides, up to 1500(–2500) m altitude, usually on sandy or rocky soils. It prefers sunny localities and a seasonal climate with a pronounced dry season.

Management *Boerhavia erecta* grows well in irrigated arable land. It is a common weed in several annual and perennial crops, but causes little damage. It is easily controlled by various chemical herbicides and repeated mechanical cultivation. The harvested parts of *Boerhavia erecta* are often used fresh, except for the roots, which may be dried in the sun for later use.

Genetic resources and breeding *Boerhavia erecta* has a large area of distribution and occurs in disturbed habitats, and is therefore not at risk of genetic erosion.

Prospects *Boerhavia erecta* has a wide range of medicinal uses similar to those of its better-known relative *Boerhavia diffusa*, but research is needed to elucidate its pharmacological properties and its compounds responsible for the activities.

Major references Adjanohoun et al., 1979; Berhaut, 1979; Burkill, 1997; Gilbert, 2000a; Slamet Sutanti Budi Rahayu, 2001a.

Other references Adehan et al., 1994; Adjanohoun et al., 1989; Adjanohoun et al., 1985; Edeoga & Ikem, 2002; Geissler et al., 2002; Neuwinger, 2000; Noba & Ba, 1992; Stintzing et al., 2004; Thulin, 1993c; Whitehouse, 1996.

Authors G.H. Schmelzer

BOERHAVIA REPENS L.

Protologue Sp. pl. 1: 3 (1753).

Family Nyctaginaceae

Chromosome number $n = 52$

Vernacular names Creeping spiderling (En). Trevinha (Po). Mkwayakwaya (Sw).

Origin and geographic distribution *Boerhavia repens* has a pantropical distribution, and possibly originates from the Old World. It occurs throughout Africa, including the Mediterranean countries and South Africa, and is especially common in regions with a distinct dry season.

Uses *Boerhavia repens* is considered to have similar properties to *Boerhavia diffusa* L., and the root is applied in India especially as a diuretic, but also as a stomachic, cardiotonic,

hepatoprotective, laxative, anthelmintic, febrifuge, expectorant and, in higher doses, as an emetic and purgative. In West Africa decoctions of the roots and leaves of *Boerhavia repens* are taken in moderate doses to cure asthma, and in larger doses as an emetic, diuretic and laxative and to cure leprosy and syphilis. The roots are boiled and applied as a poultice to cure ulcers, including those resulting from guinea-worm infections, while ground roots are applied to yaws. The ground roots mixed with ground seeds of *Blighia sapida* K.D.Koenig are applied to the body to cure chicken pox. An infusion of the whole plant is taken to cure convulsions and amenorrhoea. The Yoruba people of Nigeria give an infusion as a mild laxative and febrifuge to children. The pounded plant is applied externally against dropsy. An infusion of the leaves is taken as an abortifacient, ecbolic and to cure jaundice, and the whole plant is pulped for poulticing sprains. In Central Africa a root decoction is taken as an aphrodisiac or to cure stomach-ache, while root sap is used as eye drops to treat filaria infection. In Nigeria *Boerhavia repens* is preferred over *Boerhavia diffusa* and *Boerhavia erecta* L. because it is considered the most effective.

In West Africa the leaves are sometimes prepared in a sauce as a vegetable, and the seeds are added to cereals or other food in Senegal and Mali. In Nigeria the root is added to cake and the Hausa people eat the plant as a cure for faintness due to hunger. The leafy stems are widely eaten by sheep and cattle, and may also be cut as a fodder.

Production and international trade *Boerhavia repens* is used at a local scale, except in India where the plant enters into popular medicinal formulations, in the same way as *Boerhavia diffusa* and *Boerhavia erecta*.

Properties All plant parts of *Boerhavia repens* contain flavonoid glycosides and the alkaloid punarnavine. A methanol extract of the entire plant inhibited bone resorption induced by parathyroid hormone in mouse bone tissue culture; some flavonoid glycosides were isolated as active compounds.

Botany Annual to perennial, prostrate or straggling herb, with stems up to 60 cm long, with a slender taproot; stem few- to much-branched, fleshy, green, often flushed with red, finely hairy or glabrescent, nodes swollen. Leaves opposite, simple, unequal; stipules absent; petiole 0.5–1.5 cm long; blade broadly ovate to elliptical, 1–2.5 cm × 0.5–1.5 cm, base cuneate, rounded or truncate, apex rounded to acute, margins sinuate, pale green to whitish beneath, finely hairy, glandular hairy or glabrescent. Inflorescence an axillary, congested, irregular umbel or cyme, (3–)5–7(–13)-flowered; peduncle (2–)4–7 cm long; bracts and bracteoles small, fimbriate, caducous. Flowers bisexual, regular; pedicel (0–)1–1.5 mm long; perianth tubular-campanulate, distinctly constricted halfway, lower part ellipsoid, surrounding the ovary, 5-ribbed, green, upper part 5-lobed, up to 3.5 mm × 3 mm, lobes emarginate, white, pink or mauve, soon falling; stamens (1–)2(–3), slightly exserted; ovary superior, seemingly inferior, 1-celled, style slightly exserted, stigma head-shaped. Fruit an achene enclosed by the thickened lower part of perianth (collectively called anthocarp); anthocarp obovoid to ellipsoid, 3–3.5 mm × 1.5–2 mm, apex rounded, 5-ribbed, with rounded ribs, with glandular hairs all over, 1-seeded. Seed ovoid, pale brown. Seedling with epigeal germination.

Boerhavia comprises 5–20 species, depending on the species concept, and includes several variable pantropical weeds with complex nomenclatural histories.

In West Africa the leaf pulp of *Boerhavia coccinea* Mill., which is related to *Boerhavia repens*, mixed with peanut oil is burnt and the smoke inhaled to calm toothache. An infusion of the root is taken to treat liver problems. In Nigeria the roots are ground with other herbs and taken in water as a vermifuge. The leaves are sometimes cooked and eaten as a potherb. The nomads of the Sahara cook the protein-rich seeds in a soup.

Boerhavia repens can be found flowering and fruiting throughout the year, when sufficient water is available.

Ecology *Boerhavia repens* occurs in disturbed sandy and rocky localities, often in occasionally inundated areas, such as ditches along roadsides, dry river beds, flood plains and irrigated fields, up to 1600(–1900) m altitude. *Boerhavia repens* prefers sunny sites and a seasonal climate with a pronounced dry season.

Management The harvested parts of *Boerhavia repens* are often used fresh, except for the roots, which may be dried in the sun for later use.

Genetic resources and breeding *Boerhavia repens* has a large area of distribution and occurs in disturbed habitats, and is therefore not at risk of genetic erosion.

Prospects *Boerhavia repens* has similar medicinal uses to its better-known relative *Boerhavia diffusa*, but more research is needed to elucidate its chemistry and pharmacological activities.

Major references Abbiw, 1990; Ayensu, 1978; Gilbert, 2000a; Li et al., 1996; Neuwinger, 2000.

Other references Berhaut, 1979; Burkill, 1997; Codd, 1966; Le Bourgeois & Merlier, 1995; Noba & Ba, 1992; Philcox & Coode, 1994; Thulin, 1993c; Whitehouse, 1996.

Authors M. Muzila

BRIDELIA ATROVIRIDIS Müll.Arg.

Protologue Journ. Bot. 2: 327 (1864).

Family Euphorbiaceae (APG: Phyllanthaceae)

Chromosome number $n = 13$

Vernacular names West African hardwood, Yoruba ironwood, fever leaf (En). Mkarati (Sw).

Origin and geographic distribution *Bridelia atroviridis* occurs from Sierra Leone east to Ethiopia and south to Angola and Mozambique.

Uses Throughout West Africa a bark infusion or maceration is drunk as a purgative and diuretic, to treat urethral discharges, fever, abdominal pain, dysentery, diarrhoea and rheumatic pain. The bark infusion is also used as a mouth wash to treat thrush in children and as an aphrodisiac. The leaves are also purgative and sudorific, and are taken in decoction to treat diarrhoea and fever. The leaf infusion is also used for bathing and as vapour baths. In DR Congo a bark macerate or decoction of bark scrapings is taken to treat cough, asthma and venereal diseases. The mouth is rinsed with a twig or root bark maceration to treat caries.



Bridelia atroviridis – wild

In Nigeria, DR Congo and Uganda the leaves are used as food for African silkworm larvae (*Anaphe* spp.). The wood is used in house building, for tool handles and wooden spoons, and as fuelwood. In southern Nigeria the seeds are reported to be eaten. The roots are used as chew sticks. In Togo the bark is used to produce dyes of different colours, using various mordants to achieve the desired colour.

Production and international trade In Nigeria the bark of *Bridelia atroviridis* is sold in markets in the form of pale soft pieces with weak prickles. The bark from all *Bridelia* spp. has similar medicinal uses in West Africa. In Nigeria 1 kg of bark is sold for US$ 1.30–1.50, and between 1999 and 2003 the estimated value of marketed *Bridelia* bark was c. US$ 146,000. Regional trade values are not known, but considerable amounts of bark are transported.

Properties *Bridelia atroviridis* contains triterpenes, flavonoids and tannins, but the exact chemical composition has not been determined. The total tannin content of the bark is about 31%.

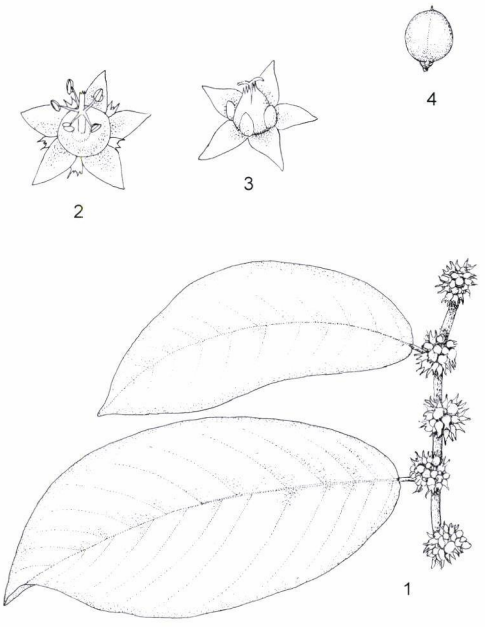
The methanol extract of the root showed toxicity to the freshwater snail *Bulinus globosus* and also reduced the number of eggs laid. The extract showed moderate toxicity to the freshwater snails *Biomphalaria glabrata* and *Archachatina marginata*. The alcohol extract of different plant parts showed depressive effects on mitotic division in onion (*Allium cepa* L.). A lyophilized leaf decoction caused a decrease of arterial pressure and a decrease of heart rate in rats. The extract did not appear to interact with adrenergic receptors or with cholinergic receptors and might act through potential-dependent calcium channels.

The aqueous leaf extract induced contractions of the isolated rat uterus in a dose-dependent manner.

The heartwood is dark brown, very hard and durable.

Adulterations and substitutes In West Africa the bark of all *Bridelia* spp. is used and traded in a similar way as that of *Bridelia atroviridis*.

Description Deciduous, much-branched, monoecious shrub or tree up to 12(–20) m tall; bole up to 45 cm in diameter; bark pale grey, smooth or rough; branches spiny, twigs brown to dark purplish brown, young shoots shortly



Bridelia atroviridis – 1, part of male flowering branch; 2, male flower; 3, female flower; 4, fruit.
Redrawn and adapted by Iskak Syamsudin

hairy to glabrous. Leaves alternate, simple and entire; stipules narrowly lanceolate, 3–8 mm long, acuminate, soon falling; petiole 2–8 mm long, shortly hairy; blade elliptical to oblanceolate, (2–)6–12(–22) cm × (1–)3–10 cm, base rounded to cuneate or almost truncate, apex acuminate, membranous, sparingly shortly hairy along the midvein, pinnately veined, with 10–22 pairs of lateral veins. Inflorescence an axillary fascicle; bracts ovate, acute, keeled, shortly hairy. Flowers unisexual, regular, 5-merous; pedicel 1–2 mm long; sepals ovate to triangular, c. 2 mm long, acuminate, greenish or pink to reddish; male flowers with obtriangular, spoon-shaped petals, c. 0.5 mm long, irregularly toothed in upper half, disk annular, entire, glabrous, staminal column c. 1 mm long, anthers c. 1 mm long, rudimentary pistil flask-shaped, c. 1 mm long, apex 2-fid; female flower with elliptical to rhombic petals c. 1 mm long, almost entire, shortly hairy, disk 3-lobed, lobes triangular, c. 1 mm long, toothed at apex, ovary superior, ovoid, 2-celled, styles 2, c. 1 mm long, stigma 2-fid. Fruit a small, ovoid drupe 6–8 mm × 5–6 mm, 1-celled by abortion, indehiscent, greenish, ripening blackish, smooth becoming rough when dry; pyrene c. 4 mm long, smooth, shiny, chestnut-brown, 1-seeded.

Other botanical information *Bridelia* is paleotropical and comprises about 50 species, of which about 15 species occur in tropical Africa and 3 in Madagascar. Most *Bridelia* spp. in Africa have medicinal uses, but they are more important for their fruit, timber or fuel. *Bridelia brideliifolia* (Pax) Fedde occurs at higher altitudes in DR Congo, Rwanda, Burundi, Uganda, Tanzania and Malawi and is only used for medicinal purposes. In DR Congo the crushed stem bark or root bark in water is given as an enema or taken orally as a purgative to treat intestinal worms. To stimulate digestion the root and twig powder is sniffed. The sap of leafy twigs is drunk to treat elephantiasis. A leaf decoction is used as an enema to hasten childbirth. An infusion of the twig bark or a leaf and root maceration is taken to treat insanity. In DR Congo and Tanzania leaf powder or cooked roots with chicken is eaten or leaf sap is used as an enema to treat female infertility. In Rwanda a leaf extract is drunk to treat gastro-intestinal problems, gastric ulcers and migraine. A leaf or bark decoction of *Bridelia ripicola* J.Léonard, endemic to DR Congo, is taken as a purgative to treat stomach-ache, diarrhoea, liver problems and also to treat female sterility. The crushed bark is used to colour pottery red. A leafy stem decoction of *Bridelia pervilleana* Baill., endemic to Madagascar, is taken to treat syphilis.

Growth and development In Benin *Bridelia atroviridis* fruits from August to November.

Ecology *Bridelia atroviridis* occurs in secondary forest, forest edges, associated bushland and thickets, also near lakes and rivers, from sea-level up to 1700 m altitude.

Propagation and planting *Bridelia atroviridis* is propagated by seed. Mature seeds are dried and stored in air-tight containers at room temperature. Two to three weeks after planting the germination rate is 50–60%. Propagation by stem cuttings is possible.

Management *Bridelia atroviridis* stands occur only in the wild; it has not been domesticated or planted on a large scale. Some wild populations are protected from destruction by annual bush fires through weeding, but further information on cultivation and management is lacking.

Harvesting Bark and fresh leaves are regularly harvested for medicinal preparations and roots for use as chew stick. Bark pieces are peeled off the bole and bark strips are removed

from branches throughout the year. Roots are harvested especially during the rainy season when the ground is soft for digging. Harvesting activities are locally done in a sustainable way, ensuring that the trees are not killed. The fruits or seeds are rarely collected.

Handling after harvest The harvested bark and roots are thoroughly sun dried for 3–4 days. After drying, the materials are packed in jute bags and stored until they can be taken to the markets.

Genetic resources In West Africa *Bridelia atroviridis* is widely harvested for its bark and for firewood production. Although some wild populations are more or less protected from bush fires, the numbers are diminishing and the genetic diversity could become threatened in the future.

Prospects The bark of *Bridelia atroviridis* is widely used for medicinal purposes and is sold in local markets. Although some pharmacological tests have been done, virtually nothing is known on the chemical composition. More phytochemical and pharmacological research is needed to evaluate the potential of the species. Silvicultural studies are needed to promote its domestication and develop management techniques.

Major references Adebisi & Ladipo, 2000; Adebisi, Ladipo & Oyeleke, 2003; Adewunmi, Segun & Ashaolu, 1983; Burkill, 1994; Corallo et al., 1997; Corallo et al., 1991; Neuwinger, 2000; Radcliffe-Smith, 1996a.

Other references Adjanohoun et al., 1989; Chifundera, 2001; Ene Obong, Nwofia & Okunji, 2001; Léonard, 1962.

Sources of illustration Carter & Radcliffe-Smith, 1988.

Authors A.A. Adebisi & D.O. Ladipo

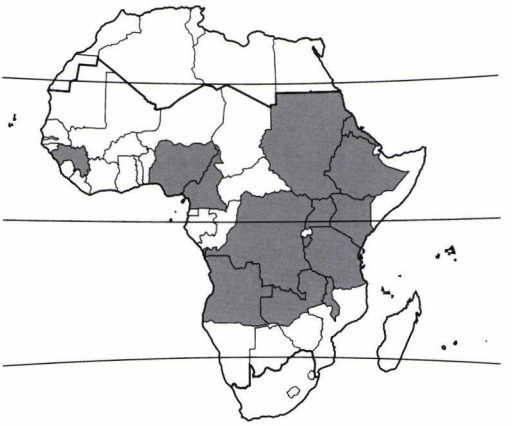
BRUCEA ANTIDYSENTERICA J.F.Mill.

Protologue Icon. anim. plant. 5: t. 25 (1779).

Family Simaroubaceae

Origin and geographic distribution *Brucea antidysenterica* occurs widely in tropical Africa, from Guinea and Nigeria east to Ethiopia and south to Angola, Malawi and Zambia.

Uses As its name suggests, *Brucea antidysenterica* is of value in traditional medicine for the treatment of dysentery. The bark, fruit and roots are widely used against dysentery, as an anthelmintic and to treat fever. The bark, fruit, seeds, leaves and roots (sometimes boiled) are used as a remedy for diarrhoea, indigestion and stomach-ache. The leaves and roots are cooked with meat, or infused with milk (for children) to relieve asthma.



Brucea antidysenterica – wild

Wounds and skin complaints, such as those caused by leprosy and scrofula, are treated with ointments made from the leaves and twigs mixed with ghee or butter, or from the ripe fruits mixed with honey. Preparations of the roots are used on sores caused by sexually transmitted diseases, while the leaves and seeds are used to treat cancerous skin tumours. The fruits, leaves and twigs are also used in ethnoveterinary medicine on skin galls and sores, and the powdered leaves to relieve bloating and colic in cattle. The roots are used to treat rabies.

In Eritrea the wood is used as firewood and for roof construction.

Properties The potent anticancer properties shown by extracts of *Brucea antidysenterica* have attracted much research attention in recent decades. Its bioactivity is attributed to the presence of quassinoid and canthin alkaloids.

Quassinoid compounds known as bruceolides, notably bruceantin and bruceanic acids, have been isolated from the leaves and stem bark. Bruceantin has shown anticancer activity against B16 melanoma, colon 38, and L1210 and P388 leukaemia in mice. However, in subsequent clinical trials no objective tumour regressions were observed and clinical development was terminated. Recently, the activity of bruceantin was studied with a number of leukaemia, lymphoma and myeloma cell lines. Treatment of HL-60 and RPMI 8226 cell lines induced apoptosis involving the caspase and

mitochondrial pathways. An in-vivo study using RPMI 8226 human-SCID xenografts demonstrated bruceantin-induced regression in early as well as advanced tumours; these responses were facilitated in the absence of overt toxicity. In addition to their antineoplastic activity, many bruceolides present in *Brucea antidysenterica* are highly effective against *Entamoeba histolytica* (IC_{50} of bruceantin = 0.018 µg/ml), and the malaria parasite *Plasmodium falciparum* (IC_{50} of bruceantin = 0.0008 µg/ml). Root extracts are reportedly active against *Plasmodium gallinaceum* in birds. Quassinoids from *Brucea antidysenterica* have exhibited weak anti-tuberculosis activity in vitro, whilst their anti-HIV potential is marred by high cytotoxicity.

Quassinoids are characteristic of the *Simaroubaceae*; they give the bark of *Brucea antidysenterica* a distinctive bitter taste

Canthin alkaloids, present in the root bark of *Brucea antidysenterica*, have anticancer and antimicrobial properties. Some of them have been produced by cell suspension cultures of *Brucea antidysenterica*.

The fruit is bitter and reportedly toxic to livestock, especially sheep. It contains about 22% oil. A yellow dye in the fruit endocarp is non-soluble in water. Crystals of calcium oxalate are present in the bark, leaves and roots.

Description Monoecious shrub or small tree up to (7–)10(–15) m tall, sometimes branching from the base; bark grey to grey-brown with heart-shaped leaf-scars; young stems terete, with red-brown hairs. Leaves alternate, usually crowded at the end of younger twigs, 10–65 cm long, imparipinnately compound with 2–6 pairs of leaflets; stipules absent; petiole up to 15 cm long, with red-brown hairs; petiolules 1–9 mm long, up to 35 mm on terminal leaflet; leaflets narrowly oblong to narrowly ovate, 3–18 cm × 1.5–8 cm, base asymmetric and rounded, apex pointed, glossy dark to pale green, with red-brown hairs. Inflorescence an axillary, erect, red-brown hairy panicle 5–35 cm long, male and female flowers in separate inflorescences in compact clusters. Flowers unisexual, regular, (3–)4(–5)-merous; pedicel 1–8 mm long; sepals almost free, oblong to ovate, 2–3 mm × c. 1.5 mm, acute, pale green, red-brown hairy; petals oblong to ovate, 1.5–3 mm × 1–1.5 mm, pale green, red-brown hairy outside; male flowers with white to pale yellow stamens; female flowers with 4–5 carpels free or joined at base, c. 1–2.5 mm × 1–3 mm, sometimes hairy, stigmas c. 1 mm long, free, bent outwards in a cruciform arrangement. Fruit composed of 1–4 drupe-like ellipsoid mericarps, 9–14 mm × 6–8 mm, apex pointed, shiny pale green, ripening yellow-orange to dark red, each mericarp 1-seeded. Seeds ovoid, 8–9 mm × 5–6 mm, apex pointed, pale brown, with a large red to dark-brown spot.



Brucea antidysenterica – flowering branch. Redrawn and adapted by Iskak Syamsudin

Other botanical information *Brucea* comprises 6 species in the Old World tropics, of which 5 occur naturally in tropical Africa. *Brucea javanica* (L.) Merr. has been introduced in DR Congo for its medicinal properties, which are similar to those of *Brucea antidysenterica*. It is found near villages and has become naturalized. The West African lowland species *Brucea guineensis* G.Don is reported to be threatened as a result of medicinal use. No details on its use are documented, but bruceantin and several other quassinoids have been isolated from the stem bark.

Growth and development Vegetative growth, flowering and fruiting of *Brucea antidysenterica* continue throughout the year, even in the dry season.

Ecology *Brucea antidysenterica* occurs in montane forests, in forest margins and commonly in secondary vegetation. It is found at altitudes of 1000–3700 m, but most frequently at 1750–2500 m altitude.

Propagation and planting *Brucea antidysenterica* can be readily propagated from seed and is sown on site. An alternative method of propagation is transplanting wildlings. Seed can be stored at room temperature for over a year.

Diseases and pests *Brucea antidysenterica* has been recorded as a host plant of the Mediterranean fruit fly, a major pest of the fruit industry.

Genetic resources *Brucea antidysenterica* is widely distributed and no threats to its genetic variability are envisaged. If demand for the bark increases, it will be worthwhile closely monitoring its status and taking protective measures against non-sustainable use, including domestication.

Prospects Bruceantin and related compounds have shown very promising anti-cancer effects. Their potency warrants further investigation as promising candidates for drug development. Bruceantin has yet to be produced synthetically. Protocols have been established for the in-vitro production of bioactive alkaloids and quassinoids from cell suspension cultures of *Brucea javanica* and there is potential for similar protocols using *Brucea antidysenterica*.

Major references Burkill, 2000; Dale & Greenway, 1961; Gillin, Reiner & Suffness, 1982; Jansen, 1981; Kokwaro, 1993; Kupchan et al., 1975; Rahman et al., 1997; Roberts, 1994; Stannard, 2000; Watt & Breyer-Brandwijk, 1962.

Other references Abebe & Hagos, 1991; Arbayah H. Siregar, 1999; Arisawa et al., 1983; Aubréville, 1959a; Chiu, Govindan & Fuchs, 1994; Cuendet & Pezzuto, 2004; Fernando, Gadek & Quinn, 1995; Fong et al., 1980; Fukamiya et al., 1987; Guru et al., 1983; Harris et al., 1985; Kupchan et al., 1973; Lemordant, 1971; Misawa, Hayashi & Takayama, 1985; Murakami et al., 2004; Odojo et al., 1981; Okano et al., 1996; O'Neill et al., 1986; Simão et al., 1991; Thomas et al., 2005.

Sources of illustration Wild & Phipps, 1963.

Authors O.M. Grace & D.G. Fowler

BULBINE ABYSSINICA A.Rich.

Protologue Tent. fl. abyss. 2: 334 (1851).

Family Asphodelaceae

Origin and geographic distribution *Bulbine abyssinica* occurs from Congo to Ethiopia and southwards to South Africa.

Uses In Botswana, South Africa and Lesotho fresh leaf sap of *Bulbine abyssinica* is applied to the skin to cure ringworm and rash. The sap is applied to wounds as a disinfectant and to promote healing. In Lesotho crushed leaves are used as a dressing for burns and leaf sap is applied to cracked lips.

Properties Anthraquinones, phenylanthraquinones and isofuranonaphthoquinones have been isolated from the roots, leaves and fruits of *Bulbine abyssinica*. The phenylanthraquinone bulbine-knipholone has been isolated from the roots. This compound showed in-vitro antiplasmodial activity, and no cytotoxic effects on mammalian cells.

Botany Tufted, perennial herb up to 70 cm tall, with short rhizome up to 1.5 cm × 1.5 cm. Leaves in a rosette, simple, erect to spreading, without stipules and petiole, terete or slightly flattened, up to 55 cm × 4 mm, fleshy, at base extending into a tubular sheath, old leaf bases persistent. Inflorescence a terminal raceme 3–18 cm long; peduncle up to 65 cm long; bracts 5–20 mm long, with a sharp point, persistent. Flowers bisexual, regular, 3-merous; pedicel c. 3 mm long at apex of inflorescence, c. 20 mm at basis of inflorescence; tepals 6, oblong, c. 6 mm × 2 mm, 1-veined, yellow; stamens 6, 3–4 mm long, densely bearded in upper third; ovary superior, 3-celled, style terete, stigma head-shaped. Fruit a globose to obovoid capsule c. 5 mm long, dehiscing loculicidally, brown to black, many-seeded. Seeds pyramidal, c. 3 mm in diameter, grey-black.

Bulbine comprises about 60 species, most of them restricted to southern Africa. *Bulbine asphodeloides* (L.) Willd., native of Mozambique, South Africa and Swaziland, has often been confused with *Bulbine abyssinica* and as their ranges overlap it is not always clear to which of the 2 species a medicinal use should be attributed. Leaf sap of *Bulbine asphodeloides* is applied to promote wound healing. A decoction of the rhizomes is drunk to cure scrophula, venereal diseases and diarrhoea. In southern Africa *Bulbine abyssinica* flowers in early summer.

Ecology *Bulbine abyssinica* occurs in small colonies in dry bushland or grassland, often on shallow soil over rock at 600–2750 m altitude.

Management *Bulbine abyssinica* is only harvested from the wild.

Genetic resources and breeding *Bulbine abyssinica* is widespread and therefore not seriously threatened by genetic erosion. In southern Africa, were the rhizomes are har-

vested and traded locally, measures should be considered to prevent overharvesting.

Prospects The ethnobotanical information on *Bulbine abyssinica* is scarce and not specific and the identification of the species is often doubtful. The presence of pharmacologically interesting compounds in *Bulbine abyssinica* and many other *Bulbine* species warrants more research.

Major references Bringmann et al., 1999; Bringmann et al., 2002; Kativu, 2001; Majinda et al., 2001; Watt & Breyer-Brandwijk, 1962.

Other references van Jaarsveld & Forster, 2001; Wanjohi et al., 2005; Whitehouse, 2002.

Authors C.H. Bosch

BULBINE CAPITATA Poelln.

Protologue Feddes Repert. 53: 37 (1944).

Family Asphodelaceae

Origin and geographic distribution *Bulbine capitata* is native to Namibia, Botswana, Zimbabwe, Swaziland, Lesotho and South Africa.

Uses In Botswana a root decoction of *Bulbine capitata* is applied to the skin to cure rashes and sexually transmitted diseases. In Lesotho it is taken orally as a mild purgative and to cure gonorrhoea.

Production and international trade In local markets in Botswana both roots and leaves of *Bulbine capitata* are sold for medicinal use.

Properties Anthraquinones, phenylanthraquinones and isofuranonaphthoquinones have been isolated from the roots and leaves of *Bulbine capitata*. Several isofuranonaphthoquinones from the roots showed antioxidant activity in a human lipoprotein oxidation assay, some of them with activity comparable to that of quercetin, a flavonoid with established antioxidant activity. These compounds also demonstrated weak antiplasmodial activities in vitro. *Bulbine capitata* is said to have antibiotic and antipyretic properties, but these remain unsubstantiated.

Botany Tufted, perennial herb up to 45 cm tall, with rhizome up to 5 cm × 1 cm. Leaves in a basal rosette, simple, erect to arching, without stipules and petiole, up to 25 cm × 2 mm, fleshy, at base extending into a tubular sheath, old leaf bases persistent. Inflorescence a terminal, densely flowered raceme 2–15 cm long; peduncle up to 25 cm long; bracts ovate, 2–10 mm long, auricled, persistent. Flowers bisexual, regular, 3-merous; pedicel up to 20 mm long at flowering, 35 mm in fruit; tepals 6, oblong-ovate, c. 7 mm × 3 mm, 1-veined, yellow; stamens 6, c. 6 mm long, densely bearded in upper third; ovary superior, 3-celled, style terete, stigma head-shaped. Fruit an ovoid capsule c. 7 mm long, dehiscing loculicidally, brown to black, many-seeded. Seeds pyramidal, 2–3 mm long, brownish black.

Bulbine comprises about 60 species, most of them restricted to southern Africa. *Bulbine narcissifolia* Salm-Dyck, a native of Botswana, South Africa and Lesotho, has several medicinal uses in South Africa. The fresh leaf sap is applied to wounds to promote healing, as a wart and corn remedy, and to cure ringworm and rash. A cold infusion of the leaves is used as a purgative. A decoction of the roots is taken to relieve rheumatic pain and to induce pregnancy. In southern Africa *Bulbine capitata* flowers in spring.

Ecology *Bulbine capitata* grows in scattered clumps in open grassland and thorn scrub on sandy soil and on rocky hillsides at about 1000 m altitude.

Management *Bulbine capitata* is only harvested from the wild.

Genetic resources and breeding There are no reports on threats to *Bulbine capitata* and harvesting of rhizomes is probably sustainable. Once demand for rhizomes increases the wild populations may need protection.

Prospects The chemistry of *Bulbine capitata* has been the subject of in-depth studies. The potential of the isolated isofuranonaphthoquinones in the development of antimalarial drugs, as well as in the development of coronary artery disease, in which the oxidation of lipoproteins is thought to play a critical role, deserves more research attention.

Major references Abegaz et al., 1999; Bezabih et al., 2001; Bezabih, Motlhagodi & Abegaz, 1997; Kativu, 2001; Majinda et al., 2001.

Other references Bezabih & Abegaz, 1998; Bringmann et al., 1999; Qhotsokoane-Lusunzi & Karuso, 2001; van Jaarsveld & Forster, 2001; Watt & Breyer-Brandwijk, 1962.

Authors C.H. Bosch

BURASAIA MADAGASCARIENSIS DC.

Protologue Syst. nat. 1: 514 (1818).

Family Menispermaceae

Origin and geographic distribution *Burasaia madagascariensis* occurs throughout eastern Madagascar, from Antsiranana in the

north to Toliara in the south. It also occurs on the Comoros, Réunion and Mauritius.

Uses A tea prepared from the roots of *Burasaia madagascariensis* is one of the oldest medicines against malaria in Madagascar, and is also used to treat enlarged spleen and hepatic affections. A decoction of the root bark is taken as a cholagogue against nausea and retching. A leaf decoction is drunk against fever and gonorrhoea.
The bitter leaves and stem bark are added to alcoholic beverages drunk during circumcision ceremonies. The fruit is edible. The root yields a bright yellow dye.

Properties From an alcohol extract of the stem N-acetylnornuciferine was isolated as were the clerodane-type diterpenes epicordatine and penianthic acid-methylester. From an alcohol extract of the wood the quaternary protoberberine alkaloids palmatine (burasaine), columbamine and jatrorrhizine were isolated. Palmatine was isolated also from the root. The root decoction has a slow-action antimalarial effect in humans. It causes a contraction of the spleen and is believed to force the *Plasmodium* parasites to stay in the bloodstream, where they can be controlled by smaller doses of chloroquine or quinine. Palmatine has mild DNA-binding properties. At high concentrations it has a very modest effect on the progression of the cell cycle, but does not promote DNA cleavage by topoisomerases.
The sap from the wood is irritant to the skin.

Botany Dioecious shrub up to 4 m tall. Leaves alternate, 3-foliolate but usually simple at stem apex; petiole 7–14 cm long, swollen and bent at the apex; petiolule up to 1 cm long; leaflets elliptical, up to 10 cm long, base cuneate, apex acuminate, pinnately veined. Inflorescence a panicle in the leaf axils or on older stems. Flowers unisexual, small, pedicellate; sepals usually 9 in 3 whorls, pale green, fleshy; male flowers c. 4 mm long, stamens 6, filaments enlarged, triangular below, fleshy; female flowers with rudimentary stamens, ovary superior, composed of 3 free carpels c. 2.5 mm long. Fruit generally a single, ovoid, fleshy drupe c. 2 cm long, 1-seeded, pale yellow to pink or orange; stone hard and brittle. Seedling with epigeal germination; cotyledons leafy and spreading.
Burasaia comprises about 5 species, all endemic to Madagascar and neighbouring islands. Revision of the genus may lead to the distinction of additional species. *Burasaia madagascariensis* is a variable species and easily confused with the other *Burasaia* spp. *Burasaia congesta* Decne. occurs in eastern Madagascar up to 1000 m altitude, *Burasaia gracilis* Decne. is endemic to northern Madagascar up to 1200 m altitude, and *Burasaia australis* Scott-Elliot is endemic to south-eastern Madagascar up to 700 m altitude. *Burasaia nigrescens* Capuron is also endemic to Madagascar. The roots of these *Burasaia* spp. are used for similar medicinal purposes as those of *Burasaia madagascariensis*. They yield a bright yellow dye. From the stem bark the protoberberine quaternary alkaloids palmatine, jatrorrhizine and columbamine were isolated, as well as clerodane diterpenes.

Ecology *Burasaia madagascariensis* is an adaptable species occurring in humid, intermediate and dry forest, from coastal sand dunes up to 1600 m altitude.

Genetic resources and breeding *Burasaia madagascariensis* is common and widespread. There are no indications that it is in danger of genetic erosion.

Prospects The antimalarial properties of *Burasaia* species were studied and active compounds have been identified. Subsequently, research was discontinued probably because alternative sources of these compounds were available. However, the interaction of the *Burasaia* alkaloids and quinine or chloroquine deserves further study.

Major references Gurib-Fakim & Brendler, 2004; Kluza et al., 2003; Mambu et al., 2002; Neuwinger, 2000; Rasoanaivo et al., 1991b.

Other references Boiteau, Boiteau & Allorge-Boiteau, 1999; de Wet, 2005; Grycova, Dostal & Marek, 2007; Ortiz, Kellogg & Van Der Werff, 2007; Rasoanaivo et al., 1999; Resplandy, 1958; Schatz, 2001.

Authors L.P.A. Oyen

CAESALPINIA BENTHAMIANA (Baill.) Herend. & Zarucchi

Protologue Ann. Missouri Bot. Gard. 77(4): 854 (1990).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae).

Synonyms *Mezoneuron benthamianum* Baill. (1866).

Origin and geographic distribution *Caesalpinia benthamiana* is widespread in West and Central Africa, where it occurs from Senegal to Gabon.

Uses In Senegal an infusion of the dried

roots is drunk or used as a bath against general malaise. In Senegal, Guinea and Nigeria a decoction of roots, bark and leaves is used to cure urethral discharge. In Guinea the young leaves are chewed as a depurative and masticatory. In Côte d'Ivoire *Caesalpinia benthamiana* stem liquid is dropped in the eye to cure inflammation and cataract. In Côte d'Ivoire and Nigeria stems and roots are used for dental hygiene, to sooth toothache and as an aphrodisiac. Leaves are applied as a paste to treat snakebites. In Senegal, Sierra Leone and Ghana wounds, skin infections, piles and ulcers are treated with a watery macerate of leafy twigs, mashed-up leaves or leaf ash. The leaves are mildly laxative and used to cure colic. Patients suffering from hookworm or guinea-worm eat the young leaves as a treatment. Patients suffering from impotence related to venereal diseases are prescribed a macerate of leafy twigs. A root decoction is drunk to cure dysentery. The roots are added to palm wine to increase the strength or its aphrodisiac properties.
In Gambia *Caesalpinia benthamiana* is grown in garden fences to make them impenetrable. When cut the stems yield drinking water.

Properties Gallic acid and gallate derivatives have been isolated from the leaves of *Caesalpinia benthamiana*. Gallic acid and its methyl ester (methylgallate) inhibit the growth of both Gram-negative and Gram-positive bacteria, but the other gallate derivatives only suppress Gram-positive bacteria. Petroleum spirit, chloroform and ethanol extracts of the roots of *Caesalpinia benthamiana* showed antimicrobial activity on a range of organisms. Also, a 4-fold and 2-fold potentiation of the activity of norfloxacin, a standard antibiotic against *Staphylococcus aureus*, was observed for the ethanol and petroleum spirit extracts, respectively. The petroleum spirit and chloroform extracts display strong free radical scavenging activity.

Botany Climbing or straggling shrub with stems up to 20 m long and up to 8 cm in diameter, armed with recurved spines. Leaves alternate, bipinnately compound, with 5–6 pairs of pinnae; stipules small, inconspicuous; petiole 5–10 cm long, swollen at base, rachis 15–20 cm long with recurved spines, especially at base of pinnae; leaflets alternate, c. 5 pairs per pinna, elliptical, 3–4 cm × 1.5–2.5 cm, base and apex rounded, glabrous. Inflorescence a branched or unbranched terminal raceme up to 20 cm long, hairy, densely flowered. Flowers bisexual, zygomorphic, 5-merous; pedicel 5–10 mm long; sepals free, unequal, the lower one hood-shaped and embracing the others; petals free, unequal, 2–2.5 cm wide, yellow, the upper one larger; stamens 10, free, c. 11 mm long, hairy; ovary superior, style slender. Fruit a linear-oblong, flattened pod c. 10 cm × 2–2.5 cm, thin, reflexed, indehiscent, winged along upper suture, wing 3–5 mm wide, bright red to pink, 4–6-seeded.
Caesalpinia is pantropical and comprises about 200 species, the majority of them native to tropical America. In tropical Africa about 25 species are indigenous, naturalized or cultivated. The generic delimitations of *Caesalpinia* have long been disputed. The former genus *Mezoneuron*, distinguished by the thin, winged pods, is now included as subgenus *Mezoneuron* within *Caesalpinia*. *Caesalpinia hildebrandtii* (Vatke) Baill. is endemic to Madagascar, and is used to counteract poison. *Caesalpinia cucullata* Roxb., a medicinal plant from Asia, has been introduced in Tanzania where it is used to cure convulsion and cramps. Piceatannol, trans-resveratrol, apigenin and scirpusin A have been isolated from it. The hydroxystilbenes piceatannol and trans-resveratrol have been shown to act as chemopreventive agents of cancer.

Ecology *Caesalpinia benthamiana* is found in humid and ruderal localities in dry deciduous woodland and savanna, but is especially common in gallery forest and on roadsides.

Genetic resources and breeding *Caesalpinia benthamiana* is widespread in disturbed habitats and is apparently not threatened by overexploitation. As the main interest is in the leaves, sustainable exploitation is feasible.

Prospects The traditional medicinal uses of *Caesalpinia benthamiana* were linked to its pharmacological properties only recently. *Caesalpinia benthamiana* and its closest relatives are potential sources of compounds that can overcome bacterial multidrug resistance, and so are likely to become or remain of interest for pharmacologists.

Major references Berhaut, 1975b; Binutu & Cordell, 2000; Burkill, 1995; Dickson et al., 2006; Keay, Hoyle & Duvigneaud, 1958.

Other references Abbiw, 1990; Adjanohoun & Aké Assi, 1979; Herendeen & Zarucchi, 1990; du Puy et al., 2002; Jain, 1991; Nihei et al., 2005b; Neuwinger, 2000; Tra Bi, Kouamé & Traoré, 2005; Wilczek et al., 1952.

Authors C.H. Bosch

CAESALPINIA BONDUC (L.) Roxb.

Protologue Fl. ind. ed. 1832, 2: 362 (1832).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Chromosome number $2n = 24$

Synonyms *Caesalpinia bonducella* (L.) Fleming (1810), nom. ill.

Vernacular names Bonduc nut, fever nut, guilandina seed, nicker nut (En). Bonduc, cadoque, cadoc, cassie (Fr). Inimbo, inimboja, nogueira de bonduque, olho de gato, silva da praia (Po). Mkomwe, mnamu, mburuga (Sw).

Origin and geographic distribution *Caesalpinia bonduc* is pantropical. It is commonly found in coastal areas of tropical Africa.

Uses Throughout the distribution area of *Caesalpinia bonduc* in Africa its leaves, bark and roots are used to cure fever, headache and chest pain and as an anthelminthic. In West Africa it is used as a rubefacient and as a tonic in the treatment of jaundice, diarrhoea and skin eruptions. At the Kenyan coast the seed and decoctions of the leaves and roots are taken to treat asthma and complications during menstruation, to avoid miscarriage, and as eye-drops to treat internal blood clots in the eye. In Tanzania the powdered kernel of the seed is taken with water to treat diabetes mellitus. In Somalia the oil from the seeds is used to treat rheumatism. A bitter extract from the seeds is known as 'poor man's quinine' and is used against malaria e.g. in India, but its use in Africa as a malaria cure has not been documented.

In tropical Asia and the Pacific Ocean islands *Caesalpinia bonduc* is an important medicinal plant as well, with largely similar uses as in Africa. In large doses it is believed to be poisonous.

In Sierra Leone and Ethiopia *Caesalpinia bonduc* is planted as a live fence. In Equatorial Guinea the oil from the seeds is used for cooking. The seeds are widely used as beads, as weights and as counters in board games.



Caesalpinia bonduc – wild and planted

Production and international trade Local trade of *Caesalpinia bonduc* seeds for medicinal use is common in tropical Africa.

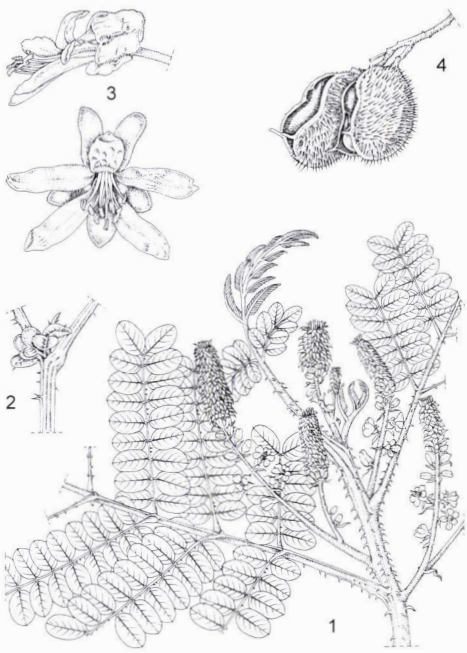
Properties The seeds of *Caesalpinia bonduc* contain the isoflavonoid bonducellin and several cassane diterpenes, including caesaldekarin A, caesalpinin B, bonducellpins A–D, α-, β-, γ-, and δ-caesalpins, and a bondenolide. Compounds isolated from the roots include caesaldekarin C and caesalpin F.

The phytochemical content of other plant parts has not yet been documented.

Several of the compounds found in the seeds, notably bonducellin and β-caesalpin, have confirmed antiplasmodial activity. Contradicting results of tests on the antiplasmodial activity may be due to faulty identification of the specimens tested. Bondenolide and seed extracts have confirmed antifungal and antibacterial activity. The effects of a leaf extract on calcium metabolism and cholinergic receptors of preparations of the isolated outer muscular layer of the uterus of pregnant rat were comparable to those obtained with acetylcholine. In normal rats, aqueous and 50% ethanolic extracts of *Caesalpinia bonduc* seeds exhibited hypoglycaemic activity and in diabetic rats, they produced a significant antihyperglycaemic effect. The aqueous extract also exhibited antihypercholesterolemic and antihypertriglyceridemic effects in streptozotocin diabetic rats. An aqueous extract of the roots, stems and leaves was found to have antiviral and anticancer activity.

The seed contains about 20% oil that is especially rich in linoleic acid (68%) and has vesicant properties.

Description Liana with stems up to 15 m long, usually armed with robust prickles. Leaves alternate, bipinnately compound, with 6–11 pairs of pinnae; stipules pinnate or 3–5-lobed, up to 20 mm long; petiole and rachis 15–80 cm long; leaflets opposite, 6–9(–12) pairs per pinna, oblong, 2–4 cm × 1–2 cm, base rounded, apex rounded to acute, shortly hairy at least on midrib and margins. Inflorescence a supra-axillary or terminal raceme or panicle 30–60 cm long, densely flowered. Flowers bisexual or functionally unisexual, zygomorphic, 5-merous;



Caesalpinia bonduc – 1, flowering twig; 2, node with stipules; 3, flowers; 4, fruits.
Source: PROSEA

sepals free, unequal, c. 5 mm × 2.5 mm, the lowest one hood-shaped; petals free, unequal, 6–7 mm × 2–3 mm, clawed, yellow, the upper one different in shape and size; stamens 10, free, c. 5 mm long, filaments hairy towards base; ovary superior, style short. Fruit an oblong, inflated pod 5–8 cm × 3–4.5 cm, dehiscent, covered with stiff, long hairy prickles, 1–2 seeded. Seeds ovoid, 1.5–2 cm in diameter, smooth, hard, pale grey. Seedling with epigeal germination; cotyledons rounded, thick.

Other botanical information *Caesalpinia* comprises about 200 species and is pantropical, most of the species occurring in tropical America. In tropical Africa about 25 species are indigenous, naturalized or cultivated. *Caesalpinia crista* L. mentioned in literature on Africa is a misapplied name and can refer to either the indigenous *Caesalpinia bonduc* or the introduced *Caesalpinia decapetala* (Roth) Alston. In tropical Africa *Caesalpinia crista* has only been recorded in the Seychelles and Mauritius and is otherwise found in the Americas, Asia, Australia and the Pacific Ocean islands. 'Brazilwood' or 'Pernambuco wood' is often associated with *Caesalpinia bonduc*, however the wood derives from an endemic of Brazil, *Caesalpinia echinata* Lam. which also yields a dye. The dyes brasilin and brasilein have only been isolated from the latter and not from *Caesalpinia bonduc*.

Growth and development *Caesalpinia bonduc* can be found flowering and fruiting throughout the year. Seeds of *Caesalpinia bonduc* float and retain their viability in water for extended periods. This explains its presence in coastal areas throughout the tropics.

Ecology *Caesalpinia bonduc* occurs especially in disturbed sites. In tropical Africa it has become naturalized around inland villages probably as a result of seeds being transported for medicinal use and for use in popular board games.

Propagation and planting *Caesalpinia bonduc* is only propagated by seed.

Management In Equatorial Guinea *Caesalpinia bonduc* has been cultivated for its seed oil.

Harvesting Mature pods of *Caesalpinia bonduc* can be collected from the plant or picked up after they have dropped. Other plant parts are harvested whenever the need arises.

Handling after harvest Seeds of *Caesalpinia bonduc* may be simply dried and stored for later use. Other plant parts are probably used fresh.

Genetic resources *Caesalpinia bonduc* is very widespread, not in danger of extinction or genetic erosion and is rare in germplasm collections.

Prospects Extracts of *Caesalpinia bonduc* show interesting pharmacological effects, e.g. modulation of cholinergic receptors and anti-hyperglycaemic activity, which merit further research.

Major references Burkill, 1995; Francis, 2003; Datte et al., 1998; du Puy et al., 2002; Ibnu Utomo, 2001; Oliver-Bever, 1986; Pakia & Cooke, 2003b; Sharma, Dwivedi & Swarup, 1997.

Other references Ali, 1973; Kinoshita, 2000; Lyder et al., 1998; Moshi & Nagpa, 2000; Peter et al., 1997; Peter et al., 1998; Simin, Khaliq-uz-Zaman & Ahmad, 2001; Stiles, 1998.

Sources of illustration Ibnu Utomo, 2001.

Authors P. Oudhia

CAESALPINIA VOLKENSII Harms

Protologue Bot. Jahrb. Syst. 45: 304 (1910).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae).

Vernacular names Msoro, mkomwe (Sw).

Origin and geographic distribution *Caesalpinia volkensii* is native to Ethiopia, Kenya, Uganda and Tanzania.

Uses *Caesalpinia volkensii* is used in Kenya and Tanzania mostly to treat malaria. In the area around Nairobi (Kenya) over 60% of the herbalists prescribe a decoction of the leaves of *Caesalpinia volkensii* to cure malaria, sometimes alone, but more often mixed with other plants. The leaf decoction is also taken to fight pains during pregnancy. Pregnant women take powdered pods dissolved in water to relieve stomach-ache. Roots are eaten cooked, raw or as an addition to palm wine for their aphrodisiac properties. They are also used to treat gonorrhoea and bilharzia. Seeds are used to cure stomach ulcers. Flower buds are crushed and applied to the eye to treat eye problems. Unspecified plant parts are used in Kenya to treat retinoblastoma. The roots are used in Tanzania as a source of red dye.

Production and international trade *Caesalpinia volkensii* used to be traded on a local scale only. Nowadays *Caesalpinia volkensii* is exported from Uganda to Kenya but quantities are unknown.

Properties In-vitro tests of leaf extracts of *Caesalpinia volkensii* showed antiplasmodial activity against chloroquine-sensitive and chloroquine-resistant strains of *Plasmodium falciparum*. Active compounds have not been reported for *Caesalpinia volkensii*.

Botany Shrub with climbing or straggling stems armed with recurved and straight prickles 2–4 mm long. Leaves alternate, bipinnately compound, with 3–6 pairs of pinnae; stipules small, c. 3 mm long, 2–3-pointed; rachis 15–50 cm long with recurved prickles, especially at base of pinnae; leaflets opposite, 3–7 pairs per pinna, ovate to ovate-elliptical, 3–8 cm × 1.5–4.5 cm, apex acuminate, glabrous. Inflorescence an unbranched or few-branched, hairy, axillary raceme, up to 20 cm long, densely flowered. Flowers bisexual, zygomorphic, 5-merous; pedicel 4–14 mm long; sepals free, unequal, the lower one hood-shaped and embracing the others; petals free, unequal, 1–1.5 cm × c. 4 mm, yellow, the upper different in shape and size; stamens 10, free; ovary superior, style slender. Fruit a broadly oblong or obovoid-ellipsoid, flattened pod up to 13 cm × 6.5 cm, covered with prickles. Seeds globose, c. 2 cm in diameter, hard.

Caesalpinia is pantropical and comprises about 200 species, the majority of them native to tropical America. In tropical Africa about 25 species are indigenous, naturalized or cultivated. Several other *Caesalpinia* spp. in tropical Africa have medicinal uses. *Caesalpinia welwitschiana* (Oliv.) Brenan is native to humid forests in Central, East and southern Africa. In DR Congo leaf sap is instilled in the nostrils to treat madness. *Caesalpinia trothae* Harms is indigenous to Ethiopia, Somalia, Kenya and Tanzania. The fruits are poisonous, but the leaves are considered a good browse for camels.

Ecology *Caesalpinia volkensii* occurs in forest and at forest margins up to 2100 m altitude.

Management *Caesalpinia volkensii* is occasionally planted near homesteads.

Genetic resources and breeding Although widespread *Caesalpinia volkensii* is apparently nowhere common. Habitat destruction and over-exploitation are potential threats. No germplasm collections are known to exist.

Prospects In view of its medicinal use *Caesalpinia volkensii* is an obvious candidate for pharmacological research. Germplasm collection and ex-situ conservation are recommended. Cultivation should be encouraged, especially in Kenya.

Major references Brenan, 1967; Graham et al., 2000; Kokwaro, 1993; Kuria et al., 2001; Thulin, 1989.

Other references Aubréville, 1970; Beentje, 1994; Chifundera, 2001; Gachathi, 1989; Greenway, 1941; Marshall, 1998; Njoroge & Bussmann, 2006; Thulin, 1993a.

Authors C.H. Bosch

CALLICHILIA BARTERI (Hook.f.) Stapf

Protologue Dyer, Fl. trop. Afr. 4(1): 133 (1902).

Family Apocynaceae

Chromosome number $2n = 22$

Synonyms *Hedranthera barteri* (Hook.f.) Pichon (1948).

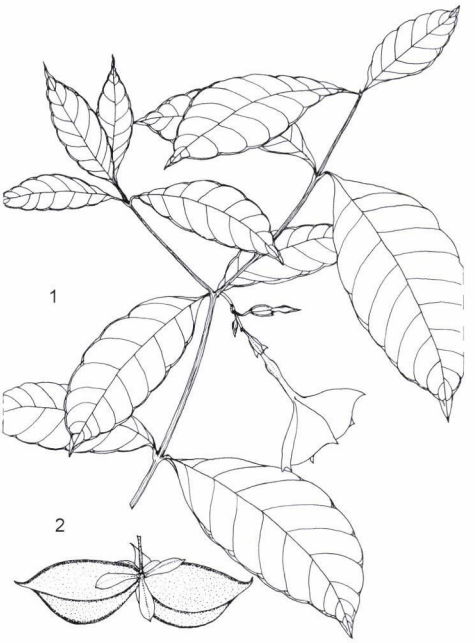
Origin and geographic distribution *Callichilia barteri* occurs in Ghana, Benin, Nigeria and Cameroon; possibly also in Congo.

Uses In Nigeria the Yoruba people use an

infusion of the leaves as a laxative for children and to treat dizziness. The leaves are applied against tumours. An extract of the fruit is taken as a vermifuge and as a treatment against gonorrhoea. The Ijo people give the fruit to teething children to bite in.

Properties The indole alkaloid lonicerine and the bisindole alkaloids vobtusine (a rare plumeran-plumeran class dimer), callichiline, beninine and amataine were isolated from the roots. Bisindole alkaloids are rare compounds in *Apocynaceae* species, and *Callichilia barteri* is an exception. Vobtusine causes hypotension as a result of peripheral vasodilatation and a direct depressant action on the heart. In moderate doses initial agitation is followed by a sedative effect; high doses may bring about convulsions and death. Vobtusine is not of clinical interest.
The methanol extract of the powdered leaves showed some antioxidant activity.

Botany Erect shrub up to 3 m tall, white latex in all parts; branches pale brown. Leaves opposite, simple and entire; stipules absent; petiole 2–10(–15) mm long; blade elliptical to narrowly ovate, 3.5–21 cm × 1–9 cm, base cuneate or decurrent into the petiole, apex acuminate, sometimes acute, papery, paler beneath. Inflorescence a cyme in the axil of deciduous scale-like bracts at the apex of a branch just below its bifurcate ramification, pendulous, 1–several-flowered; peduncle 5–35(–43) mm long; bracts few near the apex, 2–8 mm long. Flowers bisexual, regular, 5-merous, fragrant at night; sepals fused at base, broadly to narrowly obovate, 2–17 mm long, papery, with many glands at base; corolla tube cylindrical, 24–52 mm long, abruptly widening at the insertion of the stamens to a cylindrical upper part, glabrous except for 5 short hairy ridges inside extending downwards from the base of the filaments, lobes obtriangular, 11–40 mm long, with 2 apices, one acute and one rounded, white; stamens inserted up to halfway the corolla tube, included; ovary superior, consisting of 2 carpels connate at base only, surrounded by a ring-shaped disk, style slender, 9–15 mm long, consisting of 2 connate strands, pistil head 1–1.5 mm long, 5-winged, each wing touching an anther. Fruit consisting of 2, separate, ellipsoid, berry-like parts up to 5 cm long, with beak 4–10 mm long, smooth, with 2 lateral ridges, yellow to orange, dehiscent by a ventral slit, wall thin, pulp juicy, fleshy, aril very thin, 12–44-seeded. Seeds ovoid, c. 6 mm long, deeply pitted, dark brown.



Callichilia barteri – 1, flowering twig; 2, fruit. Source: Flore analytique du Bénin

Callichilia comprises 7 species in tropical Africa. Some of the uses of *Callichilia barteri* probably also apply to the closely related *Callichilia subsessilis* (Benth.) Stapf, which has a wide distribution in the forest area of West Africa.

Ecology *Callichilia barteri* occurs in rainforest, also secondary forest and in open localities, probably in humid conditions.

Genetic resources and breeding As *Callichilia barteri* is rather common in secondary forest, it is probably not in danger of genetic erosion.

Prospects The traditional uses of *Callichilia barteri* are varied and interesting, but pharmacological studies have mainly been done on the roots, which are not used. As they contain several rare bisindolic alkaloids, it might be worth analysing the aerial parts as well. The showy and fragrant flowers could make *Callichilia barteri* an interesting ornamental.

Major references Beentje, 1978; Burkill, 1985.

Other references Agwada et al., 1967; Agwada et al., 1977; Irvine, 1961; Naranjo, Hesse & Schmid, 1970; Oke & Hamburger, 2002.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors G.H. Schmelzer

CANNABIS SATIVA L.

Protologue Sp. pl. 2: 1027 (1753).

Family Cannabaceae (Cannabinaceae)

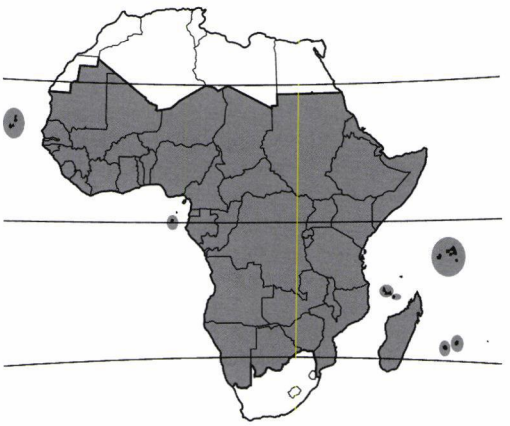
Chromosome number $2n = 20, 40, 80$

Synonyms *Cannabis indica* Lam. (1785).

Vernacular names Cannabis, hemp, marihuana, hashish (En). Chanvre, chanvre indien, cannabis (Fr). Cânhamo (Po). Mbangi (Sw).

Origin and geographic distribution Cannabis is a native of the temperate parts of Asia: near the Caspian Sea, in Iran, the Kirghiz steppe, southern Siberia and probably also the Himalayas and northern India. It escapes cultivation and naturalizes easily. Cannabis is one of the oldest non-food crops. It was already valued by the Chinese 8500 years ago. It was introduced into western Asia and Africa, and subsequently Europe in 2000–1000 BC, and cultivation in Europe became widespread from about 500 AD onwards. From Central Asia it spread eastward to China and South-East Asia. It was introduced into the Americas in the 16th century. At present it is cultivated all over the world, although in most countries, including those in Africa, cultivation as a psychotropic drug is prohibited by law.

Uses Cannabis provides several useful products: therapeutics and narcotics (flowers and leaves), fibre (stems), oil (fruit, colloquially often called seed) and food for humans and animals (fruit). It was probably first used as a source of fibre: the oldest remains of cloth made from cannabis date back 6000 years. Its cultivation for oil is more recent, but began at least 3000 years ago, and the earliest reference to narcotic use dates from 5000 years ago in China. The earliest recorded medicinal use of cannabis is found in a Chinese pharmacopoeia of 4700 years old. All parts of the plant are used in Chinese medicine and in traditional medicine in Africa. The fruits are considered useful as a tonic, alterative, emmenagogue, laxative, demulcent, diuretic, anthelmintic, narcotic and anodyne. They are prescribed for dysentery, post-partum difficulties, obstinate vomiting, and used externally on eruptions, ulcers, wounds and favus. The specially prepared fruits are prescribed for uterine prolapse, to aid parturition, and as a febrifuge. Cannabis products are used as sedative of the stomach, to treat dyspepsia with painful symptoms, cancers and ulcers. They are also used to treat migraine, neuralgia, tetanus and rheumatism.



Cannabis sativa – planted and naturalized

In western medicine, preparations rich in cannabinoids were extensively used between the middle of the 19th century and the Second World War as an anticonvulsant, analgesic, sedative and soporific, and also to treat tetanus, neuralgia, uterine haemorrhage, rheumatism, epilepsy, migraine, convulsions, spasms and pain. It was considered a milder and less dangerous analgesic than opium.

The inconsistency of its therapeutic activity, the poor shelf-life of its preparations, the difficulty in deciding optimal doses and the emergence of synthetic analgesics and hypnotics led to the use of cannabis being gradually abandoned in the first half of the 20th century, and authorized medicinal use is very limited today. In recent years, cannabis drugs have been advocated as useful for treating spasms in patients suffering from multiple sclerosis, lower intra-ocular pressure in developing glaucoma, as an analgesic in patients with rheumatism and for treating loss of appetite in AIDS patients. The best known application, however, is its use in cancer patients as a sedative and for treating side-effects of chemotherapy e.g. nausea, vomiting and convulsions, for which it is licensed in e.g. the United States and the United Kingdom. The main active compound of cannabis, Δ^9-tetrahydrocannabinol (= Δ^9-THC, dronabinol), is marketed as a medicine for these puposes.

The narcotic use varies between cultures. In Africa cannabis resin (locally known as 'dagga') has extensive ritual uses in many countries. In

India 3 types of preparations exist: 'bhang' (dried, powdered plant, made into a drink with milk or water), 'ganja' (dried flowering tips of female plants, usually smoked, sometimes eaten or drunk) and 'hashish' (crude resin scraped from the plant, which is smoked, sometimes eaten). In the western world, 'marihuana' usually refers to a preparation comprising crumbled leaves, small twigs and flowering parts of female plants, whereas 'hashish' is a stronger preparation, with more resin and little recognizable plant material. All these drugs contain resin from the glandular hairs on leaves, stems and inflorescences.

The bast fibres of cannabis (hemp) are traditionally used to make yarn, twine, rope, nets and paper, while the wooden core of the stems is used as animal bedding or fuel. Hemp yarn is mainly made by wet spinning of the long fibres. Improved yarn quality can be obtained by 'cottonization' of hemp, involving the chemical or mechanical rearrangement of bast fibres. This makes it possible to process the fibres on cotton spinning machines. However, hemp fibres and yarns currently on the market rarely meet the requirements of the textile industry with respect to fibre fineness, homogeneity, flexibility and length distribution. In Africa cannabis is not important as a fibre crop.

Cardboard can be made from hemp fibre. In the building industry, fibre and particle boards containing hemp fibre are used indoors for insulation. Hemp fibres are also used in inorganic matrix composite (IMC) technology to strengthen plaster boards, tiles, concrete, mortars and plasters. The oil in the fruits is used in cosmetics and as surfactants in detergents and can be used as a substitute for linseed oil in paints and soap. Cannabis fruits are edible, and used on a limited scale as human food, as bird and poultry feed, and as fish-bait. The press cake remaining after oil extraction is used to feed livestock.

Production and international trade Few statistics on production of cannabis for narcotic purposes exist as the cultivation, possession, preservation, transportation and trade are illegal in most countries. Cannabis drugs (herbal and resin) are by far the most commonly consumed illegal drug in the world and worldwide an estimated 161 million people used cannabis in 2003, of which 37 million in Africa. Average annual consumption is estimated at 200 g of the herbal drug or 150 g resin per user. In 2003 worldwide cannabis herb production was estimated to be more than 40,000 t, of which 30,000 t reached end users, valued at retail level at about US$ 113,000 million. Africa was a large producer (28%) with as major exporters Nigeria, South Africa, Malawi, Lesotho, Swaziland and Tanzania. The major importer is Europe, but the largest market is North America. Worldwide cannabis resin production is estimated at 7400 t, of which 6000 t reached end users, valued at retail level at about US$ 28,000 million, with northern Africa (Morocco 40%), Turkey and the Middle East (30%) as major suppliers. Major importers are Europe (78%), followed by Africa (9%) and Asia (8%). In India cannabis is cultivated for 'ganja' by a few licensed growers, and the drug is a monopoly of the Indian Government.

In 2004 world production of hemp fibre and tow was 66,000 t from 50,000 ha, of which 40,000 t was produced in Asia, mainly in China and Korea. World production of cannabis fruits in 2004 was about 30,000 t, of which 24,000 t in China.

Properties Cannabis is classified as a narcotic belonging to the psychotropic disrupters. It alters perceptions and emotions. More than 460 chemical constituents have been isolated from cannabis, and the amount of literature on their chemistry and biological activity is overwhelming. The most interesting compounds for medicinal purposes are the cannabinoids, which are mainly present in the leaves and flowering tops of female plants, and accumulate in the bracts and resin, but are absent in the fruits and stems. Cannabinoids are terpenophenolics, classified into several groups. At present, about 60 of these compounds are known, and the main representatives of each of these groups are: cannabigerol (CBG), cannabidiol (CBD), cannabichromene (CBC), cannabicyclol (CBL), cannabielsoin (CBE), cannabinol (CBN), cannabinodiol (CBDL), cannabitriol (CBTL), Δ^8-trans-tetrahydrocannabinol (Δ^8-THC) and Δ^9-trans-tetrahydrocannabinol (Δ^9-THC, sometimes also called Δ^1-THC in a different numbering system). In each group, the cannabinoids can be present either as neutral phenylmethylethers or as acidic analogues, differing only by the presence of a carboxyl group. Δ^9-THC has two acidic analogues: Δ^9-tetrahydrocannabinolic acids A and B. Acidic cannabinoids are regarded as the genuine compounds; the carboxylic group, however, is very unstable and decarboxylation readily occurs. Δ^9-THC itself is not stable either: on prolonged storage it is converted into CBN. CBD

and cannabidiolic acid are the main components of the glandular hairs (up to 15%); the remaining cannabinoids occur in smaller amounts.

In addition to cannabinoids, *Cannabis sativa* contains various other compounds: flavonoids, phenolic spiroindanes, dihydrostilbenes, dihydrophenanthrenes and spermidine alkaloids. It also contains an essential oil whose main components are β-caryophyllene, humulene, α-pinene, β-pinene, limonene, myrcene and cis-β-ocimene.

The pharmacological activity of cannabis is mainly based on Δ^9-THC; other cannabinoids seem to have less, if any, biological activity, although many of them have never been studied well. Of the two major cannabis drug-products, good quality marihuana in the 1960–1970s contained 0.1–2.7% Δ^9-THC and hashish 4–10%. In the 2000s cannabis can be much higher in THC, ranging 5–12(–31)%, but the average user seems to prefer the lower concentrations. The predominant effects of Δ^9-THC on the central nervous system in humans include analgesia and anti-emesis, as well as a 'psychological high' state with alterations in cognition and memory, and a decrease in psychomotor performance. The acute toxicity of Δ^9-THC is very low; there are no documented cases of human death caused by this component or cannabis. The initial effects caused by a common dose of inhaling one cigarette with 2% Δ^9-THC, or by oral intake of 20 mg of the purified compound e.g. in biscuits, cakes or herbal teas, are described as a feeling of well-being, euphoria and relaxation, and effects on the sensorium, sense of time, short-term memory and motivation. Δ^9-THC levels in the blood plasma are highest within 15 minutes after inhalation and maximum effects are felt 30–40 minutes later, gradually diminishing until at most 3 hours after inhalation. Bio-availability of Δ^9-THC is slower and weaker when the drug is ingested orally, but then the effects last longer. Higher doses may induce anxiety, even panic, dysphoria and hallucinations. Prolonged use in humans and in test animals leads to rapid development of tolerance. Chronic use of cannabis leads to a weak physical dependence, but psychological dependence is substantial and dependent on the user's history and personality. Chronic use may also lead to paranoid psychosis. An overdose is mainly marked by a psychotic state (anxiety, suicidal tendencies, deep mental confusion), which may last for a week. Interruption of drug intake in chronic users may cause withdrawal syndrome, which subsides in 3–4 days. Since the 1970s, many studies have been carried out to determine the impact of the use of cannabis on health, but the long-term effects are still not well known.

Cannabinoids act on the body through their action on the endogenous cannabinoid system, consisting of neurochemical substances (endogenous ligands) and specific receptors. In humans two types of endogenous cannabinoid receptors are known: CB1 and CB2. CB1 is mainly expressed in the central and peripheral nervous system, CB2 is expressed essentially in the cells of the immune system. So, CB1 is mainly involved in psychotropic effects, CB2 in immunomodulatory effects. Besides the psychological effects, cannabinoids have a vast array of other effects on, e.g. the hormonal system, cell growth and cell structures.

Although current studies suggest that cannabinoids may be useful in treating a number of human inflammatory disorders, a thorough evaluation of their immunomodulatory effects still needs to be done. Cannabinoid administration in animal models demonstrated acute alteration of multiple hormonal systems, including the suppression of sex hormones, growth hormone, prolactin hormone and thyroid hormone. The effects in humans have been inconsistent though, which can possibly partly be ascribed to the development of tolerance.

Cannabinoids have been found to affect the proliferation and growth of a variety of cell types. Reduction of cell growth and division has been observed in protozoans. Cell proliferation and growth were also reduced in HeLa cervical carcinoma cells, Lewis lung carcinoma cells and B103 neuroblastoma cells. The effects of cannabis on the gastro-intestinal propulsion and motility have been studied in detail in mice and rats. An intravenous injection of Δ^9-THC slowed the rate of gastric emptying and small intestine transit, but the effect on large bowel transit was less. A decrease in frequency of both gastric and intestinal contractions without altering the intraluminal pressure was also found. In humans, the anti-emetic effects of cannabinoids are equal to those of commonly used phenothiazines. Side-effects are common. In some studies a third of patients experienced dysphoria, and up to 80% had somnolence. Cannabis products have been reported to reduce muscle spasm and tremors in patients suffering from cerebral palsy or multiple sclerosis (MS). On the other hand, it has also been found to impair posture and balance in pa-

tients with spastic MS. Preliminary clinical trials have shown that marihuana and Δ^9-THC may help to increase food intake and slow down weight loss in cancer and AIDS patients. Cannabis has been reported to cause bronchodilation, and cannabis derivatives have been tested as anti-asthma drugs. There has been preliminary research on Δ^9-THC in the form of an aerosol spray, but other cannabinoids may also be of interest. Cannabinoids may affect the bronchi by a mechanism different from that of other anti-asthma drugs.

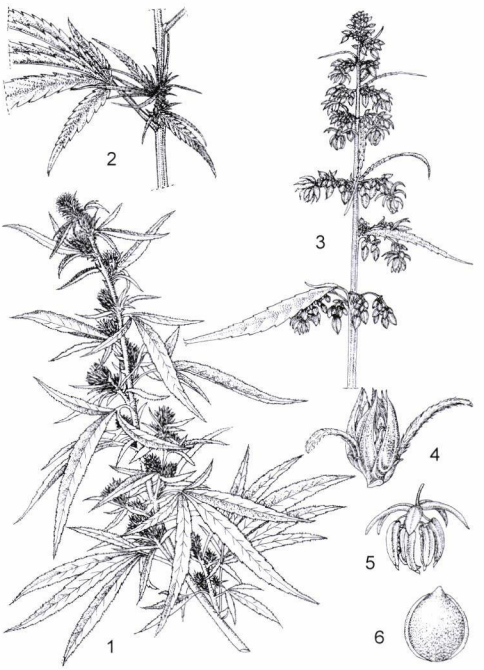
Cannabinoids can be used to slow down the development of wide-angle glaucoma, which is a major cause of blindness and is associated with high intra-ocular pressure. In a number of patients, cannabis significantly decreased this pressure for several hours. Aqueous extracts of cannabis fruits have shown strong nematicidal activity on the eggs, larvae and cysts of the nematode *Heterodera schachtii*.

The bast of the plant cultivated for fibre contains primary and secondary bast fibres rich in cellulose but low in hemicellulose and lignin. Cultivars are available containing 67% cellulose, 13% hemicellulose and 4% lignin. Primary bast fibres are 5–40 mm long and heterogenous, secondary bast fibres are smaller and more uniform with an average length of 2 mm. The woody core contains parenchyma, vessels and thick-walled short fibres with an average length of 0.55 mm. The core fibres consist of 40% cellulose, 20% hemicellulose and 20% lignin.

The fruit of cannabis contains 29–35% oil, 20–24% protein and 20–30% carbohydrates. Compounds with narcotic potential do not accumulate in the fruit but contamination may occur due to contact with the glands of flower bracts and leaves. Washing is sufficient to remove contamination. The fatty acid composition of cannabis oil is: palmitic acid 6–7%, stearic acid 3%, arachidic acid 1%, oleic acid 10–15%, linoleic acid 54–57%, omega-3-linolenic acid 15–21%, omega-6-linolenic acid 2–4% and eicosadienoic acid 0–1%.

Adulterations and substitutes Because cannabinoids have not been found in other plant species, there are no natural adulterants and substitutes. Synthetic analogues of Δ^9-THC have been developed, notably nabilone and levonantradol. They have undergone successful clinical trials, but have considerable side-effects. In 2006 the synthetic cannabinoid rimonabant was released as a medicine for a number of complaints, including obesity and drug dependency.

Description Annual erect herb up to 3(–4.5) m tall, usually branched, dioecious or sometimes monoecious, rather densely appressed-hairy when young. Leaves opposite near base of stem, arranged spirally higher up, palmately compound; stipules free, filiform or narrowly subulate, c. 5 mm long; petiole long; leaflets (3–)5–7(–11), upper leaves often with only 1 leaflet, sessile, lanceolate, 6–14 cm × 0.5–1.5 cm, base narrowed, apex long-acuminate, coarsely toothed, on the upper surface rough with short stiff hairs, on the lower surface appressed hairy, and with many sessile glands. Flowers unisexual, 5-merous, regular; male flowers in short, dense cymes, united into leafy terminal panicles, almost sessile; tepals oblong, free, c. 5 mm long, greenish white, stamens with erect linear filaments and comparatively large anthers 3–4 mm long; female flowers in spike-like fascicles, enveloped by bracts, sessile, perianth absent or present and then undivided, ovary superior, 1-celled, style up to 7.5 mm long, filiform, caducous, with 2 stigmas. Fruit a broadly ovoid, compressed achene 4–5 mm long, faintly



Cannabis sativa – 1, branch of female plant; 2, part of branch with female inflorescence; 3, part of branch of male plant; 4, part of female inflorescence; 5, male flower; 6, fruit.
Source: PROSEA

keeled on the lateral margins, smooth, shiny, yellowish or brown, closely enveloped by bracts, splitting into 2 halves, 1-seeded. Seedling with epigeal germination.

Other botanical information *Cannabis sativa* is the only species in *Cannabis*, although *Cannabis indica* L. is sometimes recognized as separate species representing the morphologically and chemically distinct drug types from Afghanistan and Pakistan. Great variation exists in *Cannabis* as a result of selection for fibre, oilseed or resin. This variation is further enhanced by the ease of crossing between these plant types making all subspecific classifications inexact. A geographical classification is in use for cultivated cannabis, in which North European, Central Russian, Mediterranean and Asiatic types are distinguished. The North European cannabis is characterized by a short stem (< 1.5 m) and early flowering. Fibre and fruit yields are generally low. Central Russian cannabis is cultivated in Europe and Asia between 50–60° latitude. Total growth duration is 90–110 days, with stems reaching 1.3–3 m in height. Fibre yields of these types are average, but high fruit yields may be obtained. Mediterranean cannabis is mainly cultivated south of 50° latitude in Europe. The total growth duration is 130–150 days, with stems reaching 2.5–4.5 m in height. Fibre production can be high and the fibre of good quality. Fruit yields are average. Asiatic type cannabis plants form branched stems of 2.5–3 m with short internodes. Growth duration is 150–170 days. For practical purposes, three types can be distinguished, based on the concentrations of Δ^9-THC and cannabidiol: the drug (resin) type, with high Δ^9-THC concentration (> 1%) and low cannabidiol content; the hemp (fibre) and seed types with very low Δ^9-THC content (< 0.3%) and high cannabidiol concentration; and the intermediate type, with moderately high concentrations of both compounds. However, concentrations may change during the growing season.

Growth and development Cannabis is normally dioecious, but monoecious cultivars have been bred; the two sexes are normally indistinguishable before flowering. In a dioecious crop, male and female plants tend to be present in similar numbers, but, depending on cultivar and growing conditions, there may be up to 50% more female than male plants. Male plants die soon after anthesis, whereas female plants live 3–5 weeks longer, until the seed is ripe. Flowers are wind-pollinated. The duration of vegetative growth of cannabis strongly depends on photoperiod and temperature. Cannabis is a quantitative short-day plant. The sensitivity to photoperiod starts after formation of a few pairs of leaves and after a certain amount of heat has been received. As a result, optimal production of fibre hemp is limited to regions with relatively long days, in which the vegetative growth phase is sufficiently long to produce long stems. The length of the flowering phase of cannabis also depends on photoperiod and temperature. At shorter daylengths and higher temperatures flowering is earlier and also more synchronized between plants and in individual plants. The degree of branching depends on propagation methods and conditions of cultivation. Cannabis has horizontal leaves, resulting in a high degree of light interception by the top of the canopy. This leads to intense shading. Although this has the advantage that weeds are suppressed, it reduces overall photosynthesis of the crop.

Ecology Cannabis requires humid tropical conditions to produce narcotic resin. For the production of fibre, temperate climates with temperatures of 15–27°C during the growing season are optimal. Cannabis thrives on moderately to very fertile soils provided there is enough water. It is suitable for alluvial soils along streams and for loamy soils.

Propagation and planting Cannabis is usually raised from seed. Seeds weigh 1.5–2.5 g/100 seeds. The seed germinates at low temperatures, but not below 1°C. It germinates after 3–7 days and early vegetative growth is often slow. Soil temperatures of 10–12°C are required for optimal crop establishment. Emergence is seriously hampered by soil compaction and water logging. Healthy seed should give 90% germination, and if properly stored it will remain viable for up to 2 years. Most modern indoor growers produce vegetatively propagated crops. Rooted cuttings from female plants develop into a uniform crop of nearly identical seedless females. As long as the material remains free of pathogens, vegetative propagation can be continued. Vegetative clones tend to have higher concentrations of Δ^9-THC than plants raised from seed, and better developed lateral branches.

Seed rate and spacing depend on the product desired. For 'ganja' production in India, seed is sown in rows 1.2 m apart at a rate of 3–5 kg/ha, followed by a thinning when the plants are 20 cm tall. For fibre production, seed is sown densely at a rate of 30–40 kg/ha, either

broadcast or in drills. For fruit production row distances of more than 1 m and inter-plant distances of 15–50 cm are used. In China seed plants are sometimes sown in clusters.

Management Weeding is rarely necessary because the dense canopy shades out most weeds. However, weeds may be a problem in the establishing crop and in gaps. Practical experience with fibre hemp on optimal soils has shown that for the production of 1000 kg stem material a fertilizer application of 15–20 kg N, 4–5 kg P_2O_5 and 15–20 kg K_2O is required. The need for nitrogen is highest during the vegetative growth phase; requirements for P and K increase gradually during vegetative growth, peaking around flowering before slowly declining again. Fibre quality is improved by increasing N, P and K contents of the plant (within certain limts), the effect being strongest for K, then P, and finally N. Cannabis is a suitable crop for rotation with almost any crop, though some problems may occur in rotations with beets, because of nematode infestations. Cannabis suppresses weeds and loosens the soil for the following crops. Moreover, root and leaf material may be left in the field to serve as organic material for the next crop. Male plants produce the best fibre and are sometimes harvested first; female plants are sometimes allowed to stand to set seed for oil production. The Asian practice of removing male plants is not because of their lower content of Δ^9-THC, but to prevent seed production in female plants, which would reduce resin production.

Diseases and pests Many diseases and pests have been described in cannabis, but few of them cause economic damage. Damping-off fungi are important because they kill germinating seeds and young seedlings. The most common leaf disease is yellow leaf spot, caused by *Septoria cannabis* and *Sclerotinia sclerotiorum*, both attacking the stems and upper leaves. *Botryotinia fuckeliana* (*Botrytis cinerea*) causes damage in high humidity conditions. In dense stands of fibre crops it attacks the stalks, whereas in hemp seed and drug crops the fungus tends to attack the female flowers because they retain moisture. *Nectria haematococca* (anamorph *Fusarium solani*) and *Thanatephorus cucumeris* (anamorph *Rhizoctonia solani*) cause root rot and may lead to losses in France and India, respectively. Cannabis may also suffer from nematodes such as *Meloidogyne hapla* in northern Europe and the stem nematode *Ditylenchus dipsaci* in southern Africa, northern America, Australia and Asia. Cannabis may be infected by the parasitic *Orobanche ramosa* L.

In cannabis crops, the most serious pests are the lepidopterous stem borers *Ostrinia nubilalis* and *Grapholitha delineana*, and several beetle larvae boring into stems and roots, e.g. *Psylliodes attenuata*, *Ceutorhynchus rapae*, *Rhinocus pericarpius*, *Thyestes gebleri* and several *Mordellistena* spp. The most important leaf-eating pests are larvae of *Autographa gamma*, *Melanchra persicariae*, *Spodoptera exigua* and *Mamestra configurata*. Flowering tops are commonly infested by budworms, such as *Helicoverpa armigera*, *Helicoverpa zea* and *Heliothis viriplaca*. Various aphids also infest cannabis and may act as a vector for viruses. The role played by terpenoid substances and exudates of cannabinoids in repelling insects has been neglected and deserves investigation. Another natural defence mechanism of cannabis, i.e. its cover of non-glandular trichomes, may serve as a mechanical defence against predators.

Harvesting How cannabis is harvested depends on the product. For 'ganja' production, male plants are pulled out as soon as they are recognized and before they shed pollen. Unfertilized female plants are left, and harvested when flower stalks begin to turn yellow, about 5 months after sowing. For the production of 'hashish', the resin is collected by men who run through the plantation in leather garments. The resin sticks to the garments and is then scraped off. Another method is to collect the resin by squeezing plant tops between the palms of the hand. Plants are harvested for fibre or seed by cutting the stems manually or by machinery. In China branched plants on the edges of the field are left for seed production.

Yield The average yield of 'ganja' in India is about 280 kg/ha. Elsewhere, average yields of 750 kg/ha on rain-fed land and 1270 kg/ha on irrigated land are mentioned. The extraction rate for resin is about 2.8%, averaging 10–45 kg/ha. Stem yields (yielding approximately 25–35% fibre) are usually between 3–8 t/ha, with a potential of 20 t/ha. When cannabis is grown solely for seed, yields of 1300–1700 kg/ha may be obtained.

Handling after harvest For the production of 'ganja', harvested inflorescences are trodden and pressed into flat cakes. For fibre production the cut stems are graded by pulling out the longest and medium stems, respectively. Short and twisted stems are not used for fibre production. Leaves are stripped off with a

knife. The stems are then dried in the field for 2–4 days. About 200 stems are bundled and immersed in water for a 3-day retting. The retted stems are dried and, if necessary, retted and dried a second time. Fibre bundles are subsequently stripped off by hand from the partly wet stems and dried on drying-lines before marketing. Another method to obtain the fibres is to dry the stems completely before breaking and combing them. The yield of fibre with the dry method is slightly higher than with the wet method; 10% versus 6% of the dry stem mass. In Europe hemp is harvested mechanically by cutting, drying in swathes on the field for a few weeks, and subsequently pressing and baling in one operation. The yield of fibre is on average 15%. The fineness of the fibre and cleanness or degree of retting are decisive for processing to ropes and textiles. Sometimes, male and female plants are therefore separated and processed differently. On modern spinning machines, in which production speeds are the determining factor, fibre length may be a limitation to the use of bast fibre. Parallel processing of the fibrous raw material is required, to prevent entanglement; this adds substantially to the costs of the fabrics. Hemp fibres may be used for paper production in which the chemical content of the fibres mainly determines the quality of the pulp. The drainability and bleachability of the pulp and sheet forming are among the many factors that determine the applicability of the pulp. For the application of fibre in composite materials the following properties are of interest: high tensile strength, rigidity, impact resistance, small volume shrinkage during curing, resistance to corrosion, low density, non-toxicity, recyclability, ease of disposal and economic price.

Genetic resources Although the N.I. Vavilov All-Russian Scientific Research Institute of Plant Industry, St. Petersburg, Russian Federation holds 450 accessions and the Institute of Crop Science (CAAS), Beijing, China 200 accessions, there has been limited preservation of germplasm of *Cannabis sativa* in gene banks because of its bad image as a narcotic. Together with the declining interest in breeding and maintaining cultivars, this has led to an impoverishment of germplasm resources. However, a large reservoir of natural variation is maintained by wild types.

Breeding Genetic variability is large. Production of large amounts of pollen and wind pollination tend to lead to extensive genetic exchange between different domesticated types and between domesticated and wild plants. Breeding has mostly focused on the creation of monoecious cultivars. In Europe breeding and selection work is directed at obtaining hemp types with a bast fibre content higher than 30% and Δ^9-THC levels below 0.3%.

Prospects Although the resin present in cannabis has been recognized to have therapeutic value, the use of cannabis as a medicinal plant is limited, mainly because it is prohibited in most countries. However, research is increasing on cannabis drugs for relieving patients suffering from diseases such as multiple sclerosis, cancer and AIDS and for the prevention of glaucoma. Since many young people smoke 'ganja' or 'marihuana', illegal cultivation of cannabis in remote areas is common and increasing. If cannabis were to become an accepted legal medicine worldwide, prospects for large-scale cultivation in tropical Africa would be good.

Hemp grown for fibre has a long history and still has good prospects, but not yet for tropical Africa where ecologically adapted cultivars are lacking. The plant fibre products have major advantages in various branches of industry. They are biocompatible and biodegradable, thereby reducing the environmental burden of waste materials. The excellent nutritional qualities of seed oil and seed protein and the ease with which it can be fitted into crop rotations may lead to an expansion of cannabis production in western countries. The research priorities include: developing ecologically adapted cultivars, determining optimal production techniques, developing field fibre extraction techniques, quantifying the relationships between production conditions, processing and fibre quality, and optimizing the management of production chains to the best use of all components of cannabis.

Major references Burkill, 1985; Grinspoon, 1995; Grotenhermen & Russo, 2002; Neuwinger, 2000; Turner, Elsohly & Boeren, 1980; UNODC, 1997; UNODC, 2005; van der Werf, 1994; Watt & Breyer-Brandwijk, 1962; Wulijarni-Soetjipto et al., 1999.

Other references Ameri, 1999; Brown & Dobs, 2002; Bruneton, 1995; Colasanti, Craig, & Allara, 1984; Croxford & Yamamura, 2005; Hillig, 2005; FAO, 2005; Gray, 1995; Guy, Whittle & Robson, 2004; Hall, Christie & Currow, 2005; Hänsel et al., 1993; McPartland, 1996a; McPartland, 1996b; Purseglove, 1968; Samuelsson, 1992; Shook & Burks, 1989;

Small, 1995; Tahir & Zimmerman, 1991; van Soest, Mastebroek & de Meijer, 1993; Wills, 1995.

Sources of illustration Wulijarni-Soetjipto et al., 1999.

Authors P.C.M. Jansen

Based on PROSEA 12(1): Medicinal and poisonous plants 1.

CAPSELLA BURSA-PASTORIS (L.) Medik.

Protologue Pfl.-Gatt. 1: 85 (1792).

Family Brassicaceae (Cruciferae)

Chromosome number $2n = 16, 32$

Vernacular names Shepherd's purse, shepherd's heart, pepper and salt, lady's purse, mother's heart, rattle pouches (En). Bourse à pasteur, bourse à berger, boursette (Fr). Bolsa de pastor (Po).

Origin and geographic distribution *Capsella bursa-pastoris* probably originated in the eastern Mediterranean area. It is more common in temperate zones than in the tropics. It currently has a worldwide distribution avoiding only the tropical lowlands. In tropical Africa it occurs at higher altitudes.

Uses *Capsella bursa-pastoris* is a prominent medicinal plant in Europe and the Mediterranean region, as well as in Latin America and Asia. The aerial parts have been used since antiquity as a haemostatic to treat internal and external haemorrhages, while a hot and bitter infusion is taken as an emmenagogue, diaphoretic, tonic, antiscorbutic, astringent, antidiarrhoeal and diuretic. It is also used in gynaecology to regulate menstruation as it constricts the blood vessels. In Ethiopia the plant is known as an abortifacient. In Rwanda ground leaves are applied as a dressing for dislocations and sprains, while the fumes of a leaf infusion in hot water are inhaled to treat colds. Mashed seeds, slightly grilled, are mixed with beer and taken to treat impotence. Indications and uses approved by Commission E are those for nosebleed, premenstrual syndrome, and wounds and burns. The species is not to be used during pregnancy. No health hazards are known with proper therapeutic dosage.



Capsella bursa-pastoris – wild

The young leaves are sometimes cooked and eaten as a vegetable; they are used fresh in salads in Rwanda and Madagascar and also in Europe and the Americas. It is even a salad crop in China. The seeds, containing 35% fatty oil, are edible as well, raw in salads, or cooked in soup. The fruits can be used as a peppery seasoning for soups and stews. One of the chemical constituents of the plant, luteolin, is a natural colouring agent (yellow or yellowish green). *Capsella bursa-pastoris* is grazed by livestock. Cows produce yellowish milk and chicken produce yellowish green egg yolks when they have eaten large amounts of the plant. It is also said to influence the taste of milk and eggs.

Production and international trade Although extracts of *Capsella bursa-pastoris* are widely used and traded as phytopharmaceuticals, no information is available on the amounts involved or the centres of production.

Properties *Capsella bursa-pastoris* contains flavonoids (including rutin, luteolin, luteolin-7-galactoside and luteolin-7-rutinoside), acids (e.g. bursic acid, fumaric acid and citric acid) and amines (e.g. acetylcholine, histamine and tyramine). The presence of tyramine and histamine might be due to fungal infection. The leaves of *Capsella bursa-pastoris* are rich in iron, calcium, nitrate and vitamin A, thiamin, riboflavin, phylloquinone and ascorbic acid. Cardioactive steroids are present presumably only in the seeds.

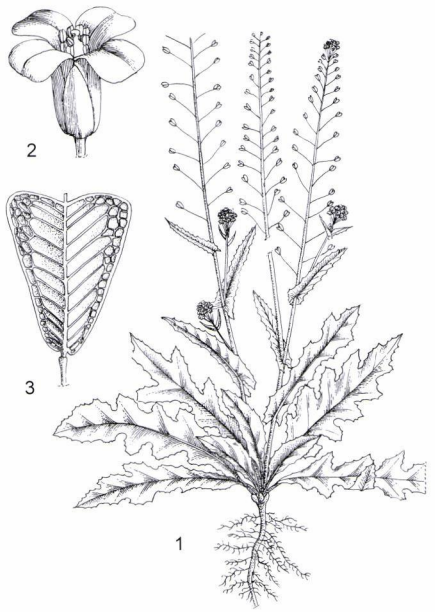
In pharmacological studies, *Capsella bursa-pastoris* has shown anti-inflammatory and diuretic actions. Intraperitoneal administration of a plant extract to rats blocked the formation of stress-induced ulcers and reduced recovery time. Antineoplastic, central nervous system depressant, and hypotensive effects have also been observed, and in-vitro tests have shown smooth-muscle stimulant effects. An extract of the whole plant produced a fall in blood pressure in dogs and rabbits, accompanied by cardiac acceleration, and caused dilata-

tion of the blood vessels in rabbits. This effect has been ascribed to acetylcholine. The toxic symptoms in mice with Ehrlich tumour that had been given mitomycin C were reduced by the administration of fumaric acid from *Capsella bursa-pastoris*.

A glucosyl flavone close to luteolin extracted from *Capsella bursa-pastoris* showed excellent antioxidative activity. Two glycine- and histidine-rich peptides, shepherin I and II, exhibited antimicrobial action against gram-negative bacteria and fungi.

A case of nitrite poisoning in pigs in South Africa has been attributed to ingestion of *Capsella bursa-pastoris*.

Description Slender, erect, annual or short-lived perennial herb up to 70 cm tall, with a taproot; stem simple or branched, angled and striate, almost glabrous to hairy. Leaves alternate, basal ones in a rosette; stipules absent; petiole short; blade very variable, from undivided and coarsely toothed to pinnatipartite, oblanceolate in outline, 3–15 cm long, base attenuate, apex rounded to acute; stem leaves few, sessile, amplexicaul, blade smaller than basal leaves, usually undivided, oblong. Inflorescence a terminal raceme up to 20 cm long. Flowers bisexual, regular, 4-merous; pedicel c. 6 mm long, elongating in fruit, up to 20 mm long; sepals c. 1.5 mm long, green, mostly pubescent; petals spatulate, 2–3 mm long, clawed, white; stamens 6, 4 longer and 2 shorter; ovary superior, dorsiventrally flattened, style c. 0.5 mm long. Fruit a heart-shaped silique, 5–10 mm × 2.5–8 mm, dehiscing by 2 net-veined valves, many-seeded. Seeds oblong, 0.5–1 × 0.5 mm, reddish to yellowish brown, with 2 longitudinal grooves, mucilaginous when wet. Seedling with epigeal germination.



Capsella bursa-pastoris – 1, plant habit; 2, flower; 3, fruit.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Capsella* comprises about 5 species, most of them from Europe. *Capsella bursa-pastoris* is extremely variable. The oldest record of *Capsella bursa-pastoris* in East Africa is from 1932 at 2600 m altitude.

Growth and development *Capsella bursa-pastoris* is a pioneer of disturbed localities and hence an opportunist species. In open localities it has a high growth rate and spreads easily, but when perennial grasses appear in the succession, it declines in abundance and disappears. It can withstand a high degree of trampling by animals. Heavy trampling may lead to rosettes with more leaves, but also to smaller plants that flower later and produce fewer seeds. Flowers are usually self-pollinated. *Capsella bursa-pastoris* is easily dispersed by wind and rain. It flowers and fruits all year round, unless the temperature drops below 5°C.

Ecology *Capsella bursa-pastoris* occurs in both urban and rural wasteland, in cultivated land and roadsides. The reported altitudinal range in Africa is 1600–2500(–3000) m. *Capsella bursa-pastoris* is found on soils ranging from clay to sandy loam with pH 5–8. It is especially frequent on fertile soils in areas of intense arable agriculture. It is more common in drier habitats than in wet ones. Its reproductive and vegetative potential is quite low in waterlogged soil, and it does not survive in extremely wet conditions. It can survive frost.

Propagation and planting The number of seeds per fruit and fruits per plant is very variable and depends on the position of the fruit on the infructescence and on habitat. Seeds remain viable for many years in the soil. They germinate at 5–30°C. Freshly matured seeds are dormant. Dormancy is easily broken by temperatures below 15°C, followed by exposure to light. Temperatures of 25–30°C and alternating temperatures accelerate

germination of non-dormant seeds. Seed stored at ambient temperatures and humidity starts to lose viability after 6 months.

Diseases and pests *Capsella bursa-pastoris* is an alternative host of several fungal diseases and insect pests of other *Brassicaceae* species. Since it often acts as a host to fungi like *Albugo candida* and *Peronospora parasitica* the presence of mycotoxins (health hazard chemicals secreted by the toxic mold) is possible. It is also host to a wide variety of plant viruses, especially seed-borne viruses.

Harvesting *Capsella bursa-pastoris* is collected from the wild, although bringing it into cultivation has been recommended to obtain higher yields. The plants can be dried rapidly in the shade at temperatures not higher than 45°C. They can be used fresh or dried, although the dried plants quickly lose their effectiveness and should not be stored for more than a year. The pungent taste is also lost by drying. During storage, *Capsella bursa-pastoris* should be protected from light and moisture.

Yield Seed production of *Capsella bursa-pastoris* under greenhouse conditions was estimated at 11,300–58,500 seeds/plant, but can be as high as 90,000 seeds/plant.

Prospects The many uses of *Capsella bursa-pastoris* in traditional medicine warrant more research attention. Its restriction in Africa to higher altitudes is a limiting factor for widespread use, both as a medicinal plant and as a vegetable.

Major references Aksoy, Dixon & Hale, 1998; Burkill, 1985; Duke, 1992; Fleming (Editor), 1998; Holm et al., 1977; Neuffer & Linde, 1999; Plants for a future, 1996–2002; Watt & Breyer-Brandwijk, 1962.

Other references Decary, 1946; Hong et al., 1995; Jansen, 1981; Jonsell, 1982a; Kuroda & Akao, 1977; Kuroda & Akao, 1980; Kuroda & Kaku, 1969; Marais, 1980a; Neuwinger, 2000; Pieroni et al., 2002; Wiese & Joubert, 2001.

Sources of illustration Holm et al., 1977.

Authors I. Vandebroek

CASSIA ABBREVIATA Oliv.

Protologue Fl. trop. Afr. 2: 271 (1871).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Vernacular names Longtail cassia, long-pod cassia, sjambok pod (En). Mbaraka, mkakatika (Sw).

Origin and geographic distribution *Cassia abbreviata* is indigenous from Gabon east to Somalia and throughout southern Africa to South Africa. It has been introduced into Mauritius.

Uses *Cassia abbreviata* has been used for many ailments. The leaves are smoked as a treatment for haematuria, whereas the smoke of smouldering twigs is inhaled to cure headache. A root infusion is kept in the mouth, or roots are chewed and swallowed to relieve toothache. A root decoction or the dried powdered roots in water are drunk to treat gastro-intestinal disorders, stomach-ache, bilharzia, venereal diseases, pneumonia, uterus complaints, heavy menstruation, snakebites, and as a purgative, stomachic, aphrodisiac, abortifacient and vermifuge. Malaria (including blackwater fever) is also treated with extracts from the roots. A water extract of the roots is used as an eyewash to cure ophthalmia. The powdered stem bark is applied to abscesses and added to food to cure diarrhoea. A decoction of the stem bark is used as a purgative and to cure malaria and diarrhoea. The seed is used as a tonic.

The wood is used to make furniture, pestles and joinery. It is termite resistant and therefore the poles are preferred for house construction. The wood is also a useful source of charcoal and firewood *Cassia abbreviata* is important in soil conservation and as a shade tree. The flowers are highly appreciated as bee forage. The stem bark is used for tanning and dyeing.

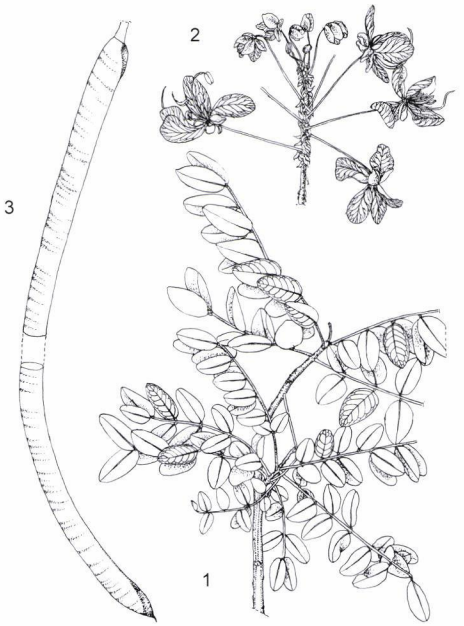
Production and international trade A decoction of *Cassia abbreviata* roots was formerly produced commercially and sold in southern



Cassia abbreviata – wild

Africa as a cure for blackwater fever and schistosomiasis. Trade of roots and bark for local use is still important in East and south-eastern Africa. Traditional healers nowadays rely on commercial traders for their supply, whereas in the past they harvested the required material themselves. High demand and destructive harvesting have led to steep price increases, at least in Malawi.

Properties From the root bark, stem bark, leaves and flowers, a number of anthraquinones, triterpenoids, flavanol derivatives and organic acids have been isolated. Extracts of both roots and leaves showed high antiplasmodial activity in vitro. Injection of crude extract of the stem bark in rats caused a drop in blood pressure which was dose-dependent. Tests on pregnant mice and rats showed no abortifacient activity of stem bark extract at doses which are not toxic to the animals. Methanol, acetone and water extracts of the stem bark showed significant inhibition against a number of gram-positive and gram-negative bacteria. Tests of a root extract showed only modest levels of cytotoxicity.
The wood is heavy and dark brown. The heartwood has a coarse texture and shows pale blotches.



Cassia abbreviata – 1, leafy branch; 2, inflorescence; 3, fruit.
Redrawn and adapted by Iskak Syamsudin

Adulterations and substitutes As a purgative *Cassia abbreviata* is often replaced by other *Cassia*, *Senna* and *Aloe* species.

Description Shrub or small tree up to 10(–15) m tall, deciduous; young twigs glabrous or hairy. Leaves arranged spirally, paripinnately compound with 5–12 pairs of leaflets; stipules linear, c. 1.5 mm long, caducous; leaflets ovate-elliptical to oblong-elliptical, 3–6 cm × 1–3 cm, base rounded to obtuse, apex obtuse to subacute. Inflorescence a terminal, lax raceme, 0.5–9 cm long, many-flowered; bracts persistent during flowering. Flowers bisexual, slightly zygomorphic, 5-merous, fragrant; sepals obtuse; petals oblanceolate to obovate, 15–35 mm × 7–18 mm, yellow; stamens 10, 3 with filaments c. 3 cm long, 4 shorter, 3 rudimentary; ovary superior, stipitate, style very short, stigma small. Fruit a pendulous cylindrical pod 30–90 cm × 1.5–2.5 cm, transversely partitioned, dehiscent by 2 valves, woody, black, many-seeded with seeds embedded in pulp. Seeds ellipsoid, 9–12 mm long, brown to black. Seedling with epigeal germination.

Other botanical information Until the early 1980s, *Cassia* was considered a very large genus of about 550 species, but was then split into 3 genera: *Cassia* s.s. with about 30 species, *Chamaecrista* and *Senna*. In *Cassia abbreviata* 3 subspecies are distinguished: subsp. *abbreviata*, subsp. *beareana* (Holmes) Brenan and subsp. *kassneri* (Baker f.) Brenan. They differ morphologically and in ecological requirements. *Cassia abbreviata* hybridizes with *Cassia burttii* Baker f., which is found in Tanzania and Mozambique. *Cassia afrofistula* Brenan has been erroneously considered synonymous with *Cassia abbreviata*; it is native to Kenya, Tanzania, Mozambique and Madagascar. Both *Cassia burttii* and *Cassia afrofistula* have similar medicinal uses in East Africa as *Cassia abbreviata*. It is probable that these 3 species have been confused.

Growth and development *Cassia abbreviata* is moderately fast growing. It has potential for intercropping as it roots deeply and probably causes only limited competition with crops for nutrients and water. Flowering occurs on the bare tree at the end of the dry season and fruits are ripe about 7 months later. *Cassia abbreviata* does not form root nodules but has a high N-content in its leaves. It has been suggested that it may fix atmospheric nitrogen in sym-biosis with ectomycorrhizas.

Ecology *Cassia abbreviata* commonly occurs in *Acacia-Commiphora* bushland and also in

woodland and wooded grassland. It is usually found on termite mounds and clayey soils. Mature trees are fire resistant, but seedlings are vulnerable. It is drought tolerant and it can withstand moderate frost.

Propagation and planting *Cassia abbreviata* is propagated by seed or wildlings. Soaking in hot water improves seed germination. Seeds germinate 4–10 days after sowing. They are sown in a sand-compost mixture (1:1) and should be kept warm and moist. It is better not to use seeding trays, but to sow seed directly into polythene bags or into the ground. Before transplanting, 1–2 weeks after sowing, root trimming is necessary because the plants develop a long taproot early.

Management Pollarding, coppicing, trimming and pruning are recommended management strategies for *Cassia abbreviata*. Overwatering results in poor flowering.

Diseases and pests The leaves of *Cassia abbreviata* are attacked by powdery mildew caused by *Phyllactinia cassiae*.

Harvesting Removal of the bark of *Cassia abbreviata* should be done in small pieces and not by ring barking, as is commonly done. Harvesting the roots is even more destructive.

Handling after harvest The harvested bark is dried in the shade for future use.

Genetic resources In Malawi and Zambia excessive cutting of the bark of *Cassia abbreviata* for medicinal use has killed many trees near homesteads. Populations in Kenya and Tanzania are also under severe pressure. Measures to protect natural stands are long overdue.

Prospects In view of the many and widespread medicinal uses of *Cassia abbreviata*, the amount of scientific research on the species is disappointing. The enormous demand for roots and bark mean that the wild populations are being depleted at a high rate. Protection measures and domestication are required urgently.

Major references Brenan, 1967; Coates Palgrave, 1983; Eriksen et al., 2005; Kayambazinthu et al., 2006; Kokwaro, 1993; Neuwinger, 2000; Otsyina & Dery, 2001; Storrs, 1979; World Agroforestry Centre, undated.

Other references Augustino & Gillah, 2005; Beentje, 1994; Chhabra, Mahunnah & Mshiu, 1987; Connelly et al., 1996; Gelfand et al., 1985; Gessler et al., 1995; Gorter & Eicker, 1987; Hogberg & Alexander, 1995; Kambizi & Afolayan, 2001; Kamuhabwa, Nshimo & de Witte, 2000; Malan et al., 1996; Mølgaard et al., 2001; Mutasa & Kahn, 1995; Ndubani & Höjer, 1999; Ndubani et al., 1998; Parry & Matambo, 1992; Parry, Mutangadura & Duri, 1992; Steenkamp, 2003; van Wyk & Gericke, 2000; von Koenen, 2001.

Sources of illustration Ross, 1977; Serrato Valenti, 1971.

Authors V. Kawanga

CASSIA ANGOLENSIS Welw. ex Hiern

Protologue Cat. afr. pl. 1: 291 (1896).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Vernacular names Mkundekunde (Sw).

Origin and geographic distribution *Cassia angolensis* occurs naturally in DR Congo, Tanzania, Malawi, Zambia, Angola and Mozambique. In South Africa it is planted as an ornamental.

Uses In Tanzania a root decoction of *Cassia angolensis* is drunk as a remedy for venereal diseases, and the fresh leaves are eaten as a cough remedy. The wood is used as firewood, as a source of charcoal and to make tool handles and spoons. The tree is planted for shade and as an ornamental.

Properties The stem bark of *Cassia angolensis* contains the anthraquinones chrysophanol, emodin and physcion.

Botany Medium-sized tree up to 25 m tall, deciduous, with straight bole; bark brown, smooth, scaling; young branches almost glabrous to shortly hairy. Leaves arranged spirally, paripinnately compound with 10–13 pairs of leaflets; stipules linear, 1.5 mm long, caducous; petiole and rachis 11–30 cm long; leaflets oblong-elliptical, 3.5–4 cm × 1.5–2 cm, apex emarginate, shortly hairy. Inflorescence an axillary raceme up to 12 cm long, c. 20-flowered; bracts soon falling. Flowers bisexual, zygomorphic, 5-merous; sepals rounded at apex; petals unequal, 2–3 cm long, golden-yellow; stamens (9–)10, the 3 lower ones largest, curved and sterile, 4 middle ones fertile, 3 upper ones rudimentary; ovary superior, linear, curved, glabrous, up to 2 cm long. Fruit a cylindrical pod up to 70 cm long, transversely partitioned, indehiscent, up to 60-seeded. Seeds compressed obovoid-cylindrical, 8–10 mm × 5–9 mm, brown. Seedling with epigeal germination.

Until the early 1980s, *Cassia* was considered a very large genus of about 550 species, but was then split into 3 genera: *Cassia* s.s. with about 30 species, *Chamaecrista* and *Senna*. *Cassia*

mannii Oliv. is very similar to *Cassia angolensis* but has white or pink petals, the leaflets are not distinctly emarginate and the margin of the leaflets is pubescent. *Cassia mannii* occurs from Côte d'Ivoire southwards to Gabon and eastwards to Sudan and Uganda. In Congo an infusion of the bark is taken to cure bronchial problems and the crushed seeds are applied to skin scarifications to treat neuralgia. The bark is used for tanning and the heartwood is handsome, hard, heavy and tough and is suitable for turning and polishing. Two other *Cassia* species occurring in the Guineo-Congolian rainforest zone, *Cassia fikifiki* Aubrév. & Pellegr. and *Cassia aubrevillei* Pellegr., are both reported to have medicinal uses. However, all uses on record are from western Côte d'Ivoire and from Liberia where *Cassia aubrevillei* does not occur and hence, the uses should probably be attributed to *Cassia fikifiki*. Water or palm-wine extracts of the stem bark and roots of *Cassia fikifiki* are drunk to treat river blindness (onchocerciasis). A decoction of the bark is used for washing leprosy patients and dry powdered bark is sprinkled on wounds to promote healing. The dried bark dissolved in palm wine is taken to cure stomach-ache. To treat dizziness ash of burned pods is mixed with water and applied to the eyelids. The bark contains chrysophanol, aloe-emodin, physcion and rhein. The alcoholic extract of the bark showed significant microfilaricidal activity in vitro. *Cassia aubrevillei* and *Cassia fikifiki* are included in the IUCN Red List of endangered species as vulnerable and endangered, respectively.

Ecology *Cassia angolensis* occurs in lowland rainforest at 800–1100 m altitude.

Management *Cassia angolensis* is only cultivated for its ornamental value.

Genetic resources and breeding As *Cassia angolensis* is fairly widespread there is no threat of genetic erosion or extinction.

Prospects *Cassia angolensis* will probably remain of local importance only as a medicinal plant.

Major references Adjanohoun & Aké Assi, 1979; Brenan, 1967; Kokwaro, 1993; Lovett et al., 2006; Southon et al., 1994.

Other references Aubréville, 1959b; Jahn, Kilian & Kraus, 1990; Kilian et al., 1990; Lock, 1990; Ross, 1977; Watt & Breyer-Brandwijk, 1962; Wilczek et al., 1952.

Authors C.H. Bosch

CASSIA FISTULA L.

Protologue Sp. pl. 1: 377 (1753).

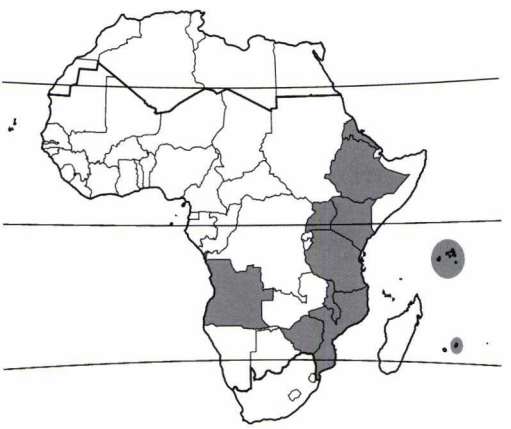
Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Chromosome number $2n = 24, 28$

Vernacular names Golden shower, Indian laburnum, golden pipetree, purging cassia, purging fistula, pudding-pipe tree (En). Canéficier, bâton casse, casse doux, casse espagnole, douche d'or (Fr). Cassia officinal, cana fistula, cássia fistula, meduro (Po). Mkundekunde (Sw).

Origin and geographic distribution *Cassia fistula* probably originates from India and Sri Lanka, but is now pantropical. The medicinal use of *Cassia fistula* dates from ancient times and has been the main factor in its spread. It is now widespread in East Africa and several of the Indian Ocean islands.

Uses The ripe pods and seeds of *Cassia fistula* are widely used as a laxative. The root-bark, leaves and flowers also have laxative properties, but to a lesser extent. In Tanzania, Zimbabwe and Mozambique *Cassia fistula* pods are used as a remedy for malaria, blood poisoning, anthrax and dysentery. In Mauritius a decoction of the pulp of the fruit is taken as a cure for kidney stones, as a vermifuge and as a laxative. In Papua New Guinea broken bones and tropical ulcers are bandaged with bark scrapings and leaf sap. In Thailand the heartwood is traditionally applied as an anthelmintic, and a decoction of the roots is applied to purify wounds and ulcers. The bark or leaves are widely applied to skin problems. In India the roots are used to treat fever. In tropical America the pods are used to treat diabetes.



Cassia fistula – planted

In modern medicine, the fruit pulp of *Cassia fistula* is sometimes used as a mild laxative in paediatrics.

Apart from its medicinal properties, *Cassia fistula* is widely planted as an ornamental, often along roads, and it provides a hard multipurpose timber. Twigs are commonly cut for forage.

The bark is used for tanning and as an ingredient in betel paste.

Production and international trade Although *Cassia fistula* pods have been traded internationally, e.g. to Europe, for centuries, no recent trade information is available.

Properties The fruit pulp and leaves of *Cassia fistula* are rich in anthraquinone derivatives (c. 2%), e.g. rhein, sennidin and related dianthrones, and sennoside (the corresponding glycoside) and related dianthroneglycosides, which are responsible for the laxative properties. In a study in Mexico, sennoside contents were found to be up to 1.5% in the leaves, and up to 1.9% in the fruits. The sugar moiety in the glycosides increases water solubility of the molecule, and thus facilitates transport to the site of action: the colon. In the colon, bacteria hydrolyze the glycosides and dianthrones to anthraquinones, a reaction which is immediately followed by the local reduction of the anthraquinones to their corresponding anthrones. The latter compounds act directly on the colon and stimulate peristalsis. In-vitro and in-vivo tests showed that seed powder of *Cassia fistula* has amoebicidal and cysticidal properties against *Entamoeba histolytica* and that it could cure intestinal and hepatic amoebiasis of laboratory animals and intestinal amoebiasis of humans. In an experiment with rats with induced hypercholesterolaemia, administration of a *Cassia fistula* pod extract caused a marked correction of the lipid metabolism and a return to normal serum levels of the transaminases GOT and GPT, and of phosphatases. The aqueous fraction of *Cassia fistula* pods produced a significant decrease in glycaemia in mice. Aqueous and methanolic bark extracts showed significant anti-oxidant activities in different in-vitro assay methods, and significant anti-inflammatory activities in both acute and chronic models using rats. An alcohol extract of *Cassia fistula* leaves showed antibacterial activity in vivo against *Staphylococcus aureus* and *Pseudomonas aeruginosa* in wounded rats and accelerated wound healing. A water extract of *Cassia fistula* leaves showed antifungal activity in vitro against the human skin pathogens *Trichophyton* spp., *Epidermatophyton floccosum* and *Microsporum ferruginum*.

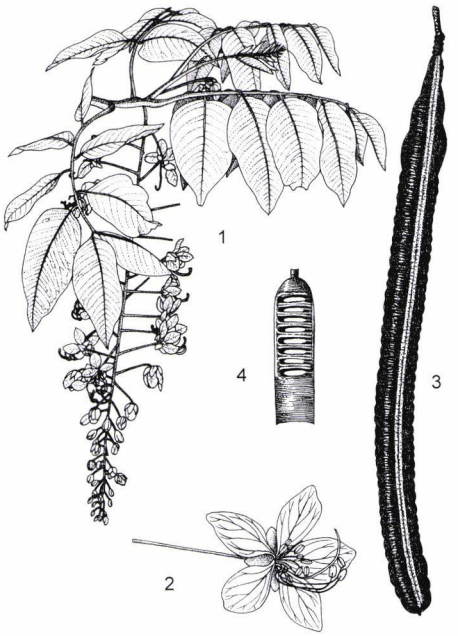
In an Indian study, the fatty acids in *Cassia fistula* seeds were: linoleic acid (52.5%), oleic acid (18.1%), palmitic acid (16%), vernolic acid (6.1%), stearic acid (3.4%), sterculic acid (2%), malvalic acid (1.5%) and myristic acid (0.4%). The fruit pulp is rich in pectins and mucilages. The water soluble gum isolated from the seeds has been evaluated for its binding properties for formulations of tablets. The gum showed overall superiority in viscosity and binding properties as compared to other binders.

The nutritive value of the forage is per 100 g dry matter: crude protein 18 g, crude fibre 30 g, ash 8 g, crude fat 8 g, N-free extract 37 g, Ca 3.3 g, P 0.3 g. The wood of *Cassia fistula* has a density of about 790 kg/m^3, with more or less straight grain and moderately coarse texture. The wood has an oven-dry energy value of 18,400 kJ/kg.

Adulterations and substitutes Anthraquinone glycosides and sennosides are also found in other *Cassia*, *Senna* and *Aloe* species, which are also used for their laxative and purgative properties.

Description Small tree up to 15 m tall, deciduous or semi-deciduous; branches spreading, young twigs glabrous. Leaves arranged spirally, paripinnately compound with 3–7 pairs of leaflets; stipules deltoid, 1–2 mm long; leaflets ovate-oblong, 7–12 cm × 4–8 cm, base broadly cuneate, apex acute, leathery, with shiny upper surface, glabrous when mature. Inflorescence an axillary, pendulous, lax raceme, 20–40(–60) cm long, 1–3 together, many-flowered; bracts soon falling. Flowers bisexual, slightly zygomorphic, 5-merous, fragrant; sepals 7–10 mm long, densely shortly hairy outside; petals broadly ovate, 30–35 mm × 10–15 mm, shortly clawed, golden–yellow; stamens 10, 3 with filaments 3–4 cm long, 4 shorter with filaments 6–10 mm long, 3 rudimentary and 3–4 mm long; ovary superior, stipitate, style long, stigma small. Fruit a pendulous cylindrical pod 20–60 cm × 1.5–2 cm, transversely partitioned, indehiscent, black, glabrous, many-seeded with seeds embedded in black, glutinous pulp. Seeds ellipsoid, 8–9 mm long, glossy brown. Seedling with epigeal germination.

Other botanical information Until the early 1980s, *Cassia* was considered a very large genus of about 550 species, but was then split into 3 genera: *Cassia* s.s. with about 30 species,



Cassia fistula – 1, branch with inflorescence; 2, flower; 3, mature fruit; 4, section of fruit showing seeds.
Source: PROSEA

Chamaecrista and *Senna*.

Growth and development *Cassia fistula* is a slow growing tree. In Singapore, *Cassia fistula* sheds its leaves at 9–10 month intervals and the inflorescences develop with the new leaves. It generally takes 8–10 years from sowing to flowering. This period can be reduced by vegetative propagation. At the beginning of flowering, the whole crown is covered with flowers; sporadic flowering continues for up to 3 months. The roots of *Cassia fistula* lack nodulating ability.

Ecology In its natural area of distribution *Cassia fistula* occurs in dry deciduous forest at lower altitudes. It is grown in areas with an annual rainfall of 500–2700 mm and average annual temperatures of 18–29°C. It tolerates some shading, is fairly drought resistant but vulnerable to frost. It seems to favour calcareous and red, volcanic soils, but is also found on sandy and loamy soils with a pH of 5.5–8.7.

Propagation and planting *Cassia fistula* can be propagated by seed and vegetatively through cuttings and layering. The seeds have a hard seed coat and germination is improved by mechanical scarification or treatment with concentrated sulphuric acid for at least 45 minutes. Seed can be stored for prolonged periods without loss of viability. *Cassia fistula* seed should be sown in full light, and adequate water supply is required for optimal germination. The seed can increase three times in weight by absorbing water. Direct sowing is practised in Asia.

Management *Cassia fistula* coppices well and produces root suckers freely. It does not compete well with weeds.

Diseases and pests In tropical Africa no diseases and pests of *Cassia fistula* have been recorded. *Colletotrichum gloeosporioides* causes brown pinhead spot disease in Malaysia. In the Philippines *Cassia fistula* is attacked by the psyllid *Heteropsylla cubana*.

Harvesting Pods of *Cassia fistula* are harvested when mature, and in general simply collected from the ground.

Yield The concentration of sennoside in the leaves of *Cassia fistula* is highest soon after the onset of the rainy season, when new leaves have appeared and flowering started. The sennoside content of the pods is highest at the mid-stage of fruit maturation, when the pods are pale brown.

Handling after harvest For domestic use of *Cassia fistula*, the pulp is scraped from the fresh pods. Pods intended for trade are dried. Prolonged boiling of the pulp leads to loss of the purgative properties.

Genetic resources In view of its wide distribution and cultivation, *Cassia fistula* is not endangered. The International Institute for Tropical Agriculture, Ibadan, Nigeria maintains a germplasm collection.

Prospects *Cassia fistula* is an interesting multipurpose tree for African farmers, and has a high ornamental value. With regard to frequent use of *Cassia* as laxative, caution seems to be needed. The hypocholesterolaemic, antifungal and anti-amoebic properties warrant further research. The seeds of *Cassia fistula* are a potential commercial source of seed gum, a potential binder for the pharmaceutical industry.

Major references Asseleih, Hernandez & Sanchez, 1990; Babeley & Kandya, 1988; Bruneton, 1999; El-Saadany et al., 1991; Gurib-Fakim, Guého & Bissoondoyal, 1995; Phongpaichit et al., 2004; Shukla & Das, 1988; Toruan-Purba, 1999a; Watt & Breyer-Brandwijk, 1962; World Agroforestry Centre, undated.

Other references Burkill, 1995; Göhl, 1981;

Ilavarasan, Mallika & Venkataraman, 2005; Khanna & Arora, 1984; Masih & Singh, 2005; Monif, Malhotra & Kapoor, 1992; Senthil Kumar et al., 2006; SEPASAL, 2006a; Thulin, 1989.

Sources of illustration Toruan-Purba, 1999a.

Authors C.H. Bosch

Based on PROSEA 12(1): Medicinal and poisonous plants 1.

CASSIA SIEBERIANA DC.

Protologue Prodr. 2: 489 (1825).

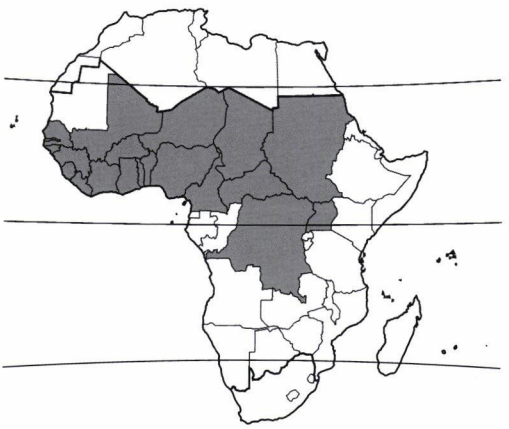
Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Chromosome number $2n = 26, 28$

Vernacular names West African laburnum, African laburnum, drumstick tree (En). Casse du Sénégal, casse de Sieber, casse à grappes, casse-flûte (Fr). Mossué, cana fístula, cacafistula (Po). Mzangaya, mzangaye (Sw).

Origin and geographic distribution *Cassia sieberiana* is distributed from Senegal and Gambia east to DR Congo and Uganda.

Uses Leaves, roots and pods of *Cassia sieberiana* are widely used in traditional medicine. The entire plant is purgative and diuretic. In Senegal an infusion of the entire plant is given against all children's diseases. In Uganda powder of different plant parts is applied to teeth to cure toothache; when mixed with butter it is used to treat skin diseases. In Senegal and Burkina Faso a steam bath of leafy twigs boiled in water is prescribed to help against malaria attacks and fever; the liquid should also be drunk. An infusion of the leaves sweetened with honey is taken against stomachache, ulcers and diarrhoea. Boiled and squeezed fresh leaves are applied as poultice in pleurisy or burns. Gonorrhoea in women is treated by taking leaf powder with food. In Benin the twigs are used to treat sleeping sickness.



Cassia sieberiana – wild

The roots, boiled in water, are used to treat haemorrhoids, bilharzia, leprosy, dropsy and bloody dysentery. In Côte d'Ivoire the decoction is taken in large doses to treat intestinal worms including tapeworms, although this is risky. An infusion of the root bark is employed against venereal diseases, sterility and dysmenorrhoea. After soaking the roots in water, the liquid is used for a bath against tiredness and for body massage. A decoction of the roots is considered an aphrodisiac. In Burkina Faso a pinch of powdered dried decorticated roots taken at the end of each meal is said to prevent malaria. Crushed roots are rubbed on the temples to treat headache. Debarked roots are boiled with bark of *Terminalia macroptera* Guill. & Perr. to combat eczema. In Burkina Faso capsules made from the root bark are prescribed against Aids. The yellow pulp around the seeds and an infusion of the pods is taken as a laxative. In Uganda diarrhoea, dysentery and vomiting are treated by a decoction of bark, leaves or roots. The roots and seeds are used as fish poison in Côte d'Ivoire and Nigeria.

The wood is suitable for making furniture, tools, construction and railway sleepers. It is used as firewood, but it is considered inferior because it produces a lot of smoke. The root wood is used in Sierra Leone and Burkina Faso as chewsticks. The tree is planted as an ornamental and as an avenue tree.

Production and international trade Bark and roots of *Cassia sieberiana* are commonly sold in local markets. The pods are locally traded, especially as vermifuge. The Centre National de Semences Forestières in Ouagadougou, Burkina Faso sells the seeds at US$ 45–55/kg.

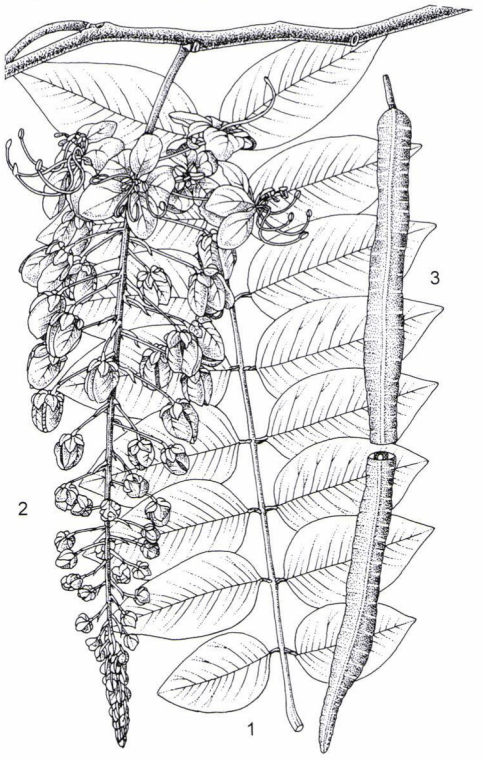
Properties *Cassia sieberiana* contains calcium oxalate in abundance. The leaves contain flavones (quercitrin, isoquercitrin), an anthraquinone (rhein) and tannins (11%). The roots contain tannins (up to 17%), anthraquinones and sterols. The purgative action can be ascribed to the anthraquinones. The flavones cause diuresis and have antibacterial and anti-inflammatory activity. An assay for antiviral activity against *Herpes simplex* virus type 1 (HSV-1) showed that *Cassia sieberiana*

extracts had a significant activity against this virus. In-vitro tests only showed a low activity of the extracts against trypanosomes. Leaf extracts were found to be active against *Staphylococcus lutea*, *Mycobacterium phlei*, *Bacillus subtilis* and *Proteus* sp., but not against *Staphylococcus albus*, *Pseudomonas aeruginosa* or *Escherichia coli*.

The termite-resistant wood changes from white or yellowish-pinkish to dark red upon exposure. It is finely textured, heavy, hard and difficult to work.

Adulterations and substitutes As a laxative *Cassia sieberiana* is often substituted by *Cassia fistula* L., *Senna podocarpa* (Guill. & Perr.) Lock and *Senna alexandrina* Mill. pods.

Description Shrub or small tree up to 15(–20) m tall; bole short, twisted; bark fissured, grey to brown, with blackish stripes; young branches densely shortly hairy. Leaves arranged spirally, paripinnately compound with 5–14 pairs of leaflets; stipules narrowly triangular, c. 2 mm long, caducous; leaflets elliptical to ovate, 3.5–10 cm × 2–5 cm, apex rounded to acute, shortly hairy. Inflorescence an axillary pendulous raceme up to 35(–45) cm long; bracts soon falling. Flowers bisexual, slightly zygomorphic, 5-merous; sepals elliptical, 5–8 mm long, slightly hairy; petals oblong to almost circular, 2–3.5 cm long, bright yellow; stamens 10, free, 3 lower ones fertile, hooked at base, much longer than the petals, 4 middle ones fertile, short, 3 upper ones rudimentary; ovary superior, sessile, style slender, much longer than the petals. Fruit a, cylindrical pod 40–60(–90) cm × c. 1.5 cm, transversely partitioned, dehiscent by 2 valves, black, many-seeded with seeds embedded in yellow pulp. Seeds ellipsoid, 8–9 mm long, rusty to dark brown, glabrous. Seedling with epigeal germination.



Cassia sieberiana – *1, leaf; 2, inflorescence; 3, fruit.*
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information Until the early 1980s, *Cassia* was considered a very large genus of about 550 species, but was then split into 3 genera: *Cassia* s.s. with about 30 species, *Chamaecrista* and *Senna*.

Anatomy Wood-anatomical description (IAWA hardwood codes):

Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal; 26: intervessel pits medium (7–10 µm); (27: intervessel pits large (≥ 10 µm)); 29: vestured pits; 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 42: mean tangential diameter of vessel lumina 100–200 µm; 43: mean tangential diameter of vessel lumina ≥ 200 µm; 46: ≤ 5 vessels per square millimetre; 47: 5–20 vessels per square millimetre; (58: gums and other deposits in heartwood vessels). Tracheids and fibres: 61: fibres with simple to minutely bordered pits; (65: septate fibres present); 66: non-septate fibres present; 69: fibres thin- to thick-walled. Axial parenchyma: 80: axial parenchyma aliform; 81: axial parenchyma lozenge-aliform; 82: axial parenchyma winged-aliform; 83: axial parenchyma confluent; 85: axial parenchyma bands more than three cells wide; 91: two cells per parenchyma strand; (92: four (3–4) cells per parenchyma strand). Rays: (96: rays exclusively uniseriate); (97: ray width 1–3 cells); 104: all ray cells procumbent; 116: ≥ 12 rays per mm. Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells.

(N.P. Mollel, P. Détienne & E.A. Wheeler)

Growth and development In West Africa *Cassia sieberiana* flowers in March–April, just before the rainy season when the trees are leafless. In Uganda flowering is in June–August, during the rainy season, when new leaves have formed. The fruits ripen in August–October in West Africa and in September–February in Uganda. *Cassia sieberiana* does not form root nodules.

Ecology *Cassia sieberiana* occurs in tree or shrub savanna with less than 800 mm annual rainfall. Acid sandy soil is preferred.

Propagation and planting *Cassia sieberiana* is mainly propagated by seed. Ripe, fresh seeds have nearly 100% viability. One kg contains 7,000–16,500 seeds. Treatment with sulphuric acid is recommended before sowing older seeds. Passage of seeds through cattle intestines also hastens germination, and enhances the distribution of seeds in grazed areas. Marcotting and side-grafting are feasible for vegetative multiplication.

Management *Cassia sieberiana* is one of the constituents of the vegetation of fallow fields in the Sahel, but unlike *Parkia biglobosa* (Jacq.) R.Br. ex G.Don (African locust bean) and *Vitellaria paradoxa* C.F.Gaertn. (shea butter tree) it is eradicated during clearing. When planted for the wood it can be left after cutting to produce at least one more ratoon.

Diseases and pests *Cassia sieberiana* is a host of the groundnut bruchid (*Caryedon serratus*), a major storage pest of groundnut, and of the bean flower thrips (*Megalurothrips sjostedti*), a pest of several pulse crops.

Harvesting Pods of *Cassia sieberiana* are harvested by hand and the seeds are extracted manually as well. For harvesting the roots, the plant has to be dug up.

Handling after harvest The seeds need to be stored in a dry place. Storage in the pods is also feasible, but in that case extra care must be taken to prevent insect damage.

Genetic resources *Cassia sieberiana* is rather common and does not seem to be endangered. However, uprooting is detrimental for the population and is reason for concern in Burkina Faso.

Prospects In view of the numerous local uses of *Cassia sieberiana* more clinical tests seem warranted. Quality control and measures for sustainable utilization are needed. Interest in the species as an ornamental is growing. Use as a pot plant in temperate zones seems to be possible.

Major references Arbonnier, 2004; Atindehou et al., 2002; Aubréville, 1970; Brenan, 1967; Burkill, 1995; Hoët et al., 2004b; Inngjerdongen et al., 2004; Neuwinger, 2000; Silva et al., 1997a; von Maydell, 1983.

Other references Adam, Echard & Lescot, 1972; Adjanohoun & Aké Assi, 1979; Adjanohoun et al., 1979; Adjanohoun et al., 1985; Berhaut, 1975b; Boussim et al., 2004; Elojuba, Abere & Adelusi, 1999; Hegnauer & Hegnauer, 1996; InsideWood, undated; Keay, 1989; Kokwaro, 1993; Nacoulma-Ouédraogo & Millogo-Rasolodimby, 2002; Nacro & Millogo-Rasolodimbi, 1993; Neuwinger, 1998; Nikiéma et al., 2004; Paris & Etchepare, 1967; Sembène & Delobel, 1998; SEPASAL, 2006b; Taïta, 2000.

Sources of illustration Keay, 1989.

Authors L.J.G. van der Maesen

CATHARANTHUS LANCEUS (Bojer ex A.DC.) Pichon

Protologue Mém. Mus. natl. Hist. nat., Paris n.s. 27: 237 (1949).

Family Apocynaceae

Chromosome number $2n = 16$

Vernacular names Lance-leaf periwinkle (En).

Origin and geographic distribution *Catharanthus lanceus* is endemic to Madagascar, where it occurs mainly in the central part.

Uses A root decoction of *Catharanthus lanceus* is taken against toothache or fever, and as a purgative, contracting agent and vermifuge. The leaves are bitter, astringent and emetic. A decoction of the aerial parts is taken to stimulate the flow of breast milk. It is also taken as an anodyne, diuretic and general tonic. Externally, the decoction is applied against several skin problems and as a haemostatic.

Production and international trade *Catharanthus lanceus* is used locally, but is also exported as a medicinal plant, although no details of destination or amounts traded are known.

Properties Several pharmacologically active alkaloids have been isolated from the aerial parts of *Catharanthus lanceus*, e.g. leurosine, perivine, yohimbine, cathanneine, tetrahydroalstonine, leurocristine, periformyline, vincristine and vindolinine.

The alkaloid fractions of *Catharanthus lanceus* have shown hypotensive activity. The main active compound is yohimbine, a potent α–adrenergic blocker, but several other com-

pounds play a role as well. A lyophilized aqueous extract was found to show anti-tumour activity, with leurosine as the most potent compound. Some alkaloids have a hypoglycaemic effect. Leurocristine, perivine, periformyline and vincristine show antiviral activity in vitro against some human pathogens.

Botany Perennial decumbent herb up to 1 m tall, with white latex; taproot carrot-shaped, up to 70 cm long; stems and branches reddish, almost quadrangular, internodes much longer than the leaves. Leaves opposite, simple and entire; stipules 1–3 at each side of the leaf base; petiole 1–3 mm long; blade oblong to narrowly ovate, 1–4.5 cm × 3–13 mm, base cuneate, apex acuminate to rounded, herbaceous to thinly leathery, shiny on both sides, glabrous. Flowers in leaf axils, bisexual, 5-merous, regular, fragrant; pedicel 5–25(–32) mm long; sepals slightly fused at base, 5–10 mm long; corolla tube cylindrical, 15–22 mm long, widening near the insertion of the stamens, throat constricted, inside with a ring of hairs just below the throat and a ring of hairs below the insertion of the stamens, green, pinkish at base, lobes ovate to obovate, 11–22 mm long, densely shortly hairy inside, spreading, pink, reddish violet or pale pink-magenta, white to cream at the base; stamens inserted just below the corolla throat, included, filaments very short; ovary superior, consisting of 2 very narrowly oblong carpels, style slender, 10–16 mm long, pistil head cylindrical with a reflexed transparent frill and with rings of woolly hairs at base and apex, stigma minute. Fruit composed of 2 free cylindrical follicles 1.5–5 cm long, striate, glabrous, green, dehiscent, 10–20-seeded. Seeds oblong, 1–3 mm long, grooved at one side, black. Seedling with epigeal germination.

Catharanthus comprises 8 species, all originating from Madagascar except for *Catharanthus pusillus* (Murr.) G.Don, which is restricted to India and Sri Lanka. *Catharanthus lanceus* flowers and fruits from September to May.

Ecology *Catharanthus lanceus* occurs on volcanic soil, laterite covering quartzite and granitic rock, in periodically burned areas, in open woodland on ridges, among rocks on hillsides, in ruderal grassland and along roadsides, at 750–2000 m altitude. It prefers sunny localities.

Genetic resources and breeding *Catharanthus lanceus* is probably not threatened by genetic erosion, although it is not common in its distribution area.

Prospects *Catharanthus lanceus* contains several pharmacological active alkaloids, with similar importance as those found in *Catharanthus roseus* (L.) G.Don. More research is needed to identify all alkaloids and their pharmacological activities, as the information which is available is rather outdated and very incomplete.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Neuwinger, 2000; van Bergen, 1996; van der Heijden et al., 2004.

Other references Blomster, Farnsworth & Abraham, 1967; Debray, Jacquemin & Razafindrambao, 1971; Farnsworth, Blomster & Buckley, 1967; Farnsworth, Loub & Blomster, 1963; Farnsworth, Svoboda & Blomster, 1986; Pernet & Meyer, 1957; Plaizier, 1981; Ramanankierana, 2000.

Authors G.H. Schmelzer

CATHARANTHUS ROSEUS (L.) G.Don

Protologue Gen. hist. 4(1): 95 (1837).

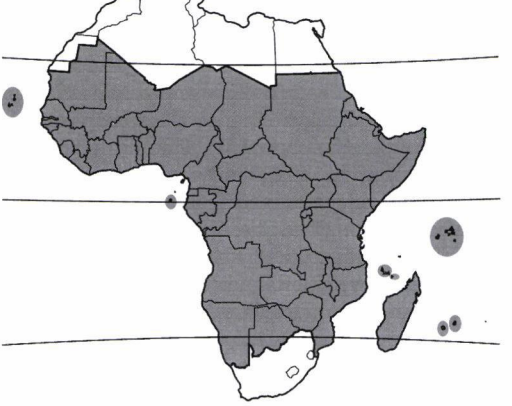
Family Apocynaceae

Chromosome number $2n = 16$

Synonyms *Vinca rosea* L. (1759), *Lochnera rosea* (L.) Rchb. ex Endl. (1838).

Vernacular names Madagascar periwinkle, rosy periwinkle (En). Pervenche de Madagascar, rose amère (Fr). Sempre noiva, flor de anjinho, pervinca de Madagascar (Po). Mtunda (Sw).

Origin and geographic distribution *Catharanthus roseus* originates from Madagascar, but for centuries it has been cultivated as an ornamental throughout the tropics and occasionally in the subtropics; it has become natu-



Catharanthus roseus – planted and naturalized

ralized in many regions. It was brought under cultivation in the first half of the 18th century in Paris, from seeds collected in Madagascar, and was later distributed from European botanical gardens to the tropics. The antimitotic properties of some of its alkaloids were discovered accidentally in the late 1950s during searches for antidiabetic substances.

Uses In Africa, especially in the Indian Ocean islands, medicinal uses of *Catharanthus roseus* are manifold and are similar to those in Asia. A decoction of all parts of *Catharanthus roseus* is well known as an oral hypoglycaemic agent. The decoction is also taken to treat malaria, dengue fever, diarrhoea, diabetes, cancer and skin diseases. Extracts prepared from the leaves have been applied as antiseptic agents for the healing of wounds, against haemorrhage and skin rash and as a mouthwash to treat toothache. The aerial parts are also considered diaphoretic and diuretic, and decoctions are taken to relieve indigestion, dyspepsia, dysentery, toothache and the effects of wasp stings, and as an emetic, purgative, vermifuge and depurative. In Uganda an infusion of the leaves is taken to treat stomach ulcers. In Botswana the leaves ground in milk are applied to mature abscesses. In Togo a root decoction is taken to treat dysmenorrhoea.

The aerial parts of the plant are used for the extraction of the medicinal alkaloids vincristine and vinblastine. The alkaloids are prescribed in anticancer therapy, usually as part of complex chemotherapy protocols. The dried root is an industrial source of ajmalicine, which increases the blood flow in the brain and peripheral parts of the body. Preparations of ajmalicine are used to treat the psychological and behavioural problems of senility, sensory problems (dizziness, tinnitus), cranial traumas and their neurological complications.

Alkaloids extracted from the aerial parts of *Catharanthus roseus* are marketed as lyophylisates (solutions of salts) designed for intravenous application. Vindesine and vinorelbine, which are semisynthetic derivatives of vinblastine, are marketed as a sulphate and a bitartrate, respectively. These are prescription drugs in Western countries.

Catharanthus roseus is a popular garden ornamental, grown as a perennial in the tropics and as an annual in temperate regions, although it can overwinter as a pot plant in a conservatory. It is valued for its bushy habit and many large flowers carried above dark green foliage. *Catharanthus roseus* can also be kept as a cut flower; the branches will last for weeks or even months, producing new, but smaller, flowers all the time.

Production and international trade The world market consumed 5–10 kg of vincristine and vinblastine in the early 1990s, with a total value of US$ 25–50 million. In 2005 the market was estimated at US$ 150–300 million. In 1991 the world market consumed 3–5 t of ajmalicine, with a total value of US$ 4.5–7.5 million. Two anticancer medicines, Oncovin® and Velban®, derived from *Catharanthus roseus*, are sold for a total of US$ 100 million per year.

Catharanthus roseus is widely cultivated in Spain, United States and China for its pharmaceutical compounds.

Properties *Catharanthus roseus* has been found to contain as many as 130 constituents with an indole or dihydroindole structure. The principal component is vindoline (up to 0.5%); other compounds are serpentine, catharanthine, ajmalicine (raubasine), akuammine, lochnerine, lochnericine and tetrahydroalstonine. Ajmalicine and serpentine are essentially present in the roots, whereas catharanthine and vindoline accumulate in aerial parts. The aerial parts contain 0.2–1% alkaloids.

The substances of pharmacological interest are the bisindole alkaloids, most of them containing a plumeran (vindoline) or an ibogan (catharanthine) moiety. Several of these alkaloids have cytostatic properties, but occur in very small amounts: vincristine (leurocristine) in up to 3 g/t of dried plant material and vinblastine (vincaleucoblastine) in a slightly larger amount. Other active compounds are leurosidine (vinrosidine) and leurosine.

Vincristine and vinblastine are highly toxic antimitotics, blocking mitosis in the metaphase. They both also have neurotoxic activity (especially vincristine), affecting neurotransmission. Their peripheral neurotoxic effects are neuralgia, myalgia, paresthesia, loss of the tendon reflexes, depression and headache; their central neurotoxic effects are convulsive episodes and respiratory difficulties. Other side effects are many and include alopecia, gastrointestinal distress including constipation, ulcerations of the mouth, amenorrhoea and azoospermia. As vinblastine decreases the total number of white blood cells in the blood, its dosage must be carefully controlled. The alkaloids are very irritating; when extravasation accidentally occurs there is a risk of tissue necrosis. It is possible to limit the side effects by careful dosage and administration, and inten-

sively monitoring the treatment. Vindesine, a semisynthetic derivative of vinblastine, is also a potent antimitotic. Its side effects include a transient decrease of the number of granulocytes in the blood and effects comparable to those caused by vincristine and vinblastine, although the neurological symptoms are less obvious. Vinorelbine (noranhydrovinblastine) is synthesized from anhydrovinblastine. It acts preferentially on mitosis and its neurological toxicity is limited. However, its haematotoxic activity is substantial, so its dosage must be carefully controlled. Vincristine (Oncovin®) is indicated in the treatment of acute leukaemia, Hodgkin's disease, small-cell lung cancer, cervical and breast cancer and various sarcomas. The indications for vinblastine (Velban®) are mainly Hodgkin's disease, non-Hodgkin's lymphoma, Kaposi's sarcoma, and renal, testicular, head and neck cancer. Vindesine (Eldisine®) is indicated in the treatment of acute lymphatic leukaemia (especially in children) and refractory lymphomas and melanomas. Vinorelbine (Navelbine®) has breast cancer and bronchial cancer as current indications. It is now part of several phase II clinical trials.

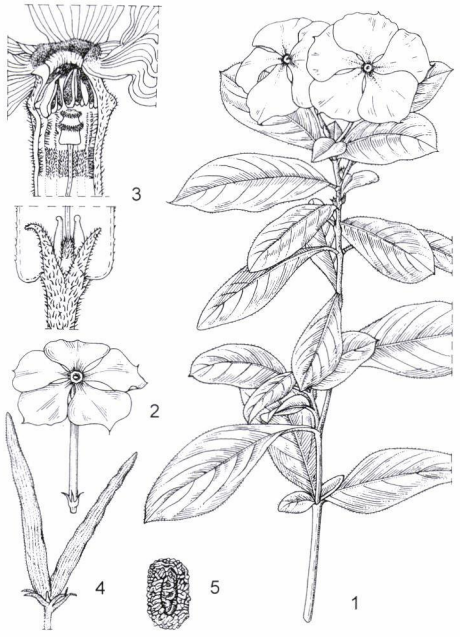
Roots to be used in pharmacy must contain at least 0.4% ajmalicine and the closely related serpentine. Ajmalicine (Hydroserpan®, Lamuran®) is an α-adrenergic blocking spasmolytic, which at high doses reverses the effects of adrenaline and moderates the activity of the vasomotor centres, especially in the brain stem. It temporarily increases the blood flow to the brain.

Some of the alkaloids (e.g. catharanthine, leurosine and vindoline) exhibit a moderate hypoglycaemic action. The fresh leaf juice though shows considerable hypoglycaemic activity. Vinblastine markedly inhibits the in-vitro reproduction of *Trypanosoma cruzi*, the organism causing Chagas' disease. Antiviral activity has been reported in vitro for some *Catharanthus* alkaloids, e.g. leurocristine, perivine and vincristine. Extracts of the plants have shown fungicidal activity (e.g. against *Fusarium solani* that causes wilt e.g. in aubergine and *Sclerotium rolfsii* that causes diseases such as southern blight in tomato) and nematicidal activity (e.g. against *Meloidogyne incognita* and *Meloidogyne javanica*). Extracts of the dried flowers, dried leaves or fresh roots have shown antibacterial activity against some human pathogens.

Callus tissue of *Catharanthus roseus* can be cultured on various media, and can produce a variety of monomeric alkaloids. The alkaloid spectra of root and shoot cultures are similar to those of roots and aerial parts, respectively. In root cultures, ajmalicine and serpentine are usually the major constituents and catharanthine in shoot cultures. Much higher yields of serpentine and ajmalicine can be produced in cell cultures than in whole plants: up to 2% on dry weight basis versus 0.3% in whole plants. The dimeric anticancer alkaloids vinblastine and vincristine are almost undetectable in cultured cells, so attention has turned to the production of catharanthine and vindoline, which can be used as precursors for the synthesis of the dimers. Multiple shoot cultures induced from seedlings produce vindoline and catharanthine in rather higher levels. Another possible method of vindoline production is by cultures of selected hairy roots. These hairy roots can be produced by infecting seedlings with *Agrobacterium rhizogenes*. Some clones not only produce levels of ajmalicine, serpentine and catharanthine comparable to those of cell suspension cultures, but also about 3 times more vindoline than usually found in cell cultures. Another approach is to produce the alkaloids (or their precursors) in other organisms such as yeast via gene transfer.

Adulterations and substitutes Vincristine, vinblastine and related compounds prevent mitosis in a different way from colchicine (from *Colchicum autumnale* L.), another potent antitumour agent. Ajmalicine and derivatives are also found in other *Apocynaceae*, such as *Rauvolfia* spp.

Description Erect or decumbent, deciduous undershrub up to 1 m tall, usually with white latex and an unpleasant smell; roots up to 70 cm long; stems narrowly winged, green or red, shortly hairy to glabrous, often woody at base. Leaves decussately opposite, simple and entire; stipules 2–4 at each side of the leaf base; petiole 3–11 mm long, green or red; blade elliptical to obovate or narrowly obovate, 2.5–8.5 cm × 1–4 cm, base cuneate, apex obtuse or acute with a mucronate tip, herbaceous to thinly leathery, glossy green above and pale green below, sparsely shortly hairy to glabrous on both sides. Inflorescence terminal, but apparently lateral, 1–2-flowered. Flowers bisexual, 5-merous, regular, almost sessile; sepals slightly fused at base, (2–)3–5 mm long, erect, green; corolla tube cylindrical, 2–3 cm long, widening near the top at the insertion of the stamens, laxly shortly hairy to glabrous outside, with a ring of hairs in the throat and another lower



Catharanthus roseus – 1, flowering twig; 2, flower; 3, base and top of corolla tube in longitudinal section; 4, fruit; 5, seed.
Source: PROSEA

down the tube, greenish, lobes broadly obovate, 1–2(–3) cm long, apex mucronate, glabrous, spreading, pink, rose-purple or white with a purple, red, pink, pale yellow or white centre; stamens inserted just below the corolla throat, included, filaments very short; ovary superior, consisting of 2 very narrowly oblong carpels, style slender, 15–23 mm long, with a cylindrical pistil head provided at base with a reflexed transparent frill and with rings of woolly hairs at base and apex, stigma glabrous. Fruit composed of 2 free cylindrical follicles 2–4.5 cm long, striate, laxly shortly hairy to glabrous, green, dehiscent, 10–20-seeded. Seeds oblong, 2–3 mm long, grooved at one side, black. Seedling with epigeal germination.

Other botanical information *Catharanthus* comprises 8 species, all originating from Madagascar except for *Catharanthus pusillus* (Murr.) G.Don, which is restricted to India and Sri Lanka. *Catharanthus* is very closely related to *Vinca*. No consistent qualitative differences have been found in alkaloid composition in relation to the different colours of the corolla of *Catharanthus roseus*.

Catharanthus coriaceus Markgr. is a rare species of central Madagascar. A leaf decoction is used to treat bilious fevers and dysentery. The bitter flowers are given to people with diabetes, who chew them to lessen their appetite. A decoction of the aerial parts was formerly drunk as an ordeal poison. *Catharanthus longifolius* (Pichon) Pichon and *Catharanthus ovalis* Markgr. occur in southern-central Madagascar. An extract of the aerial parts of either species is given to humans or calves to expel worms. A concentrated extract was formerly drunk as an ordeal poison. They are both rich in indole alkaloids, including several bisindole alkaloids. *Catharanthus ovalis* contains the pharmacologically active leurosine, vindoline, vindolinine, coronaridine, catharanthine and vinblastine (vincaleucoblastine), whereas from *Catharanthus longifolius* e.g. vindolicine was isolated. Natural hybrids exist between *Catharanthus longifolius* and *Catharanthus roseus*, and artificial hybrids have been made between *Catharanthus ovalis* and *Catharanthus longifolius*.

Growth and development *Catharanthus roseus* is usually self-compatible, and intra-flower self-pollination is common, because the stigma may come into contact with the anthers, even after anthesis. The degree of outcrossing may vary with environmental conditions and the presence of seasonal pollinating butterflies. Self-incompatible strains of *Catharanthus roseus* exist and can be locally common. In warmer climates, *Catharanthus roseus* will flower and fruit the whole year round. The seeds usually fall close to the mother plant, but are sometimes transported by ants. Within 6–8 weeks after germination the first flowers will appear. At temperatures below 5°C some branches or even the whole plant will die. When the temperature rises, the plant will regrow from basal axillary buds, especially after hard pruning of shoots and roots. Without pruning, the plant regrows mainly from the tops.
Tetraploid plants, induced with colchicine, have been found to have much higher alkaloid content than diploid plants, but the doubling of chromosomes was found to result in reduced pollen fertility and poor seed set.

Ecology *Catharanthus roseus* often occurs in sandy locations along the coast, but also inland on river banks, in savanna vegetation and in dry waste places and roadsides, sometimes in open forest or scrub, usually on sandy soils, but sometimes also on rocky soils. It is

very salt-tolerant, and is mostly found near sea-level, but occasionally up to 1500 m altitude. It can stand drought well, but not severe heat. Under severe water stress the alkaloid content of mature leaves was found to double, but it did not change in stems and immature leaves and it decreased in roots.

Propagation and planting *Catharanthus roseus* is usually propagated by seed. Seed may remain dormant for several weeks after maturity. The optimum temperature for germination is 20–25°C, and the germination rate is in general over 95%. The seeds remain viable for 3–5 years. If the germination rate is low, this might be due to storage under too dry conditions. Seedlings can be potted after 3 weeks. *Catharanthus roseus* can also be propagated vegetatively by greenwood or semi-ripe cuttings rooted in a closed container with bottom heat. When rooting powder is used, the cuttings will start to root after 4–5 weeks. Putting cuttings in water will also induce rooting but it will take longer than in the soil.

Management *Catharanthus roseus* is usually cultivated as an ornamental. It is a fast-growing plant that is easy to cultivate. When the plants become too tall, pruning is necessary. To encourage branching, the top of the seedling can be cut off, resulting in side branches that are always opposite. When the main stem is not topped, it will usually start branching at a height of 20–30 cm, but only one side branch will then develop with subsequent branching. *Catharanthus roseus* responds well to N fertilizers, but can also grow and persist on poor soils.

Catharanthus roseus is also cultivated for medicinal purposes, in Africa mainly in Madagascar. In India it is mainly cultivated as a 200-day crop for its leaves (for the extraction of vinblastine and vincristine) and its roots (for the extraction of ajmalicine). The crop needs little irrigation or fertilizer. Too excessive watering causes yellowing of the leaves. Plant spacing is 30–40 cm between plants.

Diseases and pests In Africa no diseases or pests are known, but in Malaysia *Catharanthus roseus* has been reported to be infected with 'Malaysian periwinkle yellow'. Symptoms include excessive yellowing of foliage, bunchy top and stunted flowers and leaves, suggesting infection by a mycoplasm-like organism. Similar diseases have been reported from China, Taiwan, North America and Europe. Mycoplasm-like organisms can be transferred to *Catharanthus roseus* by parasitic plants of the genus *Cuscuta*, and perhaps also by leafhoppers. Container-grown plants in the United States cultivated as ornamentals have been reported susceptible to *Phytophthora parasitica* that causes root and stem rot. In glasshouses red spider mite (*Tetranychus urticae*) is very common.

Harvesting *Catharanthus roseus* plants are harvested by uprooting the whole plant after which the roots are separated from the rest of the plant and both parts are separately processed. If only the leaves are harvested, the plants are left in the field for a ratoon crop. Harvesting leaves is done manually or by machine. The alkaloid content of the plants is highest at flowering.

Handling after harvest The aerial parts and the roots of *Catharanthus roseus* are cleaned, after which they are dried at low temperatures, then packed for shipment. Potted plants for use as ornamentals are usually traded in sealed packages. They are marketable in this condition for 18 days, and do not require watering during this period.

Genetic resources Although *Catharanthus roseus* probably originated from a limited area in south-eastern Madagascar, it is now widely planted and naturalized in all tropical areas, and is certainly not endangered. However, protection of the wild populations in Madagascar is desirable to ensure the conservation of the genetic diversity, which might be of interest for breeding purposes in the future.

Breeding *Catharanthus roseus* has been successfully crossed with *Catharanthus trichophyllus* (Baker) Pichon, with the F_1 having a high seed set and good viability when *Catharanthus trichophyllus* was the female parent. The alkaloid profiles of the two species are different, and alkaloid production seems to be higher in hybrids than in the parent species.

In breeding, the following characteristics seem to be dominant: purple corolla colour, dark eye of the flower and tall and open habit. Breeding aims at plants of which the corollas drop, because the old corolla will otherwise stick to the young fruit and to the new bud, which cannot develop well. Two large groups of cultivars exist, those with a distinct eye and those with a green to white eye. Subsequent grouping is done by corolla colour, and about 50 cultivars have so far been developed. Although hybrids are only occasionally found in nature, in cultivation many usually fertile hybrids can be made between the different *Catharanthus* species, which have the same chromosome num-

bers.

Prospects The possibility of accessing active dimeric alkaloids by biomimetic synthesis has recently attracted much attention. It is now conceivable that vinblastine could be obtained from starting materials such as catharanthine and vindoline, which are neither rare nor too expensive. These latter two compounds can be produced in sufficient amounts in in-vitro cultures of *Catharanthus roseus*. Studies on analogues of the well-known alkaloids suggest good prospects for new developments vis-à-vis *Catharanthus* alkaloids. Horticultural production of *Catharanthus roseus* for alkaloid production is little studied and deserves more attention. *Catharanthus roseus* may have good prospects as an ornamental in temperate regions.

Major references Gurib-Fakim & Brendler, 2004; Lavergne & Véra, 1989; Mukherjee et al., 2001; Neuwinger, 2000; Plaizier, 1981; Ross, 2003; Snoeijer, 1996; Sutarno & Rudjiman, 1999; van Bergen, 1996; van der Heijden et al., 2004.

Other references Bhadra, Vani & Shanks, 1993; Gurib-Fakim, Guého & Bissoondoyal, 1995; Johns et al., 1995; Kulkarni, 2001; Marfori & Alejar, 1993; Nammi et al., 2003; Ojewole & Adewunmi, 2000; Reda, 1978; Sevestre-Rigouzzo et al., 1993; Singh et al., 2001; Tabuti, Lye & Dhillion, 2003; van Wyk, van Heerden & van Oudtshoorn, 2002; Verpoorte, Contin & Memelink, 2002; Yuan, Hu & Yang, 1994.

Sources of illustration Sutarno & Rudjiman, 1999.

Authors G.H. Schmelzer

Based on PROSEA 12(1): Medicinal and poisonous plants 1.

CATHARANTHUS TRICHOPHYLLUS (Baker) Pichon

Protologue Mém. Mus. natl. Hist. nat., Paris n.s. 27: 237 (1949).

Family Apocynaceae

Chromosome number $2n = 16$

Origin and geographic distribution *Catharanthus trichophyllus* is endemic to Madagascar, where it occurs mainly in the northern part.

Uses The bitter root decoction of *Catharanthus trichophyllus* is reputed for its stimulant properties, and is applied especially against venereal diseases, impotency and back-ache. It is also taken against toothache. A leaf decoction is taken to treat bilious fevers and dysentery and as an aphrodisiac. Externally, a decoction of the aerial parts is applied as a haemostatic. An infusion of all parts is taken to treat liver diseases and to stabilize the blood composition. The bitter flowers are given to people with diabetes, who chew them to lessen their appetite.

Properties The aerial parts of *Catharanthus trichophyllus* contain mainly monomeric indole alkaloids, of which vindoline is the most important; tetrahydroalstonine, catharanthine, serpentine and vindolinine occur as minor components. The roots contain mainly serpentine, and minor components are the dimeric vincristine, but also the monomeric ajmalicine, catharanthine, lochnericine, hörhammericine, tetrahydroalstonine and cathaphylline. All alkaloids in the roots and leaves occur in lower amounts than in *Catharanthus roseus* (L.) G.Don. Lochnericine and hörhammericine are responsible for part of the cytotoxic activity.

Botany Undershrub up to 1 m tall, with white latex and a rather unpleasant smell; stems and branches reddish to purple, quadrangular, winged. Leaves opposite, simple and entire, almost sessile; stipules 2–5 at each side of the leaf base; blade oblong to narrowly ovate, 2.5–8.5 cm × 1–4 cm, base rounded to cuneate, apex acuminate, herbaceous, margin ciliate, more or less hairy on both sides. Inflorescence axillary, 1–2-flowered. Flowers bisexual, 5-merous, regular; pedicel 4–11 mm long, quadrangular; sepals slightly fused at base, 6–10 mm long, apex long-acuminate; corolla tube cylindrical, 22–26 mm long, widening near the insertion of the stamens, throat constricted, with a ring of hairs just below the throat and another below the insertion of the stamens, glabrous or laxly hairy, green, pinkish at base, lobes narrowly obovate, 8–18 mm long, densely shortly hairy at base, spreading, white, pink, red, purple, yellowish at the base; stamens inserted just below the corolla throat, included, filaments very short; ovary superior, consisting of 2 very narrowly oblong carpels, style slender, 14–19 mm long, pistil head cylindrical with a ring of woolly hairs, stigma minute. Fruit composed of 2 free cylindrical follicles 3–7 cm long, striate, glabrous to laxly hairy, green to purplish green, dehiscent, 10–20-seeded. Seeds oblong, 2.5–3 mm long, grooved at one side, dark brown. Seedling with epigeal germination.

Catharanthus comprises 8 species, all originat-

ing from Madagascar except for *Catharanthus pusillus* (Murr.) G.Don, which is restricted to India and Sri Lanka. *Catharanthus trichophyllus* flowers and fruits from July to May.

Ecology *Catharanthus trichophyllus* occurs on river banks, in open localities in forest, along forest edges and roadsides, on sand, gneiss-derived soil and laterite, from sea-level up to 1400 m altitude.

Genetic resources and breeding *Catharanthus trichophyllus* does not seem to be endangered by genetic erosion because it has a wide ecological adaptation. *Catharanthus trichophyllus* has been successfully crossed with *Catharanthus roseus*, with the F_1 having a high seed set and good viability only when *Catharanthus trichophyllus* was the female parent. The alkaloid profiles of the two species are different, and alkaloid production is higher in hybrids than in the parent species. Artificial hybridization was also successful between *Catharanthus trichophyllus* and *Catharanthus ovalis* Markgr. or *Catharanthus coriaceus* Markgr. All *Catharanthus* spp. are self-compatible; only for *Catharanthus roseus* do self-compatible and self-incompatible strains occur.

Prospects *Catharanthus trichophyllus* contains moderate amounts of mainly monomeric alkaloids, but hybrids formed through crossing with *Catharanthus roseus* have much higher alkaloid content, indicating the potential of breeding hybrids for improved alkaloid production.

Major references Boiteau & Allorge-Boiteau, 1993; Boiteau, Boiteau & Allorge-Boiteau, 1999; Kulkarni, 2001; van Bergen, 1996; van der Heijden et al., 2004.

Other references Hammer, 1994; Neuwinger, 2000; Novy, 1997; Pernet & Meyer, 1957; Plaizier, 1981; Segelman & Farnsworth, 1974; Sevestre-Rigouzzo et al., 1993.

Authors G.H. Schmelzer

CAVACOA AUREA (Cavaco) J.Léonard

Protologue Bull. Jard. Bot. Etat 25: 323 (1955).

Family Euphorbiaceae

Vernacular names Natal hickory, South African hickory (En).

Origin and geographic distribution *Cavacoa aurea* occurs from Kenya south to Malawi, southern Mozambique and north-eastern South Africa.

Uses In southern Africa a root infusion is taken to ease pain and to treat fever, and a steam bath is taken to clear sinuses.
Cavacoa aurea yields good sticks for various uses.

Botany A dioecious evergreen shrub or small tree up to 15 m tall; trunk irregularly fluted near base; bark thin, scaly, brown; branches long, greyish, glabrous. Leaves alternate, simple and entire; stipules oblong, c. 5 mm long, soon falling, leaving conspicuous annular scars; petiole 1–5 cm long; blade elliptical to elliptical-obovate or elliptical-oblanceolate, 3.5–18 cm × 1.5–8 cm, base cuneate to rounded, apex obtuse to acuminate, leathery, minutely gland-dotted, pinnately veined with 9–12 pairs of lateral veins. Inflorescence a terminal raceme up to 10 cm long, up to 10-flowered; bracts 4–6 mm long. Flowers unisexual, fragrant, cream-coloured, bright yellow or greenish yellow; pedicel 1–2.5 cm long, jointed; male flowers with 2(–4), lanceolate to broadly ovate sepals, 3.5–6 mm long, petals 4–5, free, elliptical-ovate, 7–9 mm long, disk glands 4–5, free, fleshy, stamens 15–35, 5–6 mm long; female flowers with (4–)5, oblong-lanceolate sepals 6–8 mm long, petals 5, elliptical-oblong, c. 10 mm long, disk cup-shaped, ovary superior, 2–3 mm in diameter, 3–5-celled, styles 3, fused at base, 3–5 mm long, stigmas 2-fid. Fruit a 3–5-lobed capsule 12–15 mm × 23–30 mm, smooth, hard, green turning black, 3–5-seeded. Seeds ovoid to nearly globose, c. 10 mm × 8–9 mm, smooth, pale brown, streaked and mottled dark brown.
Cavacoa comprises 3 species, all in tropical Africa. *Cavacoa aurea* has long been confused with *Heywoodia lucens* Sim in South Africa.

Ecology *Cavacoa aurea* occurs in mixed evergreen forest and coastal forest, often near streams, usually on sandy soil, at low altitudes. It grows equally well in shade or sun.

Management *Cavacoa aurea* is cultivated in South Africa. There, fruiting is from December to February. Fresh seed germinates well.

Genetic resources and breeding *Cavacoa aurea* is uncommon in most parts of its distribution area. It is protected in South Africa.

Prospects *Cavacoa aurea* will probably remain of local importance only.

Major references Coates Palgrave, 1983; Govaerts, Frodin & Radcliffe-Smith, 2000; Radcliffe-Smith, 1996a.

Other references Duthie, 1978; Neuwinger, 2000; Palmer & Pitman, 1972–1974.

Authors G.H. Schmelzer

CENTROPLACUS GLAUCINUS Pierre

Protologue Bull. Mens. Soc. Linn. Paris, ser. 2, 1: 115 (1899).

Family Pandaceae

Synonyms *Microdesmis paniculata* Pax (1899).

Origin and geographic distribution *Centroplacus glaucinus* occurs in Cameroon, Equatorial Guinea and Gabon.

Uses In Gabon a leaf decoction is taken to treat schizophrenia.

Botany Dioecious small to medium-sized tree up to 20 m tall; bark surface dark brown, inner bark red; twigs slender, terete, glabrous. Leaves alternate, simple; stipules triangular, tiny; petiole up to 4 mm long, blackish when dry; blade oblong to elliptical-oblong, 7.5–17.5 cm × 2.5–6.5 cm, base obtuse, apex acuminate, distantly and shallowly toothed, glabrous, shiny above, pinnately veined with 10–14 pairs of lateral veins. Inflorescence an axillary panicle up to 7.5 cm long, on young shoots, short-hairy; bracts spoon-shaped, c. 1 mm long. Flowers unisexual, 5-merous; pedicel c. 1 mm long; sepals ovate, c. 1 mm long, obtuse, yellowish short-hairy; male flowers with petals broadly obovate or obovate-elliptical, c. 3 mm long, white, short-hairy, disk cup-shaped, stamens with short filaments; female flowers without petals, disk saucer-shaped, fleshy, 5-lobed, ovary superior, ovoid, c. 1 mm in diameter, 3-celled, densely short-hairy, styles 3, short. Fruit an oblong-ellipsoid, slightly 3-lobed capsule c. 7 mm in diameter, densely short-hairy, green turning pinkish orange, 3-seeded. Seeds ellipsoid, c. 3 mm long, usually smooth, black, shiny, aril orange-red.

Centroplacus consists of one species only. It has formerly been placed in *Flacourtiaceae* and *Euphorbiaceae*, but is now considered to belong to *Pandaceae*, although recent molecular studies indicate that it may be better placed in a separate family *Centroplacaceae*.

Ecology *Centroplacus glaucinus* occurs as an understorey tree in primary and secondary forest, usually at low altitudes.

Genetic resources and breeding There are no signs that *Centroplacus glaucinus* is threatened by genetic erosion.

Prospects *Centroplacus glaucinus* will remain of local importance only as a medicinal plant.

Major references Akendengué & Louis, 1994; Govaerts, Frodin & Radcliffe-Smith, 2000.

Other references Brown, Hutchinson & Prain, 1909–1913.

Authors G.H. Schmelzer

CEPHALOCROTON MOLLIS Klotzsch

Protologue Peters, Naturw. Reise Mossambique, Vol. 6, Botanik 1: 99, t. 17 (1861).

Family Euphorbiaceae

Origin and geographic distribution *Cephalocroton mollis* occurs from Tanzania south throughout southern Africa, including eastern South Africa.

Uses In Namibia the Heikum Bushmen use the dried powdered root in food as criminal poison, causing bloody diarrhoea. The aerial parts are browsed by cattle.

Botany Monoecious, rarely dioecious, perennial herb or shrub up to 2(–3.5) m tall; rootstock woody; bark pale grey; all parts covered with stellate hairs, with or without long glandular hairs, later almost glabrous. Leaves alternate, simple; stipules subulate-filiform, 1–4 mm long; petiole 1–7 mm long; blade ovate-oblong to oblong-lanceolate, 1–10.5 cm × 0.5–5 cm, base rounded or truncate, apex obtuse to acute, margins entire to sinuate, leathery. Inflorescence a terminal raceme, with male flowers in a dense terminal globose cluster and 1–4 female flowers at base of peduncle; peduncle 1–10 cm long; bracts minute. Flowers unisexual, sweetly scented; pedicel 3–4(–7) mm long; petals absent; male flowers with 4 glabrous, ovate to elliptical-ovate sepals c. 2 mm long, pale yellowish green, stamens 6–8, free, 5–6 mm long; female flowers with 6 sepals, pinnately lobed, c. 4 mm × 2 mm, enlarging in fruit, lobes linear, with side lobes, stellately hairy, green, disk annular, ovary superior, c. 1.5 mm in diameter, densely hairy, 3-celled, styles 3, fused at base, 4–8 mm long, stigma multifid, orange-yellow. Fruit a 3-lobed capsule c. 1 cm × 1.5 cm, hairy, 3-seeded. Seeds ovoid, 6–8 mm long, smooth, pale to pinkish brown, slightly mottled, dull.

Cephalocroton comprises 3–4 species in tropical and southern Africa. It is closely related to *Adenochlaena* (1 species from Madagascar and the Comoros and 1 from Sri Lanka) and *Cephalocrotonopsis* (1 species from Socotra), both formerly included in *Cephalocroton*.

Ecology *Cephalocroton mollis* occurs on clayey soils (including black cotton soil) but usually on sandy soils in dried-out depressions and seasonal swamps, in open grassland and

mixed open bushland, at 500–1500 m altitude.

Genetic resources and breeding *Cephalocroton mollis* is relatively common in southern Africa and therefore not likely to be threatened by genetic erosion.

Prospects Research on the phytochemistry of *Cephalocroton mollis* is warranted in the light of the uses as a plant poison and of browse for cattle.

Major references Govaerts, Frodin & Radcliffe-Smith, 2000; Radcliffe-Smith, 1973; von Koenen, 2001.

Other references Radcliffe-Smith, 1987; Radcliffe-Smith, 1996a.

Authors G.H. Schmelzer

CERBERA MANGHAS L.

Protologue Sp. pl. 1: 208 (1753).

Family Apocynaceae

Chromosome number $2n = 40$

Synonyms *Cerbera venenifera* (Poir.) Steud. (1840).

Vernacular names Sea-mango, tanghin, ordeal plant (En). Tanghin (Fr).

Origin and geographic distribution *Cerbera manghas* is widely distributed from the islands of the Indian Ocean to tropical Asia, tropical Australia and the islands of the Pacific Ocean. In tropical Africa it has been found on Pemba Island (Tanzania), Madagascar, the Seychelles and Mauritius.

Uses The seeds of *Cerbera manghas* are used in traditional medicine in Madagascar to treat cardiac disorders. However they are very poisonous and were used until the middle of the 19th century as ordeal poison. In tropical Asia the seeds are used to treat scabies and itch, to prepare a hair tonic and as fish poison, the bark is used as a laxative and antipyretic and in the treatment of dysuria and ringworm, the flowers to treat haemorrhoids, and roots, bark and leaves to prepare a purgative. The wood is occasionally used in tropical Asia for mouldings, interior trim, fruit cases, core veneer, matches, shuttering, clogs, plain furniture and carving, and also for charcoal. *Cerbera manghas* is planted as an ornamental and the fibrous fruits, of which the skin and soft parts have decayed, are used in flower arrangements.

Production and international trade Medicinal products of *Cerbera manghas* are not traded on the international market, but can be found on local markets in Madagascar. Small amounts of timber are exported from Papua New Guinea and the Solomon Islands to Japan.

Properties The seeds contain glycosides derived from the cardenolides tanghinigenin and digitoxigenin, such as cerberin, neriifolin, thevetin B and 2'-O-acetyl-thevetin B. The principal cardenolides contained in the bark and roots are gentiobiosyl-thevetoside and glucosyl-thevetoside along with other thevetosides derived from tanghinigenin. The amount of cardenolides in the leaves varies according to the season. Some of the cardenolides showed antiproliferative activity against human colon cancer, breast cancer, lung cancer and epidermoid carcinoma cell lines, as well as anti-oestrogenic activity. Cerberin acts on plain muscle preparations as a definite stimulant both with regard to tone and peristaltic movements. As such it behaves as a parasympatomimetic poison. It acts on both the rhythm and amplitude of the heart. In moderate doses cerberin has positive inotropic properties, but in high, toxic doses it produces a negative inotropic and chronotropic effect. Phytochemical investigations also revealed the presence of a series of lignans derived from olivil (cerberalignans) and monoterpenoids such as cerberidol. Ethanolic extracts of *Cerbera manghas* have shown selective activity against vesicular stomatis virus (VSV). Olivil, carinol and cycloolivil showed antioxidant activities.

The wood is lightweight to medium-weight, with the white to pale yellow-brown heartwood not demarcated from the sapwood; grain is straight to slightly interlocked, texture fine and uneven. The shrinkage upon seasoning is moderate, and the wood works easily. It is not durable, highly susceptible to blue-staining fungi, and resistant to preservative treatment under pressure.

Botany Shrub or small to medium-sized tree up to 20(–25) m tall, with white latex in all parts, glabrous; bole up to 70 cm in diameter; bark thick, rough, peeling off, with large lenticels, grey to dark brown; branches thick and succulent, with many conspicuous leaf scars. Leaves arranged spirally, clustered at the ends of branches, simple and entire; stipules absent; petiole 1–4.5 cm long; blade narrowly obovate, 5–30 cm × 1–8 cm, cuneate at base, shortly acuminate at apex, leathery, pinnately veined with 15–40 pairs of lateral veins. Inflorescence a terminal cyme up to 25 cm × 15 cm, many-flowered; peduncle 1.5–12 cm long; bracts about as long as sepals, deciduous. Flowers bisexual, regular, 5-merous, fragrant; pedicel

0.5–3 cm long; sepals ovate or obovate, (0.5–)1–3.5 cm × c. 0.5 cm, spreading to recurved; corolla tube funnel-shaped, 1.5–5.5 cm long, widened at apex, pale green with white or pale yellow scales in the throat, hairy inside, lobes obliquely elliptical or obovate, 1.5–3 cm × 1–2 cm, spreading to recurved, white but pink at base; stamens inserted just below the top of corolla tube, included, covered by scales of corolla tube, anthers sessile; ovary superior, globose, consisting of 2 separate carpels, style long and slender, pistil head consisting of a 5-ridged basal part, a veil and a cone-shaped apex. Fruit consisting of 1 or 2 separate or basally fused, drupe-like, ellipsoid follicles 5–12 cm × 3–7 cm, rounded at both ends, dark red when mature, indehiscent, usually 1-seeded. Seed flattened orbicular, c. 2.5 cm in diameter, with small wing at apex. Seedling with hypogeal germination.

Cerbera comprises 6 species occurring in tropical Asia, tropical Australia and islands of the Pacific Ocean; *Cerbera manghas* is most widespread. In tropical Asia *Cerbera manghas* has been much confused with *Cerbera odollam* Gaertn.

The flowers of *Cerbera manghas* are pollinated by insects. The fruits, which are fibrous inside, float in water and can be distributed by sea currents; they are quite commonly washed up on shores.

Ecology In Madagascar *Cerbera manghas* is widespread, occurring in humid evergreen forest along the coast as well as in dry deciduous forest inland up to 150 m altitude.

Management *Cerbera manghas* should preferably be grown in full light in a fertile, moist but well-drained loam with additional leaf mould. The pulp of ripe fruits is removed to obtain the seeds, or the fruits are dried first, and then cracked to liberate the seeds.

Genetic resources and breeding *Cerbera manghas* is widespread and not under threat of genetic erosion. This is also the case in Madagascar, where it is still widespread.

Prospects It is unlikely that *Cerbera manghas* will play an important role in future medicine because its cardenolides are very toxic and better alternatives are available, e.g. digoxin from *Digitalis* or ouabain from *Strophanthus*. The trees seldom grow to timber size, but the wood is useful for the production of veneer. *Cerbera manghas* has good prospects as an ornamental with beautiful flowers and fruit mesocarps.

Major references Boiteau & Allorge-Boiteau, 1993; Chang et al., 2000; Leeuwenberg, 1999; Tran Dinh Ly, 1998; Tran Cong Khanh, 2001b.

Other references Abe & Yamauchi, 1977; Gurib-Fakim & Brendler, 2004; Lee et al., 1998; Markgraf, 1976; Neuwinger, 2000; Tomlinson, 1986.

Authors R.H.M.J. Lemmens

CHAMAECRISTA ABSUS (L.) H.S.Irwin & Barneby

Protologue Mem. New York Bot. Gard. 35: 664 (1982).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

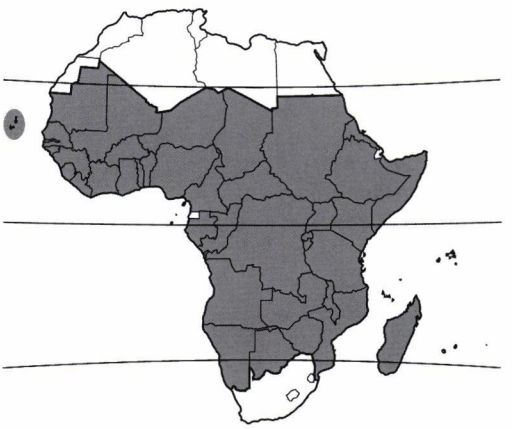
Chromosome number $2n = 28$

Synonyms *Cassia absus* L. (1753).

Vernacular names Four-leaved senna, black grain, pig's senna, tropical sensitive-pea (En). Casse absus (Fr).

Origin and geographic distribution *Chamaecrista absus* occurs naturally throughout the Old World tropics, and has been introduced and naturalized in tropical America.

Uses Dried and powdered leaves, a leaf extract or occasionally pounded ripe fruits of *Chamaecrista absus* are widely applied to eczema, ringworm, wounds, sores, abscesses, ulcers and venereal inflammations. A tea of the leaves is considered depurative. In many parts of Africa and Asia the powdered seeds or seed extracts are sprinkled on the eye to treat eye diseases, e.g. conjunctivitis and cataract. In Senegal the powdered seeds are also taken to treat diabetes and chlorosis, and the fresh plant is pounded and mixed with butter for use



Chamaecrista absus – wild

as a suppository against haemorrhoids. In Ghana a decoction of the roots, combined with palm wine and chillies, is used as a purgative to expel worms. In Congo the leaves mixed with *Heterotis rotundifolia* (Sm.) Jacq.-Fél. are pulped and diluted with palm wine to promote conception in women. In part the mix is ingested, and in part it is rubbed on the underbelly. Different plant parts are also taken in infusion as an aphrodisiac. In Kenya and Tanzania an infusion of the roots is taken to treat stomach-ache.

Reports on the value of *Chamaecrista absus* as a pasture plant are contradictory. In the Sahel it is well liked by livestock and is used to make silage. Leaves are retained well into the dry season, which makes it valuable grazing. In Nigeria it is appreciated as it is thought to favour growth of cattle and it has veterinary value, e.g. to cure diarrhoea. Elsewhere in Africa, young plants are eaten by cattle, but older plants are sticky and appear unpalatable. In Malawi *Chamaecrista absus* is applied as a green manure in maize. The leaves yield a weak yellow dye.

Production and international trade Seed of *Chamaecrista absus* is traded in India; no information is available on trade in Africa.

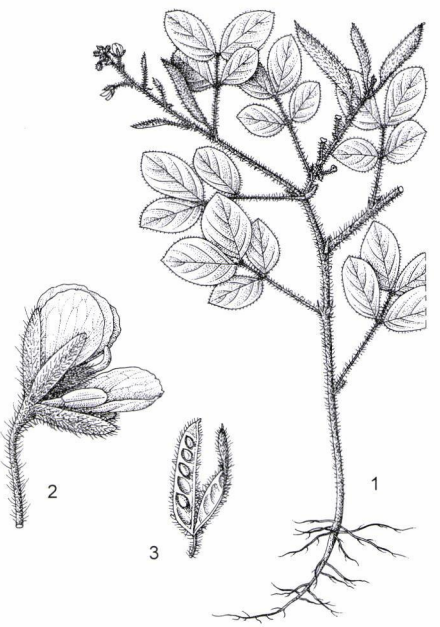
Properties All plant parts of *Chamaecrista absus* contain the monoterpenoid imidazole alkaloids chaksine and isochaksine. Chaksine suppresses the respiratory, vasomotor and heat-regulating centres and inhibits muscle activity and the sense of balance. It also has hypotensive and antibacterial activity. In a test for antifungal activity, chaksine iodide at 0.5% inhibited all fungi tested. Isochaksine has similar activities to chaksine but in general at higher doses. Aqueous extracts of the aerial parts have an allelopathic effect on root nodule growth of groundnut and mung bean.

The anthraquinones chrysophanol and emodin were isolated from the roots, and the flavonoids quercetin and rutin were isolated from the leaves. Chrysophanol and emodin have laxative activities.

The seeds of *Chamaecrista absus* contain about 4.5% oil, 52% of which is 9-ketooctadec-cis-15-enoic acid. The oil also contains 25% linoleic acid, 12% palmitic acid, 7% oleic acid, 2.5% stearic acid and 1.5% arachidic acid. Other analyses have shown the presence of gentisic acid, 5-O-D-glucopyranosyl gentisic acid, ethyl-α-D-galactopyranoside, and the flavonoids apigenin, luteolin, hydnocarpin and isohydnocarpin. These flavonoids showed antitumour activities in vitro, and some also in vivo. Sugars in the seed include galactomannan, which induces the mucilaginous properties of the endosperm.

Description Annual herb up to 60(–100) cm tall, branched towards the top, with long rigid glandular hairs on all parts, lemon-scented. Leaves alternate, paripinnate, 3–7 cm long, with 2 pairs of leaflets; stipules linear, up to 8 mm long; petiole without large gland, rachis with gland between each of the leaflet pairs; leaflets almost sessile, elliptical, up to 4.5 cm × 3 cm, largest in the upper pair, apex obtuse. Inflorescence a terminal or axillary raceme, up to 13 cm long, 4–6-flowered. Flowers bisexual, nearly regular, 5-merous; pedicel 3–5 cm long; sepals obtuse, c. 4 mm long, pubescent; petals obovate, up to 8 mm long, cream to orange-yellow, sometimes red outside; stamens 5, filaments straight; ovary superior, 1-celled, style curved. Fruit a flat pod c. 5 cm × 0.5 cm, splitting into 2 thin, slightly spiralling valves, containing 5–7 seeds. Seeds obovate to slightly rhombic, c. 5 mm long, dark brown to black, glossy.

Other botanical information *Chamaecrista* (formerly in *Cassia*) occurs throughout



Chamaecrista absus – 1, plant habit; 2, flower; 3, opened pod.
Redrawn and adapted by Achmad Satiri Nurhaman

the tropics and subtropics and comprises about 250 species. It has its largest diversity in tropical Africa and tropical America. In continental Africa about 40 species occur, in Madagascar 10, 6 of them endemic. *Chamaecrista* has a large morphological variability, rendering a comprehensive taxonomic treatment extremely difficult. *Chamaecrista absus* is variable in its morphology, which is not surprising considering its wide distribution.

Ecology *Chamaecrista absus* occurs in ruderal localities, old farmland, along roadsides, in grassy savanna, in open localities in deciduous bushland, on granite outcrops and on sand dunes, from sea-level up to 1700 m altitude. In Senegal it is abundant near the seashore. It is well adapted to the semi-arid tropics.

Propagation and planting To increase germination, nicking or abrasion of *Chamaecrista absus* seeds is recommended. A temperature of 24°C is optimum for germination.

Management In Africa *Chamaecrista absus* is collected from the wild. In Pakistan it is cultivated for its leaves and seeds.

Harvesting *Chamaecrista absus* is harvested by pulling up the plants when the pods are mature.

Handling after harvest As the pods of *Chamaecrista absus* are dehiscent, drying should be done on a firm clean threshing floor. Dry storage is preferable.

Genetic resources As a weedy species, *Chamaecrista absus* faces no risk of genetic erosion. No samples are available in seed banks.

Prospects Some of the traditional uses of *Chamaecrista absus* have been validated by research, but more research is needed on antimicrobial and antitumour activities. Chaksine and iso-chaksine seem to be the most interesting chemical compounds for commercialization. A better understanding of the cultivation and its economics could be the basis for further work. The risk of the species becoming a weed should be taken into account in areas where it does not occur naturally.

Major references Baerts & Lehmann, 2005f; Brenan, 1967; Burkill, 1995; Harborne, Boulter & Turner, 1971; Kapoor & Mukherjee, 1969; Lock, 1990; Mahajan, 1983; Neuwinger, 2000; Rao et al., 1979; Silva et al., 1996.

Other references Bartha, 1970; Berhaut, 1975b; du Puy et al., 2002; Figuière et al., 1998; Ghisalberti, Pennacchio & Alexander, 1998; Hegnauer & Hegnauer, 1996; Hosamani, 1994a; Jansen, 1981; Kapoor & Mukherjee, 1969; Khonje, 1998; Nwude & Ibrahim, 1980; Watt & Breyer-Brandwijk, 1962.

Sources of illustration Brenan, 1967.

Authors L.J.G. van der Maesen

CHAMAECRISTA BIENSIS (Steyaert) Lock

Protologue Kew Bull. 43: 335 (1990).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Synonyms *Cassia biensis* (Steyaert) Mendonça & Torre (1955).

Origin and geographic distribution *Chamaecrista biensis* is widely distributed throughout southern Africa from Angola, Botswana and Mozambique to South Africa.

Uses In Namibia the raw or boiled root of *Chamaecrista biensis* is eaten to cure stomach disorders. It is also eaten as a staple food. It is further used to bring luck; when a piece of root is chewed, undertakings such as hunting and hitchhiking are believed to become successful. The foliage is browsed by livestock.

Properties The foliage of *Chamaecrista biensis* has been tested for palatability, toxicity and feeding value in tests with rats. The results showed no differences from lucerne (*Medicago sativa* L.). The seeds showed a low palatability and feeding value, but no toxicity.

Botany Perennial herb up to 45 cm tall with woody rootstock and prostrate or decumbent stems, occasionally more or less erect; branches hairy. Leaves alternate, paripinnately compound with usually 13–24 pairs of leaflets; stipules lanceolate; petiole with a stalked or almost sessile gland, rachis channelled; leaflets sessile, obliquely linear, asymmetrical, up to 10 mm × 2 mm, apex rounded, apiculate. Inflorescence an extra-axillary raceme, usually 1-flowered. Flowers bisexual, nearly regular, 5-merous; pedicel up to 20 mm long; sepals acute, slightly shorter then petals; petals obovate, 4–7 mm long, yellow; stamens 10; ovary superior, 1-celled. Fruit an erect compressed pod 3–4.5 cm × c. 4 mm, glabrous to shortly hairy. Seeds rhombic-ellipsoid, c. 3 mm long, pale brown with dark brown spots.

Chamaecrista occurs throughout the tropics and subtropics and comprises about 250 species. It has its largest diversity in tropical Africa and tropical America. In continental Africa about 40 species occur, in Madagascar 10, 6 of them endemic.

Chamaecrista biensis forms N-fixing root nodules.

Ecology *Chamaecrista biensis* is widely distributed in savanna on deep sandy and loamy soils. It is most common in disturbed areas such as ploughed land and grazed areas. It is tolerant of low rainfall.

Genetic resources and breeding *Chamaecrista biensis* is considered not threatened. Germplasm collections are preserved at the Institute of Crops and Pastures and the Grassland Research Centre in Pretoria, South Africa, at the Australian Tropical Crops & Forages Genetic Resources Centre, Biloela, Australia and at ICRAF, Nairobi, Kenya.

Prospects The potential of *Chamaecrista biensis* as a pasture plant is high as far as nutritive properties are concerned, but few results seem to have been published on its productivity. Its tolerance of low rainfall and its nitrogen fixing ability have raised interest for use in intercropping and as a green manure. The medicinal properties have not been investigated.

Major references Leger, 1997; Lock, 1990; von Koenen, 2001.

Other references Corby, 1974; Laden & Wrangham, 2005; Mphinyane, 2001; Naisbitt, James & Sprent, 1992; Ross, 1977; Strickland, Lambourne & Ratcliff, 1987; Torre & Hillcoat, 1956.

Authors C.H. Bosch

CHAMAECRISTA FALCINELLA (Oliv.) Lock

Protologue Kew Bull. 43(2): 336 (1990).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Synonyms *Cassia falcinella* Oliv. (1871).

Origin and geographic distribution *Chamaecrista falcinella* occurs in DR Congo, Rwanda, Kenya, Uganda,Tanzania, Zambia, Namibia, Botswana, Zimbabwe and Mozambique.

Uses In Kenya a decoction of the pounded leaves of *Chamaecrista falcinella* is drunk as a remedy for rheumatism. Pounded leaves mixed with ghee are rubbed on the skin to promote healing of broken bones. In Tanzania pounded roots are mixed with water and drunk to treat diarrhoea.

Properties No data have been published on the properties of *Chamaecrista falcinella*. Several interesting compounds with pharmacological activities have been isolated from other *Chamaecrista* spp.

Botany Annual or perennial herb up to 60 cm tall. Leaves alternate, paripinnate with 5–17 pairs of leaflets; stipules falcate, slightly cordate at base; petiole with sessile gland, rachis without gland; leaflets sessile, elliptical, up to 17 mm × 3 mm, midrib asymmetrical, apex acute with prickle-like point bent sideways. Inflorescence a 1–3-flowered raceme. Flowers bisexual, nearly regular, 5-merous; pedicel 1–2.5 cm long, hairy; sepals acute, pubescent; petals obovate, up to 10 mm long, yellow; stamens 8–10; ovary superior, 1-celled, style curved. Fruit a pod up to 4.5 cm × 0.5 cm. Seeds rhombic, c. 3 mm long.

Chamaecrista comprises about 250 species with about 40 species in continental Africa, and 10 in Madagascar, 6 of them endemic. *Chamaecrista falcinella* is variable, and several varieties are distinguished.

Chamaecrista zambesica (Oliv.) Lock (synonym: *Chamaecrista hildebrandtii* (Vatke) Lock) is also used in traditional medicine. In Kenya the leaves and roots are used as a cathartic against the intestinal protozoal parasite *Giardia lamblia*. Laboratory tests confirmed the lethal effect on the parasite. *Chamaecrista lateriticola* (R.Vig.) Du Puy is endemic to Madagascar, where a leaf infusion is taken against stomach-ache.

Ecology *Chamaecrista falcinella* is found mainly in grassland at 1000–1800 m altitude.

Genetic resources and breeding *Chamaecrista falcinella* is widely distributed and hence not threatened with genetic erosion. It is not present in major germplasm collections.

Prospects In view of its medicinal uses, the complete lack of chemical and pharmacological data and the medicinal properties of other *Chamaecrista* species, research on the properties of *Chamaecrista falcinella* may prove worthwhile.

Major references Brenan, 1967; Johns et al., 1995; Kokwaro, 1993.

Other references Gereau & Walters, 2003; Lock, 1990; Ross, 1977.

Authors C.H. Bosch

CHAMAECRISTA NIGRICANS (Vahl) Greene

Protologue Pittonia 4: 30 (1899).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

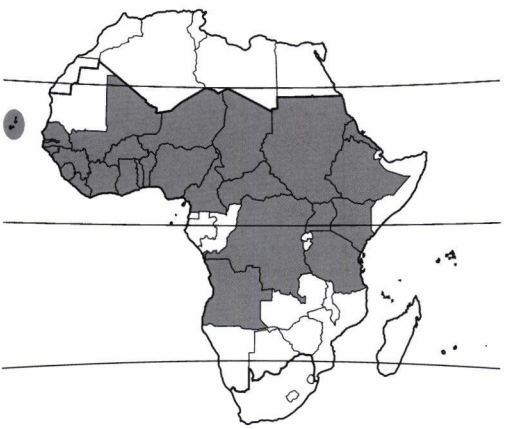
Chromosome number $2n = 16$

Synonyms *Cassia nigricans* Vahl (1790).

Vernacular names Black grain (En). Casse noircissante (Fr). Tintêro, macarra bubel (Po).

Origin and geographic distribution *Chamaecrista nigricans* is widely distributed in tropical Africa, and also occurs in western Asia and India. As a spontaneous weed it occurs throughout the tropics and subtropics and is sometimes found even in Australia.

Uses *Chamaecrista nigricans* has many uses in both human and veterinary medicine. Throughout West and East Africa, an infusion of the leaves or aerial parts is taken against fever and malaria, and to treat stomach-ache, diarrhoea and worms. Externally, an infusion or decoction of the leaves is applied to wounds and abscesses as an antiseptic. The root is pounded with water and taken against diarrhoea, while in decoction it is taken as an anthelmintic. A decoction of the leaves is also taken as cough medicine, and is externally applied for itching. The pounded leaves in water are applied to ticks on humans and horses, while pounded leaves in palm oil are rubbed on the head to kill lice. In Guinea an infusion of the aerial parts is taken as an anti-menstruation agent. In Mali an infusion of the aerial parts is added to a bath to treat haemorrhoids. In Burkina Faso the leaves are rubbed on insect stings. In Niger an infusion of the leaves is taken to treat venereal diseases. In Nigeria a leaf infusion is used to treat peptic ulcers. In Uganda, an infusion of the roots is taken against retained placenta and to promote labour. In Niger and Uganda, an infusion of the root is used for cattle as a vermifuge, as a purgative and to treat diarrhoea. Dried leaves, leaf powder, ash and extracts are used as protective in the storage of pulses and cereals.
The foliage is occasionally grazed by livestock in Senegal. In Sudan it is eaten by camels only in the rainy season. In Guinea, the bitter mature leaves are added to food as an appetizer.



Chamaecrista nigricans – wild

Properties The leaves of *Chamaecrista nigricans* contain the anthraquinone emodin and its anthrone. Methanolic extracts have shown analgesic and anti-inflammatory effects and protected rats against ulcers. The anti-ulcer activity may be via histaminergic receptor inhibition. The extract also has a dose-dependent antidiarrhoeal activity, which may be partly due to α-adrenoceptor stimulation. In mice and rats the extract showed contraceptive activity through oestrogenic and anti-implantation activities. Tests with plant extracts have shown significant action against *Herpes simplex* virus type 1 in vitro. Leaves caused a significant reduction in growth rate in rats when incorporated at 5% in the diet, induced cell hyperplasia in the liver, and reduced the mean weight of the liver and kidneys. Powdered leaves are effective as a storage protectant for pulses, as they inhibit hatching of insect larvae. They are not a health threat if removed before consumption. Ethanolic plant extracts have shown antibacterial activity against *Shigella dysenteriae*, *Staphylococcus aureus*, *Staphylococcus faecalis*, and *Vibrio cholerae*.

Description Annual, erect herb or undershrub, up to 1.5 m tall, hairy, pale green. Leaves distichously alternate, paripinnate with 10–18 pairs of leaflets; stipules 5–8 mm long; petiole with a sessile gland 2–4 mm long, rachis channelled; leaflets sessile, narrowly oblong, symmetrical, up to 25 mm × 6 mm, apex rounded, mucronate. Inflorescence a raceme, inserted slightly above the leaf axil, 3–8-flowered. Flowers bisexual, nearly regular, 5-merous; pedicel 1–3 mm long; sepals acute, slightly longer then petals; petals obovate, up to 4.5 mm long, yellow; stamens 8–10; ovary superior, 1-celled. Fruit an erect compressed pod 2–4 cm × 0.5 cm, slightly raised over the seeds, brown to black when ripe, splitting into 2 thin, spiralling valves, finely pubescent, with up to 10 seeds. Seeds obovate or rhombic, up to 4 mm long, smooth.

Other botanical information *Chamaecrista* (formerly in *Cassia*) occurs throughout the tropics and subtropics and comprises about 250 species. It has its largest diversity in tropical Africa and tropical America. In continental Africa about 40 species occur, in Madagascar 10, 6 of them endemic. *Chamaecrista* has a large morphological variability, rendering a comprehensive taxonomic treatment quite dif-



Chamaecrista nigricans – 1, flowering branch; 2, branch with pods.
Redrawn and adapted by Iskak Syamsudin

ficult.

Ecology *Chamaecrista nigricans* favours waste places, agricultural fields, roadsides and disturbed soil, and also occurs in grassland and wooded savanna, from sea-level up to 1200 m altitude. It is especially common on heavy lateritic soils. Rainfall of 950–1400 mm in 5–6 months as in the Sudano-Guinean zone of West Africa is suitable.

Propagation and planting Seed of *Chamaecrista nigricans* germinates easily.

Harvesting *Chamaecrista nigricans* is collected from the wild. The whole plant is uprooted by hand and may be subsequently dried.

Genetic resources *Chamaecrista nigricans* is not threatened by genetic erosion, because of its wide range of habitats and wide distribution.

Prospects *Chamaecrista nigricans* shows very interesting pharmacological actions: the anti-ulcer, anticonceptive and antibacteriological activities are especially promising. Further research on the medicinal actions of leaves and roots of *Chamaecrista nigricans* is warranted. Formulations for using the leaves against storage pests need to be developed.

Major references Akah et al., 1998; Baerts & Lehmann, 2002a; Belmain et al., 2001; Brenan, 1967; Chidume et al., 2001; Diallo et al., 2002; Lock, 1990; Neuwinger, 2000; Nwafor & Okwuasaba, 2001a; Nwafor & Okwuasaba, 2001b.

Other references Adam, Echard & Lescot, 1972; Berhaut, 1975b; Burkill, 1995; Benz, 2001; Figuière et al., 1998; Geissler et al., 2002; Golob et al., 1999; Harborne, Boulter & Turner, 1971; Hegnauer & Hegnauer, 1996; Mahmoud et al., 1995; Silva et al., 1996; Tabuti, Lye & Dhillion, 2003; Velayaudham et al., 2000; Vidigal, 2002.

Sources of illustration Thulin, 1983.

Authors L.J.G. van der Maesen

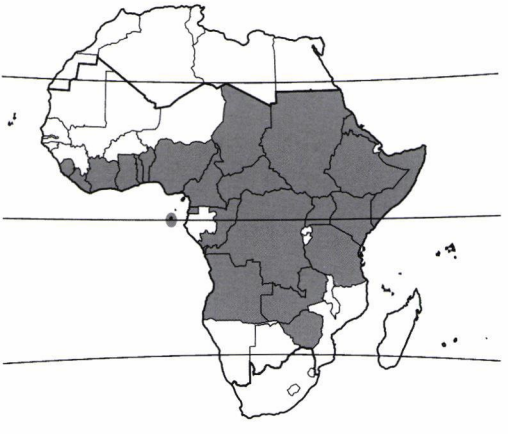
CHASMANTHERA DEPENDENS Hochst.

Protologue Flora 27: 21 (1844).

Family Menispermaceae

Origin and geographic distribution *Chasmanthera dependens* is widely distributed from Sierra Leone east to Eritrea and Somalia and south through eastern DR Congo and Tanzania to Angola, Zambia and Zimbabwe. It is commonly planted in home gardens, e.g. in Ghana.

Uses In West Africa leaf and stem sap are locally applied to cure sprains and bruises, as a dressing for fractures or mixed with shea butter as an embrocation to treat pain and stiffness. The bark is chewed as a remedy for venereal discharges or as a general tonic for physical or nervous weakness in inflammatory and exhausting diseases. In Nigeria a stem maceration together with stems and roots of several other plants is drunk against convulsions. In



Chasmanthera dependens – wild

Kenya the stem is roasted and eaten to treat convulsions in infants. In Uganda the plant is used against dementia, snakebites and epilepsy. A decoction of freshly pounded roots mixed with roots of *Vernonia* sp. is drunk to cure malaria. A decoction of pounded roots mixed with leaves of *Tagetes* sp. is drunk by children to treat cough. In DR Congo the leaf sap is applied as first aid to stop bleeding of wounds.

In Nigeria the fibrous stem is beaten and used as a sponge. In Ethiopia Borana pastoralists eat the roots and leaves.

Production and international trade Several plant parts are commonly sold in local markets as a medicine.

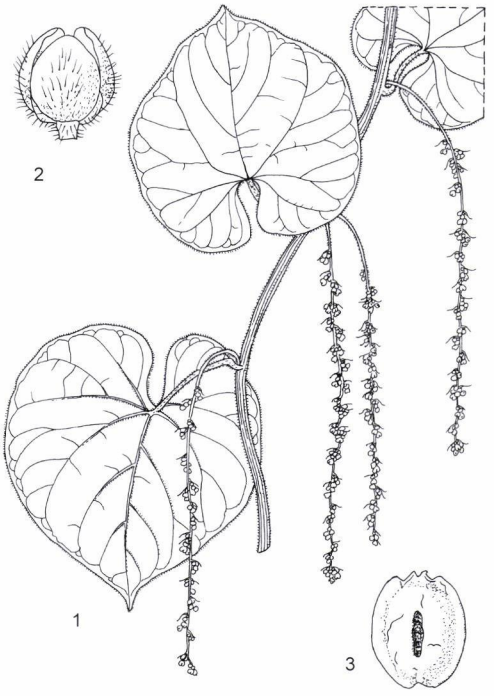
Properties The stem bark of *Chasmanthera dependens* is rich in alkaloids and contains the quaternary protoberberine alkaloids jateorrhizine, palmatine (berbericinine), columbamine, pseudicolumbamine, magnoflorine, and the non-phenolic quaternary alkaloids tetrahydropalmatine, liriodenine, lysicamine (oxonuceferine), O,O-dimethylcorytuberine, anonaine, glaucine, norglaucine, oxoglaucine and nornuceferine. It also contains the tetrahydroprotoberberine type alkaloids govanine and coreximine, the pavine type alkaloid bisnorargemonine and the morphinandienone type alkaloid pallidine, as well as the furanoid diterpene 8-hydroxycolumbine. Several of these alkaloids were also extracted from other species and were found to have interesting pharmacological effects. The roots contain berberine, which is reported to control leishmaniasis.

Methanol extracts of the dried leaves have shown significant analgesic and anti-inflammatory effects.

Ethanol extracts and crude water extracts of the roots showed significant antifungal activity against *Aspergillus flavus*, *Aspergillus fumigatus*, *Aspergillus niger*, *Candida albicans*, *Microsporum audonii*, *Trichoderma viride* and *Trichophyton mentagrophytes*. The ethanol extracts of the plants were more active than the water extracts.

Description Dioecious liana; mature branches with papery exfoliating bark; young branchlets densely short-hairy. Leaves alternate, simple; stipules absent; petiole 7–14 cm long; blade almost round to 3-angled, 7–20 cm × 7–20 cm, base cordate, apex obtuse to acuminate, margin entire or shallowly lobed, densely hairy, palmately 5–7-veined. Inflorescence a pendulous, axillary raceme or false raceme; male inflorescence a false raceme 10–30 cm long, composed of 3–5-flowered clusters; female inflorescence a raceme 10–18 cm long; bracts filiform, persistent. Flowers unisexual, regular; pedicel 3–6 mm long; sepals 6–9, 3 outer sepals lanceolate, up to 2 mm long, bract-like, hairy, inner sepals obovate, 2.5–3.5 mm long, with a tuft of hairs at apex; petals 6, obovate, 2–2.5 mm × 1.5–2 mm, fleshy, glabrous, greenish yellow; male flowers with 6 stamens 2.5–3 mm long, filaments largely fused; female flowers, with superior ovary, consisting of 3 ovoid carpels c. 2 mm long, united at apex by the recurved stigmas, staminodes 6, c. 1 mm long. Fruit composed of 3 ellipsoid and unequal-sided drupelets 1–2 cm × c. 1 cm, each drupelet 1-seeded. Seeds ovoid, 1–2 cm long, curved.

Other botanical information *Chasmanthera* is closely related to *Tinospora* and *Jateorhiza*; these genera have been combined in the past. *Chasmanthera* is an African genus which comprises two species: *Chasmanthera dependens* and *Chasmanthera welwitschii* Troupin. The species appear to be ecologically different, although their areas of distribution overlap in the Central African Republic and intermediates have been found there. Further



Chasmanthera dependens – 1, part of male flowering branch; 2, male flower; 3, drupelet. Source: Flore analytique du Bénin

research is needed to decide if the 2 species should be combined into a single species.

Ecology *Chasmanthera dependens* occurs commonly in forest margins, savanna and secondary forest, often near rocks, but sometimes also in dense and moist evergreen forest, semi-deciduous forest and riverine forest, up to 1500 m altitude. It prefers well-drained soils with ample water and sun.

Propagation and planting *Chasmanthera dependens* is propagated by seed and wildlings. The seeds remain dormant for 6 months.

Management In West Africa *Chasmanthera dependens* is sometimes cultivated as a medicinal plant, mainly in home gardens. It is found growing in cocoa plantations and is sometimes believed to reduce yields. It also hosts a medfly (*Ceratitis* sp.), which feeds on fruits.

Harvesting *Chasmanthera dependens* is collected from the wild or home gardens.

Handling after harvest The fresh leaves are ground and the leaf juice is used immediately or kept for further use on sprains or bruises. The stem bark may be used fresh or roasted. It may also be dried and kept for later use.

Genetic resources *Chasmanthera dependens* is widespread and common and is not in danger of genetic erosion.

Prospects *Chasmanthera dependens* is widely used in traditional medicine, but very few pharmacological tests have been done. Pharmacological tests on the alkaloids present in *Chasmanthera dependens*, but obtained from other species, indicate that additional research is warranted.

Major references Adekunle & Okoli, 2002; Almeida, Navarro & Barbosa-Filho, 2001; Bouquet & Debray, 1974; Burkill, 1997; Irvine, 1961; Morebise et al., 2001; Okoli, Akah & Nwafor, 2003; Oliver-Bever, 1986; Onabanjo et al., 1990; Troupin, 1960.

Other references Adjanohoun et al., 1991; de Wet, 2005; Dormon et al., 2004; Gemedo-Dalle, Maass & Isselstein, 2005; Hamill et al., 2000; Hamill et al., 2003; Ichikawa, 1987; Iwu, 1993; Iwu, Duncan & Okunji, 1999; Ohiri, Verpoorte & Baerheim Svendsen, 1982; Ohiri, Verpoorte & Baerheim Svendsen, 1983b; Thorold, 1975; Troupin, 1962.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors D.M. Mosango

CHASMANTHERA WELWITSCHII Troupin

Protologue Fl. Congo Belge 2: 241 (1951).

Family Menispermaceae

Vernacular names Njinde (Po).

Origin and geographic distribution *Chasmanthera welwitschii* occurs in the humid zone from Cameroon and the Central African Republic south to DR Congo and northern Angola.

Uses Bark preparations are taken as a tonic against bodily and nervous exhaustion. Leaf sap mixed with shea butter is rubbed on the body against pain and stiffness of limbs. A wet dressing made from the leaves is applied to furuncles and abscesses. A fishing poison is prepared from the leaves mixed with leaves of *Tephrosia vogelii* Hook.f. The roots are used as an ordeal-poison, judgement resting on whether the roots caused constipation or diarrhoea, indicating innocence or guilt, respectively. The roots are used in the preparation of palm wine to give it extra strength.
Fruits and roots are eaten by the Turumbu people in DR Congo. The Balumba people in Gabon use the stem for rope in house construction and to make fishing nets and frames.

Properties The medicinal or chemical properties have not been studied, but the presence of berberine-like quaternary alkaloids, as in *Chasmanthera dependens* Hochst., is likely.

Botany Dioecious liana up to 30 m long; branches pendulous, finely grooved, hairy. Leaves alternate, simple, densely hairy; stipules absent; petiole 12–14 cm long; blade nearly round to broadly 5-angular, 10–16 cm × 10–22 cm, base cordate, apex acuminate or obtuse, margins recurved, thinly leathery, palmately 6–7-veined. Inflorescence a pendulous, axillary raceme or false raceme; male inflorescence a false raceme 30–60 cm long, composed of 3–5-flowered clusters; female inflorescence a raceme 15–22 cm long; bracts filiform, persistent. Flowers unisexual, regular; pedicel c. 2.5 mm long; sepals 6, 3 outer ones linear-lanceolate, up to 2 mm long, 3 inner ones obovate, c. 2.5 mm long, with a tuft of hairs at apex; petals 6, obovate, c. 1.5 mm × 1 mm, fleshy, glabrous, greenish yellow; male flowers with 6 stamens c. 1.5 mm long, filaments largely fused; female flowers with superior ovary consisting of 3, ovoid carpels united at apex by the recurved stigmas, staminodes 6, c. 1.2 mm long. Fruit composed of 3 ellipsoid and unequal-sided drupelets c. 1.2 cm × 1 cm, each drupelet 1-seeded. Seeds ovoid, c. 1 cm long, curved.

Chasmanthera is closely related to *Tinospora* and *Jateorhiza*; these genera have been combined in the past. *Chasmanthera* is an African genus which comprises two species: *Chasmanthera welwitschii* and *Chasmanthera dependens*. The species appear to be ecologically different, although their areas of distribution overlap in the Central African Republic and intermediates have been found there. Further study is needed to decide if the 2 species should be combined into a single species.

Ecology *Chasmanthera welwitschii* occurs in dense evergreen and semi-deciduous humid forest, in gallery forest, humid secondary forest and bush fallow at low to medium altitudes.

Management *Chasmanthera welwitschii* is only collected from the wild.

Genetic resources and breeding Although the habitat of *Chasmanthera welwitschii* is shrinking, there are no indications that it is threatened by genetic erosion.

Prospects The pharmacological properties of *Chasmanthera welwitschii* are unknown and deserve exploratory research.

Major references Liengola, 2001; Raponda-Walker & Sillans, 1961; Troupin, 1951; Troupin, 1962.

Other references Bouquet, 1969; Burkill, 1997; Lubini, 1986.

Authors L.P.A. Oyen

CHROZOPHORA BROCCHIANA (Vis.) Schweinf.

Protologue Pl. quaed. nilot.: 9 (1862).

Family Euphorbiaceae

Origin and geographic distribution *Chrozophora brocchiana* occurs from Cape Verde and Mauritania throughout the Sahel region east to Sudan, and is also found in Algeria and Egypt.

Uses In the Hoggar region of Mali and Niger, the plant ash is applied to sores of humans and camels. In Niger the Hausa people rub crushed leaves on the affected sites to treat stitch in the side. The aerial parts are taken in decoction to strengthen lactating mothers and their children, and to treat fever and dysentery. In Benin powdered dried leaves in water are taken to treat diarrhoea. Root sap in water is used as ear drops to treat otitis.

In Senegal the plant is not browsed by most stock, except occasionally by sheep and goats, as it causes vomiting and diarrhoea. In Niger though, it is sought after by goats and at certain times of the year also by cattle. It is not suitable for making hay or silage. In central Sudan a sweet, non-drying oil is pressed from the seeds.

Properties Analysis of the chemical content of the aerial parts revealed an unusually high silica content. The aqueous methanol extract of the aerial parts contains brocchiana carboxylic acid, an analogue of brevifolin carboxylic acid, as well as gallic acid, methyl gallate, ethyl gallate, ellagic acid, mono- and di-methoxy ellagic acid, apigenin and luteolin 7-O-glucoside.

The analysis of the fatty acid composition of the seed oil showed linoleic acid as the major component, followed by palmitic, oleic and stearic acids.

Botany Monoecious, shrubby herb up to 60(–150) cm tall; taproot stout and very long; stem ascending, knotty, much-branched from the base, white-velvety hairy with stellate hairs. Leaves alternate, simple; stipules small; petiole long; blade angular-ovate to triangular-ovate, 2.5–4 cm × 1.5–3 cm, base deeply cordate with 2 glands, apex rounded, margins undulate, upper surface sparsely hairy, lower surface velvety hairy, 3-veined at base. Inflorescence a condensed axillary raceme, with male flowers at the top and female flowers at the base; bracts small. Flowers unisexual, regular, 5-merous; calyx velvety hairy, petals deep red; male flowers with short pedicel, stamens up to 10, filaments fused into a column; female flowers with pedicel elongating in fruit to 6 mm long, petals smaller than in male flowers, ovary superior, 3-celled, styles 3, fused at base, 2-fid at apex. Fruit a 3-lobed capsule c. 1 cm long, densely covered with white or violet-tinged, shiny stalked scales, 3-seeded. Seeds ovoid, smooth, yellowish brown, covered by a thin, pale, shiny aril.

Chrozophora comprises 7–8 species and is distributed in Africa, southern Europe and Asia.

Ecology *Chrozophora brocchiana* grows on sandy soils in dry regions. It resprouts throughout the dry season.

Genetic resources and breeding *Chrozophora brocchiana* is common in its distribution area and not in danger of genetic erosion.

Prospects *Chrozophora brocchiana* has several interesting medicinal uses, e.g. against diarrhoea, but no pharmacological studies have been effected to elucidate effects of the isolated compounds. The plant is important as a fodder of cattle in some times of the year although there is contradiction concerning the toxicity of the aerial parts. It would therefore be interest-

ing to investigate *Chrozophora brocchiana* phytochemically.

Major references Burkill, 1994; Hawas, 2006; Keay, 1958a; Mirghani et al., 1996; Neuwinger, 1996.

Other references Adam, Echard & Lescot, 1972; Adjanohoun et al., 1985; Bartha, 1970; Prain, 1918.

Authors G.H. Schmelzer

CHROZOPHORA PLICATA (Vahl) A.Juss. ex Spreng.

Protologue Syst. veg. 3: 850 (1826).

Family Euphorbiaceae

Chromosome number $2n = 22$

Synonyms *Chrozophora rottleri* (Geiseler) A.Juss. ex Spreng. (1826).

Origin and geographic distribution *Chrozophora plicata* occurs from Senegal east to Somalia and south throughout East Africa to northern South Africa. It also occurs from Egypt and Saudi Arabia east to tropical Asia.

Uses In Sudan pounded stems or whole plants are applied to wounds to improve healing. In Ethiopia an infusion of the seeds and leaves is taken as a laxative. The plant is also used medicinally in Saudi Arabia, Pakistan and India, e.g. against jaundice and to purify blood.

In Senegal the plant is not browsed by most stock, except occasionally by sheep and goats, as it causes vomiting and diarrhoea. In Kenya camels graze it. The fruits yield a purplish blue dye, which is used in East Africa to dye mats.

Properties The fresh shoots of *Chrozophora plicata* force-fed to Nubian goats and desert sheep caused all animals to die, and the main signs of poisoning were salivation, dyspnoea, bloat, loss of appetite, dullness, diarrhoea, paralysis of the hind limbs and lateral deviation of the head and neck. The main lesions were haemorrhage in the lungs, heart and kidneys, pulmonary cyanosis and oedema, and serious atrophy of the cardiac fat and renal pelvis. Hematological changes indicated the development of anaemia.

The seed oil resembles cotton-seed oil in its proportions of linoleic, oleic and saturated acids. The total linolenic and linoleic acid content varied from 60–75%. No chemical analyses have been effected on the aerial parts of *Chrozophora plicata*, but from the aerial parts of the related *Chrozophora tinctoria* (L.) Raf. (synonym: *Chrozophora obliqua* (Vahl) A.Juss. ex Spreng.) occurring from north-western India to the Mediterranean, several toxic dolabellane diterpene glucosides, dolabellane diterpenoids and phenylpropanoid glucosides have been isolated. Although rats fed 10% leaves in their diet had a low growth rate, bouts of soft faeces, lesions of internal organs and alterations in blood and urea, no death occurred among the rats.

Botany Monoecious, annual to perennial herb up to 50 cm tall; stem angular, much-branched from the base, densely hairy with stellate hairs, yellowish or pinkish. Leaves alternate, simple; stipules small; petiole 1–4(–7) cm long; blade broadly ovate to rhombic-ovate, 1.5–7 cm × 1–5.5 cm, base cuneate to shallowly cordate with 2 purple glands, apex rounded to obtuse, margins entire or shallowly toothed, densely hairy with stellate hairs, 3–5-veined at base. Inflorescence a condensed axillary raceme 1.5–4 cm long, with male flowers at the top and female flowers at base; bracts small. Flowers unisexual, regular, 5-merous; calyx with stellate hairs; male flowers with short pedicel, calyx with lanceolate lobes c. 3 mm long, petals elliptical-oblong, c. 3 mm long, yellowish orange or pinkish, stamens 15, filaments fused into a column; female flowers with long pedicel, extending up to 2(–3) cm in fruit, sepals linear-lanceolate, 1.5–2 mm long, petals minute or absent, ovary superior, 3-celled, densely short-hairy, styles 3, 1.5–2 mm long, fused at base, deeply 2-fid, red. Fruit a 3-lobed capsule 4–5 mm × 7–9 mm, densely stellate-hairy, reddish or bluish purple when ripe, 3-seeded. Seeds ovoid, c. 3.5 mm long, smooth or minutely dotted, pale or dark brown to blackish.

Chrozophora comprises 7–8 species and is distributed in Africa, southern Europe and Asia. Another *Chrozophora* species with medicinal use in Africa is *Chrozophora oblongifolia* (Delile) A.Juss. ex Spreng., occurring in north-eastern Africa, the Arabian Peninsula and Pakistan. In Sudan a stem or leaf extract is taken to treat gonorrhoea. The chloroform and methanol extracts show considerable antibacterial activities.

Ecology *Chrozophora plicata* occurs on flood plains of rivers, along drainage channels, usually in damp or desiccating black clay soils and alluvial soils, on mudflats and sandbanks, up to 1200 m altitude. It is also a weed of arable land.

Genetic resources and breeding *Chrozophora plicata* has a wide distribution and is

relatively common. The species is therefore not threatened by genetic erosion.

Prospects *Chrozophora plicata* has few medicinal uses, and is poisonous to livestock. It will therefore remain of local importance only.

Major references Burkill, 1994; Farouk, Bashir & Salih, 1983; Galal & Adam, 1988; Jansen, 1981; Radcliffe-Smith, 1987.

Other references Adam, Al-Redhaiman & Al-Qarawi, 1999; Barker, Dunn & Hilditch, 1950; Govaerts, Frodin & Radcliffe-Smith, 2000; Hasan et al., 1980; Mahmoud et al., 1995; Mohamed, 2001; Radcliffe-Smith, 1996a.

Authors G.H. Schmelzer

CHROZOPHORA SENEGALENSIS (Lam.) A.Juss. ex Spreng.

Protologue Syst. veg. 3: 850 (1826).

Family Euphorbiaceae

Origin and geographic distribution *Chrozophora senegalensis* occurs from Mauritania east to Nigeria.

Uses Throughout West Africa a leaf macerate is taken to treat tapeworm and roundworm. In Senegal a root decoction is given to suckling babies to treat diarrhoea. A fruit maceration is taken to treat ophthalmia, conjunctivitis and night blindness. The fruit juice is used as eye drops to treat more severe cases. A maceration of leaves and roots is drunk to treat loss of hair and diabetes. In Mali a maceration of the aerial parts is applied to wounds to improve healing. In Côte d'Ivoire an enema made from the aerial parts is given to children with rickets. An infusion of the aerial parts is taken to treat stomach-ache and venereal diseases. An infusion of the whole plant is astringent and taken in northern Nigeria with cereals to treat diarrhoea. The infusion is also topically applied to treat rheumatism. The aerial parts also enter in a complex medicine to treat venereal diseases and mental disorders.

In Senegal the plant is not browsed by most stock, except occasionally by camels, sheep and goats, as it causes vomiting and diarrhoea. The aerial parts yield a black dye, which is used to colour mats.

Properties A water extract of the aerial parts caused an in-vivo hypoglycaemic response in rats.

Botany Monoecious, shrubby herb up to 60 cm tall; taproot stout and very long; stem ascending, knotty, much-branched from the base, densely short-hairy. Leaves alternate, simple; stipules small; petiole short; blade angular-ovate to triangular-ovate, 2.5–4 cm × 1.5–3 cm, base deeply cordate with 2 basal glands, apex rounded, margins undulate, upper surface sparsely hairy, lower surface densely short-hairy, 3-veined at base. Inflorescence a condensed axillary raceme, with male flowers at the top and female flowers at the base; bracts small. Flowers unisexual, regular, 5-merous; calyx short-hairy, petals deep red; male flowers with short pedicel, stamens up to 10, filaments fused into a column; female flowers with long pedicel, petals smaller than in male flowers, ovary superior, 3-celled, styles 3, fused at base, 2-fid at apex. Fruit a 3-lobed capsule c. 1 cm long, densely covered with white, shiny stalked scales, 3-seeded. Seeds ovoid, smooth, yellowish brown, covered by a thin, pale, shiny aril.

Chrozophora comprises 7–8 species and is distributed in Africa, southern Europe and Asia. *Chrozophora senegalensis* closely resembles *Chrozophora brocchiana* (Vis.) Schweinf., but the former species has shorter hairs, shorter petioles and non-elongating sepals in fruit.

Ecology *Chrozophora senegalensis* occurs on sandy soils, in seasonally flooded areas and on riverbanks in savanna regions with a pronounced dry season. It is also a weed of cultivated land.

Genetic resources and breeding *Chrozophora senegalensis* is relatively common in its distribution area and not threatened by genetic erosion.

Prospects *Chrozophora senegalensis* has a wide range of local medicinal uses, but virtually nothing concerning its chemistry and pharmacology is known. Research is therefore warranted.

Major references Burkill, 1994; Keay, 1958a; Massing-Bias, 1991; Neuwinger, 1996.

Other references Diallo et al., 2002; Govaerts, Frodin & Radcliffe-Smith, 2000.

Authors G.H. Schmelzer

CISSAMPELOS CAPENSIS L.f.

Protologue Suppl. pl.: 432 (1782).

Family Menispermaceae

Origin and geographic distribution The distribution of *Cissampelos capensis* is limited to Namibia and the Cape Provinces of South Africa.

Uses In South Africa, where the plant is called 'dawidjie', a tincture of the rhizome in alcohol or brandy or a decoction of the rhizome

is taken as a blood purifier to treat boils and glandular swellings, syphilis, cholera, colic, diarrhoea, diabetes and several cancers. It is given against bladder ailments, bilious problems and gallstones and is applied externally and internally against erysipelas. The extract is also used to prevent miscarriage and difficult labour, and to expel retained placenta. A paste made of the leaves is applied to sores and boils. Stems are burnt as incense against evil spirits, while a stem infusion is used as a ritual wash for the same purpose.

Production and international trade Bundles of fresh or dried leaves and rhizomes are sold in local markets in South Africa.

Properties All plant parts are rich in alkaloids. Major components of the leaves are the morphinane alkaloid salutaridine and the aporphine alkaloids dicentrine and bulbocapnine, and as minor components the aporphine alkaloid lauroscholtzine, the proaporphine alkaloids crotsparine and glaziovine and the bisbenzyltetrahydroisoquinoline alkaloid cycleanine. The alkaloid yield varies from 4.7–19 mg/g dry weight. In the stems the major alkaloids are the aporphine alkaloids bulbocapnine and dicentrine and the bisbenzyltetrahydroisoquinoline alkaloids cissacapine, cycleanine and insularine. Minor alkaloids are the bisbenzyltetrahydroisoquinoline alkaloids 12-O-methylcurine and insulanoline and the benzyltetrahydroisoquinoline alkaloid reticuline. Main components of the rhizomes are the bisbenzyltetrahydroisoquinoline alkaloids 12-O-methylcurine, cycleanine and cissacarpine, and as minor components the aporphine alkaloids bulbocapnine and dicentrine, the proaporphine alkaloids glaziovine and pronuciferine and the bisbenzyltetrahydroisoquinoline alkaloid insularine. The alkaloid yield of both stem and rhizome samples varies from 0.5–2.3 mg/g dry weight. The alkaloid composition also varies among plants, the difference being largest between plants from inland localities and plants from coastal localities.

In pharmacological tests dicentrine, cycleanine and salutaridine showed significant anticancer activities against several cancer cell lines, but this was coupled with a high cytotoxicity. Cycleanine has shown selective antiplasmodial and antiprotozoal activities as well as spasmolytic activity in vitro. Cycleanine furthermore showed antimicrobial, anti-inflammatory and analgesic activities, and dicentrine antibacterial and antifungal activities in vitro. A methanol extract of the leaves, as well as isolated dicentrine and another isolated alkaloid, neolitsine, showed significant anthelmintic activity against larvae of the stomach parasite *Haemonchus contortus*. In an in-vivo essay, oral administration of dicentrine resulted in 67% reduction of worm counts in mice at a dose of 25 mg/kg.

Botany Dioecious shrub up to 1 m tall, with rhizome; stems glabrous or short-hairy, with longitudinal ridges. Leaves arranged spirally, simple; stipules absent; petiole up to 2.5 cm long, glabrous; blade ovate to deltoid, up to 4 cm × 3.5 cm, base cuneate to truncate, apex obtuse to retuse, often with mucro, margin entire to slightly undulate, leathery, glabrous to hairy, greyish to bright green, palmately 3–5-veined. Inflorescence an axillary, umbel-like cyme, solitary or clustered; male inflorescence solitary or paired, female inflorescence arranged in a short false raceme; bracts linear, tiny. Flowers unisexual; male flowers with pedicel up to 2.5 mm long, sepals 4, elliptical to obovate, 0.5–1.5 mm × 0.5–1 mm, fleshy, outer two thicker than inner two, short-hairy outside, corolla cup-shaped, 4-lobed, 0.5–1 mm in diameter, greenish, stamens 4, filaments fused; female flower with pedicel up to 3 mm long, sepals 2, orbicular to rhomboid, c. 1 mm × 1.5 mm, short-hairy outside, petals 2, elliptical to ovate, 0.5–1 mm × 0.5–1 mm, glabrous, ovary superior, striped, glabrous, 1-celled, style short, stigma u-shaped, 3-lobed. Fruit a compressed obovoid drupe up to 7 mm long, orange when mature, stone bony, horseshoe-shaped, 1-seeded. Seed with sparse endosperm and curved embryo.

Cissampelos capensis can be found flowering throughout the year.

Cissampelos comprises about 20 species, 7 in tropical America and 13 in tropical Africa. *Cissampelos pareira* L. is the only species with a pantropical distribution. *Cissampelos capensis* should not be confused with *Zehneria scabra* (L.f.) Sond. (*Cucurbitaceae*), known as 'dawidjies' in South Africa and also used medicinally.

Ecology *Cissampelos capensis* occurs in open localities on well-drained sandy or granite-derived soils, up to 1900 m altitude.

Management Leaves and rhizomes are only collected from the wild.

Genetic resources and breeding *Cissampelos capensis* occurs in a fairly large area; there are no indications that it is threatened by genetic erosion.

Prospects *Cissampelos capensis* contains some alkaloids with interesting pharmacologi-

cal properties, some of which act against several cancer cell lines. Therefore more research is warranted.

Major references Ayers et al., 2007; Cocks & Dold, 2006; de Wet, 2005; de Wet & van Wyk, 2008; Neuwinger, 2000.

Other references Cocks, 1995; Dold & Cocks, 2002; Friedrich-Holzhammer, 1968; SA Health Info, 2007; Watt & Breyer-Brandwijk, 1962.

Authors L.P.A. Oyen

CISSAMPELOS MUCRONATA A.Rich.

Protologue Fl. Seneg. tent. 1: 11 (1831).

Family Menispermaceae

Synonyms *Cissampelos pareira* L. var. *mucronata* (A.Rich.) Engl. (1899).

Vernacular names Orelha de rato (Po). Kishiki cha buga (Sw).

Origin and geographic distribution *Cissampelos mucronata* is distributed throughout tropical Africa, except the most humid areas, from Senegal east to Ethiopia and south to South Africa.

Uses *Cissampelos mucronata*, *Cissampelos owariensis* P.Beauv. ex DC. and *Cissampelos pareira* L. have often been confused; as they are also similarly used, it is often impossible to correlate uses unambiguously with a particular species. *Cissampelos mucronata* has many medicinal uses, and throughout Africa people take an infusion of the bitter rhizome, and sometimes of leaves and stems, or fruit juice, to cure gastro-intestinal complaints such as diarrhoea, dysentery, colic, intestinal worms and digestive complaints, and also urogenital problems such as menstrual problems, venereal diseases, infertility, azoospermia, to induce contraction of the uterus to start labour or abortion and to expel the placenta. In eastern DR Congo a leaf decoction is taken as a vermifuge against tapeworm.



Cissampelos mucronata – wild

In Senegal the rhizome enters into preparations to treat catarrh, whereas in Togo the rhizome is chewed to treat sore throat, cough and lung problems. In decoction the rhizome is given against oedema. In Tanzania and Madagascar a rhizome decoction is taken to diminish fever caused by malaria or jaundice. Rhizome sap is used as ear drops to treat earache. Bushmen of the Kalahari take a warm rhizome decoction to treat coughs and for general wellness. In the Okavango delta in Botswana, Namibia and Zimbabwe a rhizome decoction is drunk to treat headache, neck pain and back pain. In Namibia the Damara people apply the powdered rhizome to open wounds for quick healing. In Zimbabwe rhizomes are used to treat bilharzia.

Throughout West Africa and in Uganda, fresh leaves, heated leaves or pulped leaves are applied to wounds, ulcers, conjunctivitis and syphilis sores, and a poultice of leaves mixed with natron is applied to swellings, ulcers and Guinea worm sores. In Ghana leaf pulp is taken internally or applied to the affected area as an antidote for snake venom. In Côte d'Ivoire and Burkina Faso fresh leaf pulp is applied to relieve severe headache and is eaten mixed with clay to stop stomatitis. The vapour of a leaf decoction is inhaled to induce vomiting.

In southern Senegal an infusion of leafy stems is used as emmenagogue. In Togo the whole plant is used in preparations to treat intercostal pain. In Nigeria ash from the plant enters into a medicine against arthritis, which is rubbed into scarifications. In DR Congo and eastern Tanzania the pounded plant is applied to snakebites. In Rwanda the plant is used to treat diseases affecting the spine. In Benin, Uganda and other parts of Africa the roots are used in medical rituals to treat mental problems such as psychoses.

In Nigeria the rhizome is sometimes used in the preparation of arrow poison. In Kenya crushed rhizomes are applied to the skin of goats to remove insect parasites.

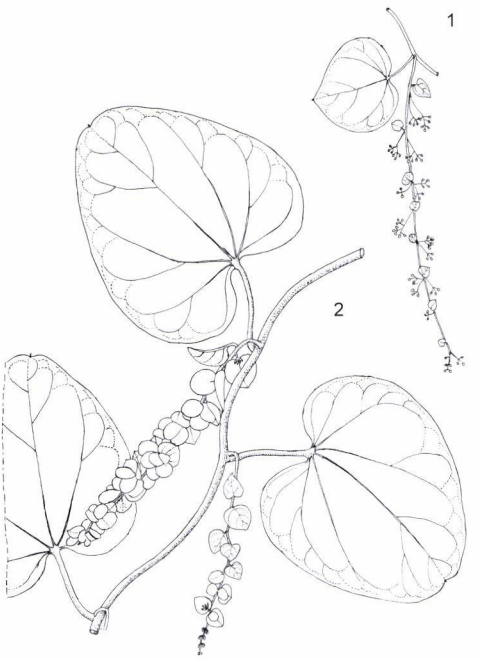
The stems of *Cissampelos mucronata* are commonly used for tying and binding and in wickerwork; in DR Congo stems are used to make fishing lines.

Production and international trade *Cissampelos mucronata* is mainly traded in local markets. It may enter wider markets by the name 'pareira brava'. True 'pareira brava' however is made from the South American *Chondrodendron tomentosum* Ruiz & Pav.; in some African countries it is permitted to sell *Cissampelos pareira* under this name, and confusion with *Cissampelos mucronata* may occur.

Properties All plant parts are rich in alkaloids, although the rhizomes contain most. The aporphine alkaloid dicentrine is the main alkaloid isolated from all plant parts. The rhizome also contains a high concentration of the bisbenzyltetrahydroisoquinoline alkaloids cissacapine, cycleanine and d-isochondrodendrine; the first 2 alkaloids occur in small amounts in the stem, as well as the aporphine alkaloid lauroscholtzine. The leaves contain the proaporphine alkaloid pronuciferine, the benzyltetrahydroisoquinoline alkaloid reticuline and the morphinane alkaloid salutaridine. A methanolic rhizome extract contained several bisbenzylisoquinoline alkaloids, including tubocurine, 12-O-methylcurine, isoliensinine and cissampentine.

Methanolic extracts from the dried rhizome have shown significant antiprotozoal activity against chloroquine sensitive and chloroquine resistant *Plasmodium falciparum*. The dichloromethane extract showed less activity. The methanolic extract also inhibited the enzyme tyrosine kinase. Alkaloids isolated from the ethanolic extracts of the rhizome have shown sedative effects in tests with mice. The ethanol extract has also shown uterine relaxant activities in pregnant and non-pregnant rats. Methanolic leaf extracts of the plant had a positive effect against indomethacin-induced stomach ulcers in rats.

Description Dioecious liana, with rhizome; older stems with longitudinal ridges, dark brown, branchlets short-hairy. Leaves arranged spirally, simple; stipules absent; petiole (1–)2–4.5(–8) cm long, inserted 0–3 mm above the base of the blade; blade ovate to heart-shaped, 4–12(–15) cm × 4–13(–14.5) cm, base cordate, apex rounded to acute, with mucro, margin entire or wavy, papery, short-hairy on both sides, later glabrescent, palmately veined with 5–7 main veins. Inflorescence an axillary, umbel-like cyme, solitary or clustered; male inflorescence either in clusters or arranged in a false raceme up to 15(–30) cm long, female inflorescence arranged



Cissampelos mucronata – 1, part of stem with male inflorescence; 2, part of stem with female inflorescence and infructescence.
Redrawn and adapted by Iskak Syamsudin

in a false raceme 5–16(–18) cm long; peduncle up to 1 cm long; bracts 10–12 mm long, mucronate. Flowers unisexual, with reddish brown or black spots; pedicel up to 2 mm long; male flowers with 4–5(–7) ovate to elliptical sepals, free or fused at base, 1–1.5 mm × 0.5–1 mm, hairy outside, petals 4–5, fused at base, 1–1.5 mm long, spreading after flowering, stamens 2–5, filaments fused, up to 1.5 mm long; female flowers with 1(–2) obovate sepals up to 1.5(–2) mm long, short-hairy, petals 1(–2), broadly ovate, c. 1 mm × 1.5 mm, glabrous, ovary superior, c. 1 mm long, almost glabrous, 1-celled, stigma 3–5-lobed. Fruit a compressed obovoid drupe 4–7 mm × 3–5(–8) mm, curved, orange-red or yellow when ripe, short-hairy, stone woody with a dorsal ridge, sides with warty ribs, 1-seeded. Seed with sparse endosperm.

Other botanical information *Cissampelos* comprises about 20 species, 7 in tropical America and 13 in tropical Africa. *Cissampelos pareira* is the only species with a pantropical distribution.

Growth and development In South Africa

Cissampelos mucronata can be found flowering almost throughout the year.

Ecology *Cissampelos mucronata* occurs in deciduous bushland, often on termite hills and rock outcrops, in riverine forests and swamps, up to 1800 m altitude. It often persists in cultivated land.

Propagation and planting *Cissampelos mucronata* is only propagated by seed.

Management *Cissampelos mucronata* is commonly planted in home gardens as a medicinal plant but details of management and yield are not known.

Genetic resources Because *Cissampelos mucronata* is very widespread in Africa and occurs in a variety of habitats, it seems not to be in danger of genetic erosion. In view of its medicinal importance and wide distribution, the establishment of a representative germplasm collection is recommended.

Prospects *Cissampelos mucronata* is an important and well-documented medicinal plant throughout Africa, but with little chemical and pharmacological data available to support its medicinal uses. Further study of the pharmacological properties of the various plant parts and of their chemical components is urgently needed.

Major references Baerts & Lehmann, 2006a; de Wet & van Wyk, 2008; Keay & Troupin, 1954; Neuwinger, 1996; Neuwinger, 2000; Nwafor & Akah, 2003; Nwafor et al., 2002; Rhodes, 1975; Troupin, 1956; Tshibangu, Wright & König, 2003.

Other references Adjanohoun et al., 1991; Akah et al., 2002; Bost, 1961; de Wet, Tilney & van Wyk, 2001; Gessler et al., 1994; Hamill et al., 2000; le Grand & Wondergem, 1987; Minja, 1994b; Tshibangu et al., 2002; Watt & Breyer-Brandwijk, 1962.

Sources of illustration Berhaut, 1979.

Authors M. Muzila

CISSAMPELOS OWARIENSIS P.Beauv. ex DC.

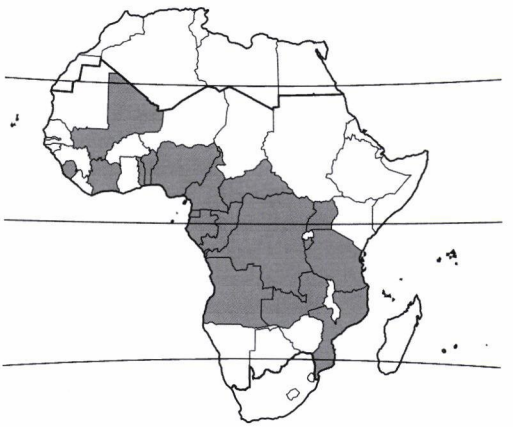
Protologue Prodr. 1: 100 (1824).

Family Menispermaceae

Synonyms *Cissampelos pareira* L. var. *owariensis* (P.Beauv. ex DC.) Oliv. (1868).

Vernacular names Liane amère, liane corde, liane serpent (Fr). Kishiki cha buga, mkasisi cha mkiwa, mlagalaga (Sw).

Origin and geographic distribution *Cissampelos owariensis* occurs from Sierra Leone east to Uganda and south to Angola, Zambia and Mozambique.



Cissampelos owariensis – wild

Uses *Cissampelos owariensis*, *Cissampelos mucronata* A.Rich. and *Cissampelos pareira* L. have often been confused; as they are also similarly used, it is often impossible to correlate uses unambiguously with a particular species.

Throughout the distribution area of *Cissampelos owariensis* people take an infusion of the bitter rhizome, leaves or stems to cure gastrointestinal complaints such as diarrhoea, dysentery, colic, intestinal worms and digestive complaints, and also urogenital problems such as menstrual problems, venereal diseases, infertility, to induce contraction of the uterus to start labour or abortion and to expel the placenta. Women of the Bini people in Nigeria use the leaves to promote foetal growth.

Leaves and rhizomes or their ash are widely used in various forms to treat abscesses, ulcers and scabies, and also as a haemostatic. In Nigeria leaf sap is used as nose or eye drops to cure headache. In Congo a decoction of stems mixed with leaves of other plants is used as a wash to treat wounds. In DR Congo leaf sap is applied to swellings, and is taken as a stomachic. A maceration of the plant is applied to snake bites. A decoction of the rhizome macerated in palm oil is taken against piles. In south-eastern Tanzania grated rhizome is applied to snakebites. The aerial parts enter in preparations to treat amnesia and psychoses and in the preparation of health tonics. A decoction of crushed leaves is used in veterinary medicine to treat diarrhoea. In Nigeria the rhizome is sometimes used in the preparation of arrow poison.

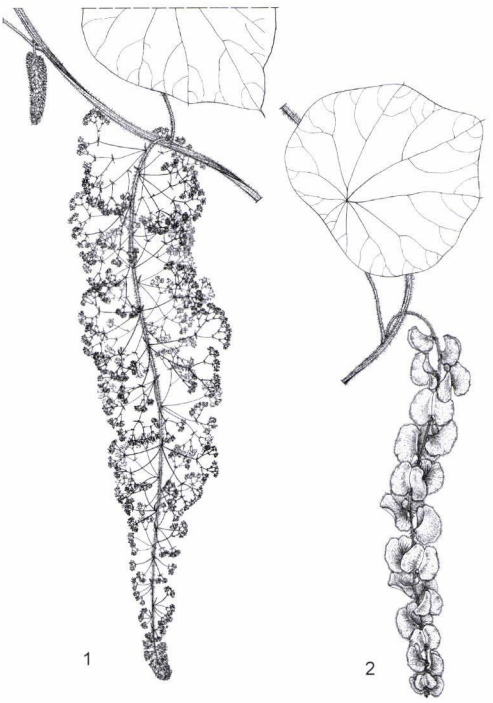
The stems are used as binding material for basket-work. The plant is occasionally cultivated as an ornamental.

Production and international trade The plant is commonly sold in local markets. It may enter wider markets by the name 'pareira brava'. True 'pareira brava' however is made from the South American *Chondrodendron tomentosum* Ruiz & Pav.; in some African countries it is permitted to sell *Cissampelos pareira* under this name, and confusion with *Cissampelos owariensis* may occur.

Properties Although the chemical and pharmaceutical properties of several *Cissampelos* spp. have been studied extensively and promising activities have been demonstrated, these aspects of *Cissampelos owariensis* have hardly been studied. Given the wide use of the plant in traditional medicine, it seems likely that it contains similar compounds, such as bisbenzylisoquinoline alkaloids.

Crude ethanol extracts of leaves and rhizomes of *Cissampelos owariensis* applied topically to adult *Acanthoscelides obtectus* (pest of beans), *Sitophilus oryzae* (pest of stored rice grain) and *Prostephanus truncatus* (pest of maize and cassava) caused significant mortality in these beetles. Seed and leaf powders and slurries were also very effective against the last 2 pests when mixed with grains at a rate of 1% w/w.

Description Dioecious liana, with rhizome; stem and branchlets with spreading hairs. Leaves arranged spirally, simple, peltate; stipules absent; petiole 4–16 cm long, inserted 1–2 cm from the base of the blade; blade broadly ovate to circular, sometimes broadly triangular, 6–12 cm in diameter, base rounded to almost cordate, apex obtuse and mucronate, papery, variably hairy, palmately 5–7-veined. Inflorescence an axillary, umbel-like cyme, solitary or clustered; male inflorescence arranged in a false raceme up to 40 cm long, female inflorescence arranged in a false raceme up to 35 cm long; peduncle 0.5–3 cm long, hairy; bracts rounded or kidney-shaped, up to 4 cm in diameter, enlarging in fruit, whitish, hairy. Flowers unisexual; pedicel c. 1 mm long; male flowers with 4(–5) obovate, spreading sepals 1–1.5 mm × 0.5–1 mm, hairy outside, corolla cup-shaped, c. 1 mm long, stamens 2–5, filaments fused; female flowers with 1 sepal, 1–2 mm × 0.5–1 mm, petals 1(–3), kidney-shaped, c. 1 mm long, ovary superior, 1–1.5 mm long, hairy, 1-celled. Fruit an obovoid drupe 4–6 mm × 4–5 mm, hairy, red when ripe, stone woody with warty ribs, 1-seeded.



Cissampelos owariensis – 1, part of stem with male inflorescence; 2, part of stem with female inflorescence.
Source: Flore analytique du Bénin

Other botanical information *Cissampelos* comprises about 20 species, 7 in tropical America and 13 in tropical Africa. *Cissampelos pareira* is the only species with a pantropical distribution.

Growth and development *Cissampelos owariensis* is very variable in leaf form, hairiness and inflorescence size. Flowering occurs towards the end of the dry season and the beginning of the rainy season, in Benin from January to May. Fruits mature in the dry season.

Ecology *Cissampelos owariensis* occurs in lowland and riverine forest, also in secondary forest, and it is often also common in clearings, orchards, fields and hedges, especially on moist soils up to 900 m altitude.

Propagation and planting *Cissampelos owariensis* is only propagated by seed

Management It is sometimes found as a medicinal plant in home gardens, mainly in coastal regions.

Harvesting Plant material is collected from the wild throughout the year, whenever re-

quired.

Handling after harvest Collected plant material may be dried for later use.

Genetic resources and breeding *Cissampelos owariensis* has a wide distribution and is not in danger of genetic erosion. In view of its medicinal importance and wide distribution, the establishment of a representative germplasm collection is recommended.

Prospects *Cissampelos owariensis* has many medicinal uses, which are similar to several other *Cissampelos* spp. However, few chemical and pharmacological investigations on *Cissampelos owariensis* have been made and additional research is warranted. If the biological activities are confirmed, biological and ecological studies are needed for domestication to ensure sustainable use.

Major references Baerts & Lehmann, 2006b; Burkill, 1994; Neuwinger, 1996; Neuwinger, 2000; Niber, 1994; Troupin, 1960.

Other references Chifundera, 1987; Igoli et al., 2005; Keay & Troupin, 1954; Maas, 1991; Niber, Helenius & Varis, 1992; Troupin, 1951; Troupin, 1962; Wome, 1985.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors D.M. Mosango

CISSAMPELOS PAREIRA L.

Protologue Sp. pl. 2: 1031 (1753).

Family Menispermaceae

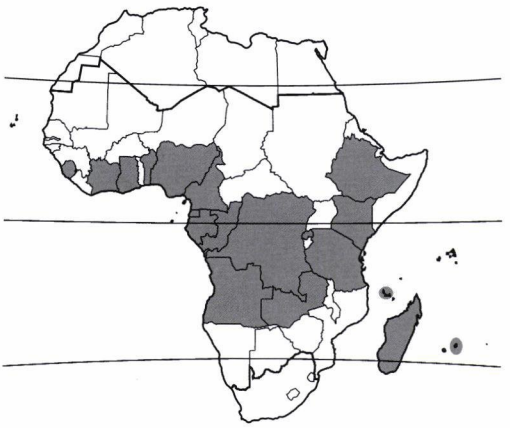
Chromosome number $n = 12$

Synonyms *Cissampelos madagascariensis* Miers (1871).

Vernacular names Velvetleaf, false pareira, abuta (En). Liane patte cheval (Fr). Pareira brava, butua (Po). Kishiki cha buga, mkasisi mkiwa, mlagalaga (Sw).

Origin and geographic distribution *Cissampelos pareira* was first described from Latin America, but actually occurs throughout the tropics; in some countries it has been introduced for its ornamental value. In Africa it has been recorded from Sierra Leone east to eastern DR Congo, Rwanda and Tanzania and south to northern Angola and Zambia. It also occurs in the Comoros, Madagascar and Mauritius, and formerly on Assumption Island (Seychelles). Its presence in Benin is uncertain.

Uses *Cissampelos pareira*, *Cissampelos mucronata* A.Rich. and *Cissampelos owariensis* P.Beauv. ex DC. have often been confused; as they are also similarly used, it is often impossible to correlate uses unambiguously with a particular species.



Cissampelos pareira – wild and naturalized

Throughout the tropics preparations of *Cissampelos pareira* are applied against a variety of complaints. People take an infusion of the bitter rhizome, and sometimes of leaves and stems, to cure gastro-intestinal complaints such as diarrhoea, dysentery, ulcers, colic, intestinal worms and digestive complaints, and also urogenital problems such as menstrual problems, venereal diseases, infertility, uterine bleeding and threatening miscarriage. A rhizome decoction or pounded leaves are also widely taken or externally applied as a febrifuge and stomachic, and against cough, heart trouble, rheumatism, jaundice, snake bites and skin infections such as sores, boils, scabies and childhood eczema. More specifically, the rhizome is used as a diuretic and against acute and chronic bladder inflammation, to dissolve urinary calcifications and as an emmenagogue. In Tanzania a rhizome extract mixed with a hot water extract of roots and leaves of *Launaea cornuta* (Hochst. ex Oliv. & Hiern) C.Jeffrey is given orally to treat epilepsy. Tribal people in India use the plant to prevent pregnancy. The Pokot people in Kenya apply crushed rhizomes to treat skin diseases of goats. In Madagascar a rhizome extract is given to poultry against avian malaria. In the Philippines the fibres of the bark are used as a fish poison. In Madagascar rhizomes were formerly used in the preparation of alcoholic liquors as a bitter. The Pokot people make thin rope from the rhizomes. *Cissampelos pareira* is commonly planted in orchards, parks and gardens for its ornamental value. In Asia the

leaves are occasionally eaten. The leaves, crushed in water, give a jelly which is used as a refreshment.

Production and international trade *Cissampelos pareira* is mainly used in local medicine and is only occasionally traded internationally. In some countries it is a permitted substitute for *Chondrodendron tomentosum* Ruiz & Pav. from South America in the drug 'pareira brava'.

Properties *Cissampelos pareira* contains a number of alkaloids, especially bisbenzylisoquinoline alkaloids. The rhizome contains hayatine, hayatidine, hayatinine, d-4"-O-methylbebeerine, l-bebeerine, isochondrodendrine, dicentrine, dehydrodicentrine, insularine; the rhizome and leaves contain cycleanine, while cissampareine has been isolated from the whole plant and the chalcone-flavone dimer cissampeloflavone from the aerial parts.

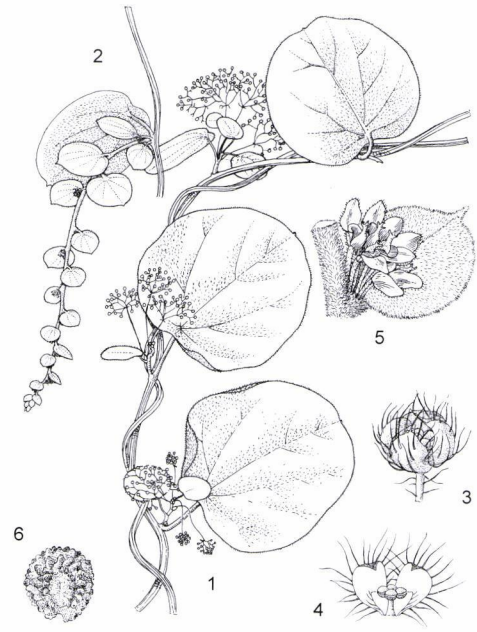
The rhizomes have also been found to be a rich source of tropoloisoquinoline alkaloids.

Pareirubrine A, pareirubrine B, grandirubrine, isoimerubrine and pareitropone have been isolated, all of which showed potent antileukaemic activity. Furthermore, two cytotoxic azafluoranthene alkaloids, structurally strongly related to tropoloisoquinoline alkaloids, have been isolated from the same extract, as has cissamine chloride.

Several experiments on rhizome extracts of *Cissampelos pareira* have been done in recent years. A water-ethanol extract of the rhizomes reduced the growth and multiplication rate of benzo(a)pyrene-induced forestomach tumours in mice in a dose-dependent manner. In another series of tests with rat models for acute, subacute and chronic inflammation, a similar extract showed significant anti-inflammatory activity without carcinogenic effects or causing gastric lesions. Mice administered the extract also showed reduced reactions against several pain stimuli. Ethanolic rhizome extracts have shown antihistaminic, hypotensive, antispasmodic and anticonvulsant properties. In a test to confirm the antifertility use of the plant, a methanol extract of the leaves administered to rats caused a significant increase in the duration of the dioestrus and a reduction in the number of litters. Altered gonadotropine and oestradiol secretion were involved.

Cissampelos pareira exhibits curare-like activity, depressing the central nervous system and relaxing smooth muscles, and has hypotensive and hypoglycaemic actions. The compound hayatinine is structurally similar to tubocurarine from *Chondrodendron tomentosum*, the active compound in curare. It shows comparable neuro-muscular blocking activities. Cycleanine has shown significant inhibition of nitric oxide production in macrophages. Cycleanine and bebeerine suppressed hepatic injury and reduced the level of tumour necrosis factor in mice treated with lipopolysaccharide and BCG, a model for the study of fulminant hepatitis.

Description Dioecious liana or scandent shrub, with rhizome; leafy stems slender, glabrous to densely hairy. Leaves arranged spirally, simple; stipules absent; petiole 4–7 cm long, short-hairy; blade broadly ovate, 2–12 cm × 4.5–12 cm, base rounded or truncate to deeply cordate, apex obtuse or notched, with mucro, entire or slightly wavy, membranous to papery, hairy below, sparsely hairy above, palmately 3–7-veined. Inflorescence an axillary, umbel-like cyme, solitary or clustered; male inflorescence up to 4 cm long, 1–3 together, female inflorescence arranged in a false raceme 5–10 cm long; bracts up to 1.5 cm in



Cissampelos pareira – 1, flowering parts of stems with male inforescences; 2, part of stem with female inflorescence; 3, male flower; 4, sectioned male flower; 5, part of female inflorescence; 6, stone.
Source: PROSEA

diameter, almost round to kidney-shaped, hairy. Flowers unisexual; pedicel up to 2 mm long; male flowers with 4(–5) sepals, ovate to obovate, c. 1.5 mm × c. 0.5 mm, keeled, hairy outside, greenish or yellowish, corolla cup-shaped, c. 1 mm long, filaments of stamens completely fused; female flowers with 1 sepal c. 1.5 mm long, 1 obtriangular to kidney-shaped petal c. 1.5 mm × 2 mm, ovary superior, hairy, 1-celled, style thick with spreading, 3-lobed stigma. Fruit a short-hairy, orange to red drupe c. 5 mm long, curved with style-scar near base; stone with 2 rows of very prominent transverse ridges, 1-seeded. Seed horseshoe-shaped; embryo elongate, narrow, embedded in endosperm, cotyledons flattened.

Other botanical information *Cissampelos* comprises about 20 species, 7 in tropical America and 13 in tropical Africa. *Cissampelos pareira* is the only species with a pantropical distribution. In tropical Africa 4 varieties of *Cissampelos pareira* are recognized. Several other *Cissampelos* spp. are used in traditional medicine in tropical Africa.

Cissampelos hirta Klotzsch (synonym: *Cissampelos pareira* L. var. *klotzschii* T.Durand & Schinz) occurs in Mozambique and northern South Africa. Its rhizome is used to treat stomach-ache, the leaves are applied against ringworm and itching skin. The leaves contain reticuline, the rhizome 12-O-methylcurine and dicentrine. *Cissampelos truncata* Engl. occurs in Uganda and Tanzania. Its rhizome pulp is applied to snakebites, while the rhizome is chewed and the sap is swallowed as an emetic. *Cissampelos torulosa* E.Mey. ex Harv. occurs in Malawi, eastern Zimbabwe, Mozambique and eastern and southern South Africa. In South Africa its leaves are taken to treat diarrhoea and dysentery, hallucinations, vomiting and pain, and the rhizome is taken to treat syphilis, kidney pain and toothache. The leaves contain the alkaloids bulbocapnine, dicentrine, laurolscholtzine, pronuciferine, cissacapine, cycleanine, insulanoline, reticuline and salutaridine; the stem bulbocapnine, dicentrine, reticuline, cissacapine, cycleanine and salutaridine.

Growth and development The flowers of *Cissampelos pareira* are probably pollinated by small insects.

Ecology *Cissampelos pareira* occurs in rainforest, coastal evergreen bushland and deciduous bushland, up to 2300 m altitude. It often persists on cleared ground and in plantations, and can also be found in secondary vegetation and near rock outcrops.

Management *Cissampelos pareira* is mostly collected from the wild. Although it is occasionally cultivated, no information on its management is available.

Genetic resources *Cissampelos pareira* is very widespread and locally common. There is no reason to assume any danger of genetic erosion, either in Africa or in other parts of the tropics. The quantity and composition of the alkaloids found in the leaves and roots seem to differ between plants from different regions. This may be a result of its great genetic diversity.

Prospects The alkaloids present in *Cissampelos pareira* have interesting properties, e.g. antileukaemic and neuromuscular blocking activity. The rhizomes are used in traditional medicine in different parts of the world for similar purposes, which seems to confirm their effectiveness. Research to confirm and further investigate these activities is warranted. The great diversity of the species also warrants further study and collection of germplasm.

Major references Amresh, Rao & Singh, 2007; Baerts & Lehmann, 2006c; Dwuma-Badu et al., 1975a; Ganguly et al., 2007; Getahun, 1976; Gurib-Fakim & Brendler, 2004; Hedberg et al., 1983a; Horsten & Lemmens, 1999; Keay & Troupin, 1954; Troupin, 1960.

Other references Amresh et al., 2004; Amresh et al., 2007; Amresh, Singh & Rao, 2007; Chevalier & Laffitte, 1937; Kondo, Takano & Hojo, 1993; Morita et al., 1993a; Morita et al., 1993b; Morita et al., 1993c; Neuwinger, 1996; Samie et al., 2005; Singthong et al., 2005.

Sources of illustration Horsten & Lemmens, 1999.

Authors L.P.A. Oyen

Based on PROSEA 12(1): Medicinal and poisonous plants 1.

CLEISTANTHUS BIPINDENSIS Pax

Protologue Bot. Jahrb. Syst. 33: 282 (1903).

Family Euphorbiaceae (APG: Phyllanthaceae)

Origin and geographic distribution *Cleistanthus bipindensis* occurs in Cameroon, the Central African Republic, Gabon and DR Congo.

Uses In DR Congo the stem bark is chewed for its tonic properties. The wood is used for temporary construction and household utensils.

Botany Monoecious shrub or small tree up

to 15 m tall; bole up to 50 cm in diameter; twigs short-hairy, later almost glabrous. Leaves alternate, simple and entire; stipules small, soon falling; petiole 5–9 mm long; blade elliptical-oblong to elliptical-lanceolate, 8–22 cm × 3–10 cm, base cuneate, apex acute, upper surface glabrous, lower surface short-hairy, pinnately veined, with 4–9 pairs of lateral veins. Inflorescence an axillary few-flowered fascicle or pseudo-raceme 0.5–3.5 cm long, densely hairy; bracts ovate-lanceolate, up to 8 mm long, densely hairy, soon falling. Flowers unisexual, regular, 5-merous, sepals triangular-lanceolate, 5–7(–8) mm long, reddish and densely hairy outside; petals spatulate to linear; male flowers with pedicel 5–6 mm long, petals c. 1 mm long, filaments of stamens fused at base, 3–4 mm long, pistillode present; female flowers with pedicel 3–4 mm long, petals 1.5–2.5 mm long, disk annular, ovary superior, reddish, densely hairy, 3-celled, styles 3, fused at base, 2–3 times 2-fid. Fruit an almost round capsule 10–12 mm long, densely hairy at first, later almost glabrous, 6-seeded. Seeds ovoid, 8–9 mm long, smooth, brown.

Cleistanthus occurs throughout the Old World tropics and comprises about 150 species. About 20 species occur in continental tropical Africa, mainly in Central Africa, and about 6 in Madagascar. Many *Cleistanthus* spp. have galls on the leaves. The highly toxic *Cleistanthus collinus* (Roxb.) Benth. from India is frequently used for homicidal and suicidal purposes. The aerial parts contain cleistanthin A, a diphyllin glycoside with promising cytotoxic and tumour-suppressing properties.

Ecology *Cleistanthus bipindensis* occurs in marshy dense forest and along small streams.

Genetic resources and breeding *Cleistanthus bipindensis* has a relatively large distribution area in Central Africa and there are no signs that it is genetically threatened.

Prospects *Cleistanthus bipindensis* will remain of local importance as a tonic.

Major references Govaerts, Frodin & Radcliffe-Smith, 2000; Léonard, 1962.

Other references Léonard, 1960; Neuwinger, 2000; Nguyen Nghia Thin, 1998.

Authors G.H. Schmelzer

CLUTIA ABYSSINICA Jaub. & Spach

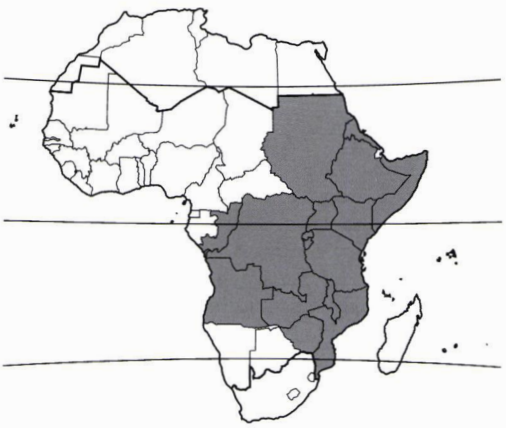
Protologue Ill. pl. orient. 5: 77, t. 468 (1855).

Family Euphorbiaceae

Vernacular names Lightning bush, smooth-fruited clutia (En).

Origin and geographic distribution *Clutia abyssinica* occurs from Congo east to Eritrea and Somalia and through eastern Africa south to Zambia, Angola, Mozambique and South Africa.

Uses Roots and leaves are commonly used for medicinal purposes. In DR Congo a root decoction is taken to treat fever and cough and is taken by pregnant women as a tonic. Ground roots are applied as an enema to treat gonorrhoea. To treat headache either a root extract is rubbed on the head or a leaf extract is drunk. The sap of leafy twigs is drunk to treat chest pain, side pain and shortness of breath. An infusion of leafy twigs or leaves is drunk or the ash eaten to treat skin problems, elephantiasis, diarrhoea and tachycardia. This infusion is also used as a wash to treat these ailments. Leaf ash in water is also taken to treat cough. Leaf powder in palm oil is applied to burns to heal them. A maceration of the crushed leaves is used as nose drops to treat pneumonia. Leaf sap diluted in water is applied as an enema to treat diarrhoea in children. In Rwanda and Kenya a root decoction is drunk, sometimes in milk, against liver problems. In eastern Africa the boiled roots are made into a soup which is taken as a remedy for enlarged spleen and kidney problems, and to treat headache, stomachache and malaria. A root extract is drunk to cure intestinal worms, influenza, colds and fever, and as a remedy for indigestion. To treat



Clutia abyssinica – *wild*

malaria, leaves are boiled to prepare a vapour bath. In Rwanda a leaf extract is drunk to induce the process of childbirth and as an abortifacient, and also to treat sciatic pain. In South Africa leaves are rubbed on the gums to treat toothache. In Uganda powdered leaves in water are taken to treat whooping cough and a leaf decoction is taken to treat shock. In Tanzania fresh leaves are rubbed on fungal skin problems. The wood is smoked by women to treat menstrual pains. In South Africa a maceration of root bark is drunk to treat abdominal problems, as a laxative and to expel intestinal worms.

In Kenya and Tanzania the roots are boiled with food to add flavour to it.

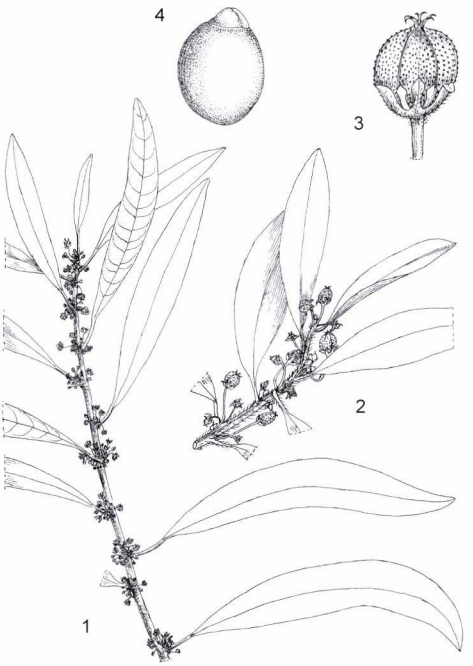
Production and international trade The roots, leafy stems and leaves are used at a local level only.

Properties The roots contain a phytosterol glucoside, cluytyl alcohol, and several bicyclic diterpenoids with a 6,7-secolabdane skeleton, clutiolide, dihydroclutiolide and isodihydroclutiolide. A chloroform extract of powdered roots yielded a complex mixture of 5-methylcoumarins. γ-Cadinene was the major constituent of the essential oil from the root, while β-ionone, α-farnesene and farnesylacetone were the major volatile constituents of the leaf. The leaves yielded the flavonoids ent-16β,17-dihydroxykaurane, spinosin and the diterpene 2"-O-glycosylisovitexin.

Ethanolic leaf, stem and root extracts showed moderate antiviral activity in vitro against polio virus and Coxsackie virus, moderate antifungal activity against *Aspergillus fumigatus* and *Fusarium culmorum*, but little antibacterial activity. An ethanol extract of the dry leaves showed antifungal activity against *Trichophyton mentagrophytes*.

There are reports that several *Clutia* spp. are highly toxic to livestock.

Description Dioecious, erect, lax shrub up to 6 m tall, with brittle branches, glabrous to evenly hairy. Leaves alternate, simple and entire; stipules absent; petiole 1–3.5 cm long; blade ovate to elliptical-lanceolate, 2–16(–20) cm × 1–7 cm, base cuneate to rounded, apex obtuse to acute, pinnately veined with 5–12 pairs of lateral veins. Inflorescence an axillary fascicle; male inflorescence dense, many-flowered, female inflorescence 1–many-flowered; bracts triangular, up to 1 mm long. Flowers unisexual, regular, 5-merous; pedicel up to 1 cm long, extending in fruit up to 2.5 cm; male flowers with sepals elliptical-ovate, c. 2.5 mm × 1 mm, each with 3–4 glands at base, pale green, petals triangular, clawed, c. 2 mm × 1.5 mm, each with gland at base, white, stamens fused into a column c. 1 mm long, ovary rudimentary; female flowers with sepals oblong-lanceolate, c. 2 mm long, obtuse, each with yellowish gland at base, petals spoon-shaped, c. 2 mm long, white, ovary superior, nearly globose, c. 1 mm in diameter, 3-celled, smooth, styles 3, c. 1 mm long, fused at base, 2-fid and reflexed at apex, persistent. Fruit a 3-lobed capsule c. 5 mm × 4.5 mm, pale green, covered with small whitish warts, 3-seeded. Seeds ovoid, c. 3 mm × 2 mm × 1.5 mm, minutely pitted, black, shining, caruncle conical, c. 1 mm long, whitish.



Clutia abyssinica – 1, part of male flowering branch; 2, part of female flowering and fruiting branch; 3, fruit; 4, seed.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Clutia* comprises about 60 species, of which about 20 occur in tropical Africa and about 40 in South Africa. Three varieties have been described in *Clutia abyssinica*, which are mainly distinguished by the hairiness of the plant, the shape of the leaves and the length of the pedicel.

Other *Clutia* spp. from eastern and southern Africa are also used medicinally. *Clutia angus-*

tifolia Knauf occurs from Burundi south to Zambia and Mozambique, and in DR Congo a leaf extract is used as a mouth wash, while leaves are rubbed in to treat toothache. A leaf decoction of *Clutia hirsuta* (Sond.) Müll.Arg. from Zimbabwe, Mozambique and South Africa, is taken to treat fever. A leaf maceration combined with other plants is taken to treat anthrax, and also gall bladder problems in livestock. Crude leaf and root extracts show moderate antimalarial activities. *Clutia lanceolata* Forrsk. (synonyms: *Clutia kilimandscharica* Engl., *Clutia robusta* Pax) occurs from Eritrea and Somalia south to Tanzania and Zimbabwe. In Ethiopia a maceration of young twigs and leaves is drunk to treat diarrhoea. The leafy twigs are also used in fumigations to treat ophthalmia. In East Africa a root decoction in milk is taken to treat colds and rheumatism. Maasai people use pieces of wood as ear plugs. *Clutia paxii* Knauf occurs from southern DR Congo south to Zimbabwe and Mozambique; a leaf infusion is drunk in DR Congo to treat angina. A hot leaf infusion of *Clutia pulchella* L. (from Zimbabwe, southern Mozambique and northern South Africa) is drunk to treat stomach-ache, diarrhoea and dysentery. Root ash is rubbed into scarifications to heal fractures and sprains. An infusion of leaves, stems and roots in milk is applied as an enema to treat stomach-ache in children.

Ecology *Clutia abyssinica* is common in dry forest, forest remnants, secondary forest and wooded grassland on rocky hillsides, and riverine, evergreen thickets, at 700–3700 m altitude.

Propagation and planting *Clutia abyssinica* is only propagated by seed.

Harvesting All plant parts of *Clutia abyssinica* can be harvested whenever the need arises.

Handling after harvest Leaves, leafy stems and roots are used fresh or are dried for later use.

Genetic resources *Clutia abyssinica* is widespread and common and hence not threatened by genetic erosion.

Prospects *Clutia abyssinica* has many medicinal uses against a range of diseases. Several tests with root, stem and leaf extracts showed antifungal and antiviral activities, while the antibacterial activities showed divergent results. It would be worthwhile to evaluate the activities of the isolated compounds.

Major references Beentje, 1994; Cos et al., 2002; de Boer et al., 2005; Kokwaro, 1993; Latham, 2007; Neuwinger, 2000; Radcliffe-Smith, 1987; Radcliffe-Smith, 1996a; Vlietinck et al., 1995; Watt & Breyer-Brandwijk, 1962.

Other references Chifundera, 2001; Gilbert, 1992; Ichikawa, 1987; Kraft et al., 2003; Mahunnah & Mtotmwema, 1985; Waigh, Zerihun & Euerby, 1990; Waigh, Zerihun & Maitland, 1991; Zerihun, Lockwood & Waigh, 1987a; Zerihun, Lockwood & Waigh, 1987b; Zilimwabagabo & Kanayire, 1990.

Sources of illustration Radcliffe-Smith, 1987.

Authors E.N. Matu

COCCULUS HIRSUTUS (L.) Theob.

Protologue Mason, Burmah ed. 4, 2: 657 (1883).

Family Menispermaceae

Chromosome number $n = 13$

Vernacular names Broom creeper, inkberry, monkey rope (En).

Origin and geographic distribution *Cocculus hirsutus* occurs from East and southern Africa eastward to India, Myanmar, Thailand and southern China. In Africa it is distributed from Sudan, Eritrea and Ethiopia south throughout East and southern Africa (including Angola) to Kwazulu-Natal (South Africa) and Swaziland.

Uses In Turkana (Kenya) a leaf infusion is taken to treat stomach-ache. In Tanzania a leaf decoction is drunk against female sterility and leaf sap is taken to treat nervous illnesses. *Cocculus hirsutus* is a popular medicine in Asia, especially Pakistan and India. The leaves are used to treat skin infections and itchy skin including eczema, rheumatism and gonorrhoea, the roots are taken as a tonic and alterative and as a diuretic and laxative. A root decoction is applied against fever, rheumatism and severe weight loss. In Rajasthan (India) the cooked leaves are eaten to treat night blindness and a jelly prepared by soaking leaves in cold water is taken to check spermatogenesis. The stems are used in basketry in South Africa and the fruits to colour baskets blue. The leaves are occasionally eaten as a vegetable, e.g. in India.

Properties From the above-ground parts of the plant the isoquinoline alkaloids hirsutine, cohirsine, cohirsinine, cohristine, cohirsitinine, haiderine, jamtinine, jamtine-N-oxide and shaheenine have been isolated, and also several bisbenzylisoquinoline alkaloids, including

coclaurine, cocsuline-N-2-oxide, magnoflorine, trilobine and isotrilobine. The plant also contains the triterpenoids sitosterol and hirsudiol. An aqueous extract of the leaves has shown diuretic and laxative properties in rats at doses more than 15 times lower than the acute toxic dose. Extracts from the fruit pulp can be used as a dye in a histological assay to test for pollen viability.

Cocculus shows one of the greatest diversities in alkaloid types in the family *Menispermaceae*. Some 135 alkaloids of 13 different classes have been isolated. Bisbenzyltetrahydroisoquinoline alkaloids represent the main type of alkaloids isolated from *Cocculus*, with erythrina alkaloids the second most common type.

Botany Dioecious scandent shrub or liana up to 15 m long; branchlets densely yellowish short-hairy. Leaves arranged spirally, simple; stipules absent; petiole 0.5–3 cm long, densely short-hairy; blade ovate, ovate-oblong to obovate, 4–8(–11) cm × (2.5–)6–10 cm, on lower main branches 3–5-lobed, base cuneate, rounded or slightly cordate, apex obtuse to rounded, with small mucro, yellowish hairy, later glabrous, basal veins 5; leaves much reduced at the end of lateral branches and on flowering branches. Inflorescence a small axillary cyme, solitary or 2–3 together, few- to many-flowered, 1–2.5 cm long; peduncle up to 1.5 cm long. Flowers unisexual, small; pedicel 0.5–2 mm long; sepals 6, long-hairy, 3 outer ones broadly ovate or obovate, 1.5–2.5 mm × 1.5–2 mm, 3 inner ones oblong to lanceolate, 1.5–2 mm × 0.5–1 mm; petals 6, ovate-oblong, 0.5–1.5 mm × c. 0.5 mm, sparsely short-hairy, with auricles surrounding the stamens; male flower with 6–9 stamens c. 1 mm long; female flower with 6 staminodes c. 0.5 mm long, ovary superior, composed of 3 free, compressed-ovoid carpels, style short, cylindrical, stigma recurved. Fruit composed of up to 3 obovoid or rounded drupes, each drupe 4–8 mm × 4–5 mm, dark blue; stone ribbed on lateral faces, 1-seeded. Seed horse-shoe shaped, laterally flattened.

In Sudan flowering occurs in June–October, fruits ripen in November–April.

Cocculus comprises about 11 species, and occurs in Central and North America, Africa, the Middle East, Asia and Polynesia. In tropical Africa 3 species occur.

Ecology *Cocculus hirsutus* occurs in bushland and semi-desert scrub vegetation, up to 1200 m altitude. It grows on sandy and gravelly soil, and can form a dense cover on top of other plants.

Management *Cocculus hirsutus* is only collected from wild stands.

Genetic resources and breeding Because *Cocculus hirsutus* is widely distributed and locally common, there is no risk of genetic erosion.

Prospects *Cocculus hirsutus* will continue to play a role in traditional African and in Chinese and Indian systems of medicine; in Africa it will probably remain of minor importance. It is unlikely that it will become a source of chemicals for the Western pharmaceutical industry. Its use as a vegetable is unlikely to become important in Africa; moreover, research on possible health risks would then be needed.

Major references de Wet, 2005; Ganapathy et al., 2002; Shaista Iqbal, 1993; Troupin, 1956; Troupin, 1960.

Other references Beentje, 1994; Chhabra, Mahunnah & Mshiu, 1990; Gupta et al., 2005; Jain et al., 2004; Neuwinger, 2000; Parrotta, 2001; Thulin, 1993b; Uddin Ahmad, Mohammad & Rasheed, 1987; Uddin Ahmad et al., 1987; van Wyk & Gericke, 2000.

Authors L.P.A. Oyen

COCCULUS PENDULUS (J.R.Forst. & G.Forst.) Diels

Protologue Engl., Pflanzenr. IV, 94: 237 (1910).

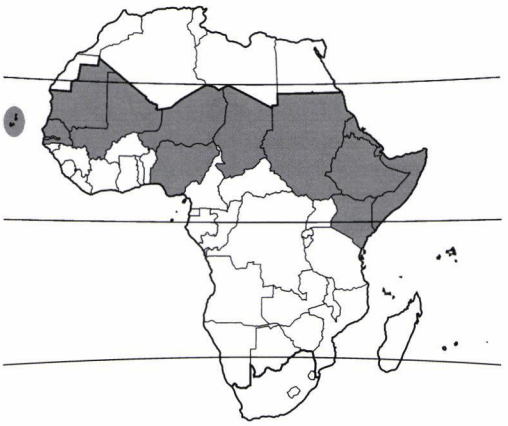
Family Menispermaceae

Chromosome number $n = 13$

Synonyms *Cocculus leaeba* (Delile) DC. (1817).

Origin and geographic distribution *Cocculus pendulus* occurs in northern Africa, the Middle East and eastward to India. In tropical Africa it is distributed throughout the Sahara desert and its semi-desert edges, from Cape Verde east to Somalia and north-eastern Kenya.

Uses People in the Sahel, as well as in Pakistan and Afghanistan, use various parts of the plant, especially the root, to cure fevers including intermittent fever. In Nigeria the leaves and root are used for this purpose, in Senegal the Toucouleur and Peul people use the stem bark and root bark. In West Africa a decoction of the roots, together with those of *Tinospora bakis* (A.Rich.) Miers, is used to prepare a stimulating tonic. In Senegal the Toucouleur



Cocculus pendulus – wild

and Peul people use stem bark and root bark decoctions against intestinal parasites and gonorrhoea. The root has a great reputation in Senegal against biliousness and menstrual problems and as a diuretic. It is also part of medicines against jaundice, yellow fever, leprosy, syphilis, and of an aphrodisiac. An infusion of the plant is used to assist in removing thorns from the feet. In Kenya a wood infusion is taken as an emetic.

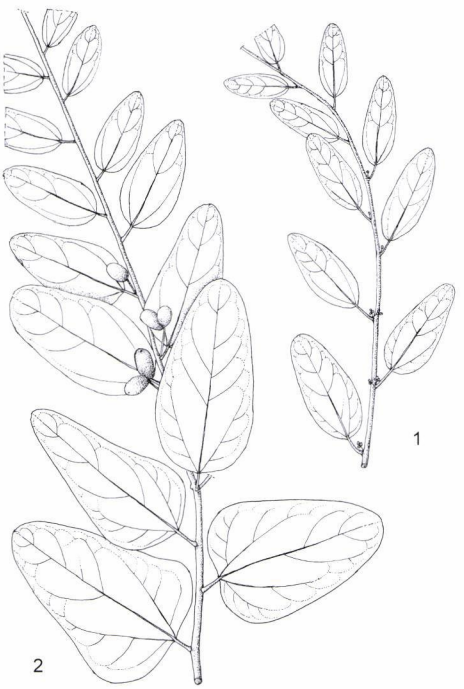
In the drier parts of West Africa the plant is browsed by all livestock, especially camels and goats, but where more browse is available, few animals eat it. The flowers are added to food. The fruits are edible and Arabs make an intoxicating drink from the fruits.

Properties The stems and leaves contain a great variety of bisbenzylisoquinoline dioxine alkaloids, including cocsuline, cocsoline, cocsulinin, siddiquine, penduline, tetradine, isotrilobine, siddiquamine, kohatine, telobine, pateline, kurramine, isotrilobine and tricordatine, and many derivatives of these. Little investigation has been made of the chemical components of the root.

Cocsulinin is the main alkaloid with anticancer properties of *Cocculus pendulus*. Kurramine derivatives have shown anticholesterinase activity in vitro. The alkaloids cocsoline, penduline, tetradine and isotrilobine have shown high antiplasmodial activity in vitro. In a comparison of 20 plant species from India, however, *Cocculus pendulus* was not selected as one of the promising species with antimalarial properties for further research. Newcastle disease, a fowl pest, provides a test-model for antiviral activity, and positive anti-Newcastle virus action has been noted in *Cocculus pendulus*.

High alkaloid-producing cell lines have been established, which produce actineoplastic agents.

Description Dioecious, much-branched liana or scandent shrub; stem up to 15 cm in diameter at base, striped, dark grey, branchlets long, slender, terete, hairy. Leaves arranged spirally, simple; stipules absent; petiole 2–10 mm long; blade oblong-lanceolate, in lower leaves sometimes ovate, 1.5–5 cm × 0.5–2 cm, base cuneate, rounded or sometimes spear-shaped, apex obtuse, with mucro, sometimes notched, leathery, glabrous, basal veins 3, conspicuous. Inflorescence a small axillary cyme, solitary or clustered; male inflorescence few- to many-flowered, up to 2 cm long; female inflorescence 1–2-flowered, up to 1.5 cm long. Flowers unisexual, small; sepals 6, ovate-elliptical, fleshy to membranous, 3 outer ones 1–1.5 mm long, slightly hairy, 3 inner ones larger, finely hairy to glabrous; petals 6, ovate-obovate, 0.5–2 mm × 0.5–1 mm, apex notched; male flowers sessile or with short pedicel, stamens 6–9, up to 1.5 mm long, free; female flowers with pedi-



Cocculus pendulus – 1, part of stem with male inflorescences; 2, part of stem with fruits. Redrawn and adapted by Iskak Syamsudin

cel up to 1 cm long, staminodes 6, c. 1 mm long, ovary superior, consisting of 3(–6) free, ovoid, laterally compressed carpels c. 1 mm long, stigma c. 0.5 mm long. Fruit composed of 1–3 obovoid, flattened drupes, each drupe 4–7 mm × 4–5 mm, dark red, stone ribbed on lateral faces, 1-seeded. Seed horse-shoe shaped, laterally flattened.

Other botanical information *Cocculus* comprises about 11 species, and occurs in Central and North America, Africa, the Middle East, Asia and Polynesia. In tropical Africa 3 species occur.

Cocculus orbiculatus (L.) DC. is an Asian species that also occurs on Réunion and Mauritius. In Asia the stem is used as a diuretic against oedema, and the root is used to treat fever and epilepsy. In China the stem and leaves are prescribed against flatulence, stomach-ache and oedema. In Réunion the branches are used as rope in construction.

Growth and development In Sudan flowering occurs in June–September, fruits ripen in November–April.

Ecology *Cocculus pendulus* grows in semi-desert scrub vegetation or deciduous bushland, sometimes in shady localities along streams, climbing on e.g. *Acacia* and *Balanites* spp., up to 1900 m altitude. It grows on sandy and gravelly soils, and sometimes colonizes dry fallow land.

Propagation and planting Protocols for in-vitro multiplication have been developed in India.

Genetic resources *Cocculus pendulus* grows in a variety of habitats and has a very wide distribution, and therefore it does not seem to be in danger of genetic erosion.

Prospects As folk medicine *Cocculus pendulus* has many uses. It is rich in bisbenzylisoquinoline alkaloids, many of which have shown pharmacological potential. There is a need for further scientific evaluation of these uses and compounds. Because of their wide utilization, the composition of the roots deserves special research attention.

Major references Atta-ur-Rahman et al., 2004; Jahan, 1988; Ozenda, 1977; Setyowati, 2003; Troupin, 1956; Verma & Lall, 2000.

Other references Al Khalil et al., 1993; Atta-ur-Rahman, 1986; Beentje, 1994; Bhakuni, Jain & Singh, 1978; Bhakuni & Joshi, 1975; Duarte, 1995; El Amin, 1990; Gaur et al., 1995; Guinaudeau et al., 1987; Ikram, Shati & Zarga, 1982; Kerharo & Adam, 1974; Oliver-Bever, 1983b; Simonsen et al., 2001; Thulin, 1993b.

Sources of illustration Berhaut, 1979.

Authors P. Oudhia

COLDENIA PROCUMBENS L.

Protologue Sp. pl. 1: 125 (1753).

Family Boraginaceae

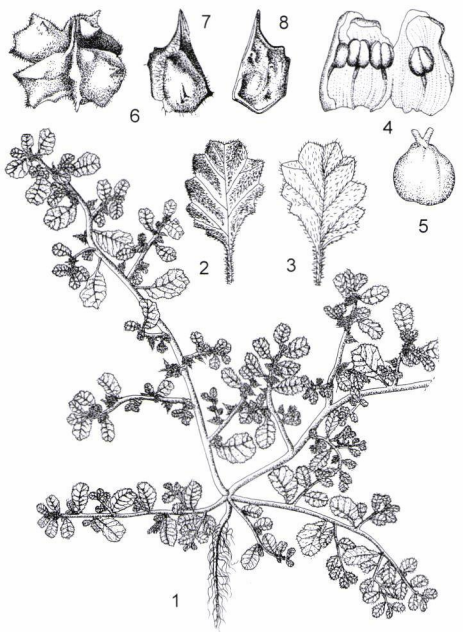
Origin and geographic distribution *Coldenia procumbens* is found throughout Africa including Cape Verde and Madagascar. It is also widespread in tropical Asia and Australia.

Uses In Sudan fresh leaves of *Coldenia procumbens* are pulped and applied to rheumatic swellings. Similar use is reported from India. The dried plant, mixed with an equal amount of fenugreek seed (*Trigonella foenum-graecum* L.), is powdered and applied to mature abscesses in Sudan. Fresh leaves are put as a poultice on mature abscesses in the Philippines.

Production and international trade *Coldenia procumbens* is offered for sale on the international market from India but quantities involved are unknown and are probably modest.

Properties Pharmacological screening of an ethanolic extract of whole *Coldenia procumbens* plants showed depression of the central nervous system in mice and prolongation of the pentobarbital-induced sleeping time in rats. Extracts exhibited some analgesic effects but had no anticonvulsant effects, did not alter the body temperature and did not abolish conditioned avoidance responses. The mechanism of the analgesic activity may possibly involve opioid receptors and enhancement of the pain threshold. Acetone, ethanol and water extracts of dried aerial parts have shown weak angiotensin-converting enzyme inhibition in vitro.

Botany Annual, prostrate herb with compressed, ascendingly branched stems up to 50 cm long, greyish hairy. Leaves alternate, simple; stipules absent; petiole up to 0.5 cm long; blade asymmetric, oblong or obovate, 0.5–3 cm × 0.5–1.5 cm, margin crenate, veins in 4–6 pairs, impressed above, prominent below. Flowers solitary, extra-axillary, bisexual, 4-merous, almost sessile, small; calyx c. 1.5 mm long, slightly accrescent in fruit; corolla up to 2 mm long, with cylindrical tube and small lobes, white; stamens inserted at about the middle of the corolla tube, included; ovary superior, style bifid nearly to the base. Fruit initially splitting into 2 halves, later each half into 2 one-seeded nutlets with a distinct beak.



Coldenia procumbens – 1, plant habit; 2, leaf upper surface; 3, leaf lower surface; 4, corolla showing stamens; 5, pistil; 6, fruit; 7, nutlet dorsal surface; 8, nutlet ventral surface.
Source: PROSEA

Coldenia comprises a single species. Several American species previously included have been transferred to the genus *Tiquilia*.

Ecology *Coldenia procumbens* is found in seasonally wet or flooded locations such as muddy river banks and lake shores, black cotton soil, rice fields and depressions. In tropical Africa it is found at altitudes up to 750 m. The wall of the nutlet is partly thick and corky, which enables dispersal by water.

Genetic resources and breeding As *Coldenia procumbens* is common, widespread and adapted to anthropogenic habitats, it is locally considered a weed and not subject to genetic erosion.

Prospects Although information on the pharmacological properties of *Coldenia procumbens* is limited, the obvious analgesic effects justify further research.

Major references Aguilar, 2003a; Burkill, 1985; Naga Rani, Vijayasekarani & Kameswaran, 1991; Verdcourt, 1991.

Other references Broun & Massey, 1929; Martins & Brummitt, 1990; Senthamarai et al., 2001; Somanadhan et al., 1999.

Sources of illustration Aguilar, 2003a.

Authors C.H. Bosch

Based on PROSEA 12(3): Medicinal and poisonous plants 3.

COMMICARPUS PLUMBAGINEUS (Cav.) Standl.

Protologue Contr. U.S. Natl. Herb. 18(3): 101 (1916).

Family Nyctaginaceae

Chromosome number $2n = 40$

Synonyms *Boerhavia plumbaginea* Cav. (1793).

Origin and geographic distribution *Commicarpus plumbagineus* is widespread from southern Spain throughout Africa to South Africa and Madagascar, extending in the east to Palestine, Israel, Jordan and Saudi Arabia.

Uses The roots and leaves of *Commicarpus plumbagineus* are expectorant and in large doses emetic, and are widely used to treat asthma. In West Africa the leaves are boiled and made into poultices for application to ulcers and guinea-worm sores. In Ghana the crushed roots are applied to treat yaws, whereas in Nigeria a poultice from the roots is used by Hausa people to treat leprosy. In Ethiopia a decoction of the leaves is taken to treat jaundice. A leaf decoction and the ash of burned stems are applied to wounds. In Ethiopia and Kenya ground leaves are applied to burns. In Kenya crushed leaves are rubbed on swollen glands. In Madagascar a decoction of the whole plant is used as laxative. In Ethiopia *Commicarpus plumbagineus* is used in veterinary medicine to treat skin diseases of cattle. In Kenya an infusion of the whole plant is used as an insecticide, e.g. against lice in humans and against other insects on camels. In DR Congo a decoction of the leaves is given as a laxative to cattle.

In northern Nigeria *Commicarpus plumbagineus* is sometimes grazed by livestock. In Kenya the plant is used as forage for all livestock, but is said to make the milk taste bitter.

Botany Shrub, with stem base and roots woody; stem procumbent or scandent up to 4(–10) m long, much branched, glabrous or hairy. Leaves opposite, simple; stipules absent; petiole up to 4 cm long; blade ovate, 1.5–12 cm × 0.5–8 cm, base cordate, truncate or rounded, apex acute, apiculate, margins entire or wavy, slightly fleshy. Inflorescence an axillary or terminal irregular umbel, laxly flowered;

bracts 1.5–4 mm long, linear-lanceolate, hairy. Flowers bisexual, regular; pedicel 1–5 mm long; perianth trumpet-shaped, 8–15 mm long, distinctly constricted above ovary, lower part surrounding the ovary with viscid glands, especially around the apex, glabrous to shortly hairy, upper part 7–12 mm long, 5–9 mm wide, lobes spreading, white, densely shortly hairy to glabrescent; stamens 3–5, long-exserted, joined at base into a short tube around the ovary; ovary superior but seemingly inferior, ellipsoid, stipitate, glabrous, 1-celled, style 15–18 mm long, long-exserted, slightly curled. Fruit an achene enclosed by the thickened lower part of the perianth (anthocarp), anthocarp cylindrical, fusiform to club-shaped, 7–11 mm × 1–2 mm, glabrous to hairy with numerous viscid glands concentrated towards apex, 1-seeded. *Commicarpus* comprises about 25 species and occurs throughout the tropics, but mainly in Africa. In Namibia a root decoction of *Commicarpus pentandrus* (Burch.) Heimerl mixed with *Thesium lineatum* L.f. is taken orally to treat gonorrhoea. Also in Namibia, a hot water extract of leaves and roots of *Commicarpus fallacissimus* (Heimerl) Pohnert is taken orally or as an enema to treat pain moving from the back to the legs.

Ecology *Commicarpus plumbagineus* occurs in forest and grassland, often along water courses on a variety of soils up to 1800 m altitude.

Genetic resources and breeding *Commicarpus plumbagineus* is widespread and hence not threatened with genetic erosion.

Prospects In view of the many medicinal uses and the complete lack of chemical and pharmacological data, research into the properties of *Commicarpus plumbagineus* may prove worthwhile.

Major references Burkill, 1997; Gilbert, 2000a; Kokwaro, 1993; Neuwinger, 2000; Stannard, 1988a.

Other references Dalziel, 1937; Getahun, 1976; Giday et al., 2003; Heine & Heine, 1988a; Heine & Heine, 1988b; Irvine, 1961; Morgan, 1981; Raimondo, Rossitto & Sartoni, 1981; von Koenen, 2001.

Authors A. de Ruijter

CORDEMOYA INTEGRIFOLIA (Willd.) Baill.

Protologue Adansonia 1: 255 (1861).
Family Euphorbiaceae
Vernacular names Bois de perroquet, Jacques marron, bois pigeon (Fr).

Origin and geographic distribution *Cordemoya integrifolia* is endemic to Réunion and Mauritius.

Uses In Réunion a stem bark infusion is taken to treat high blood pressure and to improve blood circulation. The stem bark macerated in rum is taken as a tonic, often prior to strenuous physical efforts.

Properties Preliminary phytochemical screening of the leaves yielded alkaloids, flavonoids, coumarins, saponins and terpenes. The stem bark contains alkaloids, tannins and terpenes. The acetone, ethanol and water extracts of the stem bark showed moderate antihypertensive activity in vitro. A methanol extract of the aerial parts did show low activity against several pathogenic human viruses in vitro.

Botany Monoecious shrub or small tree up to 15 m tall; bark reddish brown; young branches with deep grooves and groups of stellate hairs, older branches rounded and glabrous. Leaves arranged spirally at the end of branches, simple and entire; stipules tiny, soon falling; petiole 2–20 cm long, reddish, thickened at base; blade ovate, 5–18(–38) cm × 3.5–8(–16) cm, base rounded, apex acute. Female inflorescence an axillary, few-flowered raceme, male one a 15–30-flowered panicle 5–10 cm long. Flowers unisexual; petals and disk absent; pedicel 1–3(–5) mm long; male flowers with 3 ovate sepals 3–4 mm long, concave, stamens numerous, c. 2 mm long; female flowers with 4 lanceolate-triangular sepals c. 3 mm long, ovary superior, 3-lobed, 3-celled, styles 3, 8–14 mm long, fused at base. Fruit a 3-lobed capsule 12–14 mm in diameter, each lobe with 2 curved horns 3–6 mm long, 3-seeded. Seeds rounded, 7–9 mm long, dark brown, shiny.
Cordemoya comprises a single species, and is close to *Mallotus*.

Ecology *Cordemoya integrifolia* occurs in rainforest, at 800–1000 m altitude.

Genetic resources and breeding *Cordemoya integrifolia* is possibly threatened by genetic erosion, although the remaining rainforests on Réunion and Mauritius are protected.

Prospects *Cordemoya integrifolia* has several interesting medicinal applications, which are partly confirmed by pharmaceutical tests. It would be worthwhile investigating the active compounds.

Major references Adsersen & Adsersen, 1997; Coode, 1982; Gurib-Fakim & Brendler,

2004; Lavergne, 2001.

Other references Forgacs et al., 1981; Fortin et al., 2002; Govaerts, Frodin & Radcliffe-Smith, 2000.

Authors G.H. Schmelzer

CORDIA MYXA L.

Protologue Sp. pl. 1: 190 (1753).

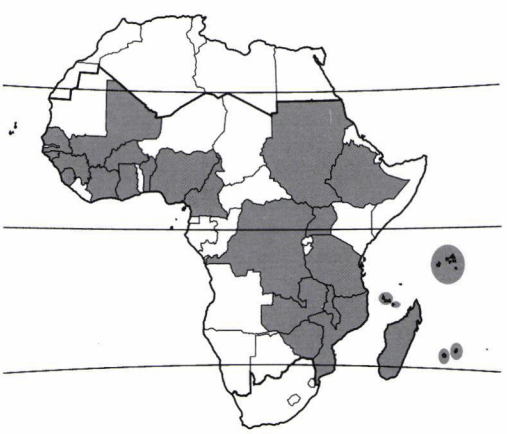
Family Boraginaceae

Chromosome number $2n = 48$

Vernacular names Sebesten plum, sapistan, clammy cherry, Indian cherry, Assyrian plum (En). Sébestier, bois savon (Fr). Sebesteira, sebesteiro do Sudao (Po).

Origin and geographic distribution *Cordia myxa* originates from the area stretching from the eastern Mediterranean region to eastern India, and was introduced long ago in tropical Africa, tropical Asia and Australia, and more recently also in the Americas.

Uses The fruit of *Cordia myxa* has long been valued throughout its distribution area for its sticky mucilaginous pulp, which is eaten to suppress cough and chest complaints, and to treat a sore throat, as it has demulcent properties. The pulp is also applied as an emollient to mature abscesses, to calm rheumatic pain and as an anthelminthic. In Tanzania the fruit pulp is applied on ringworm. In Mali and Côte d'Ivoire the leaves are applied to wounds and ulcers. A macerate of the leaves is taken to treat trypanosomiasis, and is externally applied as a lotion to tse-tse fly bites. In the Comoros the powdered bark is applied to the skin in cases of broken bones before a plaster is applied, to improve healing. Bark powder is used externally in the treatment of skin diseases. Bark juice together with coconut oil is taken to treat colic.



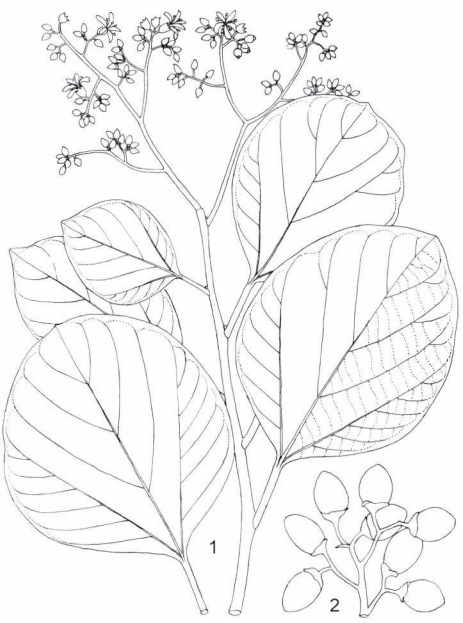
Cordia myxa – planted and naturalized

In semi-arid regions *Cordia myxa* is planted in shelter belts to prevent soil erosion. In Yemen it is used as a shade tree for coffee. The wood is suitable for furniture making, cabinetry, well curbs, boats and agricultural implements. It is marketed under the same trade name as *Cordia africana* Lam.: 'Khartoum teak' or 'Sudan teak'. The bark is fibrous and yields cordage. The sticky pulp, especially from the unripe fruits, has widespread use as bird lime. Ripe fruits are eaten raw, while tender young fruits are eaten fresh or pickled as a vegetable. Mashed fruits enter in the preparation of sorghum beer. The kernel is also edible. In India the leaves are prepared as a vegetable. In Burkina Faso the ash of the young branches is used to make soap. In South-East Asia the leaves are used as cattle fodder.

Properties Chemical screening of both the leaves and the fruits showed the presence of pyrrolizidine alkaloids, coumarins, flavonoids, saponins, terpenes and sterols. The fruit contains about 70% pulp; the pulp contains per 100 g: water 6 g, protein 35 g, fat 37 g and carbohydrate 18 g. The seed contains per 100 g: water 32 g, fat 46 g; the principal fatty acids are: palmitic acid, stearic acid, arachidic acid, behenic acid, oleic acid and linoleic acid.

The petroleum ether and alcoholic extracts showed significant analgesic, anti-inflammatory and anti-arthritic activities in tests with rats. Four flavonoid glycosides (robinin, rutin (rutoside), datiscoside and hesperidin), a flavonoid aglycone (dihydrorobinetin), and 2 phenolic derivatives (chlorogenic acid and caffeic acid) were isolated. The ethanol extract of the leaves reduced acetylcholine-induced contractions of guinea-pig ileum. Ethanol extracts from fruits and leaves showed significant antioxidant activities due to the carotenoids but no antimicrobial activity against gram-positive or gram-negative bacteria. The addition of chopped leaves to nematode infested soil reduced the populations of the nematodes *Meloidogyne incognita* and *Rotylenchulus reniformis*. The nutritive value of the forage is per 100 g dry matter: crude protein 15 g, crude fibre 20 g, ash 14 g, crude fat 6 g, N-free extract 47 g, Ca 2.5 g, P 0.3 g. The wood of *Cordia myxa* is yellowish brown and soft but strong; it polishes well and is durable in water.

Description Dioecious shrub or small tree up to 12 m tall; bole tortuous or straight; bark



Cordia myxa – 1, flowering branch; 2, infructescence.
Redrawn and adapted by Iskak Syamsudin

grey, cracked; branches spreading, forming a dense crown; branchlets hairy, later glabrous, with very prominent leaf scars. Leaves alternate, simple; stipules absent; petiole 0.5–4.5 cm long; blade broadly ovate to orbicular, sometimes obovate, 3–18 cm × 3–20 cm, base rounded to cordate or cuneate, apex rounded to obtusely acuminate, margins entire to toothed, glabrous above, glabrous to velvety hairy below. Inflorescence a lax terminal or short lateral panicle, 3–8.5 cm long, many-flowered; bracts absent. Flowers unisexual, regular, white to creamy; pedicel 1–2 mm long; male flowers with campanulate calyx 4.5–5.5 mm long, 3-lobed, shortly hairy inside, glabrous outside, corolla tube 3.5–4.5 mm long, lobes 5, elliptical, c. 5 mm × 2 mm, reflexed, stamens inserted at corolla throat, exserted, filaments 1.5–3.5 mm long, ovary rudimentary; female flower with tubular-campanulate calyx 6–8.5 mm long, irregularly 3–4-toothed, densely hairy inside, glabrous outside, corolla tube 4.5–6.5 mm long, lobes 4–6, elliptical to obovate, 5–7 mm long, reflexed and rolled up, staminodes with sterile anthers, ovary superior, ellipsoid to obovoid, 4-celled, style 8–9 mm long, with 4 stigmatic branches 4–5 mm long. Fruit a globular to ovoid drupe 2–3.5 cm long, apiculate, enclosed at base by the accrescent calyx, yellow, apricot or blackish when ripe, pulp almost transparent, mucilaginous, sweet-tasting. Pyrene broadly ellipsoid to globose, c. 12 mm long, deeply wrinkled, 1–2-seeded.

Other botanical information *Cordia* is a large pantropical genus of about 250 species, with the majority of the species occurring in the New World. *Cordia myxa* is morphologically close to *Cordia dichotoma* G.Forst. from Asia and Australia, and the species are often confused there.

Several other *Cordia* species are medicinally used in tropical Africa. In eastern Africa leaf sap and root decoctions of *Cordia goetzei* Gürke are taken to treat leprosy, while the bark and leaf ash is rubbed into scarifications. A root decoction is taken to treat malaria. The leaf sap and a root decoction are taken to cure hardened abscesses. From the stem bark the polyphenols cordigone, cordigol and 2 benzofurans were isolated. The benzofurans are responsible for the orange colour of the stem bark. All 4 compounds are fungicidal against *Cladosporium cucumerinum*. In DR Congo a leaf infusion of *Cordia dewevrei* De Wild. & T.Durand is given to children as a tonic. Drums are made from the trunk. The Mende people of Sierra Leone take a leaf decoction of *Cordia vignei* Hutch. & Dalziel as a purgative. A paste of powdered leaves is applied to the body to treat rheumatism. A bark decoction is used to wash sores, and the ground young leaves are used as a wound dressing.

Growth and development *Cordia myxa* grows fairly fast and starts flowering when 3–5 years old. Pollination is done by insects. Fruits ripen in 30–45 days, and are dispersed by birds.

Ecology *Cordia myxa* occurs in dry deciduous woodland, mainly on alluvial soil up to 1500 m altitude. It occurs naturalized around villages and abandoned habitations. It tolerates moderate shade, and is drought and frost hardy.

Propagation and planting *Cordia myxa* is propagated by seed or stem cuttings. As plants grown from seeds show large variation, vegetative propagation of plants producing large fruits is preferred. Seeds are soaked in cold water for 6 hours before planting and germinate within 40–60 days. The germination rate is 50–80%. There are about 18.000 seeds/kg. Seedlings require 4–6 months in a nursery before planting out.

Management *Cordia myxa* trees can be

pollarded and coppiced.

Diseases and pests In Egypt several spot and blight diseases caused by *Alternaria tenuissima* and *Alternaria alternata* have become common on fruits of *Cordia myxa* and other fruit-yielding *Cordia* species.

Harvesting The fruits are mostly harvested when ripe, but are picked green for use in pickles.

Yield In arid regions in India, a plantation of 8-year-old *Cordia myxa* trees yielded on average 32.4 kg fruits per tree per year. Fruit weight is about 5 g.

Genetic resources As *Cordia myxa* is fairly commonly planted, there are no indications that it is at risk of genetic erosion. Large germplasm collections do not exist.

Prospects *Cordia myxa* fruit pulp is commonly used in folk medicine to treat cough and chest complaints, as well as for the treatment of wounds and ulcers. Several studies have confirmed its anti-inflammatory and analgesic activities, but more research is needed to evaluate the active compounds. As the variability in fruit size is large, selection and vegetative propagation of high-yielding trees deserve attention.

Major references Al Awadi et al., 2001; Berhaut, 1974; Burkill, 1985; Neuwinger, 2000; Warfa, 1988.

Other references Abou Shaaban et al., 1989; Adjanohoun et al. (Editors), 1982; Afzal et al., 2004; Agharkar, 1991; Aguilar, 2001; Ficarra et al., 1995; Göhl, 1981; Marston, Zagorski & Hostettmann, 1988; Occhiuto, Circosta & Costa De Pasquale, 1989; Rapisarda et al., 1992; Rastogi & Mehrotra, 1991; Taïta, 2000; Taton, 1971; Tiwari et al., 1967.

Sources of illustration Berhaut, 1974.

Authors P. Oudhia

COSTUS AFER Ker Gawl.

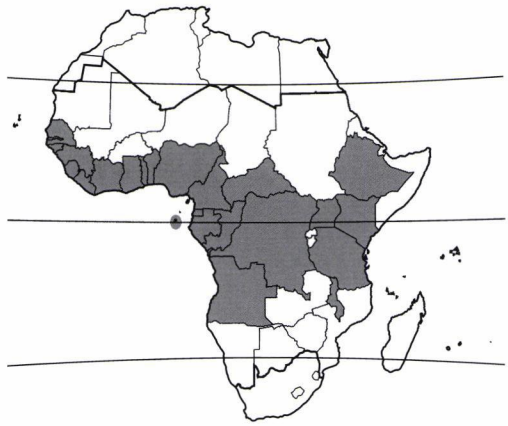
Protologue Bot. Reg. 8: tab. 683 (1823).

Family Costaceae

Chromosome number $2n = 18, 36$

Vernacular names Bush cane, ginger lily, spiral ginger (En). Costus, gingembre spirale (Fr). Fia ipqueté (Po).

Origin and geographic distribution *Costus afer* is found in the forest belt from Senegal east to Ethiopia and south to Tanzania, Malawi and Angola. It is often planted in home gardens for medicinal purposes.



Costus afer – wild and planted

Uses *Costus afer* is commonly used as a medicinal plant throughout tropical Africa. An infusion of the inflorescence is taken to treat tachycardia. The same infusion or a rhizome infusion is taken to treat stomach complaints. A stem decoction, the mashed or chewed stem or the pounded fruit, sometimes mixed with sugar cane juice, are taken to treat cough, respiratory problems and a sore throat. The smoke of the dried stem is also inhaled to treat cough. Leaf sap is used as eye drops to treat eye troubles and as nose drops to treat headache with vertigo, and in frictions to treat oedema and fever. Leaf sap or a rhizome decoction is taken to treat malaria. Stem sap is applied to treat urethral discharges, venereal diseases, jaundice and to prevent miscarriage. Stem sap is acid and rubefacient and burns on open wounds, but it is also anodyne and healing, and is applied to different skin ailments. A stem decoction is widely taken to treat rheumatoid arthritis. An infusion of the dried aerial parts is taken to treat hypertension. The powdered stems are used as an enema to treat worms and haemorrhoids. The pulped stems taken in water are strongly diuretic. In Nigeria the debarked stem is chewed to treat nausea and to quench thirst. A cold water extract of the stem is taken to treat small epileptic attacks. Rhizome pulp is applied to abscesses and ulcers to mature them, applied to teeth to cure toothache, and mixed with water it is taken to treat diarrhoea and amoebic dysentery. A rhizome decoction or the raw rhizome is taken to treat leprosy and venereal diseases. In Gabon the stem sap is rubbed on the body to treat colic.

In Togo *Costus afer* is sometimes cultivated for

the stem bark which is used to make table mats and baskets. Experiments in Uganda to use it for making paper were successful. In DR Congo the stems are used in house construction. The sap can be used to coagulate latex and is also used in skin nourishing creams. In West Africa *Costus afer* is used as a fodder for small ruminants and poultry and the leaves serve as a feed for snails. *Costus afer* is widely used for ceremonial and religious purposes.

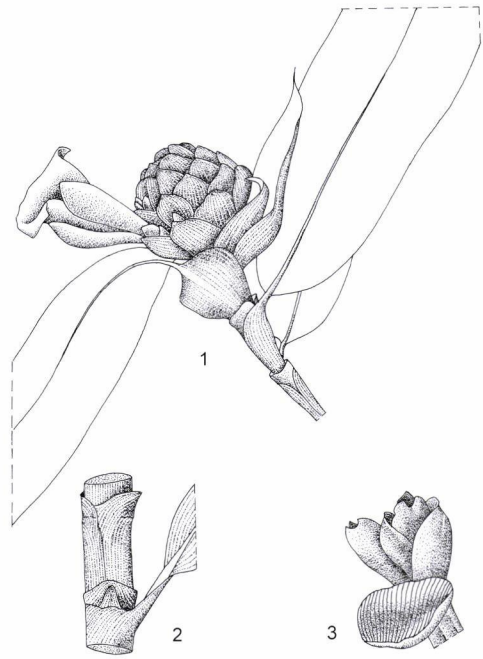
Properties The stem, seeds and rhizome of *Costus afer* contain several steroidal sapogenins, of which diosgenin is the most important one. The rhizome yields 0.5% diosgenin. Diosgenin is a very important raw material used as a precursor in the synthesis of a number of steroidal drugs, including corticosteroids, sex hormones, oral contraceptives and anabolic agents. The rhizomes also contain the saponins aferosides A–C, as well as dioscin and paryphyllin C and the flavonoid glycoside kaempferol 3-O-α-L-rhamnopyranoside. The last compound showed an ability to potentiate in vitro cisplatin cytotoxicity in a human colon cancer cell line.

Sesquiterpenoids were the most abundant group of volatile compounds in the essential oil of *Costus afer* leaves from western Nigeria, with sesquilavandulyl acetate (17.0%) as the principal component, followed by β-caryophyllene (12.3%) and Z,E-farnesol (9.9%). The essential oil did not show any antimicrobial activity. A papaverine-like alkaloid is found in the rhizome which causes relaxation of smooth muscle and is anti-spasmodic, diuretic and central nervous system depressant in tests in animals. The saponin fraction from the rhizomes and the methanolic leaf extract showed significant abortifacient activity in rats. The chloroform and methanol extracts from the aerial parts showed a significant reduction of carrageenin-induced rat paw oedema. The methanol extract of the rhizome showed significant topical anti-inflammatory activity in croton aldehyde-induced mouse ear oedema. The chloroform extract ameliorated all signs associated with adjuvant-induced polyarthritis in rats. The extracts delayed arachidonic acid and castor oil-induced diarrhoea in rats.

The aqueous extract of the leaves and stems showed significant antibacterial and amoebicidal activity in vitro. The methanolic leaf extract showed significant cytotoxicity in the brine shrimp test. The same extract showed moderate local anaesthetic activity in guinea pig skin test, and contracted the guinea pig ileum in a concentration-dependent manner. The extract exhibited antihyperglycaemic activity, and decreased the blood glucose level by 50% in streptozotocin (STZ)-induced hyperglycaemia in male rats; high doses, however, increased blood glucose level.

Adulterations and substitutes Diosgenin is mainly obtained from *Dioscorea* spp., but it is also present in most *Costus* spp., and especially obtained from the ornamental *Costus speciosus* (Fenzl) K.Schum. Another species of which the seed contains high concentrations of diosgenin is fenugreek (*Trigonella foenum-graecum* L.).

Description Perennial, rhizomatous herb up to 4 m tall. Leaves arranged spirally, simple and entire; sheath tubular, closed, green with purple blotches; ligule 4–8 mm long, leathery, glabrous; petiole 4–12 mm long; blade elliptical to obovate, 15–35 cm × 3.5–9.5 cm, base rounded to subcordate, apex acuminate, margin sparsely hairy, usually glabrous above, sometimes shortly hairy beneath. Inflorescence a very compact, terminal, conical spike 2.5–7.5 cm long, sessile; bracts oblong, convex, c. 3.5



Costus afer – 1, flowering shoot; 2, base of leaf with ligule; 3, bract with 2 flowers.
Redrawn and adapted by Achmad Satiri Nurhaman

cm long, densely imbricate, upper ones often smaller, apex truncate to rounded, green with purple markings, each subtending 2 flowers; bracteoles boat-shaped, c. 2.5 cm × c. 1 cm, keel thick and ridged, pale green with pink markings and thin pink papery margin. Flowers bisexual, zygomorphic, 3-merous; calyx tube 1.5–2 cm long, teeth c. 5 mm long, triangular, margin pink; corolla tube c. 2 cm long, hairy inside, enclosed by bract, lobes oblong to ovate, 3–4 cm long, hooded at apex, transparent to white, labellum (lip) broadly triangular, funnel-shaped, c. 2.5 cm × 2.5 cm, opposite the stamen, white or tinged pink towards the margin with an orange-yellow central line to the base of the corolla tube; stamen 1, free, petaloid, ovate, c. 3 cm × 1 cm, entire, white, anther c. 7 mm long, attached at the middle to the filament; ovary inferior, 3-celled, style 1, filiform. Fruit an ellipsoid capsule c. 1 cm long, dehiscing loculicidally, many-seeded. Seeds black, with aril.

Other botanical information *Costus* is pantropical and comprises about 70 species, of which about 40 species in tropical America, about 25 in tropical Africa and about 5 in South-East Asia. The African *Costus* spp. are much in need of revision, especially the large forest species which are difficult to collect for herbarium collections. *Costus afer* and *Costus lucanusianus* J.Braun & K.Schum. are closely related species, mainly differing in the form of the inflorescence, the number of flowers enclosed by the bracts and the colour of the flowers. In *Costus afer* the inflorescence is cone-like, each bract covers 2 flowers and the corolla is white with a yellow throat, whereas in *Costus lucanusianus* the inflorescence is globose, each bract covers 1 flower and the corolla is white with a red lip and yellow throat. In southern Nigeria *Costus afer* and *Costus lucanusianus* produce hybrids.

Other *Costus* spp. with medicinal uses in West Africa are *Costus deistelii* K.Schum., *Costus dubius* (Afzel.) K.Schum., *Costus englerianus* K.Schum., *Costus schlechteri* Winkler and the ornamental *Costus spectabilis* (Fenzl) K.Schum. An extract of the inflorescences and stems of all species is taken to treat cough and stomach complaints. Leaf and stem sap is used as eye drops to treat eye infections and as nose drops to cure headache, in frictions or a vapour bath to treat oedema and fever, or applied to treat urethral discharges, venereal diseases, jaundice and to prevent miscarriage. Rhizome pulp is applied to abscesses, ulcers and Guinea worm to mature them. The rhizome decoction of *Costus dubius* is taken to treat epilepsy; it is also a diuretic and febrifuge. The boiled leaves of *Costus schlechteri* are also applied to smallpox and are taken to treat diabetes. The rhizomes of *Costus deistelii* yield 0.25% total steroidal sapogenins, with 0.15% diosgenin.

Growth and development *Costus afer* is a very vigorous grower. It flowers and fruits throughout the year, depending on the humidity of the soil.

Ecology *Costus afer* occurs in moist localities in forest and forest edges, up to 1400 m altitude. In southern Nigeria *Costus afer* is a weed in rice fields. In cultivation it requires a rich well-drained, moist soil (2 parts peat moss to 1 part loam to 1 part sharp sand). It does well in partial shade to full sun.

Propagation and planting *Costus afer* can be propagated by seed, and also by stem cuttings or rhizome cuttings. The stems and rhizomes are cut into pieces 2.5 cm long and planted in a mixture of sand and peat moss. In-vitro storage of multiple shoot cultures of *Costus afer* was successful; after 1 year of storage under liquid paraffin, high survival rates (70–100%) were found, and even after 2 years, 75% of the cultures of *Costus afer* remained viable.

Diseases and pests In Cameroon *Costus afer* is a host of the African root and tuber scale *Stictococcus veyssierei*.

Harvesting The stems and rhizomes of *Costus afer* are harvested from the wild or from plants grown in home gardens whenever the need arises.

Genetic resources In Ethiopia *Costus afer* is harvested on a large scale from the wild for medicinal purposes, resulting in diminishing numbers. As demand for medicinal plants rises, harvest rates also increase. The situation is further aggravated by habitat destruction caused by slash-and-burn, commercial logging and firewood collection. In West and Central Africa, *Costus afer* remains a common species in forest undergrowth, and is not liable to genetic erosion.

Prospects *Costus afer* is widely used as a medicinal plant in tropical Africa and several uses have been confirmed by pharmacological tests, although no systematic evaluation of the active compounds of the different plant parts has been effected. The diosgenin content needs further study as well, especially because the content is higher than commercially grown diosgenin-producing *Costus* spp. *Costus afer* has some value as an ornamental plant.

Major references Aguiyi, Olorunfemi & Igweh, 1998; Anaga et al., 2004; Aweke, 1997; Burkill, 1985; Iwu, 1993; Iwu & Anyanwu, 1982; Lin, Hanquet & Lacaille Dubois, 1996; Lin et al., 1997; Lock, 1985; Neuwinger, 2000.

Other references Akendengué & Louis, 1994; Burkill, 2000; Chhabra, Mahunnah & Mshiu, 1993; Dekkers, Rao & Goh, 1991; Dokosi, 1998; Ebenso & Okafor, 2002; Edeoga & Okoli, 1996; Hepper, 1968; Kambu et al., 1989; Moody & Okwagbe, 2003; Moundipa et al., 2005; Okoli et al., 2003; Specht & Stevenson, 2006; Taiwo & Bolanle, 2003; Terashima & Ichikawa, 2003.

Sources of illustration Koechlin, 1965.

Authors G. Aweke

COSTUS LUCANUSIANUS J.Braun & K.Schum.

Protologue Mitt. Deutsch. Schutzgeb. 2: 151 (1889).

Family Costaceae

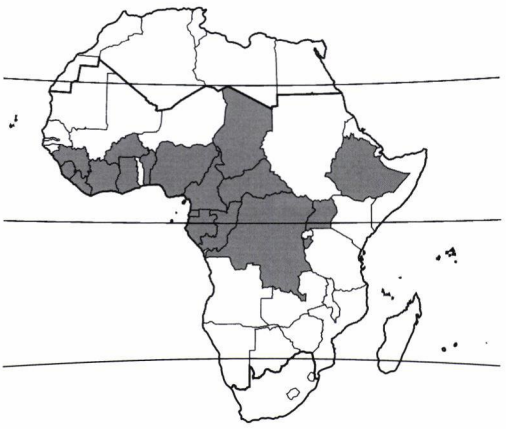
Chromosome number $2n = 18, 27$

Vernacular names Spiral ginger (En). Canne d'eau (Fr).

Origin and geographic distribution *Costus lucanusianus* is found in the forest belt from Guinea east to western Ethiopia and south to DR Congo. It has been introduced as an ornamental, mainly in the United States and South America. In Central Africa it is often planted in home gardens for medicinal purposes.

Uses *Costus lucanusianus* is commonly used as a medicinal plant in tropical Africa. An infusion of the inflorescence is used to treat tachycardia and stomach complaints. A stem decoction, warmed stem sap or the pounded fruit are taken to treat cough, bronchitis and a sore throat; the stem is also mashed or chewed to treat cough. Leaf sap is acid and is used as eye drops to treat eye troubles and headache with vertigo, and in frictions to treat oedema and fever. Leaf sap is used as nose drops and leaf pulp is rubbed on the head to calm insanity. Stem sap is applied to treat urethral discharges, venereal diseases and jaundice, and to prevent miscarriage. Stem sap is rubefacient and burns on open wounds, but it is also anodyne and healing, and is applied to mumps and measles. Rhizome pulp is applied to abscesses and ulcers to mature them, and mixed with water it is taken to treat diarrhoea. A stem decoction is widely taken to treat rheumatism. The pulped stems taken in water are strongly diuretic. In Gabon stem sap is used as eye drops to control filariasis.

In Gabon young shoots are cooked and eaten as a substitute for those of *Hibiscus sabdariffa* L.; they have a slightly acid taste. Stem sap is used to coagulate latex. *Costus lucanusianus* is commonly used for ceremonial and religious purposes. It is sold in Western countries as an ornamental container plant.



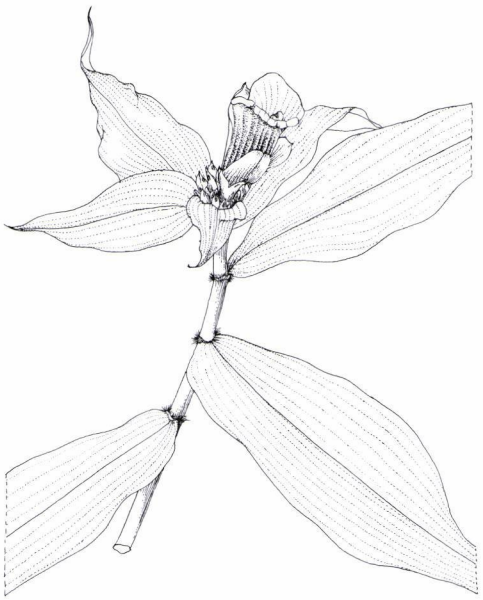
Costus lucanusianus – wild and planted

Properties The rhizomes of *Costus lucanusianus* yield 0.7% total steroidal sapogenins and 0.6% diosgenin. The juice from fresh stems of *Costus lucanusianus* showed a significant dose-related relaxation of rat duodenum and uterus in vitro.

Different extracts from the leaves did not show any antibacterial or antifungal activity, and different extracts from the rhizome tested negative for antitrypanosomal and antiplasmodial activity.

Adulterations and substitutes The rhizomes of *Costus lucanusianus* contain a higher percentage diosgenin than those of *Costus speciosus* (Fenzl) K.Schum., from which diosgenin is isolated for the pharmaceutical industry.

Description Perennial, rhizomatous herb up to 3 m tall. Leaves arranged spirally, simple and entire; sheath tubular, closed, green with purple blotches; ligule 1.5–3 mm long, leathery, with a raised ridge, long-hairy; petiole 5–9 mm long; blade elliptical, 21–24 cm × 4.5–6 cm, base rounded to subcordate, apex acuminate, margin sparsely hairy, glabrous above, shortly hairy beneath. Inflorescence a very compact, terminal, globose spike 3.5–7.5 cm long, sessile; bracts oblong, convex, c. 2.5 cm long, densely imbricate, upper ones often smaller, apex truncate to rounded, green with purple markings,



Costus lucanusianus – flowering shoot. Redrawn and adapted by Iskak Syamsudin

each subtending 1 flower; bracteoles boat-shaped, up to 2 cm long, keel thick and ridged, pale green with pink markings and thin pink papery margin. Flowers bisexual, zygomorphic, 3-merous; calyx tube 2–3 cm long, teeth 5–6 mm long, triangular, recurved, margin shortly hairy; corolla tube c. 2 cm long, hairy inside, enclosed by bract, lobes oblong, c. 2.5 cm long, hooded at apex, acute, semi-transparent to white, labellum (lip) broadly triangular, funnel-shaped, c. 3 cm × 3 cm, opposite the stamen, dark red towards the margin, with a central yellow line not extending into the corolla tube; stamen 1, free, petaloid, narrowly triangular, c. 2.5 cm × 1 cm, entire, white, tinged red at apex, anther 8–10 mm long, attached at the middle to the filament; ovary inferior, 3-celled, style 1, filiform. Fruit an ellipsoid capsule 1–1.5 cm long, dehiscing loculicidally, many-seeded. Seeds black, with white aril.

Other botanical information *Costus* is pantropical and comprises about 70 species, of which about 40 species in tropical America, about 25 in tropical Africa and about 5 in South-East Asia. The African *Costus* spp. are much in need of revision, especially the large forest species which are difficult to collect for herbarium collections. *Costus lucanusianus* and *Costus afer* Ker Gawl. are closely related species, mainly differing in the form of the inflorescence, the number of flowers enclosed by the bracts and the colour of the flowers. In *Costus lucanusianus* the inflorescence is globose, each bract covers 1 flower and the corolla is white with a red lip and yellow throat, whereas in *Costus afer* the inflorescence is cone-like, each bract covers 2 flowers and the corolla is white with a yellow throat. In southern Nigeria *Costus afer* and *Costus lucanusianus* produce hybrids.

Several other *Costus* species have medicinal uses in the forest zone of Central Africa. In DR Congo the sap of the crushed stems of *Costus dewevrei* De Wild. & T.Durand is used as an enema or drunk to treat abdominal pain. The sap, fresh or as an infusion, is also taken or externally applied to treat cough, fever, venereal diseases and rheumatism. The Masango people in Gabon drink the filtrate of the ground stems and leaves of *Costus ligularis* Baker to treat cough. *Costus phyllocephalus* K.Schum. is important as a vegetable because of its edible shoots, but the leaf sap is also medicinally used in DR Congo to treat eye diseases, wounds and ulcers and it is applied as an enema to treat post-partum haemorrhoids. A root decoction is taken to treat epilepsy and mental disorders.

Growth and development *Costus lucanusianus* is a vigorous grower. It flowers and fruits throughout the year, depending on the humidity of the soil.

Ecology *Costus lucanusianus* occurs in seasonally or permanently humid localities in forest, up to 1200 m altitude. In cultivation it prefers a humus-rich soil and partial shade.

Propagation and planting *Costus lucanusianus* can be propagated by seed, and also by stem cuttings or rhizome cuttings. The stems and rhizomes are cut into pieces 2.5 cm long and planted in a mixture of sand and peat moss. Seeds lose their viability rapidly, and need to be sown fresh in a rich, moist soil under dense shade. *Costus lucanusianus* also reproduces asexually through plantlet formation on the inflorescence (vivipary), a characteristic absent in *Costus afer*. In-vitro storage of multiple shoot cultures of *Costus lucanusianus* was successful; after 1 year of storage under liquid paraffin, high survival rates (70–100%) were found.

Management When grown in a container, *Costus lucanusianus* requires frequent repotting to control its size.

Harvesting The stems and rhizomes of *Costus lucanusianus* are harvested from the wild

or from home gardens whenever the need arises.

Genetic resources *Costus lucanusianus* is a common species in the forest zone of tropical Africa and not in danger of genetic erosion.

Prospects *Costus lucanusianus* is widely used as a medicinal plant in tropical Africa but little is known about the constituents and their pharmacological activities. This merits further research. The diosgenin content of the rhizome is very high, and seems to be economically competitive, compared to commercial diosgenin-producing plant species.

Major references Aweke, 1997; Burkill, 1985; Edeoga & Okoli, 1996; Edeoga & Okoli, 1997; Foungbe et al., 1991; Lock, 1985.

Other references Atindehou et al., 2002; Atindehou et al., 2004; Burkill, 2000; Foungbe, Sawadogo & Declume, 1987; Gassita et al. (Editors), 1982; Hepper, 1968; Lambert, Baccou & Sauvaire, 1988; Neuwinger, 2000; Raponda-Walker & Sillans, 1961.

Sources of illustration Lock, 1985.

Authors G. Aweke

CRASPIDOSPERMUM VERTICILLATUM Bojer ex A.DC.

Protologue Prodr. 8: 323 (1844).

Family Apocynaceae

Origin and geographic distribution *Craspidospermum verticillatum* is endemic to Madagascar.

Uses The leaves and bark of *Craspidospermum verticillatum* are often used in traditional medicine to treat pulmonary diseases as a tonic, antitussive and expectorant. After-effects of syphilis are treated with a decoction of the aerial parts. The wood is used as timber and is highly esteemed for construction. *Craspidospermum verticillatum* is therefore often cultivated around villages.

Properties The leaves and bark contain the indole alkaloids methoxy-11-tabersonine, hydroxy-11-tabersonine, venalstonine, Δ^{14}-vincine and craspidospermine. These alkaloids show cerebro-vascular activity. The leaves also contain the alkaloid condylocarpine, which causes irritation in workers handling the leaves. Andranginine has also been isolated. The wood is moderately heavy, with an oven-dry density of about 780 kg/m^3. It is recommended to kiln dry the wood at 41°C.

Botany Tree up to 25 m tall, glabrous, with white latex in the branchlets, not in the bark; bole up to 50 cm in diameter; bark pale grey-brown, rather smooth, branches lenticellate. Leaves in whorls of 3–4, simple and entire; stipules absent; petiole (0–)5–25 mm long; blade narrowly elliptical to obovate, 4–14 cm × 2–6.5 cm, base cuneate, apex rounded or sometimes acute, leathery, pinnately veined with 10–20 pairs of conspicuous lateral veins. Inflorescence a very dense compound dichasium, 4–12 cm long, terminal and in the axils of the upper leaves, 1–4 together; peduncle 1–8.5 cm long; lower bracts leafy, others sepal-like. Flowers bisexual, regular, 5-merous; pedicel 0.5–3 mm long; sepals connate at base, ovate, apex obtuse or rounded; corolla with cylindrical tube 6–10 mm × 1–2 mm, widened around the anthers, lobes narrowly elliptical, 3–9 mm × 2–4 mm, apex rounded, erect to spreading, overlapping to the left, hairy inside with straight hairs directed downwards, white or pale pink, throat pink or dark red; stamens inserted 2–4 mm from the base of the corolla tube, deeply included; ovary superior, almost globose, 2-celled; pistil head with basal ellipsoid stigmatic part and oblong apex. Fruit an oblong woody capsule 3–6 cm × 1–2 cm, base and apex rounded, 2-valved, septicidal, wall c. 2 mm thick, many-seeded. Seeds flat, obliquely elliptical, c. 12 mm long, dark brown, ciliate with irregularly coherent, fin-like hairs 1–2 mm long, minutely papillose.

Craspidospermum comprises only a single species. It is characterized by its whorled leaves and capsular fruits.

Ecology *Craspidospermum verticillatum* occurs in rain forest up to 1800 m altitude.

Genetic resources and breeding *Craspidospermum verticillatum* has been harvested on a large scale for its timber, and to avoid genetic erosion it should be planted on a much larger scale for timber purposes.

Prospects *Craspidospermum verticillatum* will remain a medicinal plant of only local importance. Its value and potential as cultivated timber tree need further research.

Major references Boiteau & Allorge-Boiteau, 1993; Gurib-Fakim & Brendler, 2004; Kan Fan et al., 1974; Leeuwenberg, 1997a; Markgraf, 1976.

Other references Debray, Jacquemin & Razafindrambao, 1971; Kan Fan et al., 1968; Kan Fan et al., 1971; Kan Fan, Husson & Potier, 1976; Riche & Pascard Billy, 1979; Schatz, 2001; Simpson, 1996.

Authors A. de Ruijter

CROTON ANTANOSIENSIS Leandri

Protologue Ann. Inst. Bot.-Géol. Colon. Marseille sér. 5, 7(1): 45 (1939).

Family Euphorbiaceae

Origin and geographic distribution *Croton antanosiensis* is endemic to Madagascar.

Uses The stem bark is used to make a bitter alcoholic beverage, which is used in circumcision ceremonies to induce virility. A strong stem bark decoction was taken as an ordeal poison in former times. Leafy branches are used as mattress filling, especially as lice repellent. The leafy branches are used to fumigate houses in case of epidemic diseases.

Properties More than 20 compounds have been found in the essential oil of the dried aerial parts of *Croton antanosiensis*, of which more than 70% are monoterpenes, followed by sesquiterpenes. Major components are α-pinene (33%), β-pinene (16%), limonene (6%) and trans-nerolidol (6%).

Botany Monoecious shrub up to 4 m tall. Leaves opposite or in whorls of 3, simple, strongly scented; stipules tiny; petiole 5–8 mm long; blade lanceolate, 3–4 cm × c. 1 cm, base cordate, with 2 small, sessile glands, apex acute, margins variously toothed, glabrous above, beneath with silvery whitish peltate scales. Inflorescence a terminal raceme, with numerous male flowers at end and 3–4 female flowers at base. Flowers unisexual, 5-merous, regular, white; male flowers with pedicel up to 1.5 mm long, sepals triangular, yellowish brown, petals obovate to spoon-shaped, stamens 10–11, free, white; female flowers with robust pedicel c. 2 mm long, sepals triangular, petals absent, ovary superior, rounded, 3-lobed, silky hairy, 3-celled, styles 3, several times 2-fid. Fruit not known.

Croton comprises about 1200 species and occurs throughout the warmer regions of the world. It is best represented in the Americas; about 65 species occur in continental Africa and about 125 in Madagascar. Almost 40 species from Madagascar are used in medicine, and several of them resemble morphologically *Croton antanosiensis*. An infusion of the aromatic leafy branches of *Croton anisatus* Baill. or *Croton ambanivoulensis* Baill. is taken to treat dysentery and to calm colic. An infusion or a steam bath of the aerial parts of *Croton boinensis* Leandri is often taken to treat rheumatism including rheumatoid arthritis. A leaf infusion of *Croton catati* Baill. is taken to treat stomach-ache, cough and shortness of breath. Stem and root bark are used in fumigations to treat malaria. A bitter alcoholic beverage is made from the bark of *Croton catati* or *Croton noronhae* Baill., causing euphoria. The beverage can cause severe poisoning even at relatively low intake. The aromatic leafy branches of *Croton greveanus* Baill. are used as mattress filling to repel insects, especially lice. A bark decoction is taken to treat cough. A decoction of the aerial parts is taken to treat lumbar pain caused by chronic gonorrhoea. Leafy branches of *Croton humbertii* Leandri are hung in houses to repel insects and small pouches of dried leaves are carried on the body against lice. A leaf infusion of *Croton kimosorum* Leandri is an important medicine against coughs and an antispasmodic.

Ecology *Croton antanosiensis* occurs in hilly shrubland and in forest on laterite, sometimes near streams, from sea-level up to 1500 m altitude.

Genetic resources and breeding *Croton antanosiensis* is probably not threatened by genetic erosion.

Prospects *Croton antanosiensis* is interesting for use as an insect repellent and as an antibacterial agent, but more information is needed, especially on the composition of the essential oil, to evaluate its potential.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Govaerts, Frodin & Radcliffe-Smith, 2000; Leandri, 1939; Radulovic et al., 2006.

Other references Coode, 1982; Missouri Botanical Garden, undated; Ralaivao, 1993; Rasoanaivo, Petitjean & Conan, 1993.

Authors G.H. Schmelzer

CROTON AUBREVILLEI J.Léonard

Protologue Bull. Jard. Bot. Etat 28: 113 (1958).

Family Euphorbiaceae

Origin and geographic distribution *Croton aubrevillei* occurs in Côte d'Ivoire, Ghana, Cameroon and the Central African Republic.

Uses In Côte d'Ivoire an infusion of the leaves and bark is taken to treat constipation, stomach-ache and female infertility; the bark is also rubbed on the body to treat pain and guinea-worm infection. In Cameroon the dried bark is eaten to treat stomach-ache or high blood pressure; an infusion of the roots, leaves or stem bark is used similarly. Chewed bark is rubbed on babies when they do not sleep well.

In Cameroon the stem bark is sometimes used as a toothbrush.

Properties The main constituents identified in the essential oil from the stem bark are the common terpenoids linalool (35%) and β-caryophyllene (12%).

Botany Monoecious, small tree up to 6 m tall, stellate hairy and scaly. Leaves alternate to whorled, simple and entire; stipules small, linear, 4–7 mm long, persistent; petiole 1–7.5 cm long; blade elliptical to ovate-elliptical, 3.5–10 cm × 2–5.5 cm, base rounded to cordate, with 2 small glands, apex acute to acuminate, sparsely to densely brown hairy above, with silvery white scales beneath. Inflorescence a terminal raceme 4–7 cm long, with many male flowers at end and 1–2 female flowers at base. Flowers unisexual, 5-merous, regular, white; pedicel 3–5 mm long, enlarging to 8–11 mm in fruit; sepals elliptical to triangular, fused at base, 3–4.5 mm long; male flowers with elliptical petals 3.5–4 mm long, stamens 17–24, free; female flowers with lanceolate petals 2.5–5 mm long, ovary superior, rounded, 3-lobed, hairy, 3-celled, styles 3, 2-fid to the base. Fruit a globular, slightly 3-lobed capsule c. 9 mm in diameter, green, hairy, 3-seeded. Seeds ellipsoid, 6–7 mm × 5–6 mm, brown.

Croton comprises about 1200 species and occurs throughout the warmer regions of the world. It is best represented in the Americas; about 65 species occur in continental Africa and about 125 in Madagascar.

Ecology *Croton aubrevillei* occurs in evergreen and deciduous forest at low altitudes.

Genetic resources and breeding *Croton aubrevillei* is not common in its area of distribution and is threatened by habitat destruction. It is assessed as vulnerable in the IUCN Red List of threatened species, and future re-evaluation is likely to rate this species as endangered.

Prospects *Croton aubrevillei* has several interesting medicinal uses, but little is known about its chemistry or pharmacology; more research is therefore needed.

Major references Cheek, 2004a; Léonard, 1958; Menut et al., 1995; Tshiamala-Tshibangu et al., 1999.

Other references Burkill, 1994; Missouri Botanical Garden, undated.

Authors G.H. Schmelzer

CROTON BARORUM Leandri

Protologue Ann. Inst. Bot.-Géol. Colon. Marseille sér. 5, 7(1): 66 (1939).

Family Euphorbiaceae

Origin and geographic distribution *Croton barorum* is endemic to south-western Madagascar.

Uses A decoction of the stem and root bark is drunk to treat diarrhoea, malarial fever, cough, breast cancer and leukaemia. The aromatic leafy branches are used as an insect repellent in mattress fillings, especially against lice. A leaf extract is also used to perfume soap.

Properties Crude extracts from the leaves, stems and stem bark have shown significant activity against several human bacterial pathogens.

Botany Monoecious shrub or small tree up to 5 m tall, much-branched; young twigs with short stellate hairs. Leaves alternate, simple, aromatic; stipules small, persistent; petiole c. 3 cm long; blade ovate-lanceolate, 8–15 cm × 2.5–5.5 cm, base cordate, with 2 tiny, sessile glands, apex acuminate, margins toothed, short-hairy, lower surface whitish. Inflorescence a terminal raceme, with male flowers crowded at apex and 2–3 female flowers at base. Flowers unisexual, 5-merous, white; male flowers with short pedicel, sepals fused at base, with sparse stellate hairs, petals obovate, rounded, stamens 15–16, free; female flowers with pedicel enlarging in fruit to c. 2 cm long, sepals fused at base, petals absent, ovary superior, 3-lobed, short-hairy, 3-celled, styles 3, several times 2-fid at apex. Fruit a 3-lobed capsule c. 1 cm in diameter, 3-seeded.

Croton comprises about 1200 species and occurs throughout the warmer regions of the world. It is best represented in the Americas; in continental Africa about 65 species occur and in Madagascar about 125.

Ecology *Croton barorum* occurs in dry forest.

Genetic resources and breeding There are no reports that *Croton barorum* is threatened by genetic erosion.

Prospects *Croton barorum* shows interesting antibacterial activity, and more research is warranted to evaluate its potential.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Govaerts, Frodin & Radcliffe-Smith, 2000; Leandri, 1939; Rakotoniraini, 2004.

Other references Coode, 1982; Rasoanaivo, Petitjean & Conan, 1993.

Authors G.H. Schmelzer

CROTON DECARYI Leandri

Protologue Bull. Mus. natn. Hist. nat., Paris, sér. 2, 3: 370 (1931).

Family Euphorbiaceae

Origin and geographic distribution *Croton decaryi* is endemic to south-western Madagascar.

Uses The aromatic leafy branches are used as a mattress filler to repel insects, especially lice. A decoction of the aerial parts is taken to calm patients with paranoid psychosis.

Properties Dry leaves of *Croton decaryi* contain about 0.3% essential oil, dry stems 0.2%. The essential oil of the leaves is rich in monoterpene and sesquiterpene hydrocarbons. Major components are β-caryophyllene (27%), α-pinene (21%), α-humulene (19%), β-pinene (7%) and caryophyllene oxide (5%). The essential oil of the dried stem contains mainly monoterpenes and oxygenated monoterpenes, and the major components are α-pinene (26%), borneol (13%), camphene (11%), β-pinene (7%), β-caryophyllene (9%) and caryophyllene oxide (6%).

Botany Monoecious shrub up to 2 m tall; young twigs with short, reddish stellate hairs. Leaves opposite to whorled, simple, strongly scented; stipules small, persistent; petiole c. 1.5 cm long; blade ovate, c. 3 cm × 2 cm, base cordate, with 2 small, sessile glands, apex rounded, margins toothed, with small, cup-shaped glands in forks of veins, softly hairy on both sides, whitish beneath. Inflorescence a terminal raceme with male flowers at apex and 2–3 female flowers at base. Flowers unisexual, 5-merous, regular, white; sepals small, petals rudimentary; male flowers with short pedicel, stamens c. 15, free; female flowers with pedicel c. 2 cm long, ovary superior, rounded, 3-lobed, yellowish hairy, 3-celled, styles 3, several times 2-fid. Fruit an ovoid 3-lobed capsule, softly stellate hairy, 3-seeded.

Croton comprises about 1200 species and occurs throughout the warmer regions of the world. It is best represented in the Americas; about 65 species occur in continental Africa and about 125 in Madagascar. Almost 40 of the species from Madagascar are used in medicine, and several of them resemble morphologically *Croton decaryi*. The crushed stems of *Croton bathianus* Leandri are added to a fermented beverage and taken as a bitter tonic. An infusion of the bitter bark of *Croton crocodilorum* Leandri is taken as a stimulant and aphrodisiac. An infusion of the grated bark of *Croton perrieri* Leandri is taken to treat infectious diseases.

Ecology *Croton decaryi* occurs in open forest and on stream banks, at low altitudes.

Genetic resources and breeding There are no signs that *Croton decaryi* is threatened by genetic erosion.

Prospects Probably due to its essential oil, *Croton decaryi* is interesting for use as an insect repellent, but is likely to remain of minor, local importance only.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Govaerts, Frodin & Radcliffe-Smith, 2000; Leandri, 1939; Radulovic et al., 2006.

Other references Coode, 1982; Missouri Botanical Garden, undated; Ralaivao, 1993.

Authors G.H. Schmelzer

CROTON GEAYI Leandri

Protologue Bull. Mus. natn. Hist. nat., Paris, sér. 2, 3: 368 (1931).

Family Euphorbiaceae

Origin and geographic distribution *Croton geayi* is endemic to south-western Madagascar.

Uses An infusion of the aromatic leafy twigs is taken to treat fever, cough, asthma and constipation in newborn babies.

Properties The dry aerial parts of *Croton geayi* contain about 0.3% essential oil. The essential oil contains mainly oxygenated monoterpenes, sesquiterpenes and oxygenated sesquiterpenes. Major components are 1,8-cineol (16%), β-carophyllene (15%), α-terpineol (14%), T-muurolol (7%), γ-cadinene (5%) and 4-terpineol (5%). Some diterpenes have been isolated from the wood: geanine, geaninine and derivatives.

Botany Monoecious, aromatic shrub up to 1.5 m tall; young twigs glabrous. Leaves whorled, simple and entire; stipules small; petiole 3–5 mm long; blade elliptical, c. 2 cm × 0.5 cm, base rounded, with 2 small, yellow glands, apex acute, short-hairy above, with silvery brown, shiny scales beneath. Inflorescence a terminal raceme, with many male flowers at apex and 1–2 female flowers at base. Flowers unisexual, 5-merous, regular; pedicel white to yellowish green; male flowers with small sepals and small petals, stamens c. 15, free; female flowers with small sepals, petals absent, ovary superior, globose, 3-lobed, silky hairy, 3-celled, styles 3, several times 2-fid. Fruit an ovoid 3-lobed capsule c. 7 mm long,

covered with brown scales, 3-seeded. Seeds ovoid.

Croton comprises about 1200 species and occurs throughout the warmer regions of the world. It is best represented in the Americas; about 65 species occur in continental Africa and about 125 in Madagascar. Almost 40 of the species from Madagascar are used in medicine, and several of them resemble morphologically *Croton geayi*. An infusion of the leafy twigs of *Croton adabolavensis* Leandri is taken to treat dysentery. The aromatic leafy branches of *Croton androiensis* (Leandri) Leandri and *Croton elaeagni* Baill. are used as a mattress filler to repel insects, especially lice. A root bark decoction of *Croton androiensis* is externally applied for its cicatrizing effect and to treat caries. A bark decoction of *Croton elaeagni* is taken to treat a cough. A decoction of the aerial parts of *Croton jennyanus* Gris. ex Baill. is taken to calm patients with delirium, paralysis or Parkinson's disease. The seeds are taken as a strong purgative, but are considered dangerous.

Ecology *Croton geayi* occurs in rocky localities, on calcareous or sandy soil, at 100–1400 m altitude. It prefers sunny localities.

Genetic resources and breeding There are no signs that *Croton geayi* is threatened by genetic erosion.

Prospects *Croton geayi* has some interesting local medicinal uses, but more information is needed to evaluate its potential.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; CNRE & ONE, 2001; Govaerts, Frodin & Radcliffe-Smith, 2000; Leandri, 1939; Radulovic et al., 2006.

Other references Coode, 1982; Missouri Botanical Garden, undated; Palazzino et al., 1997; Ralantonirina, 1993; Rasoanaivo et al., 1999; Razafiarison, 1993.

Authors G.H. Schmelzer

CROTON HAUMANIANUS J.Léonard

Protologue Bull. Agric. Congo Belge 48: 79 (1957).

Family Euphorbiaceae

Origin and geographic distribution *Croton haumanianus* has been recorded in southern Cameroon, Equatorial Guinea, Congo and DR Congo.

Uses In Congo an infusion of the grated, bitter, fresh bark is commonly taken as a purgative and diuretic. The grated bark is mixed with palm oil and is applied to the body to treat rheumatism, headache, pain in the side, oedema of the legs and abscesses. Sometimes mashed leaves are mixed with the grated bark. A leaf or bark decoction is taken to treat gonorrhoea, urinary infections, worms, headache, constipation, starting hernia, heartburn, oedema, rheumatism and painful urination. A decoction or infusion is also applied as an enema as a purgative. A bark infusion is taken to treat hypertension and epilepsy. Pregnant women with a history of repeated spontaneous abortions take a spoonful of the liquid obtained from crushed seeds in water to prevent abortion. In DR Congo small amounts of bark decoction, alone or in combination with other plants, are drunk to treat gonorrhoea and rheumatism. A preparation of stem bark, leaves or fruits is eaten as an aphrodisiac. Mashed stem bark and fruits are used to kill rats and in the preparation of arrow poison. The plant is used in ceremonies to chase away bad spirits, and to restore health when taboos have been broken.

The wood is used in carpentry. *Croton haumanianus* is frequently planted as a shade plant in coffee and cacao plantations.

Properties The stem bark contains several diterpenes including crotocorylifuran, a clerodane-type diterpenoid, and crotohaumanoxide, a crotofolane-type diterpenoid.

Botany Monoecious small to medium-sized tree up to 15(–35) m tall, densely scaly and stellate hairy; bole cylindrical, up to 40(–100) cm in diameter; outer bark longitudinally fissured, brownish green, inner bark yellowish orange and whitish, scented, exudate brown and sticky; crown light. Leaves alternate, simple and entire; stipules filiform, 1–15 mm long, usually with basal, filiform appendages, persistent; petiole 1.5–12 cm long; blade elliptical to ovate-elliptical, 4–19.5 cm × 2–9.5 cm, base rounded to cordate, basal glands 2(–4), apex acute to acuminate, whitish beneath. Inflorescence a terminal raceme 3–21 cm long, with many male flowers at apex and few female flowers at base. Flowers unisexual, 5-merous, regular, white; pedicel 1–5 mm long; sepals elliptical, 3.5–4.5 mm long; male flowers with elliptical petals 2.5–4 mm long, hairy on both sides, stamens 23–34, free; female flowers with linear petals 3–3.5 mm long, hairy on both sides, ovary superior, rounded, densely hairy, 3-celled, styles 3, 3–4 times deeply 2-fid. Fruit an almost globular, thick-walled drupe, 2–2.5 cm in diameter, indehiscent, upper part slightly 3-lobed, 3-seeded. Seeds ellipsoid, c. 7

mm × 5 mm, whitish. Seedling with epigeal germination.

Croton comprises about 1200 species and occurs throughout the warmer regions of the world. It is best represented in the Americas; about 65 species occur in continental Africa and about 125 in Madagascar. Several other medicinally used *Croton* species occur in Central Africa. In Congo an infusion of the fruits of *Croton draconopsis* Müll.Arg. is taken as a purgative and vermifuge; the leaves and root bark are sometimes used similarly. In Congo *Croton mayumbensis* J.Léonard is often used instead of *Croton haumanianus*. A bark decoction is used as nose drops to treat sinusitis and colds. In Gabon a bark decoction of *Croton mayumbensis* or *Croton oligandrus* Pierre ex Hutch. is drunk to treat colic. Bark powder is sniffed to treat nasal tumours and it is externally applied to treat scabies. The wood of *Croton oligandrus* is used in carpentry. In Gabon the stem bark of *Croton tchibangensis* Pellegr. is commonly used as a fish poison.

Ecology *Croton haumanianus* occurs in secondary forest and regrowth of lowland rainforest, up to 1000(–1200) m altitude.

Genetic resources and breeding *Croton haumanianus* is very common in its distribution area and not likely to be threatened by genetic erosion.

Prospects *Croton haumanianus* has many local medicinal uses. It is poisonous and should be used with caution. Despite the many uses, not much pharmacological research has been undertaken on this species.

Major references Adjanohoun et al. (Editors), 1988; Bouquet, 1969; Léonard, 1962; Neuwinger, 2000.

Other references Raponda-Walker & Sillans, 1961; Tchissambou et al., 1990; Terashima & Ichikawa, 2003.

Authors G.H. Schmelzer

CROTON JATROPHOIDES Pax

Protologue Bot. Jahrb. Syst. 43: 79 (1909).

Family Euphorbiaceae

Vernacular names Msinduzi (Sw).

Origin and geographic distribution *Croton jatrophoides* occurs in the Central African Republic, south-eastern Kenya and Tanzania.

Uses In Tanzania a strongly scented root extract is taken to treat colds and stomachache. The Washambaa people take a fruit extract to treat intestinal worms. The wood is used for firewood, and to make beehives, water containers and knife sheaths. The leaves are used as fodder. *Croton jatrophoides* is also used as a shade tree.

Properties Nine limonoids (tetranortriterpenoids) were isolated from a methanol extract of the root bark: dumsin, zumsin, dumnin, dumsenin, zumketol, zumsenin, zumsenol, musidunin and musiduol. Most of these compounds, extracted from plants collected near Mombasa, Kenya, showed potent antifeedant activity against the larvae of pink bollworm (*Pectinophora gossypiella*) and fall armyworm (*Spodoptera frugiperda*). Zumsenin and zumsenol were not tested as they occur in very small quantities.

Botany Monoecious or dioecious small to medium-sized tree up to 18 m tall; young twigs stellate hairy, older twigs pinkish to greyish brown, almost glabrous. Leaves alternate, simple, turning orange before falling; stipules linear, up to 10 mm long, soon falling; petiole 3–7 cm long; blade broadly triangular-ovate, 5–15 cm × 3.5–12 cm, base cuneate to cordate, with 2 small subsessile basal glands beneath, apex acuminate, margins coarsely toothed to almost 5-lobed, densely stellate hairy on both sides, greyish green beneath, later almost glabrous. Inflorescence a slender, terminal raceme 8–19 cm long, either with only male flowers or with 3–4 female flowers at base. Flowers unisexual, 5-merous, regular, white; male flowers with pedicel 3–4 mm long, sepals elliptical-ovate, c. 2.5 mm long, stellate hairy, petals elliptical-lanceolate, 2.5–3 mm long, acute, stamens 14–15, free; female flowers with pedicel c. 2 mm long, fleshy, sepals lanceolate, c. 3 mm long, stellate hairy, petals absent, ovary superior, 2-lobed, densely stellate hairy, 2-celled, styles 2, 2-fid to base, c. 5 mm long, spreading-recurved. Fruit an ovoid, 2-lobed drupe c. 2.5 cm × 2 cm, indehiscent, stellate hairy, 2-seeded. Seeds ovoid, c. 2 cm × 1.5 cm, greyish brown mottled, slightly shiny.

Croton comprises about 1200 species and occurs throughout the warmer regions of the world. It is best represented in the Americas; about 65 species occur in continental Africa and about 125 in Madagascar.

Ecology *Croton jatrophoides* occurs in dry coastal forest, riverine forest, forest borders and clearings, up to 250 m altitude.

Genetic resources and breeding *Croton jatrophoides* is relatively rare and is included in the IUCN Red List of threatened species. Confirmation of the occurrence of the species

outside Tanzania is needed in order to assess its genetic diversity.

Prospects The roots of *Croton jatrophoides* are used against colds and stomach-ache. Several limonoids were isolated from the root bark, which exhibit significant antifeedant activity against larvae of insects, but no information is available concerning their pharmacological activity. As many limonoids are biologically active, more research on *Croton jatrophoides* is recommended.

Major references Kokwaro, 1993; Lovett et al., 2006; Nihei et al., 2006; Radcliffe-Smith, 1987.

Other references Lovett & Clarke, 1998a; Nihei et al., 2004; Nihei et al., 2005a.

Authors G.H. Schmelzer

CROTON LOBATUS L.

Protologue Sp. pl. 2: 1005 (1753).

Family Euphorbiaceae

Chromosome number $n = 9$

Vernacular names Lobed croton (En). Velame pó de galinha (Po).

Origin and geographic distribution *Croton lobatus* occurs in the Caribbean and South America, tropical Africa and the Arabian Peninsula. In Africa it is found from Senegal east to Eritrea and Ethiopia.

Uses Throughout West Africa a leaf decoction is drunk as a strong purgative. A leaf paste mixed with palm oil is applied to treat guinea worm sores, ulcers, skin diseases and headache. In Côte d'Ivoire and Togo leaf decoctions are used as an enema to treat gynaecological affections. Heated leaves are rubbed on to the skin to treat rheumatic and costal pain. An enema made from a root bark decoction is used as a purgative. A strong arrow poison is made by crushing the plant into a paste with a little water. In Togo leaf sap is used as eye drops to treat eye problems and unconsciousness. In Benin a decoction of the flowers or roots is taken as an antispasmodic in case of risk of abortion and of hiccup. The penis is washed with a maceration of the leafy twigs as an aphrodisiac. A leaf decoction with honey and palm oil is taken to treat stiff limbs. A leaf decoction is also taken to treat fever. In Nigeria the leaf sap is applied to lessen the pain of scorpion stings.

Properties From the stems and leaves of *Croton lobatus* the monocyclic terpene alcohol vomifoliol, the diterpene geranylgeraniol, the triglyceride lobaceride (characterized by unusual poly-unsaturated fatty acids), steroids (e.g. ergosterol), the triterpene betulinic acid and several other compounds were isolated. Betulinic acid is a potent HIV-1 antiviral compound, and inhibits the growth of *Plasmodium falciparum*, whereas geranylgeraniol induces apoptosis in leukaemia cell lines.
A methanolic root extract showed significant antiplasmodial activity, against strains that are sensitive to chloroquine as well as resistant ones.

Botany Monoecious branched, annual herb up to 1 m tall; taproot long; branches densely stellate hairy. Leaves alternate, lobed; stipules small, filiform; petiole up to 10 cm long; blade deeply 3–5-lobed, in outline 2.5–10 cm in diameter, lobes oblanceolate to obovate, basal glands absent, apex acuminate, margins toothed, stellate hairy to almost glabrous on both sides. Inflorescence a slender, axillary or terminal raceme up to 12.5 cm long, with small male flowers in upper half and female flowers in lower half. Flowers unisexual, 5-merous, regular, yellowish green; pedicel short; male flowers with elliptical sepals c. 2 mm long, petals oblanceolate, c. 2 mm long, stamens 10–13, free; female flowers with linear-lanceolate se-



Croton lobatus – flowering branch.
Source: Flore analytique du Bénin

pals c. 5 mm long, petals represented by a hair c. 1.5 mm long, ovary superior, rounded, densely hairy, 3-celled, styles 3, deeply 2-fid, lobes linear. Fruit an almost globular capsule c. 7 mm in diameter, stellate hairy, green, 3-seeded. Seeds ellipsoid, c. 6 mm × 3 mm, covered with wart-like protuberances. Seedling with epigeal germination.

Croton comprises about 1200 species and occurs throughout the warmer regions of the world. It is best represented in the Americas; about 65 species occur in continental Africa and about 125 in Madagascar. *Croton lobatus* is a host of nematodes (*Meloidogyne* spp.), of fungi causing powdery mildew, and of cucumber mosaic virus (CMV).

Ecology *Croton lobatus* occurs in open sandy localities, often on river banks, along road sides and on waste land. It is a weed of cultivation.

Management As a weed, *Croton lobatus* is often invasive and difficult to eradicate from arable land because of its strong taproot and lateral roots. However, effective control with herbicides is possible.

Genetic resources and breeding As *Croton lobatus* is common and often even weedy throughout its distribution area, there is no risk of genetic erosion.

Prospects *Croton lobatus* has several interesting local medicinal applications. It is very poisonous, so due care should be taken when using it. Several potentially active compounds have been identified, but information concerning the pharmacology is lacking, except for an encouraging result concerning its antimalarial activity. More research is therefore needed.

Major references Burkill, 1994; Chabert, Attioua & Brouillard, 2006; Lagnika, 2005; Neuwinger, 2000; Weniger et al., 2004.

Other references Adjanohoun et al., 1989; Brown, Hutchinson & Prain, 1909–1913; Keay, 1958a; Neuwinger, 1996; Stäuble, 1986.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors G.H. Schmelzer

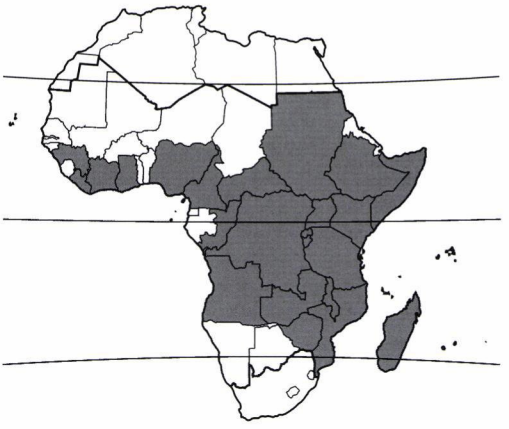
CROTON MACROSTACHYUS Hochst. ex Delile

Protologue Voy. Abyssinie 3: 158 (1847).

Family Euphorbiaceae

Vernacular names Woodland croton, forest fever tree, broad-leaved croton (En). Croton à feuilles larges (Fr). Mtumbatu (Sw).

Origin and geographic distribution *Croton macrostachyus* occurs throughout tropical Africa, including Madagascar.



Croton macrostachyus – wild

Uses Throughout its distribution area a decoction, infusion or maceration of leaves, stem bark or root bark are taken as a purgative and vermifuge. Leaf sap is used similarly. The seed oil is a very powerful purgative.

In West Africa different plant parts in decoction are taken to treat constipation, stomachache and female infertility, and are used externally to treat stitch-like pain in the side and guinea-worm sores. In Ethiopia *Croton macrostachyus* has many uses. A leaf extract is applied against itchy scalp. A decoction of the leafy twigs mixed with *Justicia schimperiana* (Hochst. ex Nees) T.Anderson is taken to treat jaundice and smallpox. The preparation is taken with pepper, butter and milk. An infusion of the leafy branches and roots is used as a mouthwash to treat toothache. The leaves or young shoots are eaten to treat fever and oedema and mashed leaves are applied to haemorrhoids. A preparation of the seed is instilled into the ear to treat ear problems. The seeds are poisonous and are used to make fish poison, while crushed seed and leaves in water are taken to treat tapeworm infection; the seed is eaten to induce abortion and a fruit, bark or root decoction or raw fruit is taken to treat venereal diseases. A bark maceration is drunk as an abortifacient and uterotonic, to expel a retained placenta. These treatments are all considered dangerous. The root or stem bark is chewed to treat toothache, but also rabies. Ripe crushed fruits mixed with butter or honey and ground leaves are applied to skin diseases. In Kenya the Luhya people lick the ash of burnt

leaves as a cough remedy. A leaf decoction is also taken to treat cough and stomach problems. A root decoction is taken to treat indigestion. The Kikuyu people take a root decoction to treat malaria; leaf juice is put on wounds to improve blood clotting, and also to treat sores, warts and ringworm. In Kenya and Tanzania a root infusion is taken to treat intestinal parasites. A decoction of the stem and root bark is used for bathing babies with skin rash. A bark infusion is taken to treat chest problems and rheumatism. Leaves made into a poultice are externally applied to treat pleurisy. A powder of leaves and twig bark is eaten to calm insanity and possession.

In Kenya *Croton macrostachyus* is commonly planted as a shade tree in villages and in coffee plantations. The wood is used in eastern and southern Africa to make tool handles, small stools, boxes, crates and plywood, as flooring and building material and in carpentry. The wood is used as fuel that burns even when green, but with a rather unpleasant spicy odour and much smoke; it is also used to make charcoal. Due to its drought hardiness and fast growth, *Croton macrostachyus* is considered useful for afforestation of shifting sand dunes, degraded waste land, hill slopes, ravines and lateritic soils. It is also grown as a hedge plant and is suitable for intercropping. In India it has been grown successfully with *Azadirachta indica* A.Juss. in shelter belts. In Uganda sheep and goats do not browse young leaves, but old leaves are readily eaten. In Sudan the leaves are burnt to make vegetable salt. In Ethiopia the leaves are used as green manure and fodder. The fruits are very popular with birds and could be used as poultry feed. The flowers are heavily scented and give a dark-amber coloured honey with strong flavour. *Croton macrostachyus* is widely used in rituals.

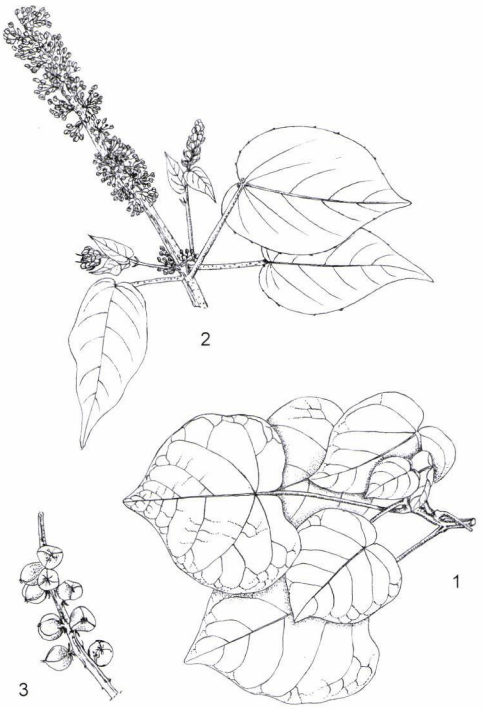
Properties The seeds contain about 19% oil, which is a slightly viscous, yellow-orange fluid and slightly vesicant. The seeds also contain several saponins and a resin, which is said to be more toxic to insects than rotenone. The plant also contains the chalcone crotin. The stem bark and twigs contain lupeol, betulin and several fatty acids. The fruits contain crotepoxide, a cyclohexane diepoxide, which inhibits certain tumours in animal models. Crotepoxide also shows moderate trypanocidal activity against *Trypanosoma brucei* and *Trypanosoma evansii*. Protein fractions from the leaves induced mitogenesis both in human and mouse isolated T cells.

Aqueous and alcoholic stem bark extracts are toxic when injected intraperitoneally in mice. However, after autopsy no marked pathological changes were recorded. The extracts showed taenicidal activity in volunteers with tapeworm infection. A hexane extract of the leaves showed antibacterial activity against *Bacillus subtilis*, *Micrococcus luteus* and *Staphylococcus aureus* in vitro. Root and stem bark extracts showed low antibacterial activities. An aqueous root extract showed toxicity in the brine shrimp lethality test. The crude ground seeds showed high molluscicidal activity in vitro.

In a field experiment in Ethiopia the decomposition rate of the leaves of *Croton macrostachyus* was found to be 3 times higher than those of *Millettia ferruginea* (Hochst.) Baker. The decomposition rate of naturally shed leaves was only marginally slower than the rate of leaves harvested green. In another field trial in Ethiopia on the effect of combined inputs of green manure and urea (both at a rate of 100 kg N/ha) on maize productivity, no consistent short-term advantage of a combination of *Croton macrostachyus* green manure and urea over pure urea was found.

The wood density is about 540 kg/m^3 at 12% moisture content. The wood is moderately soft, perishable and susceptible to attack by wood borers. The wood is difficult to saw. In tests, sulphate pulping gave a pulp of moderate strength; the wood can be used to make writing paper or newsprint paper after bleaching, but it is unsuitable for the production of wrapping paper.

Description Monoecious or dioecious, deciduous, medium-sized tree up to 25(–30) m tall; bole cylindrical, up to 100 cm in diameter; bark grey to grey-brown, finely fissured and cracked, inner bark pale brown to reddish brown, smell peppery; crown rounded and open with large, spreading branches; young branches densely stellate hairy. Leaves alternate, simple, turning orange before falling; stipules linear, up to 15 mm long, soon falling; petiole up to 12(–20) cm long, with 2 stalked glands at top; blade ovate-elliptical to almost circular, up to 17(–25) cm × 14(–20) cm, base cordate, apex acuminate, margins irregularly toothed, densely stellate hairy on both sides, whitish green beneath. Inflorescence a slender, terminal raceme up to 35 cm long, either with only male or female flowers or male and female flowers variably mixed. Flowers unisexual, 5-merous, regular, yellowish to white, fragrant; male flowers with pedicel 3–10 mm long, calyx



Croton macrostachyus – 1, leafy twig; 2, inflorescence; 3, infructescence.
Redrawn and adapted by Iskak Syamsudin

campanulate, lobes ovate to triangular, 2.5–3.5 mm long, margins densely white hairy, petals oblong to oblanceolate, 3–4.5 mm long, stamens 15–17, free; female flowers with pedicel 2–4 mm long, fleshy, calyx as in male flowers but lobes more triangular, persistent in fruit, petals linear or absent, up to 1.5 mm long, ovary superior, rounded, densely stellate hairy, 3-celled, styles 3, 2-fid to base, 3–6 mm long, twisted and curved. Fruit an almost globular capsule 8–12 mm in diameter, slightly 3-lobed, stellate hairy, apex centrally depressed, whitish to pale greyish brown, 3-seeded. Seeds ellipsoid, 6–8 mm × 4–5.5 mm, flattened, caruncle lobed, cream-coloured. Seedling with epigeal germination.

Other botanical information *Croton* comprises about 1200 species and occurs throughout the warmer regions of the world. It is best represented in the Americas; about 65 species occur in continental Africa and about 125 in Madagascar. Mature fruits of *Croton macrostachyus* split open with a sharp noise.

Growth and development In dry regions of West Africa flowering starts at the beginning of the rainy season. In Nigeria flowering occurs in March–May. In Kenya flowering occurs almost throughout the year with peaks in March–June in western Kenya and May–June in central Kenya. Fruit development takes 4–5 months. Pollination is done by insects. The maximum growth rate is about 1.5 m/year.

Ecology *Croton macrostachyus* commonly grows in secondary forests, especially on forest edges and along rivers or lakes, in moist or dry evergreen upland forest, woodland, wooded grassland, bushland and along roadsides, often on soils of volcanic origin, at 200–2500(–3400) m altitude. The mean annual rainfall varies from 150 to 1200 mm.

Propagation and planting *Croton macrostachyus* is propagated by seed or wildlings. Direct seeding is preferred, and pre-sowing treatment is not necessary. The number of seeds per kg is 16,000–27,000. The seeds are sown in a mixture of sand and compost (1:2), covered lightly with fine compost and kept moist. They take 3–8 weeks to germinate. Under ideal conditions, 40–70% of the seeds germinate in 4 weeks. If planted in a nursery, transplanting should be done at the 2-leaf stage. The seeds retain their viability for several months if kept dry and free from insects at a maximum of 20°C, and for at least 2 years when dried below 8% humidity.

Management *Croton macrostachyus* can be lopped, pollarded or coppiced. It grows well both in shade and bright sunlight; it is vulnerable though to cold wind and frost, especially young plants, which should be protected during the first two years. *Croton macrostachyus* has a long taproot and numerous side-roots, which makes it adapted to dry climates.

Diseases and pests In Ethiopia the leaves of *Croton macrostachyus* are attacked by a leaf spot caused by the fungus *Cylindrosporium* sp. The seeds are often damaged by insects while still on the tree.

Handling after harvest Fruits are sun-dried to release the seeds.

Genetic resources Although *Croton macrostachyus* occurs scattered and localized throughout its large distribution area, it is not threatened by genetic erosion.

Prospects *Croton macrostachyus* is an important medicinal plant especially in East Africa. It is widely used as a purgative and vermifuge, but also to treat venereal diseases and to induce abortion. All parts, but especially the seeds, are considered toxic, and any medicine

made from them should be used with caution. Despite the many medicinal uses, not much research has been done concerning the chemical composition and pharmacology of the different plant parts and more research is warranted. *Croton macrostachyus* has several other important uses, e.g. to control soil erosion, as a shade tree and for its green manure and fodder, which deserve additional tests in the field.

Major references Adda-Mensah et al., 1992; Bekele-Tesemma, Birnie & Tengnäs, 1993; Burkill, 1994; Desta, 1995; Gindaba, Rozanov & Negash, 2005a; Matu & van Staden, 2003; Maundu & Tengnäs, 2005; Neuwinger, 2000; World Agroforestry Centre, undated.

Other references Arbonnier, 2002; Beentje, 1994; Berhan, Asfaw & Kelbessa, 2006; Giday et al., 2003; Giday et al., 2007; Gindaba, Olsson & Itanna, 2004; Gindaba, Rozanov & Negash, 2005b; Jansen, 1981; Kokwaro, 1993; Moshi et al., 2004; Njoroge & Bussman, 2007; Oliver-Bever, 1986; Tachibana et al., 1993; Teklay, Nyberg & Malmer, 2006; Venter & Venter, 1996.

Sources of illustration Maundu & Tengnäs, 2005.

Authors F.S. Mairura

CROTON MAURITIANUS Lam.

Protologue Encycl. 2: 205 (1786).

Family Euphorbiaceae

Vernacular names Ti bois de senteur (Fr).

Origin and geographic distribution *Croton mauritianus* is endemic to Réunion, and possibly also occurs on Mauritius.

Uses A decoction of the chopped leaves is taken to treat fever and to improve the memory.

Properties The aerial parts tested positive for alkaloids. A methanol extract of the leaves and of the stem had considerable free radical scavenging activity.

Botany Monoecious shrub or small tree up to 5 m tall; stem up to 20 cm in diameter; young twigs with short stellate hairs. Leaves in whorls, simple, strongly scented; stipules small; petiole 2–5 cm long; blade ovate, 6–15 cm × 3–9 cm, base cordate, with 2 small, sessile glands, apex acute, margins variously toothed, soft-hairy on both sides. Inflorescence a terminal raceme 3–12 cm long, with up to 25 male flowers at end and 2–3 female flowers at base. Flowers unisexual, regular, 5-merous, white; male flowers with pedicel up to 15 mm long, sepals triangular, 2–3 mm long, with stellate hairs, petals oblong-obovate, c. 5 mm long, stamens 45–60, free, 4–5 mm long; female flowers with pedicel 18–20 mm long, sepals fused to half their length, c. 5 mm long, petals oblong-obovate, 3–6 mm × 1–2 mm, recurved between the sepals, with long hairs on margins, staminodes c. 3 mm long if present, ovary superior, rounded, 3-lobed, silky hairy, 3-celled, styles 3, several times 2-fid. Fruit an oblong to ovoid, 3-lobed capsule 6–8 mm long, with stellate hairs, 3-seeded. Seeds ovoid, pale brown to black.

Croton comprises about 1200 species and occurs throughout the warmer regions of the world. It is best represented in the Americas; in continental Africa about 65 species occur and in Madagascar about 125. Réunion has 1 endemic species and Mauritius about 4.

Ecology *Croton mauritianus* occurs in semi-dry forest and steep hill sides at low altitudes.

Management *Croton mauritianus* can be propagated by stem cuttings.

Genetic resources and breeding *Croton mauritianus* is commonly used as an ingredient of medicinal preparations, and is therefore becoming rare in the wild. It has a protected status in Réunion.

Prospects *Croton mauritianus* has several interesting medicinal uses, which are partly confirmed by pharmacological tests. More research is warranted to evaluate the real potential of the species. More efforts are needed to domesticate *Croton mauritianus* and protect it from extinction.

Major references Govaerts, Frodin & Radcliffe-Smith, 2000; Lavergne, 2001; Poullain, 2004; Poullain, Girard-Valenciennes & Smadja, 2004.

Other references Coode, 1982; Mauremootoo, 2003.

Authors G.H. Schmelzer

CROTON MEMBRANACEUS Müll.Arg.

Protologue Flora 47: 534 (1864).

Family Euphorbiaceae

Origin and geographic distribution *Croton membranaceus* occurs in Côte d'Ivoire, Ghana and Nigeria.

Uses In Ghana a root extract is taken to treat urinary retention caused by an enlarged prostate. It is also taken to treat measles.

Properties The root bark contains sco-

poletin and julocrotine, a glutarimide alkaloid. It also contains calcium oxalate crystals.

Botany Monoecious herb or undershrub up to 1(–2) m tall; branches slender, densely stellate hairy. Leaves opposite or alternate, when opposite the two very unequal in size, simple and entire; stipules tiny; petiole 2–6 mm long; blade ovate, 3–7.5 cm × 2–5 cm, base rounded, basal glands absent, apex acuminate, sparsely stellate hairy above, densely stellate hairy beneath. Inflorescence an axillary or terminal raceme c. 5 cm long, few-flowered, with male flowers at end and female flowers at base. Flowers unisexual, 5-merous, regular, white; pedicel short; male flowers with elliptical sepals and obovate petals c. 2 mm long, margin woolly hairy, stamens 10, free; female flowers with narrowly lanceolate sepals c. 4 mm long, petals rudimentary or absent, ovary superior, rounded, densely hairy, 3-celled, styles 3, apex 2-fid. Fruit an ellipsoid, slightly 3-lobed capsule c. 5 mm in diameter, 3-seeded.

Croton comprises about 1200 species and occurs throughout the warmer regions of the world. It is best represented in the Americas; about 65 species occur in continental Africa and about 125 in Madagascar. Another medicinally used *Croton* with a restricted distribution in West Africa is *Croton eluteria* (L.) W.Wright ('cascarilla'), which originates from the Caribbean and northern South America. It was introduced into Nigeria in the 19th century for its use as a tonic and aromatic bitter, which improves digestion. The essential oil of the bark is used in aromatherapy to treat cough, fever, flatulence, nausea and diarrhoea. In the Bahamas the leaves are used to aromatize tobacco. The active compounds of the bark are neoclerodane diterpenoids, such as cascarillins A–I and cascallin.

Ecology *Croton membranaceus* occurs in moist bush vegetation and savanna, at low altitudes.

Genetic resources and breeding *Croton membranaceus* has a limited area of distribution and it is apparently uncommon. It is grown in Aburi Botanic Gardens, Ghana.

Prospects Some preliminary tests on the activity of *Croton membranaceus* root extract have been undertaken, but more chemical and pharmacological research needs to be done to evaluate its potential. Measures should be taken to monitor the presence of this apparently uncommon species.

Major references Antwi, 1994; Atakora, 2004; Brown, Hutchinson & Prain, 1909–1913; Keay, 1958a.

Other references Aboagye et al., 2000; Hawthorne & Jongkind, 2006; Lambert et al., 2005; Vigor et al., 2002.

Authors G.H. Schmelzer

CROTON MENYHARTHII Pax

Protologue Bull. Herb. Boiss. 6: 733 (1898).

Family Euphorbiaceae

Origin and geographic distribution *Croton menyharthii* occurs from southern Ethiopia and Somalia south throughout East and southern Africa south to Natal (South Africa).

Uses In Somalia a decoction of fresh or dried roots is taken to treat dysmenorrhoea. Fresh or dried crushed leaves in water are drunk to treat hepatitis and tapeworm. Crushed root bark in water is taken to treat intestinal obstruction. In East Africa a root decoction is taken to treat influenza and malaria. In Kenya the Pokomo people inhale the smoke of burnt leaves to ease pregnancy and menstruation pains.

Properties A methanol extract of the leaves or twigs showed significant antiplasmodial activity in vitro, while a water extract was inactive.

Botany Monoecious, much-branched shrub up to 5 m tall; young twigs densely covered with yellowish scales, older twigs pale greyish brown. Leaves alternate, simple and entire; stipules tiny, soon falling; petiole 2–5(–9) mm long; blade elliptical-ovate to ovate-lanceolate, 2.5–7(–11) cm × 1–3(–4.5) cm, base rounded to shallowly cordate, with 2 minute basal glands, apex obtuse to notched, thinly stellate hairy and yellowish above, covered with shiny silvery to cream-coloured scales below. Inflorescence a slender terminal raceme up to 3(–5) cm long at the end of side-shoots, covered with yellowish scales, mostly with male flowers in upper part and 1–4 female flowers at base. Flowers unisexual, 5-merous, regular, pale yellow-green; male flowers with pedicel 2–5 mm long, sepals ovate, c. 2 mm long, petals linear-oblong to linear-oblanceolate, c. 2 mm long, margin ciliate, stamens 12–15, free; female flowers with pedicel 2–3 mm long, extending to 4 mm in fruit, calyx lobes ovate, c. 2 mm long, petals absent, ovary superior, rounded, densely scaly and stellate hairy, yellowish brown, brown or black, 3-celled, styles 3–4, deeply 2-fid, c. 2.5 mm long, spreading or incurved. Fruit a 3-lobed capsule 6–7 mm × 7–9 mm, covered with

yellowish scales, black-spotted, 3-seeded. Seeds ellipsoid to ovoid, c. 6 mm × 4 mm, brown or greyish, shiny.

Croton comprises about 1200 species and occurs throughout the warmer regions of the world. It is best represented in the Americas; about 65 species occur in continental Africa and about 125 in Madagascar. Several other medicinally used species of *Croton* occur in East Africa. *Croton polytrichus* Pax is a lax shrub or small tree occurring from Sudan south to Zambia. In East Africa an extract of its roots is taken to treat headache and labour pain. Root powder, alone or mixed with that of *Croton dichogamus* Pax, is mixed with porridge or tea to treat impotence and colds. A root decoction is taken to treat irregular menstruation. *Croton scheffleri* Pax is a shrub or small tree occurring from Kenya to Zambia. In northern Kenya its roots are soaked in water and the water is taken to treat malaria and fever. *Croton somalensis* Pax occurs in Ethiopia, Somalia and northern Kenya. In Kenya the Maasai people drink a decoction of its roots to treat fever and malaria. The wood is used in house construction. *Croton steenkampianus* Gerstner (Tonga croton) occurs in Tanzania, southern Mozambique and South Africa. The Zulu people inhale the vapour of a decoction of its fresh leaves to treat general body pain. Extracts have shown antimalarial activity. *Croton talaeporos* Radcl.-Sm. occurs in southern Somalia and Kenya. In southern Kenya a root infusion is taken as a remedy for colds and stomach complaints.

Ecology *Croton menyharthii* occurs in deciduous bushland, dune bushland and thickets, from sea-level up to 1300 m altitude.

Genetic resources and breeding There are no signs that *Croton menyharthii* is threatened by genetic erosion.

Prospects *Croton menyharthii* has several local medicinal uses, e.g. against menstrual pain, malaria and tapeworm, but nothing is known about the compounds that might be responsible for these actions. The leaves and twigs show significant antiplasmodial activity. More research is warranted to evaluate the potential of the species.

Major references Beentje, 1994; Clarkson et al., 2004; Radcliffe-Smith, 1987; Samuelsson et al., 1992.

Other references Hedberg et al., 1983a; Kokwaro, 1993; Neuwinger, 2000.

Authors G.H. Schmelzer

CROTON MUBANGO Müll.Arg.

Protologue Journ. Bot. 2: 338 (1864).

Family Euphorbiaceae

Vernacular names Mubango (Po).

Origin and geographic distribution *Croton mubango* is known from the Central African Republic, Gabon, DR Congo and Angola.

Uses In DR Congo the bark pulp is rubbed onto the gums and teeth to treat toothache, and is also applied to haemorrhoids, hernia, skin eruptions and pain in the joints. The body is rubbed with a bark maceration as a tonic. A bark decoction is taken to treat gastritis and painful periods. The bark, together with the seeds of *Monodora myristica* (Gaertn.) Dunal, is eaten to treat abdominal pain and expel intestinal worms. Powdered root or a root maceration is taken to treat diarrhoea and dysentery. The leaves are eaten to ease pain, and a leaf infusion is used as a body wash to treat fever. A stem bark decoction is also taken to treat abdominal pain and fever. In the Equator province of DR Congo a decoction of crushed stem bark is taken to treat an enlarged spleen and tuberculosis. Powdered bark in palm wine is taken to treat oedema. Young fruits soaked in palm wine are taken as a laxative.

The bark of young twigs is used as a condiment. In DR Congo *Croton mubango* is planted as a shade tree in villages. The scented flowers are very attractive to bees. Edible caterpillars (*Lobobunaea phaedusa*) feed on the leaves. The resin from the trunk is used to trap birds.

Properties Preliminary screening showed the presence of flavonoids, sterols, triterpenes, saponins and reducing sugars. Stem bark extracts showed weak antibacterial and antiamoebic activities in vitro.

Methanolic, dichloromethane and aqueous stem bark extracts showed antiplasmodial activity against *Plasmodium falciparum* in vitro. At a daily oral dose of 200 mg/kg, the dichloromethane extract, the petroleum-ether, chloroform, ethyl-acetate and residual water-soluble fractions showed antiplasmodial activity against *Plasmodium berghei* in mice. The aqueous extract of the stem bark showed relatively low toxicity in mice. It significantly increased the serum concentrations of glutamate-oxaloacetate transaminase and glutamate-pyruvate transaminase in mice. In-vitro antibacterial screening of the stem bark extract showed no activity against enteropathogens.

The wood is hard and white.

Botany Monoecious shrub to medium-sized

tree up to 17 m tall; bole up to 30 cm in diameter; branches spreading, twigs drooping, densely covered with scaly and stellate hairs. Leaves alternate, simple and entire; stipules 4–5-partite, segments linear, 4–12 mm long, persistent; petiole 2–10 cm long; blade elliptical to ovate, 4–16.5 cm × 2–9 cm, base cordate to rounded, with 2 large basal glands, apex acuminate, thinly stellate hairy above, scaly and grey below. Inflorescence a slender, terminal raceme 7.5–20 cm long, covered with scales, mostly with male flowers in upper part and 1–4 female flowers at base. Flowers unisexual, 5-merous, regular, white; pedicel (2–)5–12 mm long; sepals triangular, 4–5 mm long; petals ovate-elliptical, 3.5–5 mm long, hairy on both sides; male flowers with 22–37 stamens, free; female flowers with superior, depressed-globose ovary, densely scaly hairy, 3-celled, styles 3, 3–4 times 2-fid, spreading. Fruit a rounded capsule 18–23 mm in diameter, covered with scales, 3-seeded. Seeds ellipsoid, 13–15 mm × 9–12 mm, brownish. Seedling with epigeal germination.

Croton mubango flowers from July to September.

Croton comprises about 1200 species and occurs throughout the warmer regions of the world. It is best represented in the Americas; about 65 species occur in continental Africa and about 125 in Madagascar.

Ecology *Croton mubango* occurs in margins of dense forest, secondary forest and tree savanna.

Genetic resources and breeding *Croton mubango* occurs in disturbed forest and savanna and is probably not uncommon. Currently it is not threatened by genetic erosion.

Prospects *Croton mubango* is used to treat a wide variety of diseases, especially in DR Congo. Although the antiplasmodial activities of the stem bark are promising, not much is known about the compounds responsible for this action. Additional research is warranted.

Major references Latham, 2005; Léonard, 1962; Longanga-Otshudi, Vercruysse & Foriers, 2000; Mesia et al., 2005; Neuwinger, 2000.

Other references Brown, Hutchinson & Prain, 1909–1913; Kasuku et al., 1999.

Authors G.H. Schmelzer

CROTON MYRIASTER Baker

Protologue Journ. Bot. 20: 268 (1882).

Family Euphorbiaceae

Origin and geographic distribution *Croton myriaster* is endemic to central Madagascar.

Uses A decoction of the aerial parts is administered to children with epileptic attacks, and used as an inhalation to treat headache. The wood is used as firewood.

Properties The bark contains traces of alkaloids, but none have been detected in the leaves.

Botany Monoecious shrub or small tree up to 10 m tall; stem up to 20 cm in diameter; young twigs with short stellate hairs. Leaves alternate, simple, strongly scented; stipules small; petiole 1.5–2.5 cm long; blade ovate-lanceolate, 8–15 cm × 2.5–5.5 cm, base rounded, with 2 small, brown, sessile glands, apex acuminate, margins toothed, short-hairy, lower surface whitish. Inflorescence a terminal or axillary raceme, with male flowers at end and 2–3 female flowers at base. Flowers unisexual, regular, 5-merous, white to pale green or pale yellow; sepals small, brownish hairy, petals tiny; male flowers with short pedicel, stamens 12–16, free; female flower with pedicel enlarging in fruit to c. 2 cm long, ovary superior, 3-lobed, with pale brown hairs, 3-celled, styles 3, several times 2-fid at apex. Fruit a 3-lobed capsule c. 12 mm × 10 mm, hard, with glandular hairs, reddish brown, 3-seeded. Seeds ovoid, c. 7 mm long, grooved.

Croton comprises about 1200 species and occurs throughout the warmer regions of the world. It is best represented in the Americas; in continental Africa about 65 species occur and in Madagascar about 125. Almost 40 species from Madagascar are used in medicine, and several of them are morphologically close to *Croton myriaster*. Mattresses are filled with the strong smelling branches of *Croton meridionalis* Leandri, *Croton salviformis* Baill. and *Croton tranomarensis* Leandri to act as an insect repellent. The powder of the aerial parts of *Croton meridionalis* is added to bait as rat poison. A leaf infusion of *Croton bemaranus* Leandri is taken as a digestive. A leaf decoction of *Croton goudotii* Baill. is inhaled to treat malaria; a bark decoction is taken to treat chronic gonorrhoea. The latter is also used as a vapour bath and wash, and is taken orally to calm pain.

Ecology *Croton myriaster* occurs along humid forest margins, at 900–2200 m altitude.

Genetic resources and breeding There are no reports that *Croton myriaster* is threatened by genetic erosion.

Prospects Unless additional research reveals otherwise, *Croton myriaster* will remain of local importance only as a medicinal plant.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Govaerts, Frodin & Radcliffe-Smith, 2000; Leandri, 1939.

Other references Missouri Botanical Garden, undated; Rasoanaivo, Petitjean & Conan, 1993; Rasoanaivo et al., 1992.

Authors G.H. Schmelzer

CROTON NITIDULUS Baker

Protologue Journ. Linn. Soc., Bot. 20: 253 (1883).

Family Euphorbiaceae

Origin and geographic distribution *Croton nitidulus* is endemic to central and eastern Madagascar.

Uses The bitter stem bark is taken to treat malaria and cough. The aromatic leafy branches are used as an insect repellent in mattress fillings, especially against lice. The leafy branches are also used to make a steam bath to clear the nose. The wood is used as firewood.

Properties The aerial parts contain alkaloids.

Botany Monoecious shrub or small tree up to 9 m tall, dichotomously branched; all parts with brown stellate hairs. Leaves almost opposite to alternate, simple, aromatic; stipules absent; petiole 1.5–2.5 cm long; blade lanceolate, 7–8 cm × 3–3.5 cm, base rounded, with 2 small, sessile glands, apex acute to acuminate, margins toothed, almost glabrous above, whitish hairy below. Inflorescence a terminal fascicle, with male flowers at end and 2–3 female flowers at base. Flowers unisexual, regular, 5-merous, white to pale yellow; male flowers with short pedicel, sepals whitish green, stamens 13–16, free; female flowers with pedicel enlarging in fruit to c. 2 cm long, sepals enlarging in fruit, petals tiny, linear, ovary superior, 3-lobed, with reddish scales, 3-celled, styles 3, several times 2-fid at apex, orange. Fruit a 3-lobed capsule, brown hairy, 3-seeded.

Croton comprises about 1200 species and occurs throughout the warmer regions of the world. It is best represented in the Americas; in continental Africa about 65 species occur and in Madagascar about 125. Almost 40 species from Madagascar are used in medicine, and several of them are morphologically close to *Croton nitidulus*. The aerial parts of *Croton hovarum* Leandri, cooked with chicken bones, are used to treat colic and acute weakness of the body. The leaves are toxic, and infusions of this plant are known to cause coronary vasoconstriction. A methanol extract of the leaves contained several clerodane-type furanoditerpenes. A decoction of the bitter stem bark of *Croton mocquerysii* A.DC. is taken to treat malaria. A leafy twig infusion of *Croton macrobuxus* Baill. (synonym: *Croton sambiranensis* Leandri) is taken to treat asthma attacks. The aerial parts contain several steroids and triterpenes, but few alkaloids.

Ecology *Croton nitidulus* occurs near small streams and along forest edges, at (20–)300–2200 m altitude.

Genetic resources and breeding *Croton nitidulus* is relatively common in its distribution area and there are no signs that it is threatened by genetic erosion.

Prospects *Croton nitidulus* will probably remain of local importance as a medicinal plant.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Govaerts, Frodin & Radcliffe-Smith, 2000; Leandri, 1939.

Other references Coode, 1982; Krebs & Ramiarantsoa, 1997; Missouri Botanical Garden, undated; Rasoanaivo et al., 1999; Ratompomalala, 1983.

Authors G.H. Schmelzer

CROTON PENDULIFLORUS Hutch.

Protologue Bull. Misc. Inform. Kew 1914(9): 337 (1914).

Family Euphorbiaceae

Origin and geographic distribution *Croton penduliflorus* occurs from Sierra Leone east to Nigeria and also in the Central African Republic and Gabon.

Uses In Côte d'Ivoire a leaf infusion is taken to treat menstrual disorders. In Ghana a leaf infusion is externally applied to treat fever. In Nigeria a seed extract is taken to treat stomach complaints and uterine tumours and as an abortifacient. The seeds, mashed with cassava, are eaten as a purgative.

The yellow wood is used to make rafters.

Production and international trade In Nigeria the seeds are sold in the local markets. Also in Nigeria, a herbal laxative is made from

the seeds of *Croton penduliformis* together with the leaves of *Senna alata* (L.) Roxb. In 2006, this product was sold at US$ 30 on the internet, packaged in 30-capsule plastic containers.

Properties The seed oil is purgative. It contains crystals composed of equal amounts of palmitic, stearic and arachidic acids. Penduliflaworosin, a furanoid diterpene, was isolated from the roots.

A petroleum ether extract of the seeds given orally to mice induced purgation and showed increased gastric emptying in rats. It also produced oedema in the stomach and mild inflammatory reactions in the intestines. In addition to its irritant effect, it produced pathological lesions in several organs after chronic oral administration. Mice showed convulsions, paralysis and death after a dose of the crude seed oil. A petroleum ether seed extract showed significant dose-dependent contractions in isolated guinea-pig ileum and rat uterus primarily through a cholinergic mechanism. It also caused 100% foetal mortality by abortion in mice and rabbits during late pregnancy as well as foetal resorption during early pregnancy.

Seed oil crystals administered orally to rats offered significant protection against gastric ulcers and duodenal ulcers at moderate doses. The crystals also significantly reduced pentobarbitone-induced sleeping time in mice, thus stimulating their central nervous system, and reduced the intensity of the analgesic action of several opioids while prolonging their duration. Crude seed oil caused a reduction of the blood pressure in dogs.

Botany Monoecious medium-sized tree up to 25 m tall; branches almost glabrous. Leaves alternate, simple; stipules tiny; petiole 2–5.5 cm long, glabrous; blade elliptical to ovate-elliptical, 6–14 cm × 3.5–8 cm, base rounded to cuneate, with 2 glands on 2–3 mm long stalk, apex shortly and abruptly acuminate, margins toothed, glabrous to sparsely short-hairy. Inflorescence an elongated terminal raceme 28–42 cm long, pendulous, with many male flowers interspersed with few female flowers. Flowers unisexual, 5-merous, regular, white; pedicel c. 4 mm long; male flowers with ovate sepals c. 1.5 mm long, stellate hairy, petals obovate, c. 2 mm long, upper margin woolly hairy, stamens 12, free; female flowers with oblong to lanceolate sepals c. 2 mm long, petals absent, ovary superior, rounded, densely hairy, 3-celled, styles 3, apex 2-fid. Fruit an ellipsoid, slightly 3-lobed capsule, pale green, hairy, 3-seeded.

Croton comprises about 1200 species and occurs throughout the warmer regions of the world. It is best represented in the Americas; about 65 species occur in continental Africa and about 125 in Madagascar. Another medicinally used West African *Croton* is *Croton nigritanus* Scott-Elliot; in Sierra Leone the crushed leaves are applied to sores.

Ecology *Croton penduliflorus* occurs in lowland forest, mostly in rocky or dry localities.

Genetic resources and breeding *Croton penduliflorus* is rather widespread but in many areas uncommon. However, there are no signs that it is threatened by genetic erosion.

Prospects *Croton penduliflorus* has several medicinal uses in West Africa, some of which have been confirmed by pharmacological research. When used as a purgative, the seed oil should be taken with caution because it has toxic side-effects. Further research on the seed oil is warranted.

Major references Asuzu, 2005; Asuzu & Chineme, 2006a; Asuzu & Chineme, 2006b; Keay, 1958a; Onunkwo, 2006.

Other references Asuzu & Chineme, 1989; Asuzu, Gray & Waterman, 1988; Asuzu, Shetty & Anika, 1989; Asuzu, Shetty & Anika, 1990; Burkill, 1994; Kayode, 1981; Tra Bi, Kouamé & Traoré, 2005.

Authors G.H. Schmelzer

CROTON SAKAMALIENSIS Leandri

Protologue Ann. Inst. Bot.-Géol. Colon. Marseille sér. 5, 7(1): 54 (1939).

Family Euphorbiaceae

Origin and geographic distribution *Croton sakamaliensis* occurs in central and southern Madagascar.

Uses An infusion of the stem bark of *Croton sakamaliensis* is taken to treat diarrhoea, cough and fever, and in larger amounts as a purgative to expel intestinal worms.

Properties The plants contain essential oil, which shows significant antibacterial activity against a range of human intestinal pathogens.

Botany Monoecious small shrub up to 1 m tall; stems covered with whitish scales. Leaves in whorls, simple, strongly scented; stipules small, soon falling; petiole c. 2 mm long; blade ovate to lanceolate, 1–1.5 cm × 0.5–1 cm, base rounded, with 2 small, yellow, sessile glands, apex rounded, stellate hairy above, beneath with whitish scales and small red glands. Inflorescence a compact, terminal raceme c. 1 cm

long with 4–5 male flowers at end and 2–3 female flowers at base. Flowers unisexual, 5-merous; male flowers with short pedicel, sepals ovate, acute, petals thin, ciliate, stamens 15, free; female flowers with short pedicel c. 2 mm long, sepals small, margin membranaceous, petals rudimentary, ovary superior, rounded, 3-lobed, yellowish hairy, 3-celled, styles 3, each deeply 2-fid. Fruit an ovoid 3-lobed capsule c. 4 mm long, scaly hairy, 3-seeded.

Croton comprises about 1200 species and occurs throughout the warmer regions of the world. It is best represented in the Americas; about 65 species occur in continental Africa and about 125 in Madagascar. Almost 40 species from Madagascar are used in medicine, and several of them resemble morphologically *Croton sakamaliensis*. A stem bark infusion of *Croton bernierus* Baill. and *Croton isomonensis* Leandri is taken to treat coughs. The aromatic leafy branches are used as mattress fillers to repel insects. A bark decoction of *Croton stanneum* Baill. is taken to treat venereal diseases. *Croton stanneum* is easy to propagate and sometimes planted in villages. The aromatic leafy branches of *Croton trichotomus* Geiseler are used in fumigation to chase insects in houses.

Ecology *Croton sakamaliensis* occurs on rocky soils in valleys at 500–800 m altitude.

Genetic resources and breeding There are no signs that *Croton sakamaliensis* is threatened by genetic erosion.

Prospects *Croton sakamaliensis* shows antibacterial activities, but more information is needed to evaluate its potential.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Govaerts, Frodin & Radcliffe-Smith, 2000; Leandri, 1939; Rasoanaivo, Petitjean & Conan, 1993.

Other references Missouri Botanical Garden, undated; Rakotoniraini, 2004.

Authors G.H. Schmelzer

CROTON SYLVATICUS Hochst. ex C.Krauss

Protologue Flora 28: 82 (1845).

Family Euphorbiaceae

Synonyms *Croton oxypetalus* Müll.Arg. (1864).

Vernacular names Forest croton, fever tree, forest fever berry (En). Msinduzi (Sw).

Origin and geographic distribution *Croton sylvaticus* occurs from Guinea east to Ethiopia and south to Zimbabwe, Mozambique and South Africa (Natal).



Croton sylvaticus – wild

Uses In Central and East Africa a leaf infusion is taken as a purgative, while in Gabon the seed and seed oil are taken as a strong purgative. A bark or root decoction is taken to treat tuberculosis, fever, digestive problems and abdominal pain. Charred, powdered bark is rubbed onto bleeding gums. In Kenya a stem bark extract is taken to treat malaria. In southern Africa a bark decoction is taken to treat rheumatism; bark powder is rubbed on cuts and inflammations. In South Africa the bark is used to treat abdominal disorders, dropsy, fever and uterus problems. The bark is also used as a fish poison. In cattle the powdered bark is used as a remedy for gall bladder problems. In DR Congo wood scrapings are rubbed on the feet to treat elephantiasis. The pounded roots are used as poultice on swellings. In East Africa a leaf decoction is used as a wash to treat oedema caused by kwashiorkor and tuberculosis. In South Africa the juice of young leaves is used to treat ear infections. A leaf poultice is externally applied to treat tuberculosis.

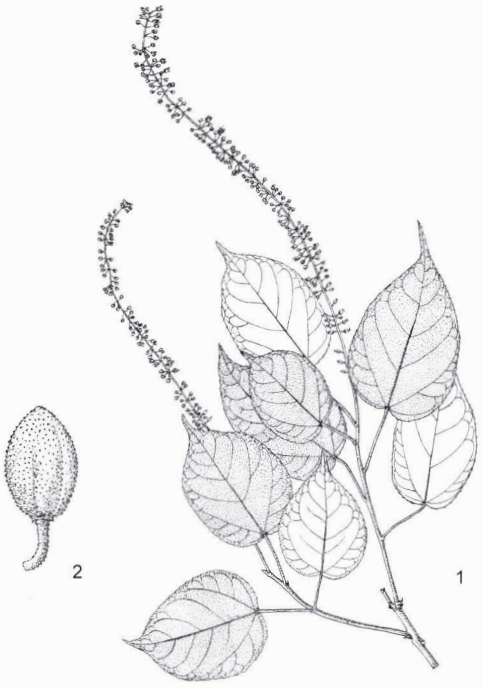
In Zimbabwe *Croton sylvaticus* is sometimes cultivated as a garden ornamental. In Central and East Africa it is used as shade tree in coffee plantations and other crops. Edible caterpillars feed on the leaves and the flowers are attractive to bees. It is a useful timber tree with soft, easily workable wood, which is used to make furniture, shelves, beehives, drums, tool handles, poles and fruit boxes. The wood burns even when green, and is also used to make charcoal.

Production and international trade The

bark is one of the most commonly stocked products in Witwatersrand (South Africa). No information is available on amounts traded or prices. In 2006, 5 seeds were sold for about US$ 11 on the internet.

Properties The seed contains an oil composed of palmitic acid, stearic acid and linoleic acid; it also contains the rare tiglic acid (2-methyl,2-butenoic acid or 2,3-dimethylacrylic acid). A glutarimide alkaloid isolated from the stem bark showed moderate toxicity in the brine shrimp test. The bark is strongly aromatic, and yields 2.7% tannins. Dichloromethane and methanol extracts of different parts of *Croton sylvaticus* show mutagenicity or DNA damage in in-vitro tests. Aqueous and methanol extracts of the stem bark showed anti-inflammatory and anti-oxidant activities in vitro.

Description Monoecious, semi-deciduous shrub or small to medium-sized tree up to 25(–40) m tall; bole cylindrical, up to 100 cm in diameter; bark smelling of black pepper, grey to greenish brown, smooth; inner bark pale brown with brown streaks; crown open; young twigs sparingly to densely stellate hairy, later almost glabrous and dark grey-brown. Leaves alternate, simple; stipules linear, up to 10 mm long, soon falling; petiole up to 7 cm long, thickened at both ends; blade ovate, elliptical-ovate to ovate-lanceolate, 3–21 cm × 2–14 cm, base cuneate to rounded, with 2 stalked or sessile glands, apex acuminate, margins glandular-toothed, young leaves stellate hairy, later almost glabrous on both sides. Inflorescence an upright, terminal raceme 6–21 cm long, with either only male or female flowers or mixed and then with male flowers in upper part and 1-several female flowers at base. Flowers unisexual, 5-merous; male flowers with pedicel 2–6 mm long, sepals elliptical-ovate to ovate-lanceolate, 2–3 mm long, pale yellowish green, petals elliptical-lanceolate to oblong-lanceolate, 2–3 mm long, whitish yellow to greenish cream, stamens 14–17, free; female flowers with pedicel 1–2 mm long, stout, sepals linear-lanceolate, c. 3 mm long, whitish, petals absent or 5, linear, c. 2 mm long, greenish, ovary superior, rounded, densely stellate hairy, 3-celled, styles 3, 2-fid to base, 4–5 mm long, twisted and curved. Fruit a rounded to ellipsoid drupe 9–11 mm × 7–10 mm, slightly 3-lobed, partly or not dehiscent, stellate hairy, apex centrally depressed, salmon-pink, orange or yellow, 3-seeded. Seeds ellipsoid, c. 6 mm × 4–5 mm, flattened, whitish, aril white. Seedling with epigeal germination.



Croton sylvaticus – 1, flowering twig; 2, fruit. Redrawn and adapted by Iskak Syamsudin

Other botanical information *Croton* comprises about 1200 species and occurs throughout the warmer regions of the world. It is best represented in the Americas; about 65 species occur in continental Africa and about 125 in Madagascar.

Growth and development In Central Africa *Croton sylvaticus* flowers from October–December and fruits from January–May. The seeds are dispersed by birds, which feed on the fruits.

Ecology *Croton sylvaticus* occurs in semi-deciduous savanna, secondary forest and mixed evergreen forest, often on rocky slopes, in river gully forest and on rocky outcrops, from sea-level up to 1700 m altitude. In Uganda it often occurs in old *Eucalyptus* plantations. It prefers light to deep shade, but survives in full sun.

Propagation and planting *Croton sylvaticus* is propagated by seed or wildlings. The fruits are collected before they open and placed in the sun to dry and open, after which the seeds are collected. The seeds need to be stored cool and dry. They are sown in containers in a mixture of river sand and compost (1:2), lightly

covered with compost and kept moist. Germination occurs after 2–3 weeks. The seedlings are transplanted at the 2-leaf stage, either in the field or in plastic bags filled with river sand and compost (1:1).

Management *Croton sylvaticus* is fast growing, and does not need particular care.

Harvesting The bark, leaves and roots can be harvested whenever the need arises. Fruits can be harvested during 5–6 months per year.

Handling after harvest The plant parts harvested are used fresh or dried and stored in a dry, cool place for later use.

Genetic resources *Croton sylvaticus* is relatively common in many parts of tropical Africa, except in West Africa, where it is quite rare. It grows in several types of vegetation and is therefore not likely to be threatened by genetic erosion, except in localities where it has been overharvested.

Prospects *Croton sylvaticus* has a wide range of local medicinal uses, especially its bark. Several laboratory tests showed toxicity but also pharmacological activity, and more research is needed to identify the active compounds in order to evaluate its effective and safe use.

Major references Baerts & Lehmann, 2006d; Elgorashi et al., 2002; Frum & Viljoen, 2006; Grace et al., 2002; Kapingu et al., 2005; Katende, Birnie & Tengnäs, 1995; Kokwaro, 1993; Latham, 2004; Moshi et al., 2004; Radcliffe-Smith, 1996a.

Other references Beentje, 1994; Burkill, 1994; Coates Palgrave, 1983; Grace et al., 2003; Léonard, 1962; Lovett et al., 2006; Raponda-Walker & Sillans, 1961; Vieux & Kabele Ngiefu, 1970.

Sources of illustration Léonard, 1962.

Authors G.H. Schmelzer

CROTON TIGLIUM L.

Protologue Sp. pl. 2: 1004 (1753).

Family Euphorbiaceae

Chromosome number $n = 10$

Vernacular names Purging croton, croton oil plant, croton (En). Croton cathartique (Fr). Crotone, crotone tiglio (Po).

Origin and geographic distribution *Croton tiglium* originates from tropical Asia and China and has been introduced into many parts of the world, including several countries of tropical Africa, e.g. Ghana, Nigeria, Cameroon and Sudan, but an exact distribution in Africa is not known.

Uses The seed and seed oil have long been used in tropical Asia as a strong purgative, cathartic and poison. In Malaysia one seed is eaten as a purgative by adults and coconut milk is drunk to stop the effect. The lethal dose for an adult is about 4 seeds and for a horse about 15 seeds. The seed oil was formerly included in several pharmacopoeias as a purgative, but because the oil is not stable, it has proved unreliable and has therefore been excluded. The seed oil and bark were widely used in folk medicine as a remedy for cancerous sores and tumours, carbuncles, colds, dysentery, fever, paralysis, scabies, schistosomiasis, snakebite, sore throat and toothache. The oil is a strong vesicant but diluted it can be employed as a counterirritant for various skin affections. Caution should be taken with all applications in view of its toxicity.

In Ghana the seeds are known to be very poisonous, and are used as fish poison or for criminal purposes. In Sudan the powdered seeds mixed with dates are eaten as a purgative. In South-East Asia the root is used as an abortifacient and purgative. The leaves are mentioned as an ingredient of arrow poison and as a poultice to treat snakebites.

An extract of the seed can be used as an insecticide for field application and in stored cereals and pulses. The seed oil may also be used in the production of soap and candles. However, for illumination it can only be used outdoors as the smoke is toxic. *Croton tiglium* is grown in southern California as an ornamental.

Production and international trade Roots, seeds and seed oil of *Croton tiglium* are locally traded in India and South-East Asia. Trade from Asia to Europe started in the 16th century and continued to be important until the beginning of the 20th century. Recent trade statistics, however, are lacking. Market value of seeds fluctuates considerably depending on demand.

Properties All plant parts are toxic, but only the seeds have been chemically analysed in detail. The seed contains 30–45% of a fixed oil named croton oil and about 20% protein. The composition of the oil varies with the method of extraction. The oil comprises the fatty acids oleic acid 37%, linoleic acid 19%, myristic acid 7.5%, arachidic acid 1.5%, palmitic acid 1%, formic acid 1%, acetic acid 0.5%, stearic acid 0.5% and smaller amounts of butyric acid, lauric acid, tiglic acid and valeric acid. The oil also contains a group of proteins

called 'crotin', about 3.5% croton resin ('crotonol'), a glucoside called crotonoside (isoguanosine), and a non-volatile unsaturated fatty acid responsible for the purgative properties. Croton oil causes severe inflammation on the skin; it is commonly used in laboratory tests to induce oedema in test animals. The names crotonol and crotin are also used for other chemical compounds.

Crotin is a mixture of the toxic proteins croton globulin and croton albumin. It has haemolytic and blood coagulant properties with a delayed poisonous effect. In humans erythrocytes are merely deformed and rapid antibody formation is induced. The vesicant and irritant properties of the seed oil are mainly due to croton resin, which contains esters of long-chain fatty acids and the diterpene phorbol. Such phorbol esters also show paradoxical biological activity, some being strongly co-carcinogenic, others having anti-cancer activity. 12-O-tetradecanoylphorbol-13-acetate is a standard tumour-promoting agent; several others are well-established causal agents of nasopharyngeal cancer as they can activate Epstein-Barr viruses. On the other hand, phorbol 12-tiglate-13-decanoate exhibits inhibitory activity against P-388 lymphocytic leukaemia in mice; 12-O-acetylphorbol-13-decanoate and 12-O-decanoylphorbol-13–2-methylbutyrate potently inhibit the HIV-1-induced cytopathic effect on MT-4 cells without activating protein kinase C. Crotonoside shows cytotoxic effect against several tumour cell lines in vitro and in vivo in mice as well.

Aqueous extracts of latex and stem bark showed molluscicidal activity against the freshwater snails *Lymnaea acuminata* and *Indoplanorbis exustus*; at high doses these extracts were also lethal to the freshwater fish *Channa punctatus*.

The seed cake retains its toxicity and is thus not suitable for cattle feed.

Botany Monoecious, evergreen shrub or small tree up to 6(–12) m tall; young branches sparsely stellate hairy, soon glabrous. Leaves alternate, almost opposite at the end of shoots, simple; stipules up to 3.5 mm long; petiole up to 2.5(–6.5) cm long; blade ovate to ovate-lanceolate, 5–17 cm × 2.5–9.5 cm, base cuneate to broadly rounded with 2 stalked or sessile glands, apex obtuse to acuminate, margins shallowly toothed to almost entire, glabrous, metallic green to bronze or orange, sparsely hairy beneath. Inflorescence an axillary or terminal raceme 5–7 cm long, with male flowers in upper half and female flowers in lower half. Flowers unisexual, 5-merous; pedicel 2–4 mm long; sepals triangular to ovate, c. 2 mm long, hairy; male flowers with elliptical-lanceolate petals c. 2 mm long, whitish, stamens 15–20, free; female flowers with petals lacking, ovary superior, rounded, c. 2 mm long, densely stellate hairy, 3-celled, styles 3, deeply 2-fid, c. 4 mm long. Fruit an oblong-obovoid to slightly 3-lobed capsule 2–2.5 cm long, dull yellow, roughly stellate hairy, 3-seeded. Seeds ellipsoid-trigonous, c. 9 mm × 6 mm, greyish brown.



Croton tiglium – 1, flowering and fruiting twig; 2, female flower in longitudinal section; 3, male flower in longitudinal section.
Source: PROSEA

Croton comprises about 1200 species and occurs throughout the warmer regions of the world. It is best represented in the Americas; about 65 species occur in continental Africa and about 125 in Madagascar.

Ecology *Croton tiglium* occurs in a wide range of vegetation and soil types, up to 1500 m altitude. In tropical Africa it is usually planted around villages. It tolerates an annual rainfall of 600–1200 mm, an annual temperature of 21–27.5°C and a soil pH of 4.5–7.5.

Management *Croton tiglium* is propagated from stem cuttings or seed. There are about

4150 seeds/kg. It may be grown as a pure crop or as an intercrop with cacao or coffee, providing some shade. Plants start flowering after 1.5 years, and seed yield in the 3rd year may be 200–750 kg seed/ha, and in the 6th year 750–1000(–2000) kg/ha, when the plant is full-bearing. Seeds ripen in November and December in South-East Asia, and should be collected before the fruits open. *Croton tiglium* is attacked by several fungi, and also by root-knot nematodes.

Genetic resources and breeding *Croton tiglium* has a wide distribution from India to Papua New Guinea, and is also cultivated. It is therefore not threatened by genetic erosion. As virtually nothing is known about the distribution of *Croton tiglium* in tropical Africa, it is not known whether it is genetically diverse there.

Prospects The seed oil of *Croton tiglium* is commonly used in laboratories throughout the world for its vesicant properties. The phorbol esters isolated from the oil also have interesting tumour-promoting or tumour-inhibiting properties, and although much research has been done, more is needed to elucidate their future potential. As the other parts of the plant are poisonous as well, it might be worthwhile investigating their chemistry and pharmacology. A large number of pharmaceutical applications of *Croton tiglium* are being patented in China. The extensive ongoing research may lead to new developments elsewhere too.

Major references Burkill, 1994; El Mekkawy et al., 1999; Neuwinger, 2000; Philcox, 1997; van Welzen & Esser, 2001.

Other references Abbiw, 1990; Duke, 1983; El Amin, 1989; El Mekkawy et al., 2000; Hecker & Schmidt, 1974; Kim et al., 1994; Nakamura, 2004; van Duuren & Sivak, 1968; Yadav et al., 2006.

Sources of illustration van Welzen & Esser, 2001.

Authors G.H. Schmelzer

CROTONOGYNE PREUSSII Pax

Protologue Bot. Jahrb. Syst. 23: 524 (1897).

Family Euphorbiaceae

Origin and geographic distribution *Crotonogyne preussii* occurs in southern Nigeria, Cameroon and the Central African Republic.

Uses In eastern Cameroon an infusion of the aerial parts is taken to treat diarrhoea.

Botany Dioecious shrub or small tree up to 8 m tall; young branches with stellate and scaly hairs. Leaves alternate, crowded at apex of branches, simple and entire; stipules small, persistent; petiole up to 2 cm long; blade linear to oblanceolate, up to 55 cm × 13 cm, base cordate-auricled, with 2 large glands, apex acuminate, pinnately veined. Male inflorescence a sessile, erect, axillary raceme up to 60 cm long, many-flowered; female inflorescence a few-flowered fascicle. Flowers unisexual, greenish yellow or white; male flowers with pedicel longer than calyx, calyx split irregularly into 2–3 lobes, covered with scaly hairs, petals c. 5, free, stamens 7–19, free; female flowers larger than male ones, pedicel stout, sepals 5, petals 5, ovary superior, 3-celled, styles 3, free, each divided into 3–8 filiform threads. Fruit a 3-lobed capsule c. 1 cm in diameter, 3-seeded. Seeds ovoid, c. 8 mm long, brown.

Crotonogyne comprises 16 species and occurs in the forest zone from Liberia to DR Congo. According to the Ebrié people of Côte d'Ivoire, all parts of *Crotonogyne strigosa* Prain are very poisonous, and there is no antidote against it.

Ecology *Crotonogyne preussii* occurs in rainforest at low altitudes.

Genetic resources and breeding *Crotonogyne preussii* is relatively common in its distribution area and there are no signs that it is threatened by genetic erosion.

Prospects *Crotonogyne preussii* will probably remain a medicinal plant of local importance only.

Major references Burkill, 1994; Govaerts, Frodin & Radcliffe-Smith, 2000.

Other references Keay, 1958a; Léonard, 1962; Stäuble, 1986.

Authors G.H. Schmelzer

CYNOGLOSSUM COERULEUM DC.

Protologue Prodr. 10: 148 (1846).

Family Boraginaceae

Chromosome number $2n = 24$

Synonyms *Cynoglossum geometricum* Baker & C.H.Wright (1905).

Origin and geographic distribution *Cynoglossum coeruleum* is fairly widespread in Central, East and southern Africa.

Uses In Kenya the vapour of crushed leaves of *Cynoglossum coeruleum* is inhaled to treat fever and influenza and crushed leaves are rubbed on scorpion sting wounds. A decoction of the leaves is drunk during delivery for quick removal of the placenta. A decoction made from

pounded and soaked roots is drunk by pregnant women to relieve abdominal pain. In southern Africa the crushed plants are applied to wounds as a plaster and the whole plant is used as a medicine for colic. In DR Congo it is used as a vermifuge specifically against tapeworm. In Kenya it is reportedly grazed by livestock.

Properties Pyrrolizidine alkaloids are common constituents of the *Boraginaceae* and *Asteraceae* and the Papilionoid genus *Crotalaria*. They are derived from amino acids including ornithine. Many pyrrolizidine alkaloids have pronounced hepatic toxicity, but the lungs and other organs may be affected as well. Mutagenic and carcinogenic activities of pyrrolizidine alkaloids have been reported.

No specific analyses of the properties of *Cynoglossum coeruleum* are known. Several other *Cynoglossum* species are highly toxic for horses and cattle, mainly during the rosette stage, due to the presence of pyrrolizidine alkaloids. Two pyrrolizidine alkaloids have been recorded from another African species, *Cynoglossum lanceolatum* Forssk.: cynaustraline and cynaustine, and five from the Asian and American *Cynoglossum amabile* Stapf & J.R.Drumm.: supinine, amabiline, rinderine, echinatine and 3'-O-acetylechinatine. *Cynoglossum officinale* L., a native of Europe and western temperate Asia and an introduced weed in the United States, is by far the most comprehensively studied species of the genus.

Botany Perennial, biennial or annual herb up to 120 cm tall, very densely hairy on young parts, usually with thick woody taproot. Leaves alternate, simple and entire; stipules absent; petiole 2–10 cm long in basal leaves, upper leaves sessile; blade narrowly ovate, elliptical-oblong, linear-oblong or oblanceolate, basal ones 8–21(–30) cm × 1–6 cm, rough with short adpressed hairs from white cystolith dots, apex acute. Inflorescence an axillary or terminal scorpioid cyme, simple, dichasial or trifid, without bracts. Flowers bisexual, regular, 5-merous; corolla blue or pinkish mauve, tube c. 2 mm long. Fruit consisting of 4 compressed ovoid nutlets, (2.5–)3.5–4 mm long, reddish, covered all over by barbed hairs.

Cynoglossum comprises about 50 species, and has a worldwide distribution. *Cynoglossum coeruleum* is variable and several subspecies are distinguished. Intermediates between *Cynoglossum coeruleum* and *Cynoglossum lanceolatum* occur, making a distinction between species complicated. *Cynoglossum lanceolatum* is used in Ethiopia as a febrifuge and leaves are added to soup in Nigeria. In Vietnam, it is considered diuretic. *Cynoglossum monophlebium* Baker is an endemic of Madagascar and is used as an antirheumatic. *Cynoglossum amabile* has been introduced in East Africa as an ornamental and has become naturalized in parts of Tanzania. It is used in traditional Chinese medicine to treat cough, scrofula and to stop bleeding of wounds.

Ecology *Cynoglossum coeruleum* occurs in a wide variety of habitats such as (overgrazed) grassland, bushland, evergreen forest and as a weed in fields at 750–3150(–3650) m altitude.

Genetic resources and breeding Germplasm collections of *Cynoglossum* do not exist. This fairly widespread species of various habitats is not threatened by genetic erosion.

Prospects Little is known about the properties of *Cynoglossum coeruleum*. Studies of related species report interesting properties, e.g. wound healing and antibacterial activities. Research on these aspects in Africa is desirable, and might enhance the medicinal importance in the region. Improvements in the taxonomic classification are considered only possible after detailed study of the taxa in both Africa and India.

Major references Burkill, 1985; Giday et al., 2003; Lugt & Lemmens, 2003; van Dam, Verpoorte & van der Meijden, 1994; Verdcourt, 1991.

Other references Boiteau & Allorge-Boiteau, 1993; Chifundera, 2001; Iwu, 1993; Jansen, 1981; Kokwaro, 1993; Suri, Sawhney & Atal, 1975; Taton, 1971.

Authors C.H. Bosch

DALECHAMPIA IPOMOEIFOLIA Benth.

Protologue Hook., Niger Fl.: 500 (1849).

Family Euphorbiaceae

Origin and geographic distribution *Dalechampia ipomoeifolia* occurs from Sierra Leone east to Ethiopia, Uganda and Tanzania.

Uses In Côte d'Ivoire the flowering aerial parts are applied topically to calm costal and rheumatic pain.

Botany Monoecious, twining shrub up to 7 m tall; stems thinly hairy. Leaves alternate, simple; stipules linear to linear-lanceolate, up to 1 cm long; petiole up to 10 cm long; blade triangular-ovate, 4–12 cm × 2–7 cm, sometimes shallowly or deeply 3-lobed, base cordate, glands 1.5 mm long, apex acute to acuminate,

margins almost entire to glandular-toothed, short-hairy beneath. Inflorescence axillary or terminal on lateral shoots, with peduncle up to 14 cm long, flowers densely crowded in a male and female part, subtended by 2 large, triangular-ovate bracts, 2–3.5 cm × 1.5–3 cm, these 5-veined from the base and pale green to yellowish; male part of inflorescence a 14–20-flowered compound cyme, surrounded by an involucre 5–6 mm in diameter, on 4–5 mm long peduncle, a central mass of fused bracts at base, covered with resin; female inflorescence an almost sessile 3-flowered cyme, subtended by 2–3 transversely ovate bracts c. 2 mm × 3.5 mm. Flowers unisexual; petals and disk absent; pedicel 1–2 mm long, in female flowers extending to 1.2 cm; male flowers with 4–6, elliptical-ovate sepals c. 2 mm long, pale yellow, stamens 10–20; female flowers with 6 pinnatifid sepals c. 2.5 mm long, extending to 1 cm in fruit, with 6 pairs of linear lateral lobes, densely stiff hairy at margins, hairs white and urticant, ovary superior, 3-lobed, short-hairy, 3-celled, style up to 7 mm long, broadened at apex. Fruit a 3-lobed capsule c. 5 mm × 8 mm, short-hairy, grey or brownish, 3-seeded. Seeds spherical, c. 3 mm in diameter, brown, grey-mottled.

Dalechampia comprises about 120 species and occurs throughout the tropics, but is best represented in tropical America, especially Brazil. In continental tropical Africa 7 species occur, and in Madagascar 9 species. The crushed fresh leaves and roots of *Dalechampia clematidifolia* Baill. from Madagascar are vesicant and are applied to stubborn ulcers. The aerial parts are used to dye *Raphia* cloth black. Most *Dalechampia* spp. are pollinated by bees, which use the triterpene resin produced in the inflorescence in nest construction.

Ecology *Dalechampia ipomoeifolia* is mainly found at forest margins, up to 1200 m altitude.

Genetic resources and breeding *Dalechampia ipomoeifolia* has a large area of distribution and is relatively common; it is therefore not likely to be threatened by genetic erosion.

Prospects *Dalechampia ipomoeifolia* will remain of local importance only as a medicinal plant. Nothing is known about its active compounds.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Burkill, 1994; Radcliffe-Smith, 1987.

Other references Armbruster & Steiner, 1992; Pernet & Meyer, 1957; Stäuble, 1986.

Authors G.H. Schmelzer

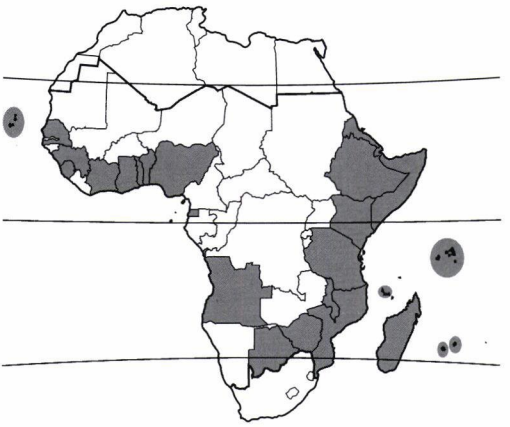
DATURA METEL L.

Protologue Sp. pl. 1: 179 (1753).
Family Solanaceae
Chromosome number $2n = 24, 48$
Synonyms *Datura fastuosa* L. (1759).

Vernacular names Downy thorn apple, metel thorn apple, metel (En). Métel, stramoine métel, concombre diable, concombre à chien, trompette de la mort (Fr). Cornucopia, trombetão-roxo, trombeta do juízo, burbiaca (Po). Mnanaha, mnawha, mnaraha, mranaha, mvundovundo wa chamboni, muranha (Sw).

Origin and geographic distribution *Datura metel* is native to the Americas and has been introduced from there throughout the tropics and subtropics. It is probably grown throughout tropical Africa as an ornamental. It is documented as a naturalized weed in many African countries but is probably seriously under-reported.

Uses *Datura metel* and *Datura stramonium* L. have largely similar medicinal uses throughout the world. In tropical Africa as well as in Asia the most widely documented use of *Datura metel* is for relieving asthma, cough, tuberculosis and bronchitis by smoking the dried leaves, roots or flowers as a cigarette or in a pipe. These 'asthma cigarettes' have been shown to be very effective in some cases, but in other cases they had little or no effect. Cigarettes made with the leaves are also used to treat Parkinson's disease. Widespread is also the use of different plant parts in various preparations for sedating patients with mental disorders. In Africa other traditional uses of the leaves include the treatment of haemorrhoids, boils, sores, skin diseases, rheumatism,



Datura metel – naturalized

headache, toothache, cholera, parasites such as ringworm and guinea worm, and as an abortifacient and anaesthetic. In Senegal, Guinea, Ghana and Nigeria crushed leaves are applied as poultices on inflammatory swellings and rheumatic joints. In Ghana a decoction of the leaves is used as eye drops to cure conjunctivitis and other eye complaints. In Nigeria dried leaves are mixed with salt and pepper and burnt to treat asthma. In Ethiopia the seed oil is used for massaging painful body parts. In Asia *Datura metel* has similar medicinal applications, and it is used additionally to treat hydrophobia, epilepsy, convulsion, syphilis, inflammation of the breasts, smallpox, mumps and leprosy.

Datura metel is also widely used as a pesticide. Seeds mixed with sorghum flour are used as poison bait for rats. Plant extracts have been used successfully against caterpillar pests in forestry, cotton pathogens and domestic vermin such as fleas and jigger, and to reduce insect damage in stored wheat and maize. They are useful to control the root knot nematode, *Meloidogyne javanica*. In Tanzania an extract made from the roots is sprinkled in houses to repel snakes.

In Africa *Datura metel* has ritual uses in many countries, e.g. in initiation rites in Nigeria and Mozambique. Most commonly the leaves are smoked, or they are boiled and eaten; seeds are similarly used. Roots, seeds or leaves are added to alcoholic drinks to increase the intoxicating effect. Side effects include dry mouth and throat, eye pain, blurred vision, restlessness, dizziness, cardiac arrythmia, flushing and faintness. An overdose will cause headache, nausea, vomiting and affect the central nervous system causing symptoms including disorientation, hallucinations, euphoria, inappropriate affect, short-term memory loss and coma. The seeds are also used for criminal purposes. Hospital admissions and fatalities, most often of adolescents, are not uncommon. It is for this reason that several countries including France have removed datura cigarettes from the Pharmacopoeia in 1992.

Datura metel is commonly cultivated as an ornamental, particularly types with double flowers and purple flowers. In East Africa the leaves are used to dye cloth green. In Ethiopia the seed oil is rubbed into fresh hides as a first step in the curing process.

Production and international trade No trade statistics are available for *Datura metel*, although it is occasionally used for industrial extraction of tropane alkaloids. At the beginning of the 1980s the market prices of scopolamine hydrobromide and hyoscyamine sulphate were approximately US$ 850/kg and US$ 470/kg, respectively.

Properties The leaves of *Datura metel* contain 0.2–0.6% tropane alkaloids, the flowers 0.1–1.0% and the seeds 0.2–0.5%. In tetraploid plants alkaloid content is almost double that of diploid plants. Scopolamine (= hyoscine) is the major constituent in mature leaves (up to 75% of the total alkaloid content). Other alkaloids are hyoscyamine (= (–)-hyoscyamine or (–)-atropine), norhyoscyamine, norscopolamine, hydroxy-6-hyoscyamine and meteloidine. Although atropine (= (+)-atropine or (+)-hyoscyamine) has often been reported to be present in *Datura* spp., it is unclear whether it is really a natural product or an artefact obtained during isolation. Scopolamine and hyoscyamine are anticholinergics. They act by competitively and reversibly inhibiting the neuro-transmitter acetylcholine from binding to its muscarinic receptors and this antagonism leads to sympathomimetic-like effects in the organs. They increase the heart rate, induce relaxation and motor inhibition in smooth muscles, decrease secretions, and induce dilation of the pupils of the eyes. Although at low doses their action tends to be depressant and sedative, at high doses they cause substantial excitation: agitation, disorientation, exaggerated reflexes, hallucinations, delirium, mental confusion and insomnia. Hyoscyamine is used to provide symptomatic relief of various gastrointestinal disorders including spasms, peptic ulcers, irritable bowel syndrome, pancreatitis, colic and inflammation of the bladder. It has also been used to relieve some heart problems, to reduce excess saliva production and control some of the symptoms of Parkinson's disease. Scopolamine is used in ophthalmology to dilate pupils, as an analgesic and to prevent motion sickness.

In-vitro production of scopolamine and hyoscyamine is feasible, though uneconomical. Cultures of hairy roots of *Datura metel* are the most productive. The growth and production of hyoscyamine and scopolamine in in-vitro root cultures was encouraged by using Gamborg's B5 liquid medium with half-strength salts. In this medium the excretion of scopolamine rose from 8.7% to 70%. Biomass and alkaloid production also increased when the permeabilizing agent Tween 20 was added for 24 hours after 2 and 4 weeks of culture. After 4 weeks, biomass

yield was 2.3 mg/l per day and scopolamine yield 0.84 mg/l per day.
Several withanolides have been identified from the flowers and aerial parts of *Datura metel*, some of these with cytotoxic activity.
The seed of *Datura metel* contains about 16% oil with an approximate fatty acid composition of palmitic acid 14%, oleic acid 30% and linoleic acid 52%. The oil also contains considerable quantities of sterols (about 13.4 g/kg) and tocopherols (about 3.4 g/kg) which are considered to be of medicinal interest.

Adulterations and substitutes Tropane alkaloids similar to those found in *Datura* are known from several other *Solanaceae* (e.g. hyoscyamine and scopolamine in *Atropa belladonna* L. and *Hyoscyamus* spp.). Scopolamine is found in high quantity in *Duboisia* spp., which are used for industrial production in Australia.

Description Annual or short-lived perennial erect herb up to 2 m tall, often much-branched; stem short-hairy to glabrous. Leaves alternate, simple; stipules absent; petiole up to 16 cm long; blade ovate to often slightly angular, 4–25 cm × 2–20 cm, base cuneate, rounded or truncate, apex acute to acuminate or obtuse, margin entire to coarsely toothed, with or without prickles and stellate hairs, pinnately veined. Flowers axillary, solitary, rarely paired, bisexual, regular, 5-merous; pedicel 5–11 mm long, up to 20 mm long in fruit; calyx tubular, 4–7.5 cm long, lobes almost equal, 0.5–2.5 cm long; corolla trumpet-shaped to tubular, 12–19 cm long, white, yellow, violet or purplish; stamens inserted above the middle of the corolla tube, alternate with corolla lobes, included, filaments short and thick, anthers yellow; ovary superior, 2–6-celled, style slender, up to 13(–17) cm long, stigma small, 2-lobed. Fruit an upright or nodding, ovoid or almost globose capsule up to 4 cm × 3.5 cm, reddish brown to purplish, spines few to many, stout, conical, usually many-seeded. Seeds almost D-shaped, flattened, 4–6 mm × 4–5 mm × c. 1.5 mm, white, yellowish brown or brown. Seedling with epigeal germination; cotyledons thin, leafy.



Datura metel – 1, stem with flowers and young fruit; 2, fruit; 3, seeds.
Source: PROSEA

Other botanical information *Datura* comprises about 10 species, which all originated in the New World; most species have been introduced throughout the world. *Datura metel* belongs to section *Dutra* and is easily confused with other *Datura* spp., especially *Datura inoxia* Mill., but the latter species is characterized by the long, soft spines on the fruit and the short-hairy stem and leaves. It is practically impossible to separate ethnobotanical records on the 2 species, also in Africa, and they probably have similar medicinal uses. *Brugmansia* is considered here as a separate genus, although it is often treated as a section of *Datura* (section *Brugmansia*). It mainly differs in its habit (a woody, comparatively long-lived shrub or small tree), its mode of growth (reproducing vegetatively by root suckers), its pendulous or inclined flowers open throughout anthesis for 4–6 days with spathe-like, not circumscissile calyx and long pedicel, and its fruit being a usually indehiscent, unarmed berry. Chemically, *Datura* and *Brugmansia* are similar, and consequently they have similar medicinal applications. However, the primary use of the *Brugmansia* species is ornamental.

Growth and development Only the basal part of the stem remains vegetative; flowering occurs on the branched part of the plant and branches do not resume vegetative growth after flowering and fruiting. The flowers are closed during the day and open in the evening, and are reported to be pollinated by hawk moths and to be largely self fertile.
In studies in India it was found that mature leaves of about the middle of the stems of *Datura metel* had the maximum alkaloid content,

and that very young fruits possessed a higher content of alkaloids than older fruits. In *Datura metel* grown experimentally in Iran, the highest scopolamine concentrations were found in the stems (0.3%) and young leaves (0.25%) of 6-week-old plants and in the roots (0.2%) of 16-week-old plants.

Ecology *Datura metel* is locally abundant in waste places, roadsides, brushwood, open grassland, teak forest and on river banks, from sea-level up to 1000 m altitude. It tolerates various soil types but prefers clayey or loamy soils. *Datura metel*, often with a double and purplish corolla, is widely cultivated in gardens.

Propagation and planting *Datura metel* is generally cultivated from seed sown either directly in the field or in a nursery bed. Soaking seed overnight improves germination. Per ha, 7–8 kg of seed is needed. Seed starts germinating after about 2 weeks, and germination is complete after one month. If the seed is sown in a nursery, seedlings are transplanted when 8–12 cm tall. Normal spacing is 70–100 cm.

Management Weeding and thinning of a direct sown crop should be done when the plants are about 10 cm tall; a second weeding is done one month later. Irrigation may be necessary and should be done at intervals of 10–15 days.

Diseases and pests *Datura metel* is a host for many diseases and pests that affect solanaceous crops. It can be infected by wilt and root rot caused by the fungus *Sclerotium rolfsii*, root rot caused by the fungus *Corticium solani* (synonym: *Thanatephorus cucumeris*) and by several virus diseases that cause symptoms like leaf curl, retarded growth and yellowing of leaves. *Alternaria crassa*, a fungus that causes leaf spot and can kill *Datura* spp., has not yet been reported from tropical Africa.

Harvesting When flowering starts, about 4 months after sowing, tender branches and leaves are harvested. Several more harvests are possible at intervals of 1–2 months. Fruits are harvested when ripe.

Yield In Nigeria the total alkaloid content of *Datura metel* has been shown to peak in the hot and dry season, and it was lowest in the rainy season. In India, yields per ha of 10.5–14.5 t of fresh plant material and 750–1200 kg of seed of *Datura metel* have been reported.

Handling after harvest The tender branches and leaves are dried in the shade. Fruits are dried in the sun till they dehisce. The seeds are separated by threshing and after further drying packed for transport.

Genetic resources *Datura metel* has an extremely wide geographical distribution, prefers anthropogenic habitats and is therefore not liable to genetic erosion.

Breeding In order to develop industrial plantations for alkaloid extraction, research should focus on breeding for a high alkaloid content, combined with the development of proper means of vegetative propagation. In India some improved cultivars have been released. Producing and selecting interspecific hybrids of *Datura* for high scopolamine production, succesfully done with *Brugmansia* in Ecuador, is promising.

Prospects Although the tropane alkaloids scopolamine, hyoscyamine and atropine can be prepared synthetically, it is more economical to extract them from plants such as *Datura* spp. However, *Atropa*, *Duboisia* and *Hyoscyamus* species are the major sources of raw materials. On the world market of pure tropane alkaloids, it will be difficult for African producers to compete with producers in China, India and Australia.

Major references Afsharypuor, Mostajeran & Mokhtary, R., 1995; Burkill, 2000; Braun et al., 1991; Goncalves, 2005; Neuwinger, 2000; Prasad et al., 2005; Sri Hartati, Imastini Dinuriah & Blomqvist, 1999.

Other references Blomqvist, 1997; Braun et al., 1991; Debnath, Malik & Bisen, 2006; Fortin, Lô & Maynart, 1990; Gupta, Bagchi & Ray, 1991; Gurib-Fakim, Guého & Bissoondoyal, 1997; Hadkins et al., 1997; Kitagawa et al., 2000; Levy & Regalado, 1991; Pan, Wang & Hu, 2007; Ramadan, Zayed & El Shamy, 2007; Roddick, 1991; Sarin, 1982; Sobti & Kaul, 1982; Zayed, Wink & El Shamy, 2006.

Sources of illustration Sri Hartati, Imastini Dinuriah & Blomqvist, 1999.

Authors O.O. Nuga & M.P. Setshogo

Based on PROSEA 12(1): Medicinal and poisonous plants 1.

DATURA STRAMONIUM L.

Protologue Sp. pl. 1: 179 (1753).

Family Solanaceae

Chromosome number $2n = 24$

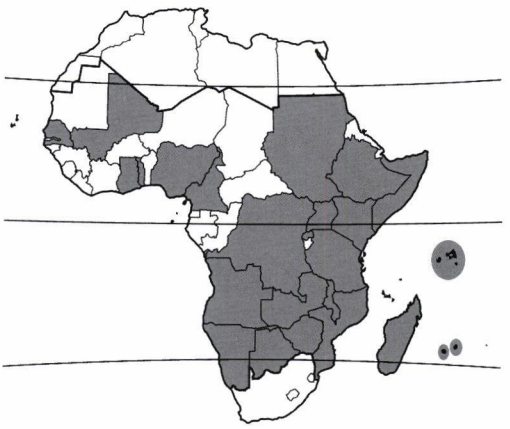
Vernacular names Thorn apple, green thorn apple, Jimson weed, Jamestown weed, devil's apple, devil's trumpet, stramonium (En). Pomme épineuse, stramoine, datura, feuille du diable, herbe du diable (Fr). Figueira

do inferno, pomo espinhoso, erva dos bruxos, palha verde, estramonio (Po). Muranha (Sw).

Origin and geographic distribution *Datura stramonium* is native to the Americas and has been introduced in many tropical, subtropical and even temperate regions. It is a naturalized weed in many African countries, but is probably seriously under-reported.

Uses *Datura stramonium* and *Datura metel* L. have largely similar medicinal uses throughout the world. The most widely known use of *Datura stramonium* and of other *Datura* species is for relieving asthma, cough, tuberculosis and bronchitis by smoking the dried leaves, roots or flowers. 'Asthma cigarettes' have been shown to be very effective in some cases, but in other cases they had little or no effect. Cigarettes made with the leaves are also used to treat Parkinson's disease. A decoction or infusion of leaves is given as a sedative to mental and schizophrenic patients. The leaves are applied as a dressing to cure rheumatic pain, swellings, wounds, gout, burns, ingrown toe-nails, fungal infections, tumours and ulcers. Dried pulverized leaves are dusted on wounds or applied after mixing the powder with fat or Vaseline.

In DR Congo pounded fresh root and fresh leaves are soaked in water and the liquid is given in enema as an abortifacient. In Zimbabwe a hot poultice of leaves and roots is applied to goitre. A leaf infusion is drunk to treat venereal diseases; to cure ulcers the skin is washed with an infusion of roots and leaves. In Burundi leaf ash is eaten as a cure for whooping cough. In Rwanda a leaf infusion is taken as an antispasmodic and to reduce stomach acidity. In Kenya dried and ground leaves and seeds are eaten mixed with fat to treat ringworm. Headache is relieved by rubbing the scalp with leaves or leaf sap. Hair loss is countered by applying fruit sap or leaf pulp and these also serve to remedy dandruff. In Ethiopia pieces of young fruit are sucked against tonsillitis and sore throat and applied to abscesses and swollen glands. In Kenya and Lesotho the fruit is heated in hot ash and after cooling juice is squeezed and used as ear drops to treat earache. In Zimbabwe an infusion of fruit ash is drunk to treat stomach-ache. In Ethiopia the smoke of burning seeds is inhaled to relieve toothache, while in Kenya fresh green fruit is applied for this purpose. In Namibia a leaf extract is administered to cows to ensure a rapid expulsion of the afterbirth and pulped roots are mixed with water and given to cattle to cure lung diseases. The dried leaves and seeds of *Datura stramonium* are included in the pharmacopoeias of many Western countries as an antispasmodic and for treatment of asthma, whooping cough and Parkinson's disease.



Datura stramonium – naturalized

The narcotic use of *Datura stramonium* varies between cultures. In Central and South America hallucinogenic uses are common among native tribes. In Africa, before they enter fighting contests, young men of the Fulfulde people of the border area of Niger and Nigeria are served drinks containing *Datura* seeds. This increases their courage and pain tolerance. The leaves are most commonly used as a narcotic, either smoked or boiled and eaten; seeds are similarly used. Roots, seeds or leaves are added to alcoholic drinks to increase the intoxicating effect. Side effects include dry mouth and throat, eye pain, blurred vision, restlessness, dizziness, arrythmia, flushing and faintness. An overdose will cause headache, nausea, vomiting and affect the central nervous system causing disorientation, hallucinations, euphoria, inappropriate affect, short-term memory loss and coma. The seeds are also used for criminal purposes. Hospital admissions and fatalities, most often of adolescents, are not uncommon. It is for this reason that several countries including France have removed datura cigarettes from the Pharmacopoeia in 1992.

Reports on the use of the plant as an insecticide vary from good control of aphids in crops in Namibia to no effects in Australia. In East Africa the leaves yield a green dye that is used to dye cloth; in Lesotho the twigs yield a blue-green dye that is used for house decoration. In

Ethiopia the plant has been used to tattoo the gums, partly as a treatment of gingivitis or dental decay. The stems are used as firewood. In Kenya the seed oil is used as massage oil.

Production and international trade In tropical Africa *Datura stramonium* is mainly used locally, but it is important for the international pharmaceutical industry. For example, in France 20–30 t of leaves were used around 1990 to produce anti-asthma and antispasm medicines and medicines against Parkinson's disease. There are many brand names for hyoscyamine and atropine on the world market.

Properties The concentration of total alkaloids in the leaves of *Datura stramonium* is 0.2–0.5%, hyoscyamine being the major compound and scopolamine (= hyoscine), apoatropine, tropine, belladonnine and hyoscyamine N-oxide minor compounds; more than 70 alkaloids have been identified in the various parts of the plant. Biosynthetically, the main compounds all belong to the tropane alkaloids and are derived from the amino acid ornithine.

Hyoscyamine, atropine and scopolamine are anticholinergics, specifically antimuscarinics. They act by competitively and reversibly inhibiting the neuro-transmitter acetylcholine from binding to its muscarinic receptors, and this antagonism leads to sympathomimetic-like effects in the organs. They increase the heart rate, induce relaxation and motor inhibition in smooth muscles, decrease secretions, and induce dilation of the pupils of the eyes. Although hyoscyamine has a stronger activity than atropine or scopolamine, atropine is more commonly prepared and used. Although at low doses their action tends to be depressant and sedative, at high doses they cause substantial excitation: agitation, disorientation, exaggerated reflexes, hallucinations, delirium, mental confusion and insomnia. Hyoscyamine is used to provide symptomatic relief of various gastrointestinal disorders including spasms, peptic ulcers, irritable bowel syndrome, pancreatitis, colic and inflammation of the bladder. It has also been used to relieve some heart problems, to reduce excess saliva production and control some of the symptoms of Parkinson's disease.

The *Datura stramonium* powder listed in the Dutch Pharmacopoeia (8th edition) is titrated to contain 0.23–0.27% total alkaloids. It is an ingredient of antitussive syrups, but is mostly used in the form of cigarettes to relieve respiratory difficulties, together with other drugs.

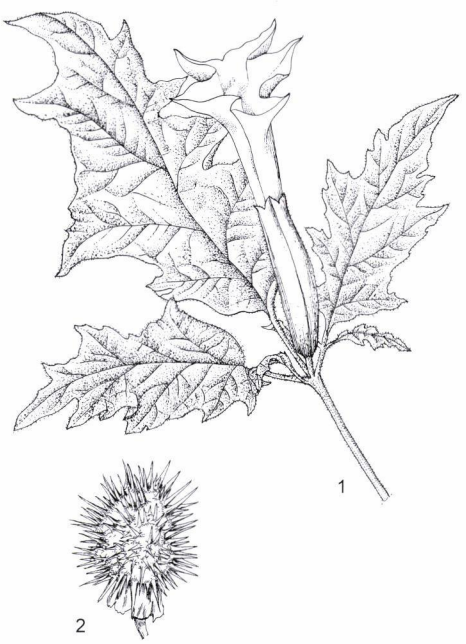
Tropane alkaloids can be biosynthesized in cell suspension cultures of *Datura stramonium* in shake flasks and bioreactors. Calluses have been induced from leaves, stems and roots and cultured on Gamborg's B5 or Murashige and Skoog medium supplemented with growth regulators. The highest alkaloid content was produced in leaf calluses grown on a medium with low concentrations of growth regulators (0.1 mg/ml of benzyladenine and 2,4-D), and in cultures grown in the dark. Total alkaloid production in a cell culture supplemented with phenylalanine and ornithine was 5 times higher than in the control culture, and higher ratios of tropine to tropic acid also stimulated alkaloid production. A hyoscyamine production of up to 7.5 mg/l daily was recorded in root cultures on Gamborg's B5 medium containing 5% sucrose at 20–25°C.

Methanol leaf extracts showed slight antibacterial activity against gram-positive bacteria in a dose dependent manner but no activity was found against *Escherichia coli* and *Pseudomonas aeruginosa*.

The seed contains about 17% of a pale yellow oil.

Adulterations and substitutes Tropane alkaloids similar to those found in *Datura* are known from numerous *Solanaceae* (e.g. hyoscyamine and scopolamine in *Atropa belladonna* L. and *Hyoscyamus muticus* L.). Scopolamine is found in high quantity in in *Duboisia* spp., which are used for industrial production in Australia.

Description Annual or short-lived perennial erect herb up to 2 m tall, often much-branched; stem sparsely hairy to glabrous. Leaves alternate, simple, minutely hairy; stipules absent; petiole up to 9.5 cm long; blade ovate to rhombic-ovate or elliptical, 3–20 cm × 1–15 cm, base cuneate, rounded, truncate or cordate, apex acute to acuminate or obtuse, margins sharply toothed with irregular teeth or almost entire, pinnately veined. Flowers axillary, solitary, rarely paired, bisexual, regular, 5-merous; pedicel 5–15 mm long, up to 30 mm long in fruit; calyx tubular, 2.5–5 cm long, lobes unequal, 0.5–1 cm long; corolla trumpet-shaped to tubular, 6–10 cm long, white or faintly tinged purple, sometimes violet or purplish in the tube; stamens inserted above the middle of the corolla tube, included, filaments short and thick, anthers yellow; ovary superior, 2(–4)-celled, style slender, 3.5–7 cm long, stigma large, 2-lobed. Fruit an upright, almost globose to ovoid capsule up to 5 cm × 4.5 cm, yellowish to brown, spines few to many, slender, stiff, up



Datura stramonium – 1, flowering branch; 2, fruit.
Redrawn and adapted by Iskak Syamsudin

to 16 mm long, many-seeded. Seeds almost D-shaped, flattened, 3.5–4.5 mm × 2.5–3.5 mm × c. 1 mm, dark brown to black. Seedling with epigeal germination; cotyledons thin, leafy.

Other botanical information *Datura* comprises about 10 species, which all originated in the New World; most species have been introduced throughout the world. *Datura stramonium* belongs to section *Stramonium*. *Datura ferox* L. (longspine thornapple, fierce thornapple) belongs to the same section, and is recorded with certainty only in Cape Verde, Namibia, Botswana and Zimbabwe. Compared to *Datura stramonium*, it has wider leaves and larger fruits with fewer but stouter spines. The medicinal uses are similar to those for the other *Datura* species. The main alkaloid in its leaves is scopolamine and not hyoscyamine as in *Datura stramonium*, although both species produce hyoscyamine in the roots. In *Datura ferox* hyoscyamine is transformed into scopolamine in the above-ground parts.

Brugmansia is considered here as a separate genus, although it is often treated as a section of *Datura* (section *Brugmansia*). It mainly differs in its habit (a woody, comparatively long-lived shrub or small tree), its mode of growth (reproducing vegetatively by root suckers), its pendulous or inclined flowers open throughout anthesis for 4–6 days with spathe-like, not circumscissile calyx and long pedicel, and its fruit being a usually indehiscent, unarmed berry. Chemically, *Datura* and *Brugmansia* are similar, and consequently they have similar medicinal applications. However, the primary use of the *Brugmansia* species is ornamental.

Growth and development Only the basal part of the stem remains vegetative; flowering occurs on the branched part of the plant and branches do not resume vegetative growth after flowering and fruiting. The flowers are closed during the day and open in the evening, and are reported to be pollinated by hawk moths and to be largely self-fertile.

The hyoscyamine/scopolamine ratio in *Datura stramonium* is influenced by the developmental stage reached by the plants. In younger plants scopolamine is the main alkaloid, whereas hyoscyamine mostly becomes the dominant alkaloid when flower development has started. The alkaloids are produced in the roots and transferred to the leaves, flowers and finally the fruits.

Ecology *Datura stramonium* occurs in open locations such as grassland, roadsides, waste places, scrub vegetation and open forest. It tolerates various soil types but prefers clayey or loamy soils. *Datura stramonium* is frost sensitive. In the United States and Australia *Datura stramonium* is considered a serious weed in crops; elsewhere it is considered a weed in waste land. Control is difficult as *Datura stramonium* is resistant to most commonly used herbicides. Contamination of wheat, rye, buckwheat and linseed with seeds of *Datura stramonium* resulting in poisoning have been reported.

Propagation and planting *Datura stramonium* is generally cultivated from seed sown either directly in the field or in a nursery bed. Soaking seed overnight improves germination. Per ha, 7–8 kg of seed is needed. Seed starts germinating after about 2 weeks, and germination is complete after one month. If the seed is sown in a nursery, seedlings are transplanted when 8–12 cm tall. Normal spacing is 70–100 cm, but in India a spacing of 3 m is common practice.

Management Experiments in Burundi with the cultivation of *Datura stramonium* showed that the application of chemical fertilizers and manure resulted in an increased production of total alkaloids. As a result of experiments in

Burkina Faso, deflowering was recommended to increase the total alkaloid content in the leaves.

Diseases and pests Many pests and diseases affecting solanaceous crops also affect *Datura stramonium*.

Harvesting In experiments in Burundi it was demonstrated that the best time for harvesting leaves of *Datura stramonium* was 8 weeks after sowing, because alkaloid content was then highest. On the basis of experiments in Burkina Faso, it was recommended to harvest the leaves in the early morning or late afternoon.

Yield The highest yields of scopolamine and hyoscyamine from *Datura stramonium* in Algeria were 7.5 kg/ha and 21 kg/ha, respectively. In India 1–1.5 t/ha of dry leaves and 500–600 kg/ha of seeds have been obtained.

Handling after harvest The tender branches and leaves are dried in the shade. Fruits are dried in the sun until they dehisce. The seeds are separated by threshing and after further drying packed for transport.

Genetic resources *Datura stramonium* has a wide geographical distribution, prefers anthropogenic habitats and is therefore not liable to genetic erosion.

Breeding No attempts have been made to improve *Datura stramonium* for yield of alkaloids but the genetics of *Datura* spp. have been extensively studied. Interspecific crosses with *Datura ferox* yield F_1-plants that have the capability to transform hyoscyamine into scopolamine; this characteristic is dominant and monofactorial.

Prospects Although the tropane alkaloids scopolamine, hyoscyamine and atropine can be produced synthetically, it is more economical to extract them from plants such as *Datura* spp. However, *Atropa*, *Duboisia* and *Hyoscyamus* species are the major sources of raw materials. On the world market of pure tropane alkaloids, it will be difficult for African producers to compete with producers in China, India and Australia.

Major references Berkov, Zayed & Doncheva, 2006; Burkill, 2000; Dethier, Cordier & Demeyer, 1993; Goncalves, 2005; Neuwinger, 2000; Nkurunziza, undated; Philipov, Berkov & Doncheva, 2007; Sri Hartati, Imastini Dinuriah & Blomqvist, 1999.

Other references Abebe & Hagos, 1991; Al-Shaikh & Sablay, 2005; Blomqvist, 1997; Braun et al., 1991; Eftekhar, Yousefzadi & Tafakori, 2005; Fortin, Lô & Maynart, 1990; Friedman, 2004; Gedif & Hahn, 2003; Gelfand et al., 1985; Gonçalves, 2002; Gurib-Fakim et al., 1993; Hamill et al., 2000; Hegnauer, 1973; Maundu et al., 2001; Nwosu, 1999; Reisman-Berman, Kigel & Rubin, 1988; Roddick, 1991.

Sources of illustration DeWolf, 1956; Goncalves, 2005.

Authors F.S. Mairura & M.P. Setshogo

DETARIUM MICROCARPUM Guill. & Perr.

Protologue Fl. Seneg. tent. 1: 271, tab. 59 (1832).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

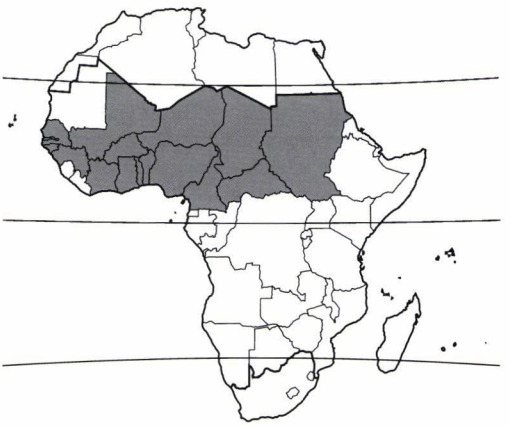
Chromosome number $2n = 22$

Synonyms *Detarium senegalense* auct. non J.F.Gmel.

Vernacular names Sweet dattock (En). Dankh, petit détar (Fr).

Origin and geographic distribution *Detarium microcarpum* occurs naturally in the drier regions of West and Central Africa, from Senegal and Gambia east to Sudan.

Uses The bark, leaves and roots of *Detarium microcarpum* are widely used throughout its distribution area because of their diuretic and astringent properties. They are prepared as infusions or decoctions to treat rheumatism, venereal diseases, urogenital infections, haemorrhoids, caries, biliousness, stomach-ache, intestinal worms and diarrhoea including dysentery. They are also used against malaria, leprosy and impotence. A decoction of the powdered bark is widely taken to alleviate pain, e.g. headache, sore throat, back pain and painful menstruation. The fresh bark or leaves are



Detarium microcarpum – wild

applied to wounds, to prevent and cure infections.

In Mali the bark is also used to treat measles, nocturia, hypertension, itch and tiredness, while a decoction of the leaves or roots is taken against paralysis, meningitis, tiredness, cramps and difficult delivery. The powdered seeds are applied to skin infections and inflammations, whereas the fruit is eaten to cure meningitis and malaria. In Burkina Faso the fruit pulp is used for treating skin infections. A preparation of the fruits is taken against dizziness in Niger and Togo. In Senegal a mixture of the leaves of *Detarium microcarpum*, *Sclerocarya birrea* (A.Rich.) Hochst. and *Acacia macrostachya* Rchb. ex DC. pounded in milk is considered very efficient for snakebites. In Benin a decoction of the leaves is taken to treat fainting and convulsions. In West Africa the roots are part of a medico-magical treatment for mental conditions, and for protection against bad spirits. In veterinary medicine the leaves and roots are used to treat diarrhoea in cattle in southern Mali, and in Benin to treat constipation. In Niger cattle are made to inhale the smoke of the leaves to treat fever.

The fruit is sweet and commonly eaten fresh, while the pulp is used in the preparation of cakes and couscous. The pulp is used as a substitute for sugar. The seeds are used as frankincense and to make necklaces for women. The seeds and leaves are eaten as a condiment and vegetable. The wood is hard and tough, with a regular grain, and is easy to work. It is used for carpentry, fence poles and joinery. It is durable and long-lasting even under water. The wood is well appreciated as firewood, as it lights quickly even if wet. *Detarium microcarpum* is well integrated in the traditional agroforestry systems of the Sahel, and it can be coppiced well. The leaves and flowers are used as fodder, and the seeds as pig feed. In southern Mali the leaves are used as roofing material, and as organic fertilizer. In Burkina Faso the leaves are used to make masks. The heated roots are sweet scented and are used as a perfume by Dinka women in Sudan, and as a mosquito-repellent in Chad.

Production and international trade Statistics on production and trade of *Detarium microcarpum* are scarce, despite the fact that the leaves and roots are commonly sold on markets throughout West Africa. In 2005 1 kg of fruits sold for about US$ 0.04 during harvest time in Mali and about US$ 0.70 at the market in Dakar, Senegal. The seeds were sold in 2004 in francophone West Africa for € 8.50/kg.

Properties The ethanol extract of the bark showed antimicrobial action against *Pseudomonas aeruginosa*, *Citrobacter freundii*, *Klebsiella pneumoniae*, *Staphylococcus aureus*, *Streptococcus pyogenes* and *Listeria monocytogenes*. The extract showed moderate antitumour activity against breast cancer cells. The flavanes present in a methanol extract of *Detarium microcarpum* showed strong inhibitory effects on HIV-1 or HIV-2 infection. A bark extract showed significant molluscicidal activity against *Lymnaea natalensis*. It has been found to contain 2 tetranorditerpenes, the clerodane diterpenes catechine and cis-2-oxokolavenic acid (0.5%), the diterpene copalic acid (1.7%) and coumarin (1%). A methanol extract of the leaves exhibited strong feeding deterrent activity against the termite *Reticulitermes speratus*. Four clerodane diterpenes were isolated as active components, which possessed strong antifeedant activity at 1%.

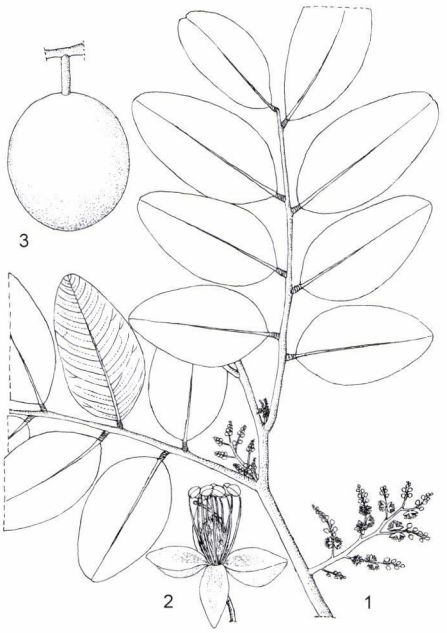
The seeds yield 7.5% oil, with linoleic acid being the predominant fatty acid. The gum content (water-soluble polysaccharides) is high. The hulled seed flour contains per 100 g: water 3.5–6.5 g, crude fibre 3 g, crude fat 13–15 g, crude protein 13.5–27 g, carbohydrate 39 g, Ca 500 mg, Mg 500 mg, Fe 100 mg. The major alcohol-soluble sugar in the hulled seed flour is sucrose. The seed flour is used as a traditional emulsifying, flavouring and thickening agent. Roasting the seeds increases crude fat content, crude protein content, ash content, the water absorption capacity, oil absorption capacity and gelation temperature, but decreases carbohydrate content, crude fibre content, the emulsion capacity and the swelling index. Soaking the seeds increased moisture content, carbohydrate content, crude protein content, ash content, the water absorption capacity, oil absorption capacity, gelation temperature and the swelling index, but decreased crude fat content, crude fibre content and the emulsion capacity.

The seed gum contains D-galactose as a major monosaccharide, as well as D-mannose and D-glucose. Incorporation of 0.5% gum in wheat flour increased the water absorption and the mixing tolerance index of the dough significantly. Oil-water emulsions stabilised by the seed flour or gum tolerate freezing and thawing better than commercial salad dressing, egg powder and gum tragacanth emulsions. Addition of the seed polysaccharide to fruit products (mango, orange, pineapple, tomato) improved their stability in storage (at 26°C) for at least 2

months and was well acceptable to consumers. The fruit pulp contains 90% dry matter, of which 4–6 g/100g protein and 3 mg/100 g ascorbic acid.
The wood of *Detarium microcarpum* is dark brown, rough and moderately heavy.

Adulterations and substitutes The fruits of *Detarium senegalense* J.F.Gmel. are eaten as substitute for those of *Detarium microcarpum*, although the fruits of certain populations are toxic.

Description Small tree up to 10 m tall; root system horizontal; bole usually straight, cylindrical, 30 cm in diameter; bark scaling on older branches, grey, brown or reddish; crown irregular. Leaves alternate, paripinnately compound 14–20 cm long, with 3–4(–6) pairs of leaflets, short hairy when young, glabrescent; stipules linear, 4–6 mm long, caducous; petiole 1–3 cm long; petiolule 0.5–1 cm long; leaflets alternate to subopposite, ovate, oblong to elliptical, 7–11 cm × 3.5–5 cm, base rounded, apex usually emarginate, thickly leathery, with numerous translucid gland-dots. Inflorescence a compact axillary panicle, 5–15(–25) cm long, 1-several together, 3–60-flowered. Flowers bisexual, regular, sessile, fragrant; sepals 4, elliptical, white or cream, densely pubescent outside; petals absent; stamens (8–)10, free; ovary superior, sessile, 1-celled, style slender, stigma terminal, head-shaped. Fruit an ovoid or rounded, indehiscent drupe-like pod, 2.5–4.5 cm in diameter, more or less flattened, glabrous, yellowish when ripe, with c. 1 cm of greenish mealy pulp, fibrous and sweet, 1-seeded. Seed orbicular, 15–20 mm × 6.5–8.5 mm. Seedling with epigeal germination.



Detarium microcarpum – 1, flowering branch; 2, flower; 3, fruit.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Detarium* belongs to the tribe *Detarieae* and is related to *Copaifera*. It is confined to Africa and comprises 3 species: *Detarium microcarpum*, *Detarium senegalense* J.F.Gmel. and *Detarium macrocarpum* Harms, which are morphologically very similar, but ecologically differentiated. *Detarium microcarpum* is typically a species of the dry savanna, *Detarium senegalense* is more riparian and also occurs in dry forest, and *Detarium macrocarpum* occurs in humid forest.

Growth and development *Detarium microcarpum* regenerates well from shoots produced by the trunk or roots. Shoots from the trunk are much more vigorous than seedlings and can reach a height of 1.5–2 m in 1–2 years. In Cameroon the average seedling height after 3 years is 0.6 m, and the seedling may reach 1.5 m in 4 years. *Detarium microcarpum* flowers during the rainy season, from July–September(–November), and bears fruit from September–January(–May). It sheds its leaves in November and produces new ones in March. The main flowering period of a tree is up to 8 days only, and flowers are pollinated by insects, especially in the mornings. Trees often produce seedless fruits.

Ecology *Detarium microcarpum* grows on dry soil in wooded savanna and open woodland, and is locally very common. It is most common in regions with an annual rainfall of 600–1000 mm. It is mainly found on shallow, stony and lateritic soils, and on hills.

Propagation and planting The seeds can be stored at ambient temperature (26°C) for 5 years. To break dormancy, they are soaked in sulphuric acid for 30 minutes, followed by thorough washing and soaking in water for 24 hours. Scarification with sand and additional fungicide treatment also improves germination. The dormancy can also be broken by boiling the seeds for 7 minutes followed by soaking in lukewarm water for 24 hours. The weight of 100 seeds is 150–200 g.
In a nursery germination started 8–10 days after sowing. After 47 days, 71–100% of the

seeds sown in polythene bags had germinated. Natural germination is hampered by bush fires and dry spells. Direct-sown plantations have not been successful because of the slow early growth. *Detarium microcarpum* can also be multiplied by grafting adult twigs or shoots.
Protocols for micropropagation of *Detarium microcarpum* using axillary explants or cotyledons have been developed. Using 6-benzylaminopurine instead of kinetin enhanced shoot formation.

Management The density of *Detarium microcarpum* in natural stands can be up to 270 trees/ha. Young trees are regularly cut down on agricultural land because of the horizontal rooting system. The trees are pruned to stimulate fruit production on young branches. The trees are either cut at soil level or at 10–60 cm height; suckers formed on high stumps survive bush fires better than root suckers.

Harvesting The plant parts used are harvested according to need and availability. Fruits are harvested from March to May, leaves from April to November, while roots and bark are harvested throughout the year.

Yield In Mali a tree can produce 675 fruits on average, i.e. about 7 kg.

Handling after harvest The fruits of *Detarium microcarpum* can be kept for 1–3 years in jute bags. The leaves and bark are used fresh or dried for future use.

Genetic resources *Detarium microcarpum* is not genetically endangered, but in regions where population pressure is high it is overexploited for wood and is also frequently cut down on agricultural land. This can lead to its local disappearance.
Germplasm collections are held at the Institut d'Economie Rurale (IER) in Mali and at the Centre National des Semences Forestières (CNSF) in Burkina Faso.

Breeding A morphological and biochemical characterization of different populations of *Detarium microcarpum* in southern Mali was made as the first step in a study of the genetic structure of the species. The farmers' criteria for distinguishing types of *Detarium microcarpum* relate especially to bark colour, leaf size and fruit quality.

Prospects *Detarium microcarpum* is considered a valuable species because of its medicinal properties, edible fruit and hard wood. To prevent overexploitation, it should be protected from cutting and bushfires. The species is worth domesticating. Despite the numerous medicinal uses, phytochemical analyses are scarce and deserve more attention. The seed flour has good nutritional quality and the functional properties confirmed their suitability for use in various food preparations. There are several opportunities for increased use of this multipurpose species.

Major references Abreu et al., 1998; Abreu et al., 1999; Adjanohoun et al., 1989; Baerts & Lehmann, 2002b; Burkill, 1995; Dione, 2001; Keay, Hoyle & Duvigneaud, 1958; Kerharo & Adam, 1974; Kouyaté, 2005; Leung, Busson & Jardin, 1968.

Other references Adjanohoun et al., 1985; Akpata & Miachi, 2001; Bationo, Ouedraogo & Guinko, 2001; Baumer, 1995; Couteron & Bergeret, 1995; Hugé, 2002; Idu, Ijomah & Omonhinmin, 2002; Kouyaté, Meyer & van Damme, 2002; Lajide, Escoubas & Mizutani, 1995; Mahmood et al., 1993; Meyer, 2001; Moustapha et al., 2003; Neuwinger, 1996; Njoku, Obioma & Frank, 1999; Okorie & Amaechi, 2003; Onweluzo, Leelavathi & Rao, 1999; Onweluzo et al., 1999; Sanogo & Sanogo, 2000; Van den Eynden, Van Damme & de Wolf, 1994; Wittig & Guinko, 1998.

Sources of illustration Berhaut, 1975b; Aubréville, 1968.

Authors A.M. Kouyaté & P. van Damme

DICHOSTEMMA GLAUCESCENS Pierre

Protologue Bull. Mens. Soc. Linn. Paris 2(159): 1260 (1896).

Family Euphorbiaceae

Origin and geographic distribution *Dichostemma glaucescens* occurs from Nigeria east to the Central African Republic and south to DR Congo.

Uses In Gabon a stem bark maceration is considered a tonic for nursing women. It is also taken as an emetic. In Congo an infusion of young leaves is taken to treat gastro-intestinal and liver complaints; the leaves are also eaten as a salad for the same purpose. In DR Congo the foul-smelling bark powder applied to the skin repels biting red ants; sometimes it is also put in the nest. Bark powder in water is taken to treat insanity and the bark enters in a mixture to treat male infertility. The sap is applied to teeth to treat toothache. In Cameroon and Gabon the juice of the twigs is an ingredient of arrow poison.
The whitish pink wood is used in house construction and as fuel.

Properties A preliminary test showed that

the leaves are rich in tannins.

Botany Monoecious, small, slender tree up to 13 m tall; twigs glabrous, with abundant latex. Leaves alternate, simple and entire; stipules absent; petiole 7–12 mm long; blade elliptical-oblong to lanceolate, 8–19 cm × 2.5–8 cm, base cuneate, apex acuminate, firmly papery to leathery, glabrous, glossy green above, glaucous beneath, pinnately veined with 6–8 pairs of lateral veins. Inflorescence a terminal, pyramidal, loose panicle up to 40 cm long, with powder-like indumentums, branches terminating in a group of 3 flower clusters enclosed by 2 deeply concave bracts, soon falling, leaving conspicuous scars; each flower cluster with cup-like, 4-angled, glandular involucre c. 2.5 mm long, containing 5–10 male flowers, sometimes also with a female flower. Flowers unisexual; male flowers reduced to a single, jointed stamen; female flowers reduced to a stalked ovary, usually 4-celled, with 4 styles fused at base, notched or shortly 2-fid at apex. Fruit a 4-lobed capsule 2.5–3.5 cm in diameter, depressed, appressed hairy with brown to dull purple hairs, 4-seeded. Seeds ellipsoid to almost globose, c. 11 mm in diameter, smooth, brown.

Dichostemma comprises 2 species, which both occur in tropical Africa.

Ecology *Dichostemma glaucescens* occurs in rainforest, including secondary forest, as an understorey tree, from sea-level up to 500 m altitude. It is locally dominant along rivers, e.g. in Congo.

Genetic resources and breeding *Dichostemma glaucescens* is common in its area of distribution and therefore not threatened by genetic erosion.

Prospects *Dichostemma glaucescens* will probably remain of local importance only unless chemical and pharmacological analyses reveal interesting compounds or pharmacological activities.

Major references Brown, Hutchinson & Prain, 1909–1913; Burkill, 1994; Neuwinger, 1996; Neuwinger, 2000.

Other references Falconer, 1990; Keay, 1989; Pauwels, 1993; Raponda-Walker & Sillans, 1961; Terashima, Ichikawa & Sawada, 1988.

Authors G.H. Schmelzer

DIPLORHYNCHUS CONDYLOCARPON (Müll.Arg.) Pichon

Protologue Bull. Mus. natn. Hist. nat., Paris, sér. 2, 19: 368 (1947).

Family Apocynaceae

Chromosome number $2n = 22$

Synonyms *Diplorhynchus mossambicensis* Oliv. (1881).

Vernacular names Horn-pod tree, wild rubber (En). Jasmineiro de Africa, jasmineiro de Cazengo (Po). Mtogo (Sw).

Origin and geographic distribution *Diplorhynchus condylocarpon* occurs from DR Congo and Tanzania south to South Africa, but is rare in Namibia and Botswana.

Uses Throughout its area of distribution, a decoction of the root bark of *Diplorhynchus condylocarpon* is used to treat indigestion, diarrhoea, fever, snakebites, infertility and venereal diseases. In Tanzania a root decoction is used to treat rectal prolapse, diabetes, testicle inflammation and is applied externally to treat sore eyes. It is also taken to facilitate giving birth. In Malawi a leaf infusion is used to treat headache and stomach problems, while a decoction of the root with salt is used to treat cough. The latex is smeared on cuts to heal them. In Zambia a root decoction is used to treat chronic cough, pneumonia and pulmonary tuberculosis. The body is washed with a root infusion to treat measles, and the infusion is also taken orally. Root powder is taken with food to treat anorexia and in porridge to treat pain in the digestive tract.

The wood of *Diplorhynchus condylocarpon* is suitable for ornaments, furniture, fencing and firewood and to make charcoal. *Diplorhynchus condylocarpon* is a food plant of the edible caterpillar *Brunaea alcinoe*. In Zambia branches are cut as cattle feed. The bark fibre is used for weaving in a similar way as the bark fibre of baobab (*Adansonia digitata* L.). In DR Congo the latex is used to repair bicycle tyres and for trapping birds. In Namibia it is used as glue to stick feathers and metal tips to arrows. In southern Africa the latex is also smeared on hides of drums to improve the tone.

Properties Alkaloids are present in both the stem bark and root bark of *Diplorhynchus condylocarpon*, the latter being richer. These alkaloids belong to 3 main groups: yohimbine and its isomer β-yohimbine; nor-macusine B (tombozine or diplorrhyne), stemmadenine and condylocarpine; and 14-hydroxy-(–)-akuammicine (mossambine or diplorhyncine) and nor-

fluorocurarine. Most of these compounds also occur in other members of *Apocynaceae*.
An aqueous extract of the roots and stems is reported to be a useful sympatholytic. Ethanolic extracts of the roots did not show a significant antiplasmodial activity in vitro.

Botany Shrub or small tree up to 12(–20) m tall, with white or yellow latex; bole up to 50(–200) cm in diameter; bark smooth to rough, longitudinally fissured or reticulate, greyish to brownish or blackish. Leaves decussately opposite, simple and entire; stipules absent; petiole 1–2 cm long, hairy; blade obovate to elliptical, ovate or almost circular, 4–9 cm × 2–5 cm, base cuneate to obtuse, apex acute, acuminate, rounded or emarginate, leathery, glabrous to shortly hairy. Inflorescence a lax to congested thyrsoid cyme, terminal and in axils of the upper leaves; peduncle 0.5–4 cm long; bracts obscure, rounded. Flowers bisexual, regular, 5-merous, very sweet-scented; pedicel 0.5–2.5 mm long; sepals connate at base, ovate, acute; corolla tube cylindrical, 2–3 mm × 1–1.5 mm, constricted at throat, lobes narrowly oblong to narrowly ovate, c. 5 mm long, rounded to slightly acute, with many glandular hairs, with a scale between bases of lobes, white to creamy; stamens inserted near the middle of the corolla tube and included, anthers c. 1 mm long; ovary superior, consisting of 2 free, obovoid carpels, style slender, c. 1 mm long, pistil head almost cylindrical, woolly hairy. Fruit consisting of 2 obliquely oblong, widely spreading follicles 3–6.5 cm × 1–2 cm, coherent at the base, apex abruptly curved, woody, green or pale to dark brown, 2-valved, 4-seeded. Seeds obliquely oblong, 3.5–4.5 cm long, laterally compressed, dark brown, at apex with large transparent wing.
Diplorhynchus comprises a single species.

Ecology *Diplorhynchus condylocarpon* occurs in dry deciduous woodland and on stony hillsides, up to 1700 m altitude.

Management Propagation can be done by means of seed, cuttings and wildlings. Cut trunks sprout easily from the base. Coppicing and pollarding are appropriate management techniques.

Genetic resources and breeding *Diplorhynchus condylocarpon* is widespread in most of its area of distribution and is not in danger of genetic erosion.

Prospects *Diplorhynchus condylocarpon* is a useful medicine in rural communities. In view of its many medicinal uses, further research into the pharmacological activities of *Diplorhynchus condylocarpon* may prove worthwhile.

Major references Chilufya & Tengnäs, 1996; Hedberg et al., 1982; Leeuwenberg et al., 1985; Neuwinger, 2000; Plaizier, 1980.

Other references Chhabra, Mahunnah & Mshiu, 1987; Chinemana et al., 1985; Coates Palgrave, 1983; Gelfand et al., 1985; Kokwaro, 1993; Latham, 2004; Leger, 1997; Ndubani & Höjer, 1999; van Wyk & Gericke, 2000.

Authors A. de Ruijter

DISCOCLAOXYLON HEXANDRUM (Müll.Arg.) Pax & K.Hoffm.

Protologue Engl., Pflanzenr. IV 147 VII: 137 (1914).

Family Euphorbiaceae

Synonyms *Claoxylon hexandrum* Müll.Arg. (1864).

Origin and geographic distribution *Discoclaoxylon hexandrum* occurs from Sierra Leone east to Ghana and from Nigeria east to Uganda and south to DR Congo.

Uses In Ghana a decoction of the leafy twigs is taken as a purgative. Children play with the bright red seeds.

Botany Small, dioecious, sparingly branched small tree up to 6(–10) m tall; bark grey; young shoots and petioles sparingly short-hairy, later almost glabrous, yellowish grey-green. Leaves alternate, simple; stipules tiny, soon falling; petiole (5–)8–17(–20) cm long, purplish; blade elliptical-oblong, 20–35 cm × 10–15 cm, base rounded to cuneate, apex acute to obtuse, margins toothed, firmly papery to leathery, almost glabrous, but short-hairy on main veins, purplish, later dark and glossy green. Inflorescence an axillary raceme up to 30(–50) cm long; bracts c. 1.5 mm long, acuminate, densely hairy. Flowers unisexual, petals absent; male flowers with jointed pedicel 3–4(–7) mm long; sepals 4, broadly triangular-ovate, c. 1.5 mm long, densely short-hairy outside, glabrous inside, pale green, disk shallowly lobed, c. 1.5 mm in diameter, papillose, stamens 6–7(–9), filaments c. 0.5 mm long, free; female flowers almost sessile, pedicel extending to 2 mm in fruit, basally jointed, calyx lobes 4, ovate, 1–1.5 mm long, united at base, densely woolly hairy outside, grey-green, disk glands 2, broadly triangular, c. 1 mm × 1.5 mm, ovary superior, 2-lobed, c. 1.5 mm in diameter, densely woolly hairy, 2-celled, styles 2, c. 0.5 mm long, free, feathery-hairy. Fruit a 2-lobed capsule c. 5 mm

× 10 mm, lobes almost globular, densely yellowish grey-green woolly hairy, 2-seeded. Seeds almost globose, 3.5–4 mm in diameter, smooth, blackish, with a yellow, fleshy pseudoaril.

Discoclaoxylon comprises 4 species, which all occur in tropical Africa. *Discoclaoxylon hexandrum* is the only species with a relatively widespread distribution; the other 3 species are endemic to different islands in the Gulf of Guinea. How distinct they are from one another requires further study. Some authors include *Discoclaoxylon* in *Claoxylon*.

Ecology *Discoclaoxylon hexandrum* occurs in the understorey of secondary forest, often near paths, from sea-level up to 1200 m altitude.

Genetic resources and breeding *Discoclaoxylon hexandrum* occurs in secondary vegetation and does not seem to be threatened by genetic erosion.

Prospects *Discoclaoxylon hexandrum* will probably remain of limited local importance as a medicinal plant.

Major references Burkill, 1994; Irvine, 1961; Radcliffe-Smith, 1987.

Other references Abbiw, 1990; Govaerts, Frodin & Radcliffe-Smith, 2000; Keay, 1958a; Keay, 1989.

Authors G.H. Schmelzer

DISCOGLYPREMNA CALONEURA (Pax) Prain

Protologue Bull. Misc. Inform. Kew 1911: 317 (1911).

Family Euphorbiaceae

Chromosome number $n = 6$

Vernacular names Atieghe (Fr).

Origin and geographic distribution *Discoglypremna caloneura* occurs from Guinea east to Uganda and south to DR Congo.

Uses In West Africa a decoction of the crushed leaves is taken as an expectorant in bronchial problems. The seed or seed oil is taken as an emetic and purgative against dysentery, diarrhoea and oedema, and to help in cases of difficult childbirth and as an abortifacient. The seed oil mixed with bait is used to kill unwanted animals. In Congo a bark decoction is taken to relieve coughing fits and intestinal pain caused by food poisoning, and as an emetic. Bark powder is applied to sores to promote healing. A maceration of ground leaves in water is applied to the head to kill lice.

The wood is easy to carve and masks and domestic utensils are made from it. It is suitable for light construction, light flooring, joinery, interior trim, ship building, vehicle bodies, furniture, cabinet work, boxes, crates, matches, turnery, veneer, plywood, hardboard, particle board and pulpwood. It is also used as fuel. In Ghana the fleshy fruits are used as bait in bird traps.

Properties Preliminary tests showed the presence of tannins in the stem bark and roots, and several diterpene derivatives in the stem bark. The stem bark also contains 3-O-acetyl aleuritolic acid, which exhibited significant antifilarial activity, affecting the vitality of adult male filaria of *Onchocerca gutturosa*. A crude ethanolic leaf extract showed moderate bacteriostatic effects in vitro against *Staphylococcus aureus* and *Enterococcus faecalis*.

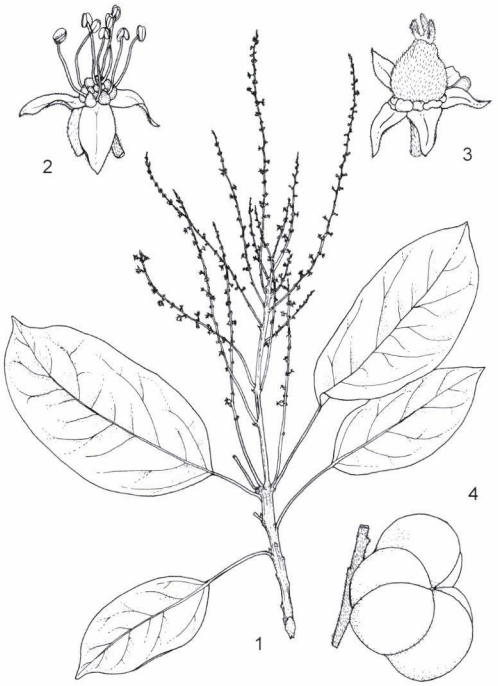
The heartwood is whitish to yellowish brown and indistinctly demarcated from the sapwood. The grain is straight, texture rather coarse. Radial surfaces show some darker streaks and a slight silvery figure. The wood is lightweight, with a density of 380–420 kg/m^3 at 12% moisture content. It air dries fairly well and rapidly. The rates of shrinkage are moderate, from green to oven dry 2.0–4.0% radial and 5.6–7.5% tangential. Once dry, it is moderately stable in service.

At 12% moisture content, the modulus of rupture is 64–85 N/mm^2, modulus of elasticity 6960–8430 N/mm^2, compression parallel to grain 24–36 N/mm^2, shear 4.5–6 N/mm^2, cleavage 7.5–17 N/mm and Chalais-Meudon side hardness 1.0–1.4.

The wood is easy to saw and work with both hand and machine tools. It planes to a nice surface. It is easy to nail and screw, and it glues satisfactorily. Veneer production by peeling and slicing gives good results. The wood is not durable, being liable to blue stain, termite and *Lyctus* attacks. The heartwood is resistant to impregnation by preservatives, the sapwood permeable.

The papermaking qualities of the wood have been examined in a series of tests. They were not good enough to recommend the establishment of plantations for paper pulp. The wood ash is reported to produce sores on the skin.

Botany Large, dioecious tree up to 45 m tall; bole branchless for up to 30 m, up to 200 cm in diameter, with buttresses up to 3 m high; bark smooth, silvery; twigs dark purplish grey, sparingly short-hairy, later almost glabrous. Leaves alternate, simple, almost opposite to verticillate below the inflorescence; stipules tiny, soon falling; petiole (1–)3–5(–7) cm long, slightly



Discoglypremna caloneura – 1, flowering branch; 2, male flower; 3, female flower; 4, fruit.
Source: Flore analytique du Bénin

thickened at both ends, short-hairy above; blade oblong, elliptical-oblong to sometimes rounded, (3–)6–10(–15) cm × (2–)4–6(–10) cm, base rounded to cuneate with 2 elliptical glands, apex short-acuminate, margins entire or with remote, rounded teeth, 3-veined at base, almost glabrous, but short-hairy on main veins, purplish, later dark and glossy green. Inflorescence a terminal panicle with racemose branches, some arising from the base; male inflorescence up to 20 cm long; female inflorescence up to 8(–12) cm long; bracts c. 1 mm long, acuminate, hairy. Flowers unisexual, petals absent; male flowers with jointed pedicel 1–1.5 mm long, sepals 3–4, ovate, c. 1.5 mm long, acute, densely short-hairy outside, greenish, disk glands c. 15, ovoid, c. 0.5 mm in diameter, hairy at apex, stamens (6–)8(–15), filaments c. 2 mm long, free; female flowers with pedicel 1–1.5 mm long, jointed at base, calyx lobes (4–)5, ovate, c. 1.5 mm long, acute, reflexed, short-hairy outside, disk glands 6–8, obovoid, ovary superior, 3-lobed, c. 1.5 mm in diameter, densely yellowish hairy, 3-celled, styles 3, c. 1 mm long, free, feathery-hairy. Fruit a 3-lobed capsule 4–5 mm × 6–8 mm, smooth, sparsely short-hairy, greenish, 3-seeded. Seeds ovoid, 3–4 mm × 2–3 mm, smooth, black, with a red, fleshy pseudoaril.

Discoglypremna comprises a single species.

Anatomy Wood-anatomical description (IAWA hardwood codes):

Growth rings: (1: growth ring boundaries distinct); (2: growth ring boundaries indistinct or absent). Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal; 27: intervessel pits large (≥ 10 µm); 31: vessel-ray pits with much reduced borders to apparently simple: pits rounded or angular; 32: vessel-ray pits with much reduced borders to apparently simple: pits horizontal (scalariform, gash-like) to vertical (palisade); 42: mean tangential diameter of vessel lumina 100–200 µm; (43: mean tangential diameter of vessel lumina ≥ 200 µm); 46: ≤ 5 vessels per square millimetre; 56: tyloses common. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 68: fibres very thin-walled; 69: fibres thin- to thick-walled. Axial parenchyma: (76: axial parenchyma diffuse); 77: axial parenchyma diffuse-in-aggregates; 93: eight (5–8) cells per parenchyma strand. Rays: 97: ray width 1–3 cells; (98: larger rays commonly 4- to 10-seriate); (100: rays with multiseriate portion(s) as wide as uniseriate portions); (107: body ray cells procumbent with mostly 2–4 rows of upright and/or square marginal cells); 108: body ray cells procumbent with over 4 rows of upright and/or square marginal cells; 115: 4–12 rays per mm; 116: ≥ 12 rays per mm. Mineral inclusions: 136: prismatic crystals present; 137: prismatic crystals in upright and/or square ray cells; 140: prismatic crystals in chambered upright and/or square ray cells; (141: prismatic crystals in non-chambered axial parenchyma cells); 142: prismatic crystals in chambered axial parenchyma cells; (144: druses present); (145: druses in ray parenchyma cells); (146: druses in axial parenchyma cells); (148: druses in chambered cells).

(M. Thiam, P. Détienne & E.A. Wheeler)

Ecology *Discoglypremna caloneura* occurs in rainforest and old secondary forest, from sea-level up to 1100 m altitude. In West Africa it flowers from November to March and fruits from December to April. The fruits are dispersed by birds.

Genetic resources and breeding There are no signs that *Discoglypremna caloneura* is

at risk of genetic erosion.

Prospects *Discoglypremna caloneura* has several interesting medicinal uses, and more research into its chemistry and pharmacological activity seems warranted.

Major references Atindehou et al., 2002; Burkill, 1994; Manewa, 1997; Neuwinger, 2000; Nyasse et al., 2006.

Other references Abbiw, 1990; Akoègninou, van der Burg & van der Maesen, 2006; Akubue, Mittal & Aguwa, 1983; Bolza & Keating, 1972; InsideWood, undated; Normand, 1955; Petroff, Doat & Tissot, 1967; Stäuble, 1986; Takahashi, 1978; Téré, 2000.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors G.H. Schmelzer

DRYPETES CHEVALIERI Beille

Protologue Bull. Soc. Bot. France 61, Mém. 8: 293 (1917).

Family Euphorbiaceae (APG: Putranjivaceae)

Origin and geographic distribution *Drypetes chevalieri* occurs from Liberia east to Congo.

Uses In Liberia the sap from the leaves and twigs is taken to treat dysentery and other intestinal troubles. In Côte d'Ivoire the powdered leaves are sniffed to treat colds, sinusitis and bronchial problems.

In Nigeria twiggy branches are made into brooms.

Properties An extract of the dried stem yielded the sterol erythrodiol and the triterpenes drypechevalin A and drypechevalin B, lupeol, lupeone, putranjivadione and friedelin.

Botany Monoecious or dioecious shrub or small tree up to 6 m tall; young stems with yellow to orange erect hairs. Leaves alternate, distichously arranged, simple; stipules small, soon falling; petiole up to 4 mm long; blade ovate to orbicular, 5–18 cm × 2–7.5 cm, base asymmetrical, one side deeply cordate, overlapping the twig, other side rounded to cordate, amplexicaul on young lateral shoots, apex long-acuminate, margins sharply toothed, with 6–8 pairs of looping lateral veins. Flowers axillary, unisexual, regular; petals absent; male flowers 2–3 together, with pedicel up to 2 mm long, sepals 4, small, short-hairy, stamens 8–15; female flowers solitary, with a pedicel up to 8 mm long, sepals 4, triangular to rounded, c. 2 mm long, short-hairy, yellowish green, ovary superior, slightly 2-lobed, densely white-hairy, 2-celled, styles 2, c. 1 mm long, stigma large, 2-lobed, flattened. Fruit an ellipsoid drupe up to 2.5 cm long, short-hairy, smooth, yellow to orange, 2-seeded. Seeds compressed ovoid, pale cream to brown.

Drypetes comprises about 210 species and is distributed throughout the tropics and subtropics. About 60 species occur in continental Africa and about 15 in the Indian Ocean islands. Several other *Drypetes* spp. are medicinally used in West Africa. *Drypetes ivorensis* Hutch. & Dalziel occurs from Liberia east to Cameroon. In Côte d'Ivoire the bark and fruits are crushed to make a dressing to mature abscesses. The bark is toxic and is used to prepare bait to poison rats and mice. In Liberia the fruits are eaten. Small rice mortars are made from the wood. *Drypetes leonensis* Pax occurs from Guinea to the Central African Republic, Gabon and DR Congo. A palm wine maceration of the stem bark is drunk to treat colic in children. The vapour from boiling bark is inhaled and a decoction is used as a mouth wash to treat scurvy.

Ecology *Drypetes chevalieri* occurs in wet or dry forest, from sea-level up to 1000 m altitude.

Genetic resources and breeding *Drypetes chevalieri* is relatively common in its distribution area and therefore probably not threatened by genetic erosion.

Prospects *Drypetes chevalieri* has several medicinal uses. Research showed the presence of several phytochemically active compounds, but more research is needed to evaluate its potential.

Major references Burkill, 1994; Hawthorne & Jongkind, 2006; Wansi et al., 2006.

Other references Neuwinger, 2000; Wurdack et al., 2004.

Authors G.H. Schmelzer

DRYPETES GOSSWEILERI S.Moore

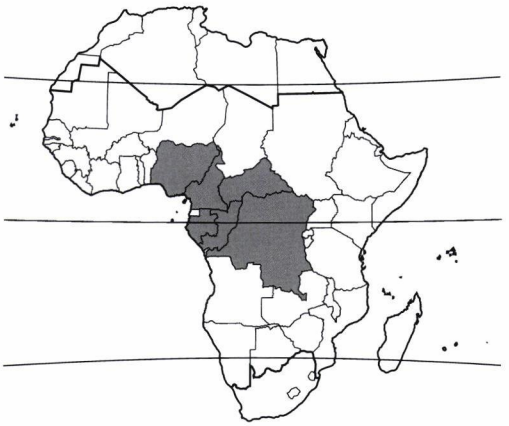
Protologue Journ. Bot. 58: 271 (1920).

Family Euphorbiaceae (APG: Putranjivaceae)

Synonyms *Drypetes amoracia* Pax & K.Hoffm. (1922).

Vernacular names Horseradish tree, okhuaba, akot (En). Bossmé, yungu, youngou (Fr).

Origin and geographic distribution *Drypetes gossweileri* occurs from Nigeria east to the Central African Republic and south to DR



Drypetes gossweileri – wild

Congo.

Uses The bark has a pungent taste, and has many medicinal uses. A bark decoction or maceration is widely drunk as a purgative to expel intestinal worms and treat diarrhoea; it is also applied as an enema. The ground stem bark mixed with palm oil is rubbed in to treat headache, toothache, intercostal pain, kidney pain, rheumatism and bronchitis.

In Cameroon and Congo stem bark powder is eaten to treat sexual asthenia and to treat venereal diseases. In Congo the bark powder cooked with banana is taken as an aphrodisiac. In the Central African Republic a bark decoction is drunk as a tonic after childbirth, and to treat bronchitis, cough and other lung problems. A bark decoction is rubbed onto scabies and is also used for bathing children to treat fever. A paste of stem bark scrapings in water is applied to injuries, ulcers and swellings. In DR Congo a leaf decoction is used as a wash and is drunk as a treatment for asthma in children. The bark powder is taken by women to induce abortion.

The stem bark, leaves and fruits are used to stupefy fish to catch them more easily. In Cameroon the cooked seeds are eaten by the Baka pygmies. The wood is used for planks and carpentry, but the sawdust can cause dermatitis, ocular and respiratory problems. In Gabon the fruit husks are used in ritual dances, attached to the limbs and clothing. In Congo the strong-smelling roots are placed on the roof or a root decoction is sprinkled around the house to repel snakes.

Production and international trade *Drypetes gossweileri* is only traded locally as a medicinal plant. The dried stem bark is sold in the local markets of Cameroon for the treatment of typhoid diarrhoea; in 2002 the bark was sold at about US$ 0.20 per g.

Properties All parts of the tree when bruised or cut emit a pungent smell, resembling that of horseradish or mustard. The essential oil of the stem bark obtained from samples from the Central African Republic and Gabon contained mainly benzyl isothiocyanate (56–94%), accompanied by benzyl cyanide and benzaldehyde. The main component in a sample from Cameroon was benzyl cyanide (19.4–73.7%). Minor compounds are the triterpenes friedelin, friedelane-3,7-dione and derivatives, methyl putranjate, stearic acid, stigmasterol stearate and β-sitosterol stearate. The bark also contains the alkaloid drypetesgenine and the podocarpane diterpenoid gossweilone.

Crude aqueous and ethanol extracts of the stem bark inhibited the growth of *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Klebsiella* sp. and *Proteus* sp., with the ethanol extracts exhibiting the highest inhibitory activity. The acetone extract of the stem bark showed a strong purgative effect in mice. The LD_{50} of the methanol stem bark extract in the brine shrimp test was low. The extract showed significant phytotoxic activity against *Lemna minor* L. as well as antifungal activity against *Microsporum canis* and *Trichophyton longiformis*. The antioxidant and antiradical activities of the essential oil were found to be low.

The wood is pale yellow or whitish with fine texture and moderately heavy, with a density of 760–800 kg/m^3 at 12% moisture content. It is moderately hard, elastic and often has a bad smell.

Adulterations and substitutes The pungent smell and medicinal uses of the stem bark of *Drypetes gossweileri* are similar to those of the roots of *Pentadiplandra brazzeana* Baill. And the two species are often used indiscriminately.

Description Medium-sized dioecious tree up to 30(–42) m tall; bole straight, up to 120 cm in diameter, often irregularly fluted; bark greyish green to yellowish green, with many lenticels, strong-smelling when cut. Leaves alternate, simple; stipules small; petiole up to 2 cm long; blade oblong, 10–24 cm × 3–9 cm, base cuneate to rounded, asymmetrical, apex acuminate, margins toothed or sometimes entire, leathery, glabrous. Inflorescence an axillary fascicle, female one few-flowered. Flowers unisexual,

regular; pedicel up to 2 cm long; sepals 5, ovate, 12–16 mm long, densely short-hairy, brownish green; petals absent; male flowers with c. 30 stamens, disk cup-shaped; female flowers with superior ovary, short-hairy, styles 2. Fruit an apple-shaped drupe 8–10 cm × 5–6 cm, greenish brown or yellow, velvety brown-hairy, pulp yellow, 3–7-seeded. Seeds compressed ovoid, pale brown.

Other botanical information *Drypetes* comprises about 210 species and is distributed throughout the tropics and subtropics. About 60 species occur in continental Africa and about 15 in the Indian Ocean islands. Several other *Drypetes* spp. are medicinally used in Central Africa. *Drypetes capillipes* (Pax) Pax & K.Hoffm. occurs throughout Central Africa. In Cameroon pulverized root bark is applied to furuncles to ripen them. In Congo a bark decoction is used as a mouthwash to treat toothache and as a wash to treat kidney pain. The neck is massaged with the leaves to treat a stiff neck. *Drypetes klainei* Pierre ex Pax occurs in Côte d'Ivoire and Gabon, and in Gabon a maceration or decoction of fresh stem bark is rubbed in to treat rheumatism. An extract of the stem bark together with dried unripe fruits of hot pepper is drunk to expel worms. A decoction of the stem bark and leaves of *Drypetes natalensis* (Harv.) Hutch., occurring in eastern and southern Africa, is taken to reduce fever in patients with malaria. The wood is used for firewood, charcoal, wooden spoons, tool handles and beds.

Growth and development *Drypetes gossweileri* flowers from May to December and fruits mainly in June. In Cameroon it was found that it forms an association with vesicular-arbuscular mycorrhizae (VAM).

Ecology *Drypetes gossweileri* occurs in semi-deciduous humid forest, including secondary forest, at low altitudes.

Handling after harvest The harvested stem bark is used fresh or can be dried for later use.

Genetic resources There are no signs that *Drypetes gossweileri* is threatened by genetic erosion.

Prospects *Drypetes gossweileri* does not seem to be of particular interest to researchers, which is possibly due to the cyanide-containing compounds in the stem bark. The stem bark is expected to remain important in traditional medicine though.

Major references Adjanohoun et al., 1996; Bouquet, 1969; Burkill, 1994; Keay, 1958a; Mve-Mba et al., 1997; Neuwinger, 2000; Ngoupayou, 2003; Tailfer, 1989; Vivien & Fauré, 1985.

Other references Agnaniet et al., 2003; Betti, 2002; Dupont et al., 1997; Gessler et al., 1995; Ijah & Oyebanji, 2003; Lovett et al., 2006; Ndouga et al., 1991; Ngouela et al., 2003; Raponda-Walker & Sillans, 1961; Sow et al., 1994; Thirakul, 1983; Vivien & Fauré, 1988.

Authors A.T. Tchinda & V.S.T. Sob

DRYPETES MOLUNDUANA Pax & K.Hoffm.

Protologue Engl., Pflanzenr. IV 147 XV: 258 (1922).

Family Euphorbiaceae (APG: Putranjivaceae)

Origin and geographic distribution *Drypetes molunduana* occurs in Nigeria, Cameroon and Gabon.

Uses In Cameroon a decoction of the leafy stem is taken to treat inflammations, boils, swellings and tumours. It is also used as a pain killer.

The wood is hard and in southern Nigeria it is used for construction.

Properties Chemical analysis of the stems revealed the presence of the sesquiterpene lactone drypemolundein A, friedelane-3,7-dione and the friedelane derivatives drypemolundein B and acetyldrypemolundein, erythrodiol, oleanolic acid, hederagenin, syringaresinol and bayogenin.

Oral administration of the stem extract showed significant anti-inflammatory and analgesic activities in rats. Drypemolundein A is mainly responsible for these activities. Drypemolundein B was found to be inactive.

Botany Dioecious shrub or small tree up to 6 m tall; branchlets deeply grooved, short-hairy. Leaves alternate, simple; stipules 5–10 mm long, persistent; blade elliptical-oblong to obovate-oblong, 11–27 cm × 4–9 cm, base cuneate to obtuse, apex long-acuminate, margins toothed. Inflorescence a dense fascicle, cauliflorous on the main stem. Flowers unisexual, regular, sweet-scented; sepals 5, ovate, 6–9 mm × 4–6 mm, short-hairy outside, greenish to yellowish or white; petals absent; male flowers with short pedicel, stamens 12–18; female flowers with a short pedicel, extending up to 2.5 cm in fruit, ovary superior, globose, white-hairy, styles 2, triangular, persistent. Fruit an ovoid to ellipsoid drupe, c. 3 cm × 2.5 cm, orange to red when ripe, 2-seeded. Seeds com-

pressed ovoid, pale brown.

Drypetes comprises about 210 species and is distributed throughout the tropics and subtropics. About 60 species occur in continental Africa and about 15 in the Indian Ocean islands. *Drypetes staudtii* (Pax) Hutch. occurs in Nigeria and Cameroon. It is listed as vulnerable in the IUCN Red List of threatened species. In Cameroon different plant parts are medicinally used in infusions and decoctions. The seeds were found to contain triterpenoids and flavonoids. One species from the Indian Ocean islands is medicinally used. The pulp made from the leafy branches of *Drypetes madagascariensis* (Lam.) Humbert & Leandri, endemic to Madagascar, is rubbed into scarifications to increase milk production. The fruits are eaten by children.

Ecology *Drypetes molunduana* occurs in the understorey of primary forest, from sea-level up to 1000 m altitude.

Genetic resources and breeding There are no signs that *Drypetes molunduana* is threatened by genetic erosion.

Prospects *Drypetes molunduana* merits further phytochemical and pharmacological research as the results so far have been promising.

Major references Burkill, 1994; Keay, 1958a; Nkeh et al., 2001; Nkeh et al., 2003; Wandji et al., 2000.

Other references Boiteau, Boiteau & Allorge-Boiteau, 1999; Cheek, 2004b; Leandri, 1958; McPherson, 2000.

Authors G.H. Schmelzer

ECHIUM STENOSIPHON Webb

Protologue Hook., Niger Fl.: 155, t. 15 (1849).

Family Boraginaceae

Vernacular names Língua de vaca (Po).

Origin and geographic distribution *Echium stenosiphon* is endemic to Cape Verde.

Uses In Cape Verde *Echium stenosiphon* is used to prepare a drink to cure colds. It is considered a valuable forage plant, especially the flowers, which are appreciated by livestock.

Properties No information on the chemical properties of *Echium stenosiphon* is available, but probably pyrrolizidine alkaloids are present as in other species of the *Boraginaceae*. Seed of several *Echium* species is rich in γ-linolenic acid.

Botany Shrub or undershrub up to 1.2 m tall, little branched, bristly hairy. Leaves alternate, simple and entire; stipules absent; petiole up to 2(–3) cm long; blade ovate, elliptical, obovate or rarely lanceolate, 3.5–14 cm × 2–5 cm, base cuneate or rounded, apex acute to rounded. Inflorescence a very lax, thyrsoid panicle with 3–10 lateral cymes. Flowers bisexual, 5-merous; calyx deeply lobed, lobes unequal; corolla lilac-blue, tube slightly curved, up to 2.5 cm long, lobes up to 2.5 mm long; stamens inserted on the corolla tube, unequal; ovary superior, 4-parted, style up to 2.5 cm long, stigma head-shaped. Fruit splitting into 4 muricate nutlets, each up to 3 mm long.

Echium comprises about 45 species, more than half of them endemic to Cape Verde, Madeira, the Azores and Canary Islands, while the other species have mainly a European, Mediterranean or North African distribution with a few species extending into Asia. *Echium arenarium* Guss. is applied in Sudan as a poultice against tumours and abscesses. In tropical Africa *Echium horridum* Batt. is only recorded in Mauritania, where it is considered to be useful fodder. It contains echimidine as major pyrrolizidine alkaloid, which is hepatotoxic, pneumotoxic, mutagenic and carcinogenic. Extracts of the aerial parts inhibit the growth of the gram-negative bacteria *Escherichia coli* and *Klebsiella* and of the fungus *Candida albicans*.

Ecology *Echium stenosiphon* occurs in rocky escarpments and fallow fields from sea-level up to 1250 m altitude.

Genetic resources and breeding *Echium stenosiphon* is considered vulnerable and measures to conserve it are long overdue. Clearing for agriculture is a major threat. No germplasm collections exist.

Prospects The use of *Echium stenosiphon* in traditional medicine and as forage seems marginal and will probably not gain in importance. The possible presence of toxic pyrrolizidine alkaloids warrants research.

Major references Gomes et al., 1995; Hilger & Böhle, 2000; Johnston, 1953; Martins, 1995; Silva et al., 1999.

Other references Andrews, 1956; Burkill, 1985; El-Shazly et al., 1999; Graham et al., 2000; Guil-Guerrero, Garcia-Maroto & Gimenez-Gimenez, 2001; Mahmoud et al., 1995; Qaiser, 1979; Verdcourt, 1991; Yousif, Iskander & Eisa, 1983.

Authors C.H. Bosch

EFULENSIA CLEMATOIDES C.H.Wright

Protologue Dyer, Icon. pl. 26: t. 2518 (1897).

Family Passifloraceae

Chromosome number $2n = 22$

Synonyms *Deidamia clematoides* (C.H.Wright) Harms (1897).

Origin and geographic distribution *Efulensia clematoides* occurs from southern Nigeria to DR Congo.

Uses In DR Congo a concentrated root decoction of *Efulensia clematoides* is used to produce arrow poison. The leaves are eaten to treat liver problems and enlargement of the spleen.

Properties Some saponins are present in the bark and roots of *Efulensia clematoides*. Hydrocyanic acid is abundant in the roots and traces of it occur in the bark. *Efulensia clematoides* contains the cyanohydrin glycosides barterin (tetraphyllin B) and deidaclin.

Botany Liana up to 30 m long; stem up to 5 cm in diameter, axillary tendrils present or not. Leaves alternate, 3-foliolate; stipules linear, 1.5–5 mm long; petiole 3.5–8.5 cm long, with a pair of glands at base; petiolules 1–3 mm long, distinctly articulate; leaflets obovate to elliptical, 3.5–12 cm × 2.5–7.5 cm, base cuneate to obtuse, apex acuminate or obtuse and mucronate, glossy at both sides, glaucous beneath. Inflorescence a terminal cyme, 10–many-flowered, often with a tendril in place of the terminal flower; peduncle 3–20 cm long. Flowers bisexual or functionally unisexual, regular, 5-merous, glabrous, whitish to greenish; pedicel 10–20 mm long; hypanthium shallowly cup-shaped or nearly flat, c. 5 mm wide; sepals ovate, 6–10 mm long, apex obtuse to acute; petals oblong, 5–8 mm long, apex acute; corona white, with tube 1–1.5 mm high and threads 3–7 mm long; stamens fused at base for 1–1.5 mm, sometimes with 5 small teeth alternating with the 6–10 mm long filaments; ovary superior, ellipsoid, 2–3 mm long, with stipe up to 1 mm long, 1-celled, styles 3, almost free to over halfway fused, 2–3 mm long, stigmas globose. Fruit a globular to flattened capsule c. 1.5 cm × 2.5 cm, with (2–)3(–4) longitudinal grooves, yellow to orange, 4–12-seeded. Seeds 7.5–9.5 mm long, with roughly pitted black testa.

Efulensia comprises 2 species, both occurring in tropical Africa.

Ecology *Efulensia clematoides* occurs in rainforest on dry and swampy localities, often in secondary forest and forest margins, from sea-level up to 900 m altitude.

Genetic resources and breeding *Efulensia clematoides* is widely distributed and not threatened with genetic erosion.

Prospects In view of the medicinal use on record, research into the properties of *Efulensia clematoides* may prove worthwhile. However, the species is likely to remain of limited importance.

Major references Bouquet & Debray, 1974; Burkill, 1997; Neuwinger, 2000; Olafsdottir, Andersen & Jaroszewski, 1989; Robyns, 1995.

Other references de Wilde, 1974; Long, Clapp & Ettlinger, 1970; Paris, Bouquet & Paris, 1969; Yamada, 1999.

Authors A. de Ruijter

EHRETIA OBTUSIFOLIA DC.

Protologue Prodr. 9: 507 (1845).

Family Boraginaceae

Synonyms *Ehretia coerulea* Gürke (1900).

Vernacular names Sandpaper bush, big-leaved puzzle bush (En). Mkilika (Sw).

Origin and geographic distribution *Ehretia obtusifolia* occurs in almost all countries of eastern and southern Africa and in Madagascar. It extends into Asia up to Pakistan and northwest India.

Uses In Zimbabwe the leaves of *Ehretia obtusifolia* are used as an infusion to treat sore throat and are rubbed on the gums of infants suffering from teething pains. In Zimbabwe powdered root is added to porridge to treat painful menstruation and infertility in women and an infusion of the roots is taken against retained placenta. A decoction of the roots is taken as a painkiller, specifically against abdominal pain in Zimbabwe and in Tanzania. The wood is used to make pestles for pounding grain in Zimbabwe. In Pakistan the leaves are used as a fodder and the wood as firewood.

Properties *Ehretia obtusifolia* has so far escaped attention of pharmacological research, but several Asian species of the genus (e.g. *Ehretia philippinensis* DC.) have been the subject of tests and analyses. In tests with mice, a crude stem bark extract of *Ehretia philippinensis* was found to be moderately toxic when administered intraperitoneally and slightly toxic when administered orally. A decrease in motor activity and slight analgesia were observed as well. Extracts of the stem bark showed inhibitory activity against compound 48/80, a potent histamine liberator. Rosmarinic acid was iden-

tified as the active constituent. A stem bark extract was also tested for anti-inflammatory activity using animal models, and was found comparable in potency to an aspirin reference. Five cyanoglucosides have been isolated: ehretiosides A1, A2, A3 and B, and simmondsin.

Botany Deciduous shrub or small tree up to 6 m tall; often straggling or with several branches from base; bark grey. Leaves alternate, simple; petiole up to 2 cm long; blade elliptical, oblong-elliptical or obovate, 1–9(–11) cm × 0.5–6(–8.5) cm, pubescent to velvety; base cuneate; apex obtuse to shortly acuminate. Inflorescence a corymbose cyme, terminal or on short lateral shoots, c. 2.5 cm wide, many-flowered, axes densely glandular pubescent. Flowers bisexual, regular, 5-merous, fragrant; pedicel up to 4.5 mm long; calyx lobes ovate, elliptical or narrowly triangular, 2 mm × 1 mm, puberulous, only joined at the base; corolla pink, blue, pale lilac or mauve, tube cylindrical, 4–4.5 mm long, lobes narrowly triangular to oblong, 3–4.5 mm × 1 mm, acute or obtuse; stamens exserted for 2–4 mm; ovary superior, 2-celled, style 3–6 mm long, deeply forked. Fruit a globose drupe 5–6 mm in diameter, orange or red, splitting into two 2-seeded pyrenes.

The genus *Ehretia* comprises about 33 species, most of them in tropics and subtropics of the Old World and a few in Central America and the West Indies. *Ehretia* is sometimes placed in the small family *Ehretiaceae*. Several other African *Ehretia* species are used in traditional medicine as well as for timber. A root decoction of *Ehretia bakeri* Britten, a species restricted to Kenya and Tanzania, is used as a cure for gonorrhoea in Kenya. *Ehretia coerulea* is sometimes distinguished as a separate species differing in its much-branched inflorescence and blue to purplish blue corolla colour (versus the white tube and mauve or blue lobes in *Ehretia obtusifolia*). However, as both species occur in Zimbabwe and it is not clear to which one the information on uses refers, they are kept together here, with *Ehretia coerulea* as a synonym of *Ehretia obtusifolia*.

Ecology *Ehretia obtusifolia* is found in woodland, wooded grassland and in thickets, often in rocky localities at of 700–1500 m altitude.

Genetic resources and breeding *Ehretia obtusifolia* is widespread but obviously not common in most of its range. In Madagascar the species is only known from 4 collections and hence qualified there as 'Endangered' according to the IUCN Red List categories.

Prospects Research on the pharmacological compounds of *Ehretia obtusifolia* may prove worthwhile, because Asian *Ehretia* species have compounds with interesting activities.

Major references Gelfand et al., 1985; Schmelzer, 2003; Verdcourt, 1991.

Other references Coates Palgrave, 1983; Hutchings et al., 1996; Kokwaro, 1993; Martins & Brummitt, 1990; Retief & van Wyk, 2001.

Authors C.H. Bosch

ELAEOPHORBIA DRUPIFERA (Thonn.) Stapf

Protologue Prain, Icon. pl. 29: t. 2823 (1906).

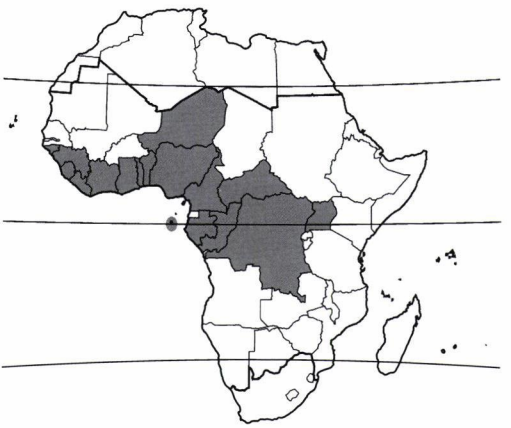
Family Euphorbiaceae

Synonyms *Euphorbia drupifera* Thonn. (1827).

Vernacular names Pago olho de marcaçao (Po).

Origin and geographic distribution *Elaeophorbia drupifera* occurs from Guinea east to Uganda and south to DR Congo and perhaps Angola.

Uses The latex is commonly applied to ringworm, snakebites, insect stings and scorpion stings to relieve the pain. It is applied to warts because of its caustic effects. It is also applied to the gums against toothache. Ground leaves with salt and chopped onions are applied to Guinea worm sores, to extract the worms. In Côte d'Ivoire a leaf decoction is taken as a purgative, or applied as an enema for the same purpose. In West Africa and Gabon the latex dissolved in water is drunk or latex is eaten in manioc porridge or on a piece of sugar cane as



Elaeophorbia drupifera – wild and planted

a purgative. In Congo a bark decoction is used as mouth wash to treat toothache. In DR Congo root bark sap is rubbed in and scrapings are used as a dressing to treat craw-craw wounds. A leaf decoction is drunk to treat cough and whooping cough, and is also used to wash leprous sores.

The latex or crushed leaves are widely used as a fish poison or as an ingredient of arrow poison. In Ghana the fruit is also used as fish poison. The latex is also used as ordeal poison.

Throughout West Africa and in Gabon *Elaeophorbia drupifera* is planted near villages for use in religious rituals. Mixed with oil the latex is applied to the eyeball, which affects the optic nerve and causes strange visual effects and confusion. It can also lead to severe eye damage. The plants are planted near houses and on graves to protect against bad spirits and lightning. In West Africa *Elaeophorbia drupifera* is also planted as a live fence around home gardens. In Ghana the soft wood is used to smoke fish.

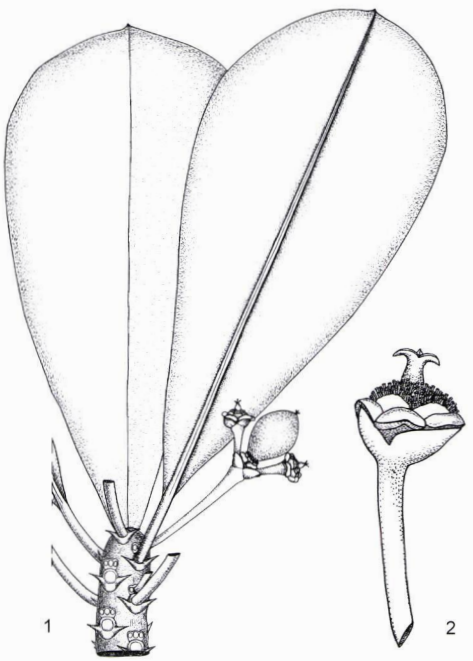
Properties The stem latex contains 0.3–0.5% of the diterpene alcohol ingenol and several ingenol diterpene esters. Ingenol is also present in *Euphorbia* spp. The esters are toxic and co-carcinogens. The triterpenes euphol, tirucallol and euphorbol were also isolated as major components. The latex contains the lectins euphorbain d_1 and euphorbain d_2, which agglutinate erythrocytes in vitro.

Extracts of the latex were found to inhibit replication and cytopathicity of several HIV-1 and HIV-2 strains, even after delayed treatment. The latex was also selectively toxic to Molt-4/HIV cells and inhibited HIV-1 reverse transcriptase.

A crude leaf extract evoked significant dose-dependent contractions in isolated guinea-pig ileum and rat uterine preparations. It significantly reduced blood glucose levels in rats. A crude root extract decreased both the blood pressure and heart rate in a dose-dependent manner in anaesthetized rats. Also, the extract was found to prolong acetylcholine-induced hypotension in rats. In-vitro studies using isolated arterial strips revealed that the extract had a dose-dependent relaxant effect on vascular smooth muscle tissue. The water extract of leaves administered orally in graded doses to rats did not show adverse changes in liver and kidney.

A crude leaf extract administered intraperitoneally showed an LD_{50} of 135 mg/kg in mice, and a crude root extract an LD_{50} of 145 mg/kg.

Description Monoecious, glabrous, small to medium-sized tree up to 22 m tall, with copious white latex; bole stout, up to 60 cm in diameter, often low-branching; bark grey, rough; branches spreading, forming a large rounded crown, branchlets obtusely 5-angled, becoming cylindrical, with conspicuous leaf scars. Leaves arranged spirally, crowded at branch apex, simple and entire; stipules soon falling; petiole up to 2.5 cm long, subtended by a pair of prickles up to 3 mm long; blade oblanceolate, up to 28 cm × 10 cm, base cuneate, apex rounded to emarginate, fleshy, pinnately veined. Inflorescence an axillary cyme, usually 3 together, 1–2-forked, consisting of cyathia; peduncle up to 4.5 cm long and branches up to 2.5 cm long; bracts broadly deltoid, c. 7 mm long, paired, persistent; cyathia sessile, c. 4 mm × 12 mm, involucre widely funnel-shaped, 5-lobed, with large glands c. 2.5 mm × 6 mm, brownish yellow, each cyathium containing 1 female flower surrounded by many male flowers. Flowers unisexual, perianth absent; male flowers with fan-shaped bracteoles, consisting of a single stamen c. 4 mm long; female flowers consisting of a superior ovary, 3-celled, smooth, merging into the pedicel, styles 3, c. 1.5 mm long, fused,



Elaeophorbia drupifera – 1, flowering and fruiting branch; 2, cyathium.
Source: Flore analytique du Bénin

stigmas flattened, reflexed. Fruit an almost sessile, obovoid, slightly 3-lobed, fleshy drupe up to 5 cm × 3.5 cm, green becoming yellow; stone grooved, 1–3-seeded. Seeds ovoid, 7–8 mm × 4.5 mm, with 2 ridges, smooth, greyish brown.

Other botanical information *Elaeophorbia* comprises 3–5 species in tropical Africa. It is sometimes included in *Euphorbia*, from which it differs in lacking a perianth in the female flowers, in the ovary merging into the pedicel, and in its large indehiscent drupe-like fruits in contrast to the dry dehiscent fruits of *Euphorbia*. *Elaeophorbia drupifera* and *Elaeophorbia grandifolia* (Haw.) Croizat are closely related and the common occurrence of intermediate specimens e.g. in Ghana indicates that it could represent a single variable species.
In Central Africa *Elaeophorbia drupifera* is sometimes confused with *Euphorbia teke* Schweinf. ex Pax.

Ecology *Elaeophorbia drupifera* occurs in forest edges, flooded coastal plains and occasionally rainforest, on brown-black humid soil, often near termitaria, at 700–1000 m altitude.

Propagation and planting *Elaeophorbia drupifera* is propagated by seed or wildlings. *Elaeophorbia grandifolia* is also propagated by stem cuttings, and this may be a suitable propagation method for *Elaeophorbia drupifera*.

Harvesting The leaves, bark, roots and latex can be harvested whenever the need arises.

Handling after harvest All plant parts that are harvested are used fresh, as is the latex. The latex may also be used after coagulation.

Genetic resources *Elaeophorbia drupifera* is widespread and relatively common, and therefore not likely threatened by genetic erosion.

Prospects The latex of *Elaeophorbia drupifera* is caustic and co-carcinogenic, and it should therefore be used with extreme care. However, the anti-HIV tests in vitro are promising, and more research should be done to evaluate the possible development of lead compounds for the pharmaceutical industry. Biosystematic studies are needed to clarify the status of *Elaeophorbia drupifera* and *Elaeophorbia grandifolia*.

Major references Ayisi & Nyadedzor, 2003; Burkill, 1994; Carter & Radcliffe-Smith, 1988; Hall & Swaine, 1981; Hawthorne & Jongkind, 2006; Neuwinger, 1996; Neuwinger, 2000; Nielsen et al., 1979; Ponsinet & Ourisson, 1968.

Other references Abo, 1994; Ahiahonu & Goodenowe, 2007; Akoègninou, van der Burg & van der Maesen, 2006; Akpanabiatu et al., 2003; Ayensu, 1978; Bruyns, Mapaya & Hedderson, 2006; Eno & Itam, 1998; Eno & Itam, 1999; Eno & Owo, 1999; Eno et al., 1999; Gassita et al. (Editors), 1982; Keay, 1958a; Lynn & Clevette-Radford, 1985; Lynn & Clevette-Radford, 1986; Lynn & Clevette-Radford, 1987a; Lynn & Clevette-Radford, 1987b; Terashima & Ichikawa, 2003.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors G.H. Schmelzer

ELAEOPHORBIA GRANDIFOLIA (Haw.) Croizat

Protologue Bull. Jard. Bot. Etat 15: 109 (1938).

Family Euphorbiaceae

Origin and geographic distribution *Elaeophorbia grandifolia* occurs from Senegal east to Benin and also in Cameroon, the Central African Republic and Gabon.

Uses The latex is used as a drastic purgative and is only used in serious situations, such as food poisoning and severe constipation. In Senegal and Sierra Leone the latex is applied to the gums to assist tooth extraction. In Côte d'Ivoire a leaf extract is taken to treat angina and chest complaints. Dried powdered leaves in water are also taken to treat chest complaints. A bark or leaf decoction is applied to guinea worm sores to assist extraction of the worms, and the pulped bark is applied as a dressing. The latex has been applied to relieve the pain of scorpion stings and to remove warts. In Ghana a leaf decoction is used as a contraceptive, and it is externally applied to heal boils, ringworm and warts. In Togo the latex in water is taken to treat haemorrhoids.
The latex is used in arrow and fish poisons in Côte d'Ivoire, Ghana and Gabon, whereas in Burkina Faso the roots are used in the preparation of arrow poison. In Côte d'Ivoire suspected criminals have the latex applied to the eye as an ordeal-poison. A herbal antidote is applied quickly if the suspect admits to the crime, but cases of permanent eye damage have been recorded.
In West Africa *Elaeophorbia grandifolia* is widely planted to protect against lightning and to keep away ghosts and evil spirits. In Sierra Leone it is planted as a hedgerow.

Properties The latex contains 0.3–0.5% of the diterpene alcohol ingenol and several ingenol diterpene esters. Ingenol is also present in *Euphorbia* spp. The esters are toxic and co-carcinogens. The triterpenes euphol, tirucallol and euphorbol have also been isolated. The latex also contains the lectins euphorbain d_1 and euphorbain d_2, which agglutinate erythrocytes in vitro. The latex was found to be highly irritant in mouse ear tests.

Botany Monoecious, glabrous small tree up to 15(–25) m tall, with copious white latex; bole stout, up to 80 cm in diameter, often low-branching; bark grey, rough; branches spreading, forming a large rounded crown, branchlets obtusely 5-angled, becoming cylindrical, with conspicuous leaf scars. Leaves arranged spirally, crowded at branch apex, simple and entire; stipules soon falling; petiole up to 3 cm long, subtended by a pair of prickles up to 3 mm long; blade ovate to oblanceolate, 8–30(–40) cm × 4–12 cm, base cuneate, apex rounded to emarginate, fleshy, pinnately veined. Inflorescence an axillary cyme, usually 3 together, consisting of cyathia; peduncle up to 4.5 cm long and branches up to 2.5 cm long; bracts broadly deltoid, c. 7 mm long, paired, persistent; cyathia sessile, c. 15 mm in diameter, involucre widely funnel-shaped, 5-lobed, with large glands c. 2.5 mm × 6 mm, brownish yellow, each cyathium containing 1 female flower surrounded by many male flowers. Flowers unisexual, perianth absent; male flowers with fan-shaped bracteoles, consisting of a single stamen c. 4 mm long; female flowers consisting of a superior, 3-celled, smooth ovary merging into the pedicel, styles 3, c. 1.5 mm long, fused, stigmas flattened, reflexed. Fruit an almost sessile, obovoid, slightly 3-lobed, fleshy drupe up to 3.5 cm × 2.5 cm, green becoming yellow; stone grooved, 1–3-seeded. Seeds ovoid, c. 8 mm × 4.5–5 mm, with 2 ridges, smooth, greyish brown.

Elaeophorbia comprises 3–5 species in tropical Africa. It is sometimes included in *Euphorbia*, from which it differs in lacking a perianth in the female flowers, in the ovary merging into the pedicel, and in its large indehiscent drupe-like fruits in contrast to the dry dehiscent fruits of *Euphorbia*. *Elaeophorbia grandifolia* and *Elaeophorbia drupifera* (Thonn.) Stapf are closely related and the common occurrence of intermediate specimens, e.g. in Ghana, indicates that they could represent a single variable species.

Ecology *Elaeophorbia grandifolia* occurs in dry forest, on rocky slopes, from sea-level up to 800 m altitude. It sometimes also occurs in moist lowland forest.

Management *Elaeophorbia grandifolia* can be easily propagated by stem cuttings, which should be at least 20 cm long. After cutting they should be allowed to lie in a shaded place for at least a week to develop a callus on the cut end. *Elaeophorbia grandifolia* can also be grown from seed.

Genetic resources and breeding *Elaeophorbia grandifolia* is widespread and relatively common, and therefore not likely threatened by genetic erosion.

Prospects The latex of *Elaeophorbia grandifolia* is caustic and co-carcinogenic, and it should therefore be used with extreme care in local medicine. Biosystematic studies are needed to clarify the status of *Elaeophorbia grandifolia* and *Elaeophorbia drupifera*.

Major references Burkill, 1994; Eggli, 2002; Keay, 1958a; Neuwinger, 1996; Neuwinger, 2000.

Other references Abo, 1994; Bruyns, Mapaya & Hedderson, 2006; Dalziel, 1937; Eggli, 2002; Evans & Kinghorn, 1977; Hall & Swaine, 1981; Hawthorne & Jongkind, 2006; Mshana et al., 2000.

Authors L.E. Newton

ERYTHROCOCCA ANOMALA (Juss. ex Poir.) Prain

Protologue Ann. Bot. 25: 614 (1911).

Family Euphorbiaceae

Chromosome number $2n = 30$

Synonyms *Erythrococca aculeata* Benth. (1849).

Vernacular names Bush lime (En).

Origin and geographic distribution *Erythrococca anomala* occurs from Guinea Bissau east to Cameroon, Equatorial Guinea (Bioko) and Gabon.

Uses The leaves are laxative and purgative and considered very effective against tapeworm. A decoction of young leaves is applied against skin lesions and subcutaneous parasites. Sap of the leaves is used as eye drops to treat sore eyes, as nose drops to treat sinusitis and as ear drops to treat ear infections. To treat eye injuries, leaves are folded into a funnel and filled with water; after a while the water is dropped into the eye. Leafy twigs are used to clean and disinfect wounds and ulcers. In Guinea dried and ground leaves mixed with

seeds of melegueta pepper (*Aframomum melegueta* (Roscoe) K.Schum.) is taken as a snuff against chronic headache. Leaf pulp is also used as a rub to treat local pain. In Côte d'Ivoire powdered leaves alone or mixed with those of *Psychotria peduncularis* (Salisb.) Steyerm. and clay are applied in friction against malaria in children and rubbed on the neck and throat against meningitis. In Cameroon a decoction of the leaves is taken to expel tapeworms. A leaf macerate is applied to the tooth to treat toothache. In Nigeria the bark is used against arthritis and rheumatism. The fruit pulp or the root bark are taken as a tonic against general weakness.

Properties The roots and bark contain about 1% alkaloids, the twigs and leaves about 0.1%. Alkaloids have also been found in the seeds.

Botany Dioecious, spiny shrub up to 3 m tall; bark flaky, brown. Leaves alternate, simple; stipules formed into persistent spines, brown; petiole short; blade ovate to oblong, 4–5 cm × 2–3 cm, base obtuse, apex acuminate, margin wavy, glabrous, pinnately veined with 2–3 pairs of lateral veins. Inflorescence an axillary raceme. Flowers unisexual, minute, whitish to pale yellow; calyx 4-lobed; corolla absent; male flowers with 9–15 stamens; female flowers with superior ovary, 3-lobed. Fruit a 2(–3)-lobed capsule, red when mature. Seeds globular, pitted, covered by a thin orange to bright red aril.

Erythrococca comprises about 40 species and is confined to mainland Africa. *Erythrococca anomala* is a fast growing heliophile. It flowers at the end of the dry season and the beginning of the rainy season.

Erythrococca africana (Baill.) Prain occurs from Cape Verde and Senegal to Cameroon. The powdered dry leaves are taken with food as a mild purgative; crushed leaves are applied to whitlow. In Nigeria hunters add the leaves to meat to make it tender. *Erythrococca chevalieri* (Beille) Prain, occurring from Guinea east to Cameroon and the Congo basin, and *Erythrococca welwitschiana* (Müll.Arg.) Pax & K.Hoffm. from Central Africa have similar medicinal uses in Congo. The leaves are considered aphrodisiac and are taken against gonorrhoea and are also applied to heal sores and scabies. Leaf sap is drunk against bronchial complaints and is externally applied to treat itch and a stiff neck. An infusion of the roots is taken to relieve stomach complaints. The leaves are eaten as a vegetable. In Cameroon *Erythrococca chevalieri* is also used in witchcraft. *Erythrococca hispida* (Pax) Prain occurs in forest in Cameroon. The leaves are ground with salt and applied to scarifications to treat kidney pain. Young leaves are eaten with vegetable salt and cooked banana against gastrointestinal problems.

Ecology In Sierra Leone *Erythrococca anomala* occurs in forest relics in the savanna; in Cameroon in riverine forest and in shady forest undergrowth. It occurs from sea-level up to 1600 m altitude.

Genetic resources and breeding *Erythrococca anomala* has a wide distribution and is common, and is not in danger of genetic erosion.

Prospects *Erythrococca anomala* has important uses in traditional medicine. As a recent revision of the genus is lacking and almost nothing is known on its chemical and pharmacological properties, there is an urgent need for botanical and pharmacological studies to verify its potential.

Major references Adjanohoun et al., 1996; Basilevskaia, 1969; Burkill, 1985; Keay, 1958a; Tokuoka, 2007.

Other references Brisson, 1988; Kabouw et al., 2008; Keita et al., 1999; Malato Beliz, 1977.

Authors R.B. Jiofack Tafokou

ERYTHROCOCCA BONGENSIS Pax

Protologue Bot. Jahrb. Syst. 19: 88 (1894).

Family Euphorbiaceae

Origin and geographic distribution *Erythrococca bongensis* occurs from southern Sudan and Ethiopia south to eastern DR Congo, Burundi and Tanzania.

Uses Leaf sap diluted with water is drunk or leaves mixed with butter are eaten against cough. Leaves are eaten against stomach complaints and are given, sometimes in decoction, to children as a fortifier. A leaf decoction is drunk, or used as a wash or vapour bath, against diarrhoea. A decoction of leaves and roots is drunk to expel intestinal parasites. Leaf powder is sniffed against vomiting. An infusion of the leaves is used as a wash to treat skin problems, while a decoction of leafy twigs is applied as a wash to treat rectal prolapse. A decoction of the leaves together with several other plants is taken orally or is applied as an enema against diarrhoea. An infusion of the leaves mixed with several other plants is applied as an enema against various skin infec-

tions. A decoction of the leaves, also mixed with several other plants, is given to drink to women whose foetus does not move. Leaves and stems are applied as an enema against haemorrhoids. A decoction of the roots and leaves together with the leaves of *Hibiscus fuscus* Garcke is drunk against intestinal parasites. An infusion of the root is given as an enema against stomach-ache and indigestion. In Uganda ground leaves mixed with milk are drunk or raw leaves are eaten to expel tapeworm. Root or leaf powder is taken in milk to treat tonsillitis. In Rwanda a decoction of the leaves with salt is given against dehydration, while the residue is rubbed onto the skin.

In veterinary medicine, leaf sap is given to facilitate parturition. A decoction of the leaves is given in serious cases of anthrax and East Coast fever.

The leaves are eaten as a vegetable. The branches are used to make arrow shafts and walking sticks.

Properties No information is available on the pharmaceutical or chemical properties of *Erythrococca bongensis*.

Fresh leaves contain per 100 g: water 68 g, protein 7.2 g, fat 2.7 g, carbohydrate 18.5 g, fibre 4.3 g, Ca 678 mg and P 107 mg (Leung, Busson & Jardin, 1968).

Botany Dioecious, erect or scandent shrub or small tree up to 3.5(–6) m tall; bark pale grey or brown, flaking; branchlets grey-green, hairy when young, becoming glabrous. Leaves alternate, simple; stipules developed into spines c. 2 mm long, straight or hooked, yellowish; petiole (2–)3–9 mm long, hairy, becoming glabrous; blade ovate, elliptical or elliptical-lanceolate, (1–)3–7.5(–12) cm × (0.5–)1–3(–5) cm, base cuneate, apex obtuse or rarely acute, margins notched or toothed, pinnately veined with 5–7 pairs lateral veins, often looped. Inflorescence a head, solitary or fascicled, sessile or with peduncle up to 1.5 cm long; bracts minute. Flowers unisexual; male flowers with slender pedicel up to 12 mm long, flexible, glabrous, calyx with 3(–4) lobes, triangular to ovate, c. 1.5 mm × 1 mm, greenish cream, glabrous, extra-staminal disk-glands 7, small, rounded, inter-staminal glands numerous, angular, truncate, dark green, stamens 9–15 in 2 whorls, c. 0.5 mm long; female flowers with pedicel up to 4 mm long, calyx lobes smaller, disk glands 3, ovate, flattened, ovary superior, 3-lobed, c. 1 mm in diameter, style c. 1 mm long, stigma fringed, white. Fruit composed of 2–3 free cocci, each 3.5–4 mm in diameter, sparingly hairy, greenish or purplish, each coccus 1-seeded. Seed almost spherical, 3–3.5 mm in diameter, shallowly pitted or netted, aril orange-yellow or red.

Erythrococca comprises about 40 species and is confined to mainland Africa. Several other *Erythrococca* spp. have medicinal uses in Central and eastern Africa. *Erythrococca atrovirens* (Pax) Prain occurs in equatorial Africa, extending south-east to Zambia. Leaf sap or a paste from the roots, heated together with lemon juice, is applied to syphilitic sores. Leaf powder is applied to wounds. The leaves are eaten as a vegetable. *Erythrococca fischeri* Pax occurs in eastern equatorial Africa. A decoction of its root is drunk to treat intestinal worm infections and gonorrhoea. The fruits are edible. *Erythrococca menyharthii* (Pax) Prain occurs in East and southern tropical Africa. The roots are ground and eaten with honey against cough. Leaf sap is applied as drops in the eye as anti-venom after attacks by spitting snakes. The leaves are eaten as a vegetable and used to add taste to other vegetables. The fruits are edible.

Ecology *Erythrococca bongensis* occurs in forest edges and associated bushland or thickets, especially in fire-protected localities, along rivers and lakesides, in the shade of riverine *Acacia* forest and in savanna, at 200–2450 m altitude.

Genetic resources and breeding Because of its wide distribution there are no indications that *Erythrococca bongensis* is threatened by genetic erosion.

Prospects *Erythrococca bongensis* has important uses in traditional medicine and as a leafy vegetable. As a recent revision of the genus is lacking and nothing is known on its chemical and pharmacological properties, there is an urgent need for research to verify its potential.

Major references Baerts & Lehmann, 2008a; Leung, Busson & Jardin, 1968; Neuwinger, 2000; Radcliffe-Smith, 1987; Radcliffe-Smith, 1991a.

Other references Beentje, 1994; Coates Palgrave, 1983; Geissler et al., 2002; Ichikawa, 1987; Kokwaro, 1993; Latham, 2004; Maundu et al., 2001; Tabuti, Lye & Dhillion, 2003.

Authors L.P.A. Oyen

ERYTHROPHLEUM AFRICANUM (Welw. ex Benth.) Harms

Protologue Repert. Spec. Nov. Regni Veg. 12: 298 (1913).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae).

Vernacular names Ordeal tree (En). Mucaráti (Po).

Origin and geographic distribution *Erythrophleum africanum* occurs in much of tropical Africa, from Senegal east to Sudan, and south throughout Central Africa, Kenya, Tanzania and southern Africa to Transvaal.

Uses In Ghana a mouth wash for relieving toothache is made from the bark of *Erythrophleum africanum*. In Zimbabwe an infusion of the bark is drunk to treat stomach-ache or dysmenorrhoea. The bark steeped in water is applied externally and internally to cure cardiac diseases and epilepsy. In Namibia the powdered root bark mixed with urine is applied to the skin to treat leprosy. A hot water extract from pounded roots is drunk to induce vomiting in case of poisoning and as a cure for insanity. Inhaling the smoke of burning leaves is said to relieve pain. A paste of root bark is applied to the skin to cure scabies. The bark has been used as an ordeal poison in Tanzania, Malawi and Zimbabwe.

The timber of *Erythrophleum africanum* and several other *Erythrophleum* species is marketed under the trade name 'missanda'. It is used for furniture, heavy and light construction, posts, poles and tool handles. The wood is used as firewood and to make good-quality charcoal, useful in iron working. Cuttings are used to establish living fences. The gum from the bark is used to make baskets water proof and to fix arrow heads and hoe and axe handles. In Zambia the foliage is reportedly used as a fodder but sources from several other countries report that it is toxic and that cattle are kept away from it.

Properties The complex alkaloids of *Erythrophleum* spp. are esters of tricyclic diterpene acids, and 2 main types exist: dimethylaminoethylesters and monomethylaminoethylesters (nor-alkaloids). In addition, compounds have been found in which the amine link is replaced by an amide link, but it is not clear whether these are natural compounds or artefacts. The bark of *Erythrophleum africanum* contains erythrophlamine, norcassamidine, norerythrophlamide and norerythrostachamide. The alkaloid content of the bark ranges from 0.04% to 0.6%. The alkaloids have similar cardiotonic, anaesthetic and diuretic properties as those from other *Erythrophleum* spp.

The bark contains the flavone 2,3-dihydroxymyricetin that colours violet after addition of magnesium powder and a few drops of hydrochloric acid. This reaction allows it to be distinguished from the bark of *Erythrophleum suaveolens* (Guill. & Perr.) Brenan, which colours orange after treatment because of the presence of luteolin.

The wood is red-brown, heavy, hard and very durable and is resistant to termites, powder-post beetles and marine borers.

Adulterations and substitutes *Erythrophleum* alkaloids have similar pharmacological activities as digitoxine and ouabain.

Botany Small tree up to 15 m tall; bole straight and cylindrical, up to 120 cm in diameter; crown spreading, fairly dense; young parts very variable hairy. Leaves alternate, bipinnately compound with (2–)3–4 pairs of opposite pinnae; stipules minute; petiole 3.5–5.5 cm long, rachis 3–15 cm long; leaflets alternate, 8–17 per pinna, elliptical or ovate, up to 6.5 cm × 3.5 cm, base asymmetrical, apex obtuse to rounded. Inflorescence an axillary or terminal panicle consisting of spike-like racemes up to 10 cm long, often shortly hairy. Flowers bisexual, regular, 5-merous, white to yellowish green; pedicel c. 1 mm long, hairy; calyx c. 2.5 mm long, tube about as long as lobes; petals narrowly obovate, up to 4 mm × 1 mm; stamens 10, free, up to 8 mm long; ovary superior, long woolly hairy, 1-celled, stigma broadly peltate. Fruit a flat, straight, dehiscent pod, elliptical in outline, 5–19 cm × 2–4.5 cm, base rounded, apex rounded or tapering, thick leathery, pendulous, 3–4-seeded. Seeds ovoid, compressed, c. 12 mm × 10 mm × 4 mm.

Erythrophleum comprises about 10 species, 4 or 5 of which occur in continental Africa, 1 in Madagascar, 3 in eastern Asia, and 1 in Australia. The genus is one of the few *Caesalpiniaceae* reported to contain alkaloids. The areas of distribution of *Erythrophleum africanum* and *Erythrophleum suaveolens* largely overlap and the 2 species share many uses and properties and therefore confusion is quite likely. The results of earlier pharmacological work are blurred by doubtful identifications. The 2 species differ in ecology, a number of morphological characteristics and the alkaloid profile of the bark. Nodulation and vesicular-arbuscular mycorrhizae were observed in the roots of

Erythrophleum africanum. The rhizobium involved in nodulation probably belongs to the genus *Bradyrhizobium*.

Ecology *Erythrophleum africanum* is common in deciduous woodland, and is absent from riparian woodlands and the dry savanna of the Sahel. It occurs at 600–1400 m altitude, and resists bushfires.

Management *Erythrophleum africanum* can be grown from seed, but wildlings are used as well. Coppicing and pollarding are recommended management practices for *Erythrophleum africanum* in Zambia but coppicing often gives poor results.

Genetic resources and breeding *Erythrophleum africanum* is widespread and not commercially exploited on a large scale. There is no reason to assume it will become threatened in the near future.

Prospects The huge variation in alkaloid contents of *Erythrophleum africanum* bark warrants caution in medicinal use. Morphological and pharmacological studies could yield a better understanding of the variation in this species.

Major references Arbonnier, 2004; Coates Palgrave, 1983; Neuwinger, 1996; von Koenen, 2001.

Other references Brenan, 1967; Burkill, 1995; Chilufya & Tengnäs, 1996; Gelfand et al., 1985; Hogberg & Alexander, 1995; Luoga, Witkowski & Balkwill, 2004; Manfouo et al., 2005; Ross, 1977; Storrs, 1979.

Authors V. Kawanga

ERYTHROPHLEUM COUMINGA Baill.

Protologue Adansonia 10: 105 (1871).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae).

Origin and geographic distribution *Erythrophleum couminga* is endemic to Madagascar and restricted to a part of the west coast of about 400 km long and extending 30–40 km inland.

Uses The powdered bark of *Erythrophleum couminga* is used in minute doses as a purgative and laxative. In former days, it was used as an ordeal poison. The branches are used as fence posts but the wood is hardly used otherwise.

Properties The leaves of *Erythrophleum couminga* are toxic to cattle, but bark and flowers are even more poisonous. The odour of the flowers is said to cause violent headaches and to kill birds. The alkaloid content of the bark is 0.3–0.5%. The bark contains several complex diterpenoid alkaloids, which are esters of tricyclic diterpene acids, with as main components alkaloids of the dimethylaminoethylester type, e.g. coumingine. The alkaloids have a stimulant effect on the heart like the cardiac glycosides of *Digitalis*, but the effect is very short-lasting. Coumingine has similar effects as cassaine and cassaidine, which are major components in other *Erythrophleum* species. They have strong anaesthetic and diuretic effects, and increase contractions of the intestine and uterus. Apart from an increase of heart contraction in systole, the alkaloids also demonstrated an increase in diastole. In addition, coumingine caused depressive effects. Coumingine produced severe and long-lasting diarrhoea when given orally. In higher doses, the bark extract is an extremely strong, rapid-acting cardiac poison, in warm-blooded animals causing shortness of breath, seizures and cardiac arrest in a few minutes.

The wood is hard and durable and is resistant to decay.

Botany Small to medium-sized deciduous tree up to 20 m tall; bark rough, fissured; young twigs thinly pubescent, soon glabrescent. Leaves alternate, bipinnately compound with 2–4 pairs of pinnae; stipules triangular, c. 1 mm long, soon falling; petiole 2–6 cm long, rachis up to 20 cm long; leaflets alternate, 8–12 per pinna, ovate, up to 6 cm × 3.5 cm, base rounded, apex shortly acuminate. Inflorescence an axillary panicle consisting of spike-like racemes up to 10 cm long; peduncle hairy. Flowers bisexual, regular, 5-merous, whitish yellow; pedicel c. 1 mm long, hairy; calyx with tube c. 2 mm long, lobes triangular, 1–1.5 mm long; petals oblong to obovate, up to 3 mm long; stamens 10, free, 6–8 mm long; ovary superior, densely woolly hairy, 1-celled, stigma small, cup-shaped. Fruit a flat, straight or slightly curved, dehiscent pod 20–25 cm × c. 5 cm, apex rounded or obtuse, woody, pendulous, (2–)4–8-seeded. Seeds disk-like to oblong or triangular, flattened, 18–23 mm × 17–20 mm × 6–8 mm.

Erythrophleum comprises about 10 species, 4 or 5 of which occur in continental Africa, 1 in Madagascar, 3 in eastern Asia, and 1 in Australia. The genus is one of the few *Caesalpiniaceae* reported to contain alkaloids. *Erythrophleum couminga* resembles the African mainland species *Erythrophleum suaveolens* (Guill. & Perr.) Brenan but has larger, more robust pods and seeds and is apparently more

poisonous. *Erythrophleum couminga* flowers in the period July–October.

Ecology *Erythrophleum couminga* occurs in deciduous woodland on sandy soils near sea-level and in wooded grassland in association with palms. It is resistant to annual grassland fires.

Genetic resources and breeding *Erythrophleum couminga* is restricted to a small area, but quite common. The limited use indicates that it is not subject to threats of genetic erosion or extinction.

Prospects *Erythrophleum couminga* is likely to remain little used.

Major references du Puy et al., 2002; Hegnauer & Hegnauer, 1996; Rasoanaivo, Petitjean & Conan, 1993; Schatz, 2001.

Other references Cronlund & Oguakwa, 1975; Hegnauer & Hegnauer, 1994; Oguakwa & Cronlund, 1976; Hegnauer & Hegnauer, 1994.

Authors C.H. Bosch

ERYTHROPHLEUM IVORENSE A.Chev.

Protologue Vég. util. Afr. trop. Franç. 5: 178 (1909).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae).

Vernacular names Ordeal tree, sasswood tree (En). Lim du Gabon, tali (Fr). Mancone (Po).

Origin and geographic distribution *Erythrophleum ivorense* occurs from Gambia to the Central African Republic and Gabon.

Uses The bark traded as 'sassy-bark', 'mancona bark', 'casca bark' or 'écorce de tali' has several medicinal uses. A bark extract is taken orally in Sierra Leone as an emetic and laxative, and is applied externally to relieve pain. In Côte d'Ivoire water, in which the bark of young branches of *Erythrophleum ivorense* is crushed, is rubbed on the skin to treat smallpox.

The bark and sometimes the seeds are widely used as hunting and ordeal poison. In Liberia and Gabon the bark of *Erythrophleum ivorense* is preferred to that of *Erythrophleum suaveolens* (Guill. & Perr.) Brenan. The bark is used as fish poison in Sierra Leone.

The timber of *Erythrophleum ivorense* is marketed as 'erun', 'missanda', 'sasswood', 'alui', 'bolondo' or 'tali'. The wood is quite hard and heavy, and suitable for joinery, flooring, railway sleepers, harbour and dock work, turnery, construction and bridges. It is also used for boat building and wheel hubs. It makes excellent charcoal and good firewood. In Sierra Leone and Côte d'Ivoire the bark is used for tanning. A bark decoction added to fermenting palm wine would make it a more potent drink.

Production and international trade In trade statistics, the timber of *Erythrophleum ivorense* and *Erythrophleum suaveolens* is usually not differentiated. In 2005 the export of *Erythrophleum* ('tali') logs from Cameroon amounted to 37,500 m^3 and of sawn wood to 38,600 m^3, which made *Erythrophleum* the fourth most important timber of Cameroon. In 2005 the price of logs free-on-board was US$ 123–151/m^3, depending on the quality. The major importer is China.

Properties The alkaloid content of *Erythrophleum ivorense* is similar to that of *Erythrophleum suaveolens*; only the distribution of the main compounds is different. First investigations yielded the alkaloid erythrophleine, but this was later identified as a mixture of different alkaloids with similar activities. The alkaloids are esters of tricyclic diterpene acids, and 2 main types exist: dimethylaminoethylesters and monomethylaminoethylesters (nor-alkaloids). In addition, compounds have been found in which the amine link is replaced by an amide link, but it is not clear whether these are natural compounds or artefacts. The bark contains as main components alkaloids of the dimethylaminoethylester type: cassaine, cassaidine and erythrophleguine, but no dominant alkaloid of the amide type. The alkaloid content of the bark ranges from 0.2% to 1.1%. In high doses, the bark extract is an extremely strong, rapid-acting cardiac poison, in warm-blooded animals



Erythrophleum ivorense – *wild*

causing shortness of breath, seizures and cardiac arrest in a few minutes.

The alkaloids have a stimulant effect on the heart similar to that of the cardenolides digitoxine (from *Digitalis*) and ouabain (from *Strophanthus gratus* (Wall. & Hook.) Baill.), but the effect is very short-lasting, as the alkaloids are quickly metabolized in the organism. Cassaine and cassaidine have strong anaesthetic and diuretic effects, and increase contractions of the intestine and uterus. Apart from an increase of heart contraction in systole, the alkaloids also demonstrated an increase in diastole. In addition, cassaidine caused depressive effects, while cassaine caused a violent state of excitation. Although the alkaloid content in the seeds is markedly lower than in the stem bark, the seeds are more toxic. This strong activity is due to a strong haemolytic saponin, which acts in a synergistic way with the alkaloids.

Wood from *Erythrophleum ivorense* and *Erythrophleum suaveolens* is not differentiated in trade and the following wood description is applicable to both species.

The heartwood is yellowish brown to reddish brown, darkening on exposure, sometimes striped, clearly demarcated from the 3–6 cm wide, creamy-yellow sapwood. The grain is interlocked, texture coarse. The wood is moderately lustrous.

The density is about 900 kg/m^3 at 12% moisture content. The wood dries slowly with high risks of distortion and checking. The shrinkage rates from green to oven dry are 5.1–5.8% radial and 8.4–8.6% tangential. Once dry, the wood is moderately stable in service.

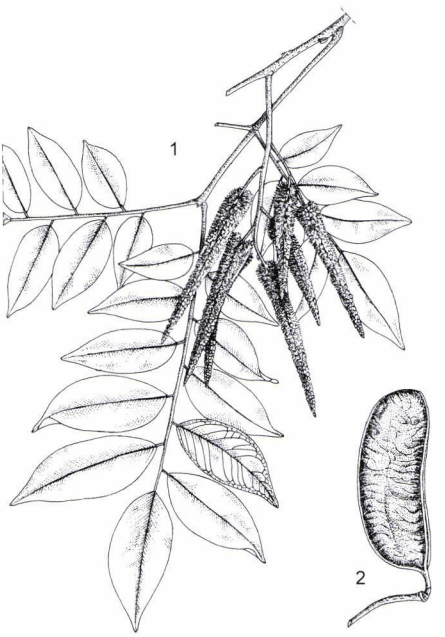
At 12% moisture content, the modulus of rupture is 99–162 N/mm^2, modulus of elasticity 10,550–19,500 N/mm^2, compression parallel to grain 56–97 N/mm^2 and Janka side hardness 13,000 N.

The wood is difficult to saw; stellite-tipped sawteeth are recommended. Finishing is generally fair, but planing may be difficult due to interlocked grain. Pre-boring is necessary for nails and screws. The gluing properties are good.

The wood is durable and resistant to fungi, dry wood borers and termites. It is suitable for use in contact with the ground. It is not permeable for preservatives. The sawdust may irritate mucous membranes and may cause allergy and asthma of labourers in sawmills.

Adulterations and substitutes *Erythrophleum* alkaloids have similar pharmacological activities as digitoxine and ouabain. The timber from *Erythrophleum ivorense* and *Erythrophleum suaveolens* is marketed indiscriminately under the trade names: 'tali', 'erun', 'bolondo' and 'alui'. The timber of *Pachyelasma tessmannii* (Harms) Harms resembles that of *Erythrophleum*, hence the trade name 'faux tali'. *Erythrophleum* wood can be used as a substitute for azobé (*Lophira alata* Banks ex P.Gaertn.).

Description Large tree up to 40 m tall; bole cylindrical, but sometimes fluted at base, with or without buttresses; bark scaly, often fissured, grey, inner bark reddish, granular; young twigs brown hairy. Leaves alternate, bipinnately compound with 2–4 pairs of pinnae; stipules minute; petiole 2–7 cm long, rachis 5–15 cm long; leaflets alternate, (6–)8–14 per pinna, elliptical to ovate, up to 8.5 cm × 4 cm, base asymmetrical, apex shortly acuminate. Inflorescence an axillary or terminal panicle consisting of spike-like racemes up to 8 cm long, shortly reddish brown hairy. Flowers bisexual, regular, 5-merous, red-brown; pedicel c. 1 mm long, shortly hairy; calyx c. 1.5 mm long, lobes c. 0.5 mm long; petals narrowly obovate, c. 2 mm × 0.6 mm, densely hairy; stamens 10, free, 2–3.5 mm long; ovary superior,



Erythrophleum ivorense – 1, branch with leaf and inflorescence; 2, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

long woolly hairy, 1-celled, stigma broadly peltate. Fruit a flat, elliptical, dehiscent pod 5–10 cm × 3–5 cm, base rounded, apex obtuse or rounded, thick leathery, pendulous, 2–6(–10)-seeded. Seeds ovoid, compressed, c. 13 mm × 9 mm × 5 mm.

Other botanical information *Erythrophleum* comprises about 10 species, 4 or 5 of which occur in continental Africa, 1 in Madagascar, 3 in eastern Asia, and 1 in Australia. The genus is one of the few *Caesalpiniaceae* reported to contain alkaloids. *Erythrophleum ivorense* and *Erythrophleum suaveolens* share many uses, vernacular names, trade names and properties and therefore confusion is common. Especially the results of earlier pharmacological work are blurred by doubtful identifications. The 2 species differ in ecology, some morphological characteristics and the alkaloid profile in the bark. Only in semi-deciduous forest does *Erythrophleum ivorense* co-occur with *Erythrophleum suaveolens*, from where the latter extends into drier habitats like woodland savanna. However, it is often difficult to distinguish the two species from each other. The leaflets of *Erythrophleum suaveolens* are often wider, its inflorescences wider (often 1.5 cm versus 1 cm in *Erythrophleum ivorense*) and its pods longer.

Anatomy Wood-anatomical description (IAWA hardwood codes):
Growth rings: (1: growth ring boundaries distinct); (2: growth ring boundaries indistinct or absent). Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal; 26: intervessel pits medium (7–10 µm); 29: vestured pits; 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 43: mean tangential diameter of vessel lumina ≥ 200 µm; 46: ≤ 5 vessels per square millimetre; 47: 5–20 vessels per square millimetre; 58: gums and other deposits in heartwood vessels. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; 69: fibres thin- to thick-walled; 70: fibres very thick-walled. Axial parenchyma: 79: axial parenchyma vasicentric; 80: axial parenchyma aliform; 81: axial parenchyma lozenge-aliform; (83: axial parenchyma confluent); (84: axial parenchyma unilateral paratracheal); 91: two cells per parenchyma strand; 92: four (3–4) cells per parenchyma strand; (93: eight (5–8) cells per parenchyma strand). Rays: (96: rays exclusively uniseriate); (97: ray width 1–3 cells); 104: all ray cells procumbent; 115: 4–12 rays per mm; 116: ≥ 12 rays per mm. Mineral inclusions: (136: prismatic crystals present); (142: prismatic crystals in chambered axial parenchyma cells).
(E. Uetimane, H. Beeckman & P.E. Gasson)

Growth and development *Erythrophleum ivorense* flowers during the rainy season. Nodulation was observed in primary rainforest and the rhizobium involved belongs to the genus *Bradyrhizobium*. In Côte d'Ivoire the mean annual bole diameter increment has been recorded as 6.5 mm, in the Central African Republic 4.5 mm.

Ecology *Erythrophleum ivorense* occurs in evergreen primary and secondary forest and moist semi-deciduous forest. *Erythrophleum ivorense* is essentially a tree of old secondary forest.

Propagation and planting *Erythrophleum ivorense* has been classified as a non-pioneer light demander. Seedlings are often found in smaller forest gaps. *Erythrophleum ivorense* can be propagated in nurseries; seed takes 3 weeks to germinate. Inoculation with *Bradyrhizobium* is beneficial and results in increases in height and diameter of about 40% after 4 months.

Management *Erythrophleum ivorense* trees usually occur scattered in the forest. In Gabon the average bole volume has been recorded as 1.4 m^3/ha. In Liberia the mean density of trees with a minimum bole diameter of 60 cm is 0.7 tree/ha. Reforestation with *Erythrophleum ivorense* is an option in degraded forests where natural regeneration of economically important species is unlikely. In Gabon the clear-cut method is superior to enrichment planting: 6 years after planting the survival rate was 97% vs 79%, the height 16 m vs 11 m and the bole diameter 13.6 cm vs 6.8 cm for the 2 methods respectively.

Harvesting Old *Erythrophleum ivorense* trees very often have heart rot. The bark of *Erythrophleum ivorense* is harvested from the wild whenever the need occurs.

Handling after harvest The logs sink in water and can consequently not be transported by floating along a river.

Genetic resources *Erythrophleum ivorense* is often abundant in West and Central African evergreen forest. Although logging of *Erythrophleum ivorense* for its timber has shown a distinct increase in Cameroon, there are no indications that the species is under too much pressure yet.

Prospects *Erythrophleum ivorense* contains pharmacologically interesting compounds and further study of its pharmacology is justified. Internal use of unpurified medicines made from *Erythrophleum ivorense* is extremely dangerous. The differences in active ingredients between individual trees in a single population and the differences in composition related to age of the plant are large. Although *Erythrophleum ivorense* has recently gained much importance as a timber tree, especially in Cameroon, comparatively little is known about proper management practices for sustainable harvesting in natural forest.

Major references Aubréville, 1959b; Aubréville, 1968; Burkill, 1995; Chudnoff, 1980; CIRAD Forestry Department, 2003; Cronlund, 1976; de Saint-Aubin, 1963; ITTO, 2004; Neuwinger, 1996; Richter & Dallwitz, 2000.

Other references Bakarr & Janos, 1996; Diabate et al., 2005; Durrieu de Madron, Nasi & Détienne, 2000; Hegnauer & Hegnauer, 1996; Hogberg & Alexander, 1995; InsideWood, undated; Koumba Zaou et al., 1998; Siepel, Poorter & Hawthorne, 2004; Sprent, 2005; Voorhoeve, 1979.

Sources of illustration Voorhoeve, 1979.

Authors C.H. Bosch

ERYTHROPHLEUM SUAVEOLENS (Guill. & Perr.) Brenan

Protologue Taxon 9: 194 (1960).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

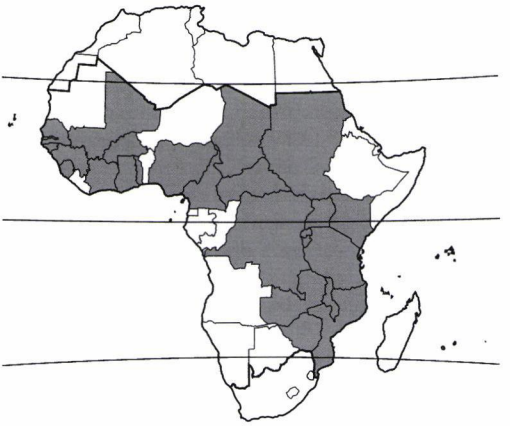
Chromosome number $2n = 24, 28$

Synonyms *Erythrophleum guineense* G.Don (1832).

Vernacular names Forest ordeal tree, red water tree, sasswood tree (En). Bois rouge, poison d'épreuve, tali, grand tali, mancône (Fr). Mancone, muave (Po). Mwavi, mwavi dume, mbaraka mkuu, mkelekele (Sw).

Origin and geographic distribution *Erythrophleum suaveolens* is distributed from Senegal to Sudan and Kenya in the east and from there south to Zimbabwe and Mozambique. It has been introduced as an ornamental in tropical Asia.

Uses The bark, traded as 'sassy-bark', 'mancona bark' or 'casca bark' is used as emetic and purgative. The crushed bark is applied to swellings caused by *Filaria*. In DR Congo the dried powdered bark is taken as a snuff to cure headache. In Kenya a diluted decoction of the roots is used as an anthelminthic, especially against tapeworm. In Malawi a decoction of the roots and bark is applied to soothe general body pain. Pieces of root or bark are a protective and love charm. The bark has been used in arrow poisons and as ordeal poison and the bark and leaves as fish poison. The use as an anaesthetic for fish in aquaculture is tricky as small differences in dosage will kill, rather than stupefy fish. In the Western world, bark extracts were used in the late 19th century to treat heart failure. Side effects and better results with digitoxine ended this practice.



Erythrophleum suaveolens – wild

The tree produces quite hard, heavy and durable wood, marketed as 'alui', 'tali', 'erun', 'missanda' or 'sasswood', which is suitable for joinery, flooring, railway sleepers, harbour and dock work, turnery, construction and bridges. It is also used for boat building and wheel hubs. The bark has been used in West Africa for tanning hides and skins; it is used in DR Congo to colour leather brown. *Erythrophleum suaveolens* is planted as an ornamental and avenue tree. In West Africa the powdered bark is mixed with the residue of palm oil processing, and after boiling it is mixed with seeds of maize, cowpea or cotton, which effectively reduces pest damage to the seeds. Dried leaves are mixed with stored grains and pulses to repel or kill storage insects. The use in agroforestry has been promoted: nitrogen fixation and the large amount of leaf litter are advantageous to intercrops. However, in experiments a negative effect of *Erythrophleum suaveolens* leaf mulch on the yield of crops has been noted. When clearing bush to prepare fields, trees are often left standing because the wood is hard

and felling is too taxing. *Erythrophleum suaveolens* wood is not highly valued as firewood but charcoal made from it is excellent.

Production and international trade Export of bark of *Erythrophleum* for medicinal purposes no longer plays a role. In local markets however, the bark is an important and expensive article. In trade statistics, the timber of *Erythrophleum ivorense* and *Erythrophleum suaveolens* (Guill. & Perr.) Brenan is usually not differentiated. In 2005 the export of *Erythrophleum* ('tali') logs from Cameroon amounted to 37,500 m^3 and of sawn wood to 38,600 m^3, which made *Erythrophleum* the fourth most important timber of Cameroon. In 2005 the price of logs free-on-board was US$ 123–151/m^3, depending on the quality. The major importer is China.

Properties The alkaloid content of bark was found to range from 0.3% to 1.5%. The alkaloid content was found to vary with the age of the tree: a water extract of the bark contained 0.5% and 0.9% respectively in 60 year- and 150 year-old trees.

The alkaloid content of *Erythrophleum suaveolens* is similar to that of *Erythrophleum ivorense*; only the distribution of the main compounds is different. First investigations yielded the alkaloid erythrophleine, but this was later identified as a mixture of different alkaloids with similar activities. The alkaloids are esters of tricyclic diterpene acids, and 2 main types exist: dimethylaminoethylesters and monomethylaminoethylesters (nor-alkaloids). In addition, compounds have been found in which the amine link is replaced by an amide link, but it is not clear whether these are natural compounds or artefacts. The bark contains as main components alkaloids of the dimethylaminoethylester type: cassaine, erythrophlamine, erythrophleguine and norcassamidine as well as the amide erythrophlamide. The bark extract has excellent local anaesthetic activity on eyes and skin, although its use on the eye was disputed because of its irritant effect on the conjunctiva. Trials using it as anaesthetic in operations or tooth extractions were less successful, as symptoms of poisoning appeared in higher doses. In high doses, the bark extract is an extremely strong, rapid-acting cardiac poison, in warm-blooded animals causing shortness of breath, seizures and cardiac arrest in a few minutes.

The alkaloids have a stimulant effect on the heart similar to that of the cardenolides digitoxine (from *Digitalis*) and ouabain (from *Strophanthus gratus* (Wall. & Hook.) Baill.), but the effect is very short-lasting, as the alkaloids are rapidly metabolized in the organism. The alkaloids also have strong diuretic effects, and increase contractions of the intestine and uterus. Apart from an increase of heart contraction in systole, the alkaloids also demonstrated an increase in diastole. In addition, cassaine caused a violent state of excitation. Although the alkaloid content in the seeds is markedly lower than in the stem bark, the seeds are more toxic. This strong activity is due to a strong haemolytic saponin, which acts in a synergistic way to the alkaloids. Norcassamidine has local anaesthetic action, and is a convulsant.

The bark further contains procyanidins (polyphenols) and hence has antioxidant properties. The relaxant effect of the bark extract of *Erythrophleum suaveolens* is due to its procyanidins.

The bark also contains the trihydroxystilbene resveratrol. Resveratrol shows antiplatelet aggregation, coronary vasodilator, antileukaemic, antifungal and protein-tyrosine kinase inhibitory activities. Trihydroxystilbenes are thought to protect against atherosclerosis and coronary heart disease. Resveratrol is, however, only registered as a food supplement, not as a medicine. The bark contains the flavone luteolin that colours orange after addition of magnesium powder and a few drops of hydrochloric acid. This reaction allows it to be distinguished from the bark of *Erythrophleum africanum* (Welw. ex Benth.) Harms, which colours violet after treatment because of the presence of 2,3-dihydroxymyricetin.

Wood from *Erythrophleum ivorense* and *Erythrophleum suaveolens* is not differentiated in trade and the following wood description is applicable to both species.

The heartwood is yellowish brown to reddish brown, darkening on exposure, sometimes striped, clearly demarcated from the 3–6 cm wide, creamy-yellow sapwood. The grain is interlocked, texture coarse. The wood is moderately lustrous.

The density is about 900 kg/m^3 at 12% moisture content. The wood dries slowly with high risks of distortion and checking. The shrinkage rates from green to oven dry are 5.1–5.8% radial and 8.4–8.6% tangential. Once dry, the wood is moderately stable in service.

At 12% moisture content, the modulus of rupture is 99–162 N/mm^2, modulus of elasticity 10,550–19,500 N/mm^2, compression parallel to

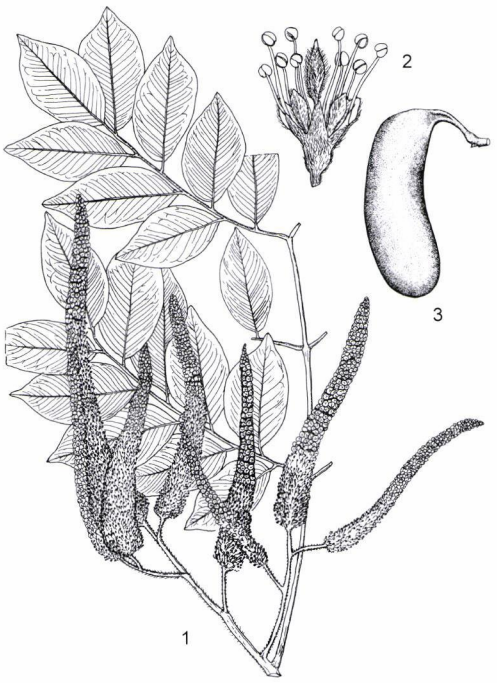
grain 56–97 N/mm^2 and Janka side hardness 13,000 N.

The wood is difficult to saw; satellite-tipped sawteeth are recommended. Finishing is generally fair, but planing may be difficult due to interlocked grain. Pre-boring is necessary for nails and screws. The gluing properties are good.

The wood is durable and resistant to fungi, dry wood borers and termites. It is suitable for use in contact with the ground. It is not permeable for preservatives. The sawdust may irritate mucous membranes and may cause allergy and asthma of labourers in sawmills.

Adulterations and substitutes *Erythrophleum* alkaloids have similar pharmacological activities as digitoxine and ouabain. The timber from *Erythrophleum suaveolens* and *Erythrophleum ivorense* is marketed indiscriminately under the trade names 'tali', 'erun', 'bolondo' and 'alui'.

Description Medium-sized tree up to 25(–30) m tall, often branching low; bark finely fissured, scaly, grey; twigs glabrous. Leaves alternate, bipinnately compound with 2–4 pairs of pinnae; stipules minute, soon falling; petiole and rachis up to 35 cm long, petiole thickened at base; leaflets alternate, 7–14 per pinna, ovate to ovate-elliptical, up to 9 cm × 5.5 cm, base asymmetrical, apex obtusely acuminate. Inflorescence an axillary panicle consisting of spike-like racemes up to 12 cm long, shortly yellowish hairy. Flowers bisexual, regular, 5-merous, yellowish white to greenish yellow; pedicel c. 1.5 mm long, reddish hairy; calyx lobes 1–1.5 mm long; petals 2–3 mm × 0.5 mm, short hairy at margins; stamens 10, free, c. 5 mm long; ovary superior, rusty hairy, 1-celled, stigma cup-shaped. Fruit a flat, slightly curved, dehiscent pod 5–17 cm × 3–5 cm, stipe often lateral, broadly rounded at apex, pendulous, 6–11-seeded. Seeds oblong-ellipsoid, c. 15 mm × 11 mm × 5 mm.



Erythrophleum suaveolens – 1, branch with part of leaf and inflorescence; 2, flower; 3, pod. Source: Flore analytique du Bénin

Other botanical information *Erythrophleum* comprises about 10 species, 4 or 5 of which occur in continental Africa, 1 in Madagascar, 3 in eastern Asia, and 1 in Australia. The genus is one of the few *Caesalpiniaceae* reported to contain alkaloids. *Erythrophleum suaveolens* superficially resembles *Burkea africana* Hook. Mistakes in identification have led to accidental poisoning and even death.

Erythrophleum lasianthum Corbishley, the 'Swazi ordeal tree', closely resembles *Erythrophleum suaveolens*. It is restricted to the area from southern Mozambique south to Swaziland. In South Africa the powdered bark is taken as a snuff to relieve headache, as a remedy for other pains and fever, and to cure lung sickness in cattle. The bark has been used as ordeal poison in the same way as *Erythrophleum suaveolens*, and is also used as a fish and rat poison. The bark contains cardioactive alkaloids, mainly norcassamidine.

Anatomy Wood-anatomical description (IAWA hardwood codes):

Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal; 26: intervessel pits medium (7–10 µm); (27: intervessel pits large (≥ 10 µm)); 29: vestured pits; 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 42: mean tangential diameter of vessel lumina 100–200 µm; 43: mean tangential diameter of vessel lumina ≥ 200 µm; 46: ≤ 5 vessels per square millimetre; (47: 5–20 vessels per square millimetre); 58: gums and other deposits in heartwood vessels. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres

present; 70: fibres very thick-walled. Axial parenchyma: 80: axial parenchyma aliform; 81: axial parenchyma lozenge-aliform; 83: axial parenchyma confluent; 84: axial parenchyma unilateral paratracheal; 91: two cells per parenchyma strand; 92: four (3–4) cells per parenchyma strand. Rays: 97: ray width 1–3 cells; 104: all ray cells procumbent; 115: 4–12 rays per mm. Storied structure: 118: all rays storied; 122: rays and/or axial elements irregularly storied. Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells.
(E. Uetimane, H. Beeckman & P.E. Gasson)

Growth and development Regeneration of *Erythrophleum suaveolens* is best in fairly open forest. Flowering has been noted to occur in January–April in West Africa, December–February in Kenya and in March–July in southern Africa. Nodulation was observed and the rhizobium involved belongs to the genus *Bradyrhizobium*.

Ecology *Erythrophleum suaveolens* occurs in moist semi-deciduous forests, gallery forest and wooded grasslands, from sea-level up to 1100 m altitude. It is absent from the evergreen forest.

Propagation and planting *Erythrophleum suaveolens* can be propagated in nurseries; seed takes 3 weeks to germinate. Inoculation with *Bradyrhizobium* is beneficial, with increases in height and diameter of 20% and 28% respectively after 4 months.

Management In Sierra Leone attempts have been made to grow *Erythrophleum suaveolens* in plantations, but growth was slow.

Harvesting The main parts of *Erythrophleum suaveolens* harvested for medicinal purposes are roots and bark, while the wood is exploited for timber. Traditional herbalists use ad hoc techniques to excavate the roots and debark the stems. Virtually all trees are used, from young to old ones.

Handling after harvest *Erythrophleum suaveolens* roots and bark are washed and air-dried before use or trade. In Malawi sawing of the logs mainly takes place in the forest and the timber is transported to timber merchants before or after seasoning.

Genetic resources *Erythrophleum suaveolens* is widespread and locally common, and as such not threatened by genetic erosion. However, locally it is heavily exploited. One can hardly find a mature tree of *Erythrophleum suaveolens* that has not been debarked in Malawi and therefore it is a species of conservation concern there.

Prospects *Erythrophleum suaveolens* is an important medicinal plant and further study of its pharmacology is justified. Internal use of unpurified medicines made from *Erythrophleum suaveolens* is extremely dangerous. The difference in active ingredients between individual trees in a single population and the differences in composition related to age of the plant are not understood at all, which makes use even more hazardous. Breeding and management programmes should be started in target countries to enhance deliberate propagation and establishment in indigenous forests and plantations.

Major references Arbonnier, 2004; Ayensu, 1978; Betti, 2002; Brenan, 1967; Burkill, 1995; Kamanyi et al., 2003; Marshall, 1998; Oliver-Bever, 1986; Neuwinger, 1996.

Other references Abbiw, 1996; Aubréville, 1968; Beentje, 1994; Coates Palgrave, 1983; Cronlund, 1976; Diabate et al., 2005; Hegnauer & Hegnauer, 1996; InsideWood, undated; Ladipo & Onyeachusim, 1993; McGaw, Jäger & van Staden, 1997; Mgbenka & Ejiofor, 1998; Naderali, Doyle & Williams, 2000; Onuorah, 2001; Sprent, 2005; Wilczek et al., 1952.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors J.M. Okeyo

EUPHORBIA ANTSO Denis

Protologue Euphorb. Iles Austr. Afr.: 45 (1921).

Family Euphorbiaceae

Origin and geographic distribution *Euphorbia antso* is endemic to southern Madagascar.

Uses The latex is toxic and caustic. It is applied to the skin to treat scabies and is used to poison rodents. The latex is also used in religious ceremonies.
In the past the dried stem was used to start fire by friction. *Euphorbia antso* is sometimes sold on the internet as it has some ornamental value.

Properties The wood is soft and perishable.

Botany Monoecious, deciduous, glabrous, strongly branched shrub or small tree up to 15 m tall; bark pale greyish brown; copious latex in all parts. Leaves arranged spirally, crowded towards the stem apex, simple and entire, almost sessile; stipules absent; blade lanceolate, up to 9 cm × 1.5 cm, base cuneate, apex acute,

midvein prominent, lateral veins not prominent. Inflorescence a terminal 3–5-rayed false umbel, consisting of a central, almost sessile, gland-bearing cluster, called a 'cyathium', c. 1 cm in diameter, enclosed in a funnel-shaped involucre, and containing 1 female and many male flowers; basal bracts 5–8, leafy, pale green, upper bracts deltoid, c. 2 cm long, yellowish; nectar-producing glands 2–5, tubular, yellowish green or red. Flowers unisexual; male flowers consisting of a single stamen; female flowers with superior ovary, purple, 3-celled, style long. Fruit a round to lobed capsule, 2–4 cm in diameter, covered with fleshy spines, 3-seeded. Seed globose, 1 cm in diameter.

Euphorbia comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150 species in Madagascar and the Indian Ocean islands. Most species present in Madagascar are endemic to the island.

Several other endemic, non-succulent, shrub-like *Euphorbia* species have medicinal uses in Madagascar. Root decoctions of *Euphorbia boivinii* Boiss., *Euphorbia erythroxyloides* Baker and *Euphorbia tetraptera* Baker (synonym: *Euphorbia bakeriana* Baill.) are used to treat stomach-ache and lumbago. A root decoction of *Euphorbia erythroxyloides* is drunk to treat kidney problems and increase urine production. Its root sap is drunk as a purgative. This species is endangered and occurs on the IUCN Red List. The latex of *Euphorbia boivinii* is used to poison rats. The latex of *Euphorbia pervilleana* Baill. is applied to warts. The spineless shrub *Euphorbia pyrifolia* Lam. ('tanghin rouge') is endemic to the Seychelles, Réunion and Mauritius. In Mauritius a decoction of the aerial parts is taken to treat tetanus.

Ecology *Euphorbia antso* occurs in deciduous forest and thickets, from sea-level up to 500 m altitude.

Genetic resources and breeding *Euphorbia antso* is relatively common in its area of distribution, although it is becoming less common in the coastal region due to habitat destruction. There are no signs of genetic erosion.

Prospects *Euphorbia antso* will probably remain of local importance as a medicinal plant.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Eggli, 2002; Razafiarison, 1993; Stiles, 1998.

Other references Cremers, 1977; Debray, Jacquemin & Razafindrambao, 1971; Gurib-Fakim, Guého & Bissoondoyal, 1996; Haevermans & Labat, 2004; Rakotondravony & Volaharisolo, 2000; Ravelombola, 2004; Steinmann & Porter, 2002.

Authors G.H. Schmelzer

EUPHORBIA CALYPTRATA Coss. & Kralik

Protologue Bull. Soc. Bot. France 4: 495 (1857).

Family Euphorbiaceae

Chromosome number $2n = 40$

Origin and geographic distribution *Euphorbia calyptrata* occurs in Mauritania and throughout northern Africa.

Uses The nomadic Touareg people in the Sahara region apply the latex to warts and pustules. The crushed fresh leaves are applied to snakebites and scorpion stings. The powdered dried leaves, mixed with honey, are applied to the eyes against conjunctivitis and trachoma, or boiled in oil and massaged onto the skin to treat baldness, rheumatism and numbness because of the cold. Leaf powder is applied to infected wounds.

The latex is very irritating to the skin and caustic to the eyes. It is considered very poisonous and the nomads prevent their camels from browsing on the plants.

Properties Crude methanol extracts from both roots and cell cultures of *Euphorbia calyptrata* were found to possess significant activities on the central nervous system (CNS). From both the crude methanolic root extract and the cell cultures the diterpenoids helioscopinolide A, C, D and E were isolated. These diterpenes, administered intraperitoneally to mice, showed different effects on the CNS. Helioscopinolide C showed a clear depressant effect, helioscopinolide E a mild, short-duration depressant effect, whereas helioscopinolides A and D had an opposite, excitatory effect.

Biotransformation of the ergot alkaloids chanoclavine, agroclavine and elymoclavine by *Euphorbia calyptrata* cell culture is being attempted, to obtain derivatives with promising medicinal properties.

Botany Monoecious, annual to perennial glabrous herb up to 70 cm tall, with a fleshy taproot. Leaves arranged spirally, simple and entire, sessile; stipules absent; blade linear, up to 10 cm long, base tapering, apex 2–3-fid, in upper leaves acute. Inflorescence a terminal or axillary cluster of flowers, called a 'cyathium',

on short leafy shoots; cyathia almost sessile, 2–3 mm in diameter, with a cup-shaped involucre, lobes minute, glands 4, transversely ovate, with 2–4 short horns or palmately 6–10-fid, each involucre containing 1 female flower surrounded by many male flowers. Flowers unisexual, greenish; male flowers sessile, bracteoles 2-fid, perianth absent, stamen c. 1.5 mm long; female flowers with pedicel c. 1.5 mm long, reflexed in fruit, perianth a rim, ovary superior, glabrous, 3-celled, styles 3, 2-fid. Fruit a 3-lobed capsule 5–6 mm in diameter, 3-seeded. Seeds conical, 2–2.5 mm long, smooth, bluish grey, caruncle large with 10–15 membranous ridges.

Var. *involucrata* Batt. differs from var. *calyptrata* in its large bracts clasping the stem.

Euphorbia comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150 species in Madagascar and the Indian Ocean islands.

Euphorbia retusa Forssk. (synonym: *Euphorbia cornuta* Pers.) occurs from Mauritania through northern Africa east to western Asia. The Touareg people apply the latex to eczema, warts, ingrown eyelashes and scorpion stings. In Saudi Arabia the aerial parts are used as an expectorant in the treatment of coughs and asthma.

Ecology *Euphorbia calyptrata* occurs in sandy, rocky localities, sandy wadis and sandy-muddy soils, sometimes in large stands.

Genetic resources and breeding *Euphorbia calyptrata* is relatively common in its distribution area and not threatened by genetic erosion.

Prospects The helioscopinolides isolated from *Euphorbia calyptrata* showed interesting activity on the central nervous system. More research on chemistry and pharmacology is therefore needed to evaluate the potential of *Euphorbia calyptrata* as a medicinal plant in drug development.

Major references Hammiche & Maiza, 2006; Jafri & El-Gadi, 1982; Ozenda, 1977; Scigelova et al., 1995; Speroni et al., 1991.

Other references Atiqur Rahman et al., 2004; Borghi et al., 1991; Crespi-Perellino et al., 1996; Kren et al., 1996a; Kren et al., 1996b; Minghetti et al., 1996; Sahara Nature, 2008.

Authors G.H. Schmelzer

EUPHORBIA CANDELABRUM Trémaux ex Kotschy

Protologue Mitt. Geogr. Ges. Wien 1: 169 (1857).

Family Euphorbiaceae

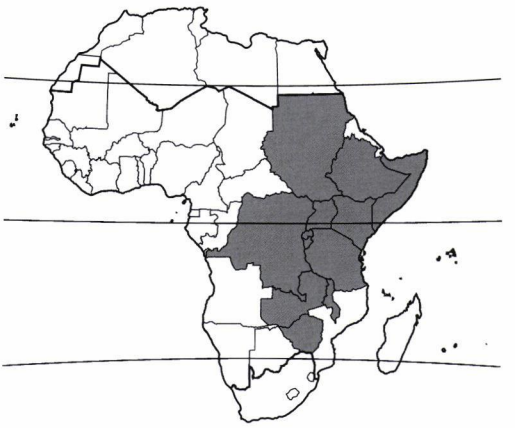
Chromosome number $2n = 56$

Synonyms *Euphorbia reinhartii* Volk. (1899).

Vernacular names Candelabra tree, tree euphorbia (En). Euphorbe candélabre (Fr). Mtungutungii, mtongotongo, mtupa, mtomwu (Sw).

Origin and geographic distribution *Euphorbia candelabrum* occurs from Sudan, Ethiopia and Somalia south to DR Congo and Zimbabwe.

Uses The latex is very toxic and may cause blindness when it comes into contact with the eyes. It is also blistering and irritating to the skin and mucous membranes. In Central Africa several drops of latex diluted in water are taken to treat coughs and tuberculosis, or as an emetic and abortifacient. The latex is also applied to wounds, sores and warts. The Loita Maasai people mix the latex with fat, which is rubbed on the body to treat malaria. A decoction of the pith of the branches is given to women just after childbirth to expel the placenta. In Kenya and Tanzania roots are boiled with chicken or meat, or with stomach fluids from a slaughtered goat or cow, and the liquid is drunk as a strong emetic to treat stomachache, severe constipation and infertility. Latex is taken in porridge as a strong purgative, and to treat HIV infection. In Kenya the latex is also applied to wounds and sores of cattle. Stem ash is powdered and used to treat eye



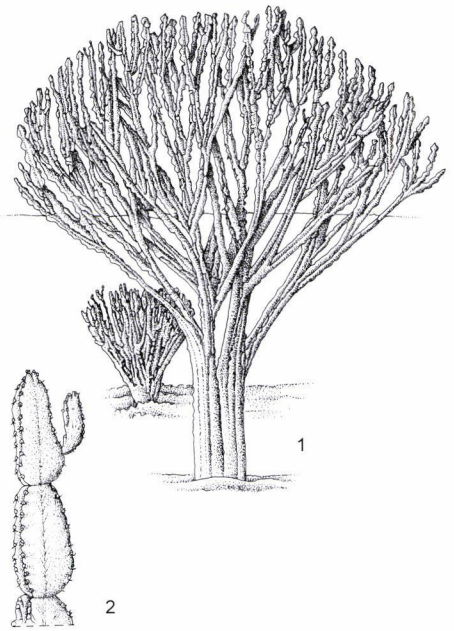
Euphorbia candelabrum – wild

infections. The latex is an ingredient of arrow poison. Fresh, pounded branches are thrown into watering holes and streams as a fish poison and to poison wild animals.

The stems can be used as firewood, although the smoke is irritant. The light, durable wood is used to make roofing, tables, doors, matches, boxes, mortars, musical instruments and saddles. The trunk split into halves is hollowed and re-joined to make beehives. Cut branches are used as fencing and planted for shade. The flowers of *Euphorbia candelabrum* produce much nectar, but the honey causes a burning sensation in the mouth, which is intensified by drinking water. The sticky latex is used as birdlime.

Properties The latex of *Euphorbia candelabrum* contains highly irritant ingenol diterpene esters. Ingenol and its derivatives show tumour-promoting activity, but also anti-HIV and anti-leukaemia activities. Much research is directed toward synthesis and biological evaluation of ingenol analogs and derivatives. The latex also contains about 12.5% rubber. Latex from cultivated plants in the United Kingdom was moderately irritant in the mouse ear test, with an ID_{50} = 1.6 µg / 5 ml after 4 hours, which is similar to the latex of *Euphorbia tirucalli* L., and much less irritant than the latex of *Euphorbia ingens* E.Mey. ex Boiss. An ethanol extract of the stem showed low toxicity in the brine-shrimp test.

Description Monoecious, succulent small tree up to 12(–20) m tall with abundant latex; bole up to 90 cm in diameter; bark grey, roughly fissured; branches persistent from c. 3 m upwards, almost erect, rebranching, forming a large, broadly rounded crown, terminal branches fleshy, 5–10 cm in diameter, constricted at irregular intervals into oblong segments 15–25 cm long, usually 4-angled, with wings up to 2.5 cm wide, margins of angles entire to toothed, with shallow teeth 1–1.5 cm apart; spine shields obtusely triangular, c. 8 mm × 7 mm, soon becoming corky, with 2 pairs of spines, 1 pair stout, c. 5 mm long, 1 (stipular) pair triangular, c. 1.5 mm long, flexible, soon falling. Leaves at the end of branches, in 4 rows, sessile; stipules transformed into small spines; blade deltoid, c. 5 mm × 5 mm, soon falling, in young plants up to c. 7 cm × 1.5 cm. Inflorescence an axillary cyme, 1–6 crowded together at the end of branches, consisting of clusters of flowers, each cluster called a 'cyathium'; peduncle 5–20 mm long, branches 2, c. 5 mm long; bracts 2, c. 5 mm long; cyathia c. 4 mm × 9 mm, with a cup-shaped involucre, lobes c. 2.5 mm long, glands 5, transversely elliptical, c. 2 mm × 4 mm, golden-yellow, each involucre containing 1 female flower surrounded by many male flowers. Flowers unisexual; male flowers sessile, perianth absent, stamen c. 6 mm long; female flowers with pedicel c. 5 mm long in fruit, perianth irregularly 3-lobed, lobes filiform, 2–4 mm long, ovary superior, glabrous, (2–)3-celled, styles (2–)3, c. 3 mm long, fused at base, apex 2-fid. Fruit an almost globose, shallowly (2–)3-lobed capsule c. 8 mm × 12 mm, fleshy, green becoming red, hardening before dehiscence, (2–)3-seeded. Seeds almost globose, c. 3 mm in diameter, greyish brown speckled with pale brown, smooth.



Euphorbia candelabrum – *1, habit; 2, top of branch.*
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Euphorbia* comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150 in Madagascar and the Indian Ocean islands. *Euphorbia candelabrum* belongs to subgenus *Euphorbia*, section *Euphorbia*, a large group which is characterized by succulent, usually angular stems, stipules modified into small spines (or absent), a spine shield with an addi-

tional pair of spines (sometimes fused into a single spine), axillary inflorescences and seeds without a caruncle. *Euphorbia candelabrum* comprises 2 varieties; var. *bilocularis* (N.E.Br.) S.Carter has 2-celled fruits instead of 3-celled fruits of var. *candelabrum*.

Euphorbia candelabrum is very similar to *Euphorbia ingens* from southern Africa, and may be conspecific. The branches of *Euphorbia ingens* are usually more distinctly and shortly segmented, the teeth along the angles are usually further apart and the branch tips bear fewer inflorescences. *Euphorbia conspicua* N.E.Br. (synonym: *Euphorbia candelabrum* Welw. non Kotschy), a tree up to 15 m tall endemic to western Angola, is also very similar to *Euphorbia candelabrum*, as is *Euphorbia abyssinica* J.F.Gmel. (synonym: *Euphorbia obovalifolia* A.Rich.), which occurs from Sudan east to Djibouti and Somalia. In Ethiopia a stem bark decoction of *Euphorbia abyssinica* is taken to treat gastro-intestinal complaints. Latex is taken in milk or eaten with bread to treat gonorrhoea or ascariasis. Latex is applied to wounds to accelerate healing. The latex is applied to ticks of cattle. The soft, yellow wood is used as firewood and for roofing, matches, boxes, tables and saddles. *Euphorbia ampliphylla* Pax (synonym: *Euphorbia obovalifolia* auct. non A.Rich.) is a montane forest tree and occurs from Ethiopia and Somalia south to Malawi and Zambia. In Ethiopia a little latex, probably in water, is taken orally to treat rabies. In Kenya a wood decoction is given to treat stomach-ache during childbirth.

Ecology *Euphorbia candelabrum* is a striking tree, growing in dry deciduous and evergreen open wooded grasslands, on rocky slopes, sometimes on termite mounds, from sea-level up to 2200 m altitude.

Propagation and planting *Euphorbia candelabrum* can be propagated by seed or by stem cuttings. Seeds germinate readily after they have fallen from the trees. Stem cuttings need to be stored for a few days to dry before planted or else they will rot. It is best to plant the cuttings when the rain is about to stop, in a well-drained soil.

Management If grown as a live fence *Euphorbia candelabrum* needs continuous reinforcement planting.

Harvesting The latex or branches can be harvested whenever the need arises.

Genetic resources *Euphorbia candelabrum* is relatively common in its large area of distribution and is therefore not at risk of genetic erosion. As a succulent *Euphorbia* species, its trade is controlled under CITES appendix 2.

Prospects Despite the many traditional medicinal uses, not much is known concerning the chemistry and pharmacology of *Euphorbia candelabrum*. It contains carcinogenic ingenol diterpene esters and the latex should therefore be used with care.

Several tree-sized *Euphorbia* spp. occurring in tropical Africa are very similar to *Euphorbia candelabrum*. They may be conspecific and detailed fieldwork is needed to establish their status.

Major references Beentje, 1994; Bekele-Tesemma, 2007; Carter & Radcliffe-Smith, 1988; Evans & Soper, 1978; ITDG & IIRR, 1996; Maundu et al., 2001; Neuwinger, 1996; Neuwinger, 2000; Uzabakiliho, Largeau & Casadevall, 1987.

Other references Carter, 1985; Giday et al., 2007; Gilbert, 1990; Heine & Heine, 1988b; Ichikawa, 1987; Katende, Birnie & Tengnäs, 1995; Moshi et al., 2004; SEPASAL, 2008b; Teklehaymanot et al., 2007; Yamada, 1999.

Sources of illustration Bekele-Tesemma, 2007.

Authors G.H. Schmelzer

EUPHORBIA CHAMAESYCE L.

Protologue Sp. pl. 1: 455 (1753).

Family Euphorbiaceae

Vernacular names Wood spurge, ground spurge, prostrate sandmat (En). Euphorbe petit-figuier (Fr).

Chromosome number $2n = 18$

Synonyms *Chamaesyce canescens* (L.) Prokh. (1933).

Origin and geographic distribution *Euphorbia chamaesyce* occurs from the Canary Islands east throughout the Mediterranean region to north-western Russia and Pakistan. It is becoming naturalized in the United States and Japan. In tropical Africa it occurs in Cape Verde.

Uses In Cape Verde large quantities of the leaves are put in water holes and canals as a fish poison. In southern Europe an infusion of the aerial parts is applied to painful scars and as eye drops to treat weak eyes.

In Turkey the whole plant is roasted and eaten.

Properties Several ergostane-type steroids have been isolated from the plant, including obtusifoliol, as well as several triterpenoids,

including lupeol, butyrospermol, wrightial, lup-20(30)-ene-3β,29-diol, 11α,12α-oxidotaraxerol and several derivatives. An ergostane-type steroid showed a potent inhibitory effect on Epstein-Barr virus early antigen activation induced by the tumour promoter 12-O-tetradecanoylphorbol 13-acetate (TPA). Two oleananes showed strong cytotoxicity against a panel of 39 human cancer cell lines.

Botany Monoecious, prostrate, annual herb with branches up to 30 cm long; whole plant glabrous to short-hairy. Leaves opposite, simple; stipules triangular, c. 0.5 mm long; petiole short; blade oblong to obovate, 2–8 mm × 2–4 mm, base asymmetrical, one side obliquely rounded and the other cordate, apex rounded or notched, margins entire or toothed. Inflorescence an axillary cluster of flowers, called a 'cyathium'; cyathia almost sessile, c. 0.5 mm long, with a cup-shaped involucre, lobes triangular, minute, margin hairy; glands 4, minute, elliptical, with very small 3-lobed appendages, each involucre containing 1 female flower surrounded by many male flowers. Flowers unisexual; male flowers sessile, bracteoles linear, perianth absent, stamen tiny; female flowers with short pedicel, perianth a rim, ovary superior, glabrous, 3-celled, styles 3, minute, 2-fid. Fruit a 3-lobed capsule c. 1.5 mm × 1.5 mm, glabrous to densely short-hairy, 3-seeded. Seeds ovoid, c. 1 mm long, acutely 4-angled, without caruncle.

Euphorbia comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150 species in Madagascar and the Indian Ocean islands. *Euphorbia chamaesyce* belongs to subgenus *Chamaesyce* section *Chamaesyce*, a group of annual or sometimes perennial herbs with obvious stipules, further characterized by a main stem aborting at the seedling stage, the plant thus consisting of an expanded dichotomously branching umbel-like inflorescence, with the floral bracts appearing as normal leaves, cyathia solitary or up to 5 together in congested leafy cymes, 4 involucral glands with petal-like appendages or entire and conical seeds without a caruncle.

Another *Euphorbia* from Cape Verde, *Euphorbia tuckeyana* Steud. ex Webb ('Cabo Verde spurge'), is used medicinally. It is a shrub up to 3 m tall. The latex is applied to decaying teeth and also to mark animal hides. The wood is used as firewood. It is sometimes sold as an ornamental in Europe. The aerial parts contain the jatrophane diterpene polyesters tuckeyanols A and B and euphotuckeyanol, several cycloartane-type triterpenes, including cyclotucanol, cycloeucalenol and 24-methylenecycloartanol, as well as helioscopinolides A, B, D and E, naringenin, aromadendrin, coniferaldehyde, several 5-hydroxyphorbol derivatives and dehydrodiconiferyl diacetate. Simiarenone and β-sitosterol were also isolated. Several compounds have shown to be moderate inhibitors of the growth of gastric and pancreatic tumour cell lines. Several plant extracts exhibited activity against Gram-positive bacteria and *Candida albicans*.

Ecology *Euphorbia chamaesyce* occurs in dry, sandy to stony soils and along roadsides, from sea-level up to 1000 m altitude.

Genetic resources and breeding There are no signs that *Euphorbia chamaesyce* is threatened by genetic erosion.

Prospects Several of the compounds present in *Euphorbia chamaesyce* show very potent inhibitory effects on Epstein-Barr virus and strong cytotoxicity against a range of human cancer cell lines. Therefore more research is warranted to evaluate the potential of this species for the development of lead compounds.

Major references Figueiredo, 1996; Kerharo, Guichard & Bouquet, 1961; Tanaka et al., 2000; Tanaka et al., 2006.

Other references Duarte, Lage & Ferreira, 2008; Ferreira, Duarte & Ascenso, 1996; Ferreira, Pinto & Ascenso, 2001; Ozenda, 1977; Tanaka et al., 1994; Tanaka et al., 1999; Tosco, 2005.

Authors G.H. Schmelzer

EUPHORBIA CONVOLVULOIDES Hochst. ex Benth.

Protologue Hook., Niger Fl.: 499 (1849).

Family Euphorbiaceae

Origin and geographic distribution *Euphorbia convolvuloides* occurs in the drier parts of West Africa, from Mauritania and Senegal east to Sudan.

Uses In Senegal and Ghana an infusion of the plant is taken to treat urethritis and sexually transmitted diseases, while in Côte d'Ivoire an infusion is applied as eye drops to treat eye problems. In Nigeria crushed leaves, mixed with palm oil, are applied to dry up the rashes associated with measles, chickenpox and formerly smallpox. The crushed leaves are taken to treat diarrhoea as they have an astringent effect, and an infusion of the dried

leaves is taken against dysentery. In contrast, an infusion of the whole plant is taken orally or as an enema for its laxative effects. An extract of the plant is taken to treat coughs, a sore throat, asthma and bronchitis. The vapour of latex in hot water is also inhaled to treat coughs and bronchitis. The pulp of fresh leaves mixed with those of *Citrullus colocynthis* (L.) Schrad., and sometimes with other plants, is applied to the breasts or given in infusion to increase milk production and quality of the milk. In Nigeria scorpion stings and snakebites are said to be prevented if the plant is chewed and swallowed, and a mixture of the plant, saliva and the sap of *Calotropis procera* (Aiton) R.Br. is rubbed on the hands. The latex is considered an antidote for scorpion stings. The plant is also considered narcotic and is used magically. In Senegal a plant infusion is given to cattle to drink to treat urinary infections. *Euphorbia convolvuloides* is generally browsed by livestock.

Properties The aerial parts have an astringent effect due to the presence of tannins.

Botany Monoecious, erect, hairy, annual herb up to 40 cm tall; branches drooping at the tips, often reddish. Leaves opposite, distichous, simple; stipules minute; petiole up to 1 mm long; blade oblong to lanceolate, 2–4 cm × 0.5–1.5 cm, base slightly unequal, cuneate, apex acute, margins minutely toothed. Inflorescence a terminal or axillary cluster of flowers, called a 'cyathium', several cyathia densely clustered together, pink; cyathia almost sessile, c. 1 mm × 1 mm, with a cup-shaped involucre, densely white-hairy, lobes triangular, minute, hairy, glands 4, tiny, round, with or without appendages, pink with white rim, each involucre containing 1 female flower surrounded by many male flowers. Flowers unisexual; male flowers sessile, bracteoles linear, perianth absent, stamen c. 0.5 mm long; female flowers with pedicel c. 1.5 mm long, reflexed in fruit, perianth a rim, ovary superior, densely hairy, 3-celled, styles 3, minute. Fruit a hairy 3-lobed capsule c. 2 mm in diameter, 3-seeded. Seeds ovoid, c. 1.5 mm long, acutely 4–5-angled, whitish or pale reddish, without caruncle. Seedling with epigeal germination; cotyledons almost sessile, elliptical; epicotyl absent.

Euphorbia comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150 species in Madagascar and the Indian Ocean islands. *Euphorbia convolvuloides* belongs to subgenus *Chamaesyce* section *Chamaesyce*, a group of annual or sometimes perennial herbs with obvious stipules, further characterized by a main stem aborting at the seedling stage. The plant thus consists of an expanded dichotomously branching umbel-like inflorescence, with the floral bracts appearing as normal leaves, cyathia solitary or up to 5 grouped together in congested leafy cymes, 4 involucral glands with petal-like appendages or entire and conical seeds without a caruncle. *Euphorbia kilwana* N.E.Br. (synonym: *Euphorbia convolvuloides* var. *integrifolia* Pax) occurs in Tanzania, Malawi, Zimbabwe and Mozambique and closely resembles *Euphorbia convolvuloides*. *Euphorbia forskalii* J.Gay (synonym: *Euphorbia aegyptiaca* Boiss.) also belongs to section *Chamaesyce* and occurs on clay soils throughout tropical West Africa east to Somalia, and from northern Africa east to the Arabian Peninsula and Turkey. It also occurs in Namibia. In Nigeria extracts of *Euphorbia forskalii* are taken as a purgative to treat tapeworm; the latex is applied to warts, sores, guinea-worm and jiggers. In Nigeria and Sudan the plant is pounded with a little water and applied to the head and neck to treat headache, bone fractures or traumatic swellings. In Sudan the latex is applied to the breasts as a galactagogue. Sheep and goats browse the plants. Petroleum-ether extracts of the whole plant show significant activity against freshwater snails.

Several other *Euphorbia* spp. not belonging to section *Chamaesyce* are used medicinally in West Africa. *Euphorbia baga* A.Chev. has a rounded tuber and short thickened stems with tufts of lanceolate, acute leaves at the apex. It occurs from Côte d'Ivoire and Mali east to Nigeria and also in Sudan. In Sudan the latex or crushed plant is used as fish poison. *Euphorbia kerstingii* Pax occurs from Togo east to Cameroon. It has annual stems up to 16 cm long arising from a woody rootstock. The Kotokoli people from Togo use a plant extract to harden the fontanel of newborn babies.

Ecology *Euphorbia convolvuloides* occurs in savanna, waste places and along roadsides, sometimes as a weed in crops, usually on sandy soil.

Management *Euphorbia convolvuloides* can be collected during the rainy season, and dried for future use.

Genetic resources and breeding *Euphorbia convolvuloides* is relatively common in its area of distribution and there are no signs that it is threatened by genetic erosion.

Prospects *Euphorbia convolvuloides* has many local medicinal uses but will remain of local importance only, unless chemical and pharmacological research can confirm its medicinal value.

Major references Adjanohoun et al., 1989; Brown, Hutchinson & Prain, 1909–1913; Burkill, 1994; Neuwinger, 2000; Stäuble, 1986.

Other references Berhaut, 1975a; Bouquet & Debray, 1974; Iwu, 1993; Keay, 1958a; Le Bourgeois & Merlier, 1995; Manu, 2002.

Authors O.M. Grace

EUPHORBIA COOPERI N.E.Br. ex A.Berger

Protologue Sukkul. Euphorb.: 83 (1906).

Family Euphorbiaceae

Vernacular names Lesser candelabra tree, Transvaal candelabra tree (En).

Origin and geographic distribution *Euphorbia cooperi* occurs from Tanzania south to north-eastern South Africa and Swaziland.

Uses The latex is said to be one of the most poisonous of the *Euphorbia* spp., causing intense skin irritations and producing a burning sensation in the throat when standing next to bleeding plants. The latex may cause blindness if it comes into the eyes. It has a pungent, acrid smell. In South Africa the latex is boiled until black and then dried; the powder is applied to infected wounds. A root decoction, together with a root decoction of *Euphorbia ingens* E.Mey. ex Boiss., is applied as a dressing to treat paralysis. A bundle of grass soaked in the latex is attached to a stone and thrown into the water as fish poison.

Euphorbia cooperi is sometimes used to make fence poles. The flowers produce much nectar, but the honey, known as 'noors honey', causes a burning sensation in the mouth, which is intensified by drinking water. *Euphorbia cooperi* is planted as an ornamental in succulent gardens or rock gardens in South Africa and the United States.

Properties Several diesters and triesters of 16-hydroxy-12-desoxyphorbol were isolated from the latex. The diterpene esters showed more or less pronounced irritation on mice ears, as well as tumour-promoting activity in vitro.

Botany Monoecious, succulent, candelabriform small tree up to 6(–9) m tall, with abundant latex; bole stout, cylindrical, scarred from fallen branches; branches curved upwards, simple or sometimes branched near the apex, forming a flat-topped crown, branches 5–20 cm in diameter, deeply constricted at irregular intervals into oblong segments 10–50 cm long, (3–)4–6(–8)-angled, margins of angles wavy, with tubercles 8–25 mm apart; spine shields joined into a continuous horny margin 3–10 mm large, with 2 pairs of spines, 1 pair of stout spines up to 10 mm long, 1 (stipular) pair tiny, soon falling. Leaves at the end of branches, in 3–7 rows, sessile; stipules transformed into tiny spines; blade deltate, c. 1.5 mm × 1.5 mm, soon falling. Inflorescence an almost sessile, axillary cyme, crowded at the end of branches, 1–3 together in a horizontal line, consisting of clusters of flowers, each cluster called a 'cyathium', cyme branches 2; bracts 2, tiny; cyathia c. 4.5 mm × 8 mm, with a cup-shaped involucre, lobes c. 1.5 mm long, glands 5, transversely oblong, c. 1.5 mm × 4 mm, golden-yellow, each involucre containing 1 female flower surrounded by many male flowers. Flowers unisexual; male flowers sessile, perianth absent, with a single stamen; female flowers with pedicel 4–10 mm long in fruit, perianth shallowly 3-lobed, ovary superior, glabrous, 3-celled, styles 3, variably fused, 2–5.5 mm long, apex 2-fid. Fruit an obtusely to deeply 3-lobed capsule 6–10 mm × 10–13.5 mm, fleshy, green becoming red, 3-seeded. Seeds almost globose, 2.5–3.5 mm in diameter, pale greyish brown speckled with pale brown, smooth.

Euphorbia comprises about 2000 species and has a worldwide distribution, with at least 750 occurring in continental Africa and about 150 species in Madagascar and the Indian Ocean islands. *Euphorbia cooperi* belongs to subgenus *Euphorbia*, section *Euphorbia*, a large group which is characterized by succulent, usually angular stems, stipules modified into small spines (or absent), a spine shield with an additional pair of spines (sometimes fused into a single spine), axillary inflorescences and seeds without a caruncle. *Euphorbia cooperi* is variable and 3 varieties are distinguished.

There are several other tree-sized *Euphorbia* spp. with medicinal uses. *Euphorbia magnicapsula* S.Carter occurs in East Africa. In Kenya the crushed roots in water are given to sheep and goats to treat coenurosis, an infection with tapeworm larvae. The dried stems with the thorns burnt off are crushed in water and cattle are given the water to drink to treat venereal diseases. *Euphorbia magnicapsula* is cultivated as an ornamental pot plant in the United States. *Euphorbia nyikae* Pax ex Engl.

occurs in Kenya and Tanzania. In Kenya the latex is added to *Acokanthera* arrow poison used by the Giriama people. Young pounded stems are thrown in water as fish poison. In Tanzania a root decoction or latex in soup is drunk to treat urinary tract infections and epilepsy. *Euphorbia nyikae* is also planted as a hedge. *Euphorbia bussei* Pax has the same distribution area and can be confused with *Euphorbia nyikae*. Stems of *Euphorbia bussei* are used by the Kamba people to build grain stores. *Euphorbia trigona* Mill. from Central Africa, Angola and Malawi is commonly planted as a ritual plant and hedge near villages, especially in Gabon. It is possibly of hybrid origin, as it is only known in cultivation and is not known to flower. The latex is an additive to *Periploca nigrescens* Afzel. arrow poison, and is also used as fish poison or as a criminal poison. The latex is also used during trials by ordeal. In Congo some drops of latex in palm wine are taken in severe cases of constipation or in case of an epileptic attack. *Euphorbia trigona* is widely cultivated as a pot plant. The latex contains 8-methoxyingol esters, which are very irritant to the skin. It also contains lectins with potent erythrocyte agglutinating ability.

Ecology *Euphorbia cooperi* occurs in wooded grassland and on rocky hillsides, usually forming colonies, at 200–1500 m altitude. It flowers from September to October. The ripe fruits burst open, flinging seeds several metres away.

Management *Euphorbia cooperi* is easily propagated from seeds or cuttings, which must be dried before planting to prevent rotting. Great care must be taken when collecting cuttings, to prevent the poisonous latex from coming into contact with skin or eyes. *Euphorbia cooperi* does not require much water.

Genetic resources and breeding *Euphorbia cooperi* is relatively common in its area of distribution and there are no signs of genetic erosion. As a succulent *Euphorbia* species, its trade is controlled under CITES appendix 2.

Prospects The latex of *Euphorbia cooperi* is in general too toxic to be medicinally used. Several irritant and cocarcinogenic derivatives of 16-hydroxy-12-desoxyphorbol were isolated, indicating that its use in modern medicine will be limited.

Major references Baloyi & Ferreira, 2005; Carter & Leach, 2001; Coates Palgrave, 1983; Gschwendt & Hecker, 1971; Gundidza, Sorg & Hecker, 1992.

Other references Beentje, 1994; Clark, Appleton & Drewes, 1997; Eggli, 2002; Gschwendt & Hecker, 1970; ITDG & IIRR, 1996; Latham, 2007; Neuwinger, 1996; Neuwinger, 2000; Sosath, Ott & Hecker, 1988; Tyiso & Bhat, 1998.

Authors G.H. Schmelzer

EUPHORBIA CROTONOIDES Boiss.

Protologue A.DC., Prodr. 15(2): 98 (1862).

Family Euphorbiaceae

Origin and geographic distribution *Euphorbia crotonoides* occurs from Sudan and Ethiopia southwards throughout East Africa and southern Africa.

Uses In Ethiopia a root decoction is taken to treat stomach problems and hookworm infection. In East Africa the root bark is chewed and the sap is swallowed as a purgative to treat obesity. The latex is applied to warts and skin diseases. An infusion of the aerial parts is mixed with other plants and taken to treat malaria.

Botany Monoecious, much-branched, annual herb up to 50(–100) cm tall, with spreading white hairs and white latex; branches longitudinally ridged to winged. Leaves alternate, simple; stipules glandular, dark red; petiole up to 5 cm long, 2-winged; blade linear-lanceolate to ovate, 3–14 cm × 0.5–6 cm, base tapering into the petiole, apex acute, margins almost entire to toothed, teeth gland-tipped, red, midvein winged on lower surface. Inflorescence an axillary or terminal cyme consisting of clusters of flowers, each cluster called a 'cyathium', in 3-branched umbels; branches up to 12 cm long; bracts narrower than leaves, with petiole up to c. 5 mm long; cyathia almost sessile, c. 2.5 mm × 3.5 mm, with a cup-shaped involucre, lobes quadrangular, c. 2 mm long, margin hairy, glands 4, transversely elliptical, c. 1 mm × 1.5 mm, yellow, turning brown then red, each involucre containing 1 female flower surrounded by many male flowers. Flowers unisexual; male flowers sessile, bracteoles fringed, perianth absent, stamen c. 3 mm long; female flowers with pedicel c. 3 mm long in fruit, ovary superior, densely hairy, 3-celled, styles 3, 2–2.5 mm long, fused to halfway, apex thickened, spreading. Fruit an almost globose capsule 6.5–7 mm in diameter, base truncate, with shallow longitudinal grooves, long-hairy, 3-seeded. Seeds ovoid or conical, 4-angled, c. 4.5 mm × 2.5 mm, apex rounded or acute, obscurely or distinctly warty, brown to grey or reddish black; caruncle

absent.

Euphorbia comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150 species in Madagascar and the Indian Ocean islands. *Euphorbia crotonoides* belongs to subgenus *Eremophyton*, section *Pseudacalypha*, a group consisting of annual or short-lived perennial herbs or shrubs with glandular or filamentous stipules, leafy bracts, 4 involucral glands, almost globose capsules on a short pedicel and warty seeds without a caruncle. In southern Africa the growth of *Euphorbia crotonoides* is more lush and the leaves are more ovate. Throughout the species range the size of the glandular teeth on the leaf margins varies considerably, as does the density of the hairiness and the colour of the seeds.

Several other *Euphorbia* spp. of section *Pseudacalypha* are used for medicinal purposes in tropical Africa. *Euphorbia acalyphoides* Hochst. ex Boiss. occurs from Sudan east to Somalia and Kenya, in Angola, and also in Yemen and Saudi Arabia. In Somalia the crushed herb or the latex is applied to fungal skin diseases. *Euphorbia hadramautica* Bak. occurs in Ethiopia and Somalia and possibly in northern Kenya; it is also found in Yemen, including Socotra. In Somalia the latex is applied to foot rot and foot abscesses in sheep and goats, and skin parasites of camels. *Euphorbia systyloides* Pax occurs from Kenya and Uganda south to Zimbabwe and Mozambique. In southern Uganda a leaf decoction with salt is taken to treat tapeworm infections. The leaves are eaten by goats and camels. The following species belong to *Euphorbia* section *Eremophyton*, which differs mainly from section *Pseudacalypha* by oblong, well exserted capsules and seeds with a cap-like caruncle. *Euphorbia agowensis* Hochst. ex Boiss. occurs in Ethiopia, Somalia, Kenya and Angola, and also in Yemen and India. In Somalia the crushed herb or the latex is applied to fungal skin diseases. *Euphorbia polyantha* Pax occurs in Ethiopia, Somalia, Kenya and Tanzania. In Somalia the latex is taken in milk as a purgative to treat stomach problems. In Tanzania a stem bark decoction is taken to treat stomach troubles and oedema.

Ecology *Euphorbia crotonoides* occurs on sandy and stony soils in open grassy woodland or disturbed localities, at 350–1250 m altitude.

Genetic resources and breeding *Euphorbia crotonoides* is widespread and common and not threatened by genetic erosion.

Prospects *Euphorbia crotonoides* will probably remain of local importance as a medicinal plant.

Major references Carter & Leach, 2001; Gemedo-Dalle, Maass & Isselstein, 2005; Giday et al., 2003; Neuwinger, 2000.

Other references Catley & Mohammed, 1996; Eggli, 2002; Hamill et al., 2003; Heine & Heine, 1988b; Hurskainen, 1994; Samuelsson et al., 1992.

Authors G.H. Schmelzer

EUPHORBIA DIDIEREOIDES Denis & Leandri

Protologue Bull. Mus. natn. Hist. nat., Paris, sér. 2, 6: 121 (1934).

Family Euphorbiaceae

Origin and geographic distribution *Euphorbia didiereoides* is endemic to central and southern Madagascar.

Uses A leaf decoction is taken to treat coughs in children, urogenital infections, haematuria and prostatic hypertrophy.

Euphorbia didiereoides is used as a succulent pot plant.

Botany Monoecious, succulent, very spiny shrub with many erect stems from the base, up to 2.5 m tall; stems up to 15 cm in diameter, tapering to c. 3 cm at apex, with many short branches of 1–2 cm long; copious latex in all parts. Leaves arranged spirally, simple and entire, almost sessile; stipular spines 2, long, with cluster of shorter spines at base; blade lanceolate, V-folded, up to 2.5 cm × 1.5 cm, base cuneate, apex acute, margins red, densely hairy beneath, midvein prominent. Inflorescence a dense terminal head, consisting of clusters of flowers, each cluster called a 'cyathium', c. 3 mm in diameter, enclosed in an involucre, containing 1 female flower, several male flowers and several glands; peduncle up to 15 cm long, hairy; bracts erect, yellow to orange, hairy; nectar-producing glands ovate, yellow. Flowers unisexual; male flowers consisting of a single stamen; female flowers with superior ovary, 3-celled. Fruit a 3-lobed capsule, c. 5 mm in diameter, dark red, hairy.

Euphorbia comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150 species in Madagascar and the Indian Ocean islands. Most species present in Madagascar are endemic to the island. *Euphorbia didiereoides* belongs to subgenus *Lacanthis*. The spiny, succulent *Euphorbia pri-*

mulifolia Baker also belongs to this subgenus. The latex is applied to syphilitic sores. The thickened root is used as bait to poison rats; it is also used for criminal purposes.
Several small leafy *Euphorbia* spp. endemic to Madagascar are also used medicinally.
The leafy stems of *Euphorbia emirnensis* Baker are crushed and the latex applied on skin parasites and warts. The thickened root is very toxic and fried slices are used as bait to poison rodents; it is also used as fish poison. An infusion of the leafy stem of *Euphorbia orthoclada* Baker is widely taken as a diuretic to treat kidney problems. The latex of *Euphorbia trichophylla* Baker is put on a sweet and given to children as a vermifuge. The latex is also used in bait to poison rats. The plant is used to prepare a black dye for locally made cloth. *Euphorbia trichophylla* is classified as vulnerable on the IUCN Red List.
For ornamental purposes *Euphorbia didiereoides* has been hybridized, e.g. with *Euphorbia milii* Des Moul. resulting in *Euphorbia* 'Honkytonk'.

Ecology *Euphorbia didiereoides* occurs on rock outcrops scattered in grassland and in the plateau areas, from sea-level up to 700 m altitude.

Management *Euphorbia didiereoides* can be propagated by stem cuttings or seed.

Genetic resources and breeding *Euphorbia didiereoides* has a limited distribution area, and numbers are diminishing due to habitat degradation, fires and collection for horticultural trade. *Euphorbia didiereoides* is classified as endangered on the IUCN Red List of threatened species. As a succulent *Euphorbia* species, its trade is controlled under CITES appendix 2.

Prospects *Euphorbia didiereoides* has some interesting local uses, but no phytochemical analyses have been done. More research is therefore warranted in order to evaluate its potential.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Eggli, 2002; Ralantonirina, 1993; Rasolondratovo et al., 1995.

Other references Cremers, 1977; Haevermans, 2004; Haevermans et al., 2004; Leandri, 1962; Raharinirina, 2006; Randriamantsoa, 2003.

Authors G.H. Schmelzer

EUPHORBIA GRANTII Oliv.

Protologue Trans. Linn. Soc. London 29: 144 (1875).

Family Euphorbiaceae

Vernacular names African milkbush (En).

Origin and geographic distribution *Euphorbia grantii* occurs from eastern DR Congo, Uganda and Kenya south to Tanzania and northern Zambia.

Uses The milky latex of *Euphorbia grantii* is used medicinally, despite its toxicity. The latex may cause rupturing of the cornea if it comes into contact with the eyes, and poisoning in people and animals if ingested. In East Africa the latex is applied to wounds to promote blood clotting and tissue healing. The latex is warmed by placing a section of the stem in hot ash, and applied as ear drops to treat earache. In Rwanda and Burundi the diluted latex is drunk to treat infections of tapeworm and other intestinal worms. Stem ash is applied to sores caused by leprosy. In Rwanda a leaf decoction, roasted leaves or leaf sap mixed with beer is taken to treat gonorrhoea.
The roots are a strong purgative and are given to children to chew to treat stomach complaints, whereas adults chew the roots as an emetic to treat epilepsy, poisoning and snakebites. Ground roots are eaten in porridge to treat constipation. The Maasai people use the stems in a tonic that is mixed with soup and given to new mothers after labour. The leaves, bark and roots are boiled and given to cattle, to prevent infection of the uterus when the placenta is expelled.
In Rwanda and Tanzania the latex is added to *Acokanthera schimperi* (A.DC.) Schweinf. arrow poison.
The stems are taken as a recreational stimulating drug by the Maasai people. *Euphorbia grantii* is sometimes planted as a hedge.

Properties *Euphorbia grantii*, like many related species, has severely irritant effects on the skin and mucosa. The principle toxic constituents in *Euphorbia* species are diterpenes present in the milky latex. The rubber content of latex from *Euphorbia grantii* is low (2.5–6.9% of dry latex). From the stem 3-O-methylquercetin and several other 3–methoxyflavones were isolated, exhibiting potent antiviral activity against picornaviruses such as polio-, coxsackie- and rhino-viruses, and against vesicular stomatitis virus at low concentrations (0.01 µg/ml) and with minimal cytotoxicity. Biochemical studies on the

mechanism of action of these compounds on poliovirus replication suggested that these 3-methoxyflavones are able to protect the host cells from a virus-induced shutdown of cellular protein synthesis. Naturally occurring and synthetic 3-O-methylquercetin are equally effective. Strikingly, other natural compounds structurally related to 3-O-methylquercetin such as quercetin, catechin, kaempferol, myricetin and rutin do not block poliovirus replication.

In-vivo bioassays have shown that 3-O-methylquercetin has anti-inflammatory activity, with up to 55% and 31% inhibition of acute and chronic inflammation, respectively. Due to its multiple bioactivities, and the absence of ciliotoxicity towards nasal cilia, 3-O-methylquercetin has shown potential as a nasal antirhinoviral drug to treat the common cold.

Botany A few-stemmed shrub or sparingly branched small tree up to 9 m tall; bark smooth, grey, horizontally grooved; branches semi-succulent, with large prominent closely-set leaf scars and abundant latex. Leaves alternate, simple and entire, sessile, glabrous; stipules glandular, minute, soon falling; blade linear to linear-lanceolate, up to 30 cm × 3 cm, base rounded, apex acuminate, midrib prominent on the lower surface, pale green. Inflorescence a short-hairy, 3-branched umbel, consisting of clusters of flowers, each cluster called a 'cyathium'; peduncle up to 10(–15) cm long; branches up to 5(–7) cm long, each forking up to 8 times; bracts sessile, deltoid, c. 4 cm × 4 cm, base slightly cordate, apex long-acuminate; cyathia c. 1 cm × 3 cm, with a barrel-shaped involucre, lobes c. 3 mm × 5 mm, rounded, margin sharply toothed, all parts short-hairy, glands 4, spreading, c. 4 mm × 8 mm, transversely elliptical, outer margin with 6–10 finger-like processes c. 8 mm long, branching several times at the tips and terminating in minute knobs, the glands yellowish green, with reddish processes; each involucre containing 1 female flower surrounded by many male flowers. Flowers unisexual; male flowers with many fan-shaped, deeply divided, feathery bracteoles, stamen c. 15 mm long; female flowers with curved pedicel up to 1.5 cm long in fruit, perianth with lobes c. 1.5 mm long, ovary superior, short-hairy, 3-celled, styles c. 1 cm long, fused to nearly halfway, with shortly 2-fid thickened stigma. Fruit an almost globose capsule c. 13 mm × 17 mm, glabrous when mature, tinged purplish, 3-seeded. Seeds almost globose, c. 6 mm × 5 mm, slightly compressed laterally and obscurely 3-angled, surface minutely rough, greyish brown.

Euphorbia comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150 species in Madagascar and the Indian Ocean islands. *Euphorbia grantii* belongs to section *Trichadenia*, a group of trees, shrubs or perennial herbs with a fleshy rootstock and usually fleshy stems, stipules absent or soon falling or modified into glands, large, terminal, umbel-like inflorescences, glands usually with slender lobes or appendages, relatively large fruits and seeds without a caruncle. Several other *Euphorbia* spp. of section *Trichadenia* are used in medicine in tropical Africa. *Euphorbia noxia* Pax occurs in Somalia and southern Yemen; in Somalia the latex is an ingredient of arrow poison. *Euphorbia somalensis* Pax occurs in Ethiopia and Somalia. In Somalia the latex is applied to bruised skin caused by mange; it is applied undiluted to the skin of camels and diluted to sheep and goats. The latex of *Euphorbia transvaalensis* Schltr. from southern Africa is used to treat warts. *Euphorbia monteiri* Hook.f. belongs to section *Pseudeuphorbium* which has many characteristics similar to those of section *Trichadenia*, but the fleshy, tuberous roots are lacking and the stem is succulent with prominent tubercles. *Euphorbia monteiri* occurs in Angola, Namibia, Botswana, Zimbabwe and South Africa. In Namibia the latex is applied to decaying teeth. An infusion of the crushed roots is drunk as a purgative. Sliced lateral roots are added to boiling milk, which is drunk as a blood purifier and tonic. Crushed roots are added to milk for better butter production. In Botswana a leaf and root decoction is taken to treat biliousness. In southern Zimbabwe the roots are taken as an emetic. Cooked aerial parts are given to aggressive dogs.

Ecology *Euphorbia grantii* occurs in sandy or rocky soils, in open woodland, and on rocky hillsides, up to 1750 m altitude.

Genetic resources and breeding *Euphorbia grantii* is fairly common throughout its extensive range and there are no signs of genetic erosion.

Prospects The 3-methoxyflavones isolated from the stem of *Euphorbia grantii* show interesting antiviral activity and merit further research.

Major references Carter & Leach, 2001; De Meyer et al., 1991; Dimova et al., 2003; Neu-

winger, 1996; Neuwinger, 2000.

Other references Catley & Mohammed, 1996; Deng et al., 1997; Ichikawa, 1987; Middleton, Kandaswami & Theoharides, 2000; Minja, 1999; SEPASAL, 2008h; Uzabakiliho, Largeau & Casadevall, 1987; van Hoof et al., 1984; Vlietinck et al., 1995; Vrijsen et al., 1987.

Authors O.M. Grace & D.G. Fowler

EUPHORBIA GRANULATA Forssk.

Protologue Fl. aegypt.-arab.: 94 (1775).

Family Euphorbiaceae

Chromosome number $2n = 22$

Origin and geographic distribution *Euphorbia granulata* occurs in northern and eastern Africa east to central Asia and India. In tropical Africa it occurs in dry regions from Mauritania east to Somalia and south to Tanzania.

Uses The nomadic Touareg people of the Sahara use the latex internally to expel intestinal worms, and externally apply it to snakebites and scorpion stings. In Saudi Arabia the latex is taken as a purgative, anthelmintic and diuretic, as well as for its blood purifying properties.

Properties From petroleum and alcoholic extracts of the whole plant the following compounds were isolated: hentriacontane, dotriacontanol, lupeol acetate, taraxasterol acetate, lupeol, taraxasterol, sitosterol and gallic acid.

A methanol extract of the leaves showed considerable inhibitory effects against HIV-1 protease. A water extract of the leaves showed considerable inhibitory effects against hepatitis C virus protease.

An aqueous extract of *Euphorbia granulata* significantly and invariably inhibited germination and radicle growth of a range of crop plants and weeds in a laboratory bioassay. Artificially decomposed *Euphorbia granulata* litter in a nutrient medium significantly reduced germination and fresh and dry weight gain of the same test species. The toxins affected germination and growth independently and it is therefore suggested that its litter must be removed from the fields during weeding.

Botany Monoecious, prostrate, annual herb with branches up to 15 cm long; whole plant short-hairy or sparsely hairy. Leaves opposite, simple; stipules up to 1.5 mm long, deeply 2–4-fid; petiole up to 1 mm long; blade obovate to oblong-ovate, up to 8 mm × 4.5 mm, base obliquely rounded to cordate, apex rounded, margins entire or toothed. Inflorescence a terminal or pseudo-axillary cluster of flowers, called a 'cyathium', on short leafy shoots; cyathia almost sessile, c. 1 mm × 1 mm, with a cup-shaped involucre, lobes triangular, minute, margin hairy; glands 4, minute, transversely elliptical, with very small appendages, pink or white, each involucre containing 1 female flower surrounded by many male flowers. Flowers unisexual; male flowers sessile, bracteoles linear, perianth absent, stamen c. 1 mm long; female flowers with pedicel c. 1.5 mm long, reflexed in fruit, perianth a rim, ovary superior, glabrous, 3-celled, styles 3, minute, 2-fid. Fruit an acutely 3-lobed capsule c. 1.5 mm × 1.5 mm, 3-seeded. Seeds oblong-conical, c. 1 mm × 0.5 mm, acutely 4-angled, transversely wrinkled, pinkish brown, without caruncle.

Euphorbia comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150 species in Madagascar and the Indian Ocean islands. *Euphorbia granulata* belongs to subgenus *Chamaesyce* section *Chamaesyce*, a group of annual or sometimes perennial herbs with obvious stipules, further characterized by a main stem aborting at the seedling stage, the plant thus consisting of an expanded dichotomously branching umbel-like inflorescence, with the floral bracts appearing as normal leaves, cyathia solitary or up to 5 grouped together in congested leafy cymes, 4 involucral glands with petal-like appendages or entire and conical seeds without a caruncle. In *Euphorbia granulata* 3 varieties are distinguished, based mainly on the hairiness of the plants.

Euphorbia scordiifolia Jacq. also belongs to subgenus *Chamaesyce*, and occurs from West Africa and northern Africa east to Ethiopia and also in the Arabic Peninsula. In Senegal the aerial parts enter in a mixture with other plants used as a bath to treat mental illness. In Nigeria the latex is applied as an analgesic to aching teeth and tsetse fly bites. A plant decoction is applied to breasts as a galactagogue. In Nigeria and Ethiopia the latex is taken to treat dysentery. In Saudi Arabia an extract of the aerial parts is taken to treat fever and constipation. In West Africa cattle, sheep and goats browse the plants, although they have also been reported as poisonous.

Ecology *Euphorbia granulata* occurs in exposed sandy, gritty to stony soils, often on lava, from sea-level up to 1000 m altitude. It is also

a weed in agricultural land.

Management *Euphorbia granulata* is a host of the nematodes *Meloidogyne incognita* and *Meloidogyne javanica*.

Genetic resources and breeding *Euphorbia granulata* is a common weedy plant throughout its area of distribution and is therefore not threatened by genetic erosion.

Prospects Several extracts of the leaves of *Euphorbia granulata* show interesting inhibitory effects against HIV-1 protease and hepatitis C virus protease, and more research concerning its chemistry and pharmacology is needed to evaluate its potential.

Major references Atiqur Rahman et al., 2004; Carter & Radcliffe-Smith, 1988; Hammiche & Maiza, 2006; Hussein et al., 2000; Hussein et al., 1999.

Other references Ahmad, 1986; Asres et al., 2005; Burkill, 1994; Hussain, 1980; Jansen, 1981; Mani & Al Hinai, 1996; Neuwinger, 2000.

Authors G.H. Schmelzer

EUPHORBIA HETEROPHYLLA L.

Protologue Sp. pl. 1: 453 (1753).

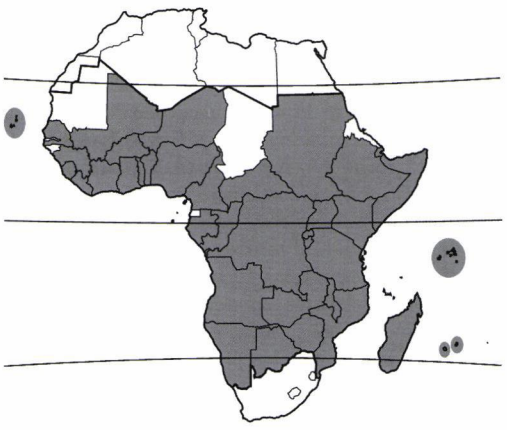
Family Euphorbiaceae

Chromosome number n = 12, 14, 19, 27, 28; $2n$ = 46, 54, 56

Synonyms *Euphorbia geniculata* Ortega (1979).

Vernacular names Fiddler's spurge, mole plant, annual poinsettia, wild poinsettia, Japanese poinsettia (En). Caca poule (Fr). Flor do poeta (Po). Kisawanyemungo (Sw).

Origin and geographic distribution *Euphorbia heterophylla* is native to Central and South America, but now widely distributed throughout the tropics and subtropics. It occurs throughout most of tropical Africa and the Indian Ocean islands, as well as in the Mediterranean region and South Africa.



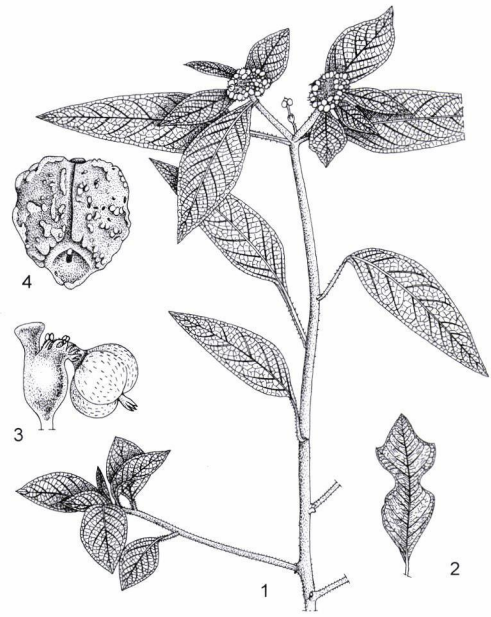
Euphorbia heterophylla – naturalized

Uses *Euphorbia heterophylla* is widely used in traditional African medicine and elsewhere in tropical countries. In Africa a decoction or infusion of the stems and fresh or dried leaves is taken as a purgative and laxative to treat stomach-ache and constipation, and to expel intestinal worms. A leaf infusion is used as a wash to treat skin problems, including fungal diseases, and abscesses. In Nigeria the latex and preparations of the leaves and root are applied to treat skin tumours. In East Africa the roots are used in the treatment of gonorrhoea or to increase milk production in breast-feeding women. The latex is irritant to the skin and eyes and may be employed as a rubefacient and to remove warts. However, the latex is also used as an antidote against the irritation caused by the latex of other *Euphorbia* species. In peninsular Malaysia a leaf extract is taken to treat body pain. The latex is used in the preparation of arrow poison and fish poison.
In Benin the leaves are eaten as a vegetable or famine food, despite their laxative action. The plant is grazed by livestock, and can be fed to guinea pigs as an addition to fresh forage. Honey bees collect the nectar from the flowers.

Properties All parts of *Euphorbia heterophylla* contain latex: leaves 0.42%, stems 0.11%, roots 0.06% and whole plant up to 0.77%. In Sudan it is reported to have been exploited during World War II as a substitute for rubber, but this has never been followed up. The plant furthermore contains lectins and carbohydrates. A dimeric N-acetylgalactosamine-specific lectin was isolated from the seeds. Germinating seeds contain endo-1,4-β-glucanases which degrade carboxymethylcellulose. The red colouring matter of the coloured leaves and bracts is porcetin. The ethylacetate fraction of a leaf decoction contained quercetin tetracetate. The butanolic fraction had laxative action and contained saponins, phenols and terpenes including phorbolic diterpenes. The residual aqueous solution contained mainly sugars. The purgative action was found to be a joint action of both the phorbols and the bulk-forming laxative sugars. A water extract from the leaves exhibited strong purgative effects when given orally to rats. In-vitro experiments with guinea-pig ileum suggest that the effect is

caused by an increase in intestinal motility.
The hexane, chloroform and ethyl acetate extracts from the roots showed significant antinociceptive activity in rats at doses of 150–300 mg/kg. An aqueous decoction of the leaves showed significant antinociceptive activity in rats at doses of 50–150 mg/kg. The crude water extracts of the aerial parts, given orally to rats, caused anorexia, anaemia and excitement followed by dullness. They also caused leucocytosis and a significant increase in the level of albumin.
The butanol extract of the dried leaves exhibited marked inhibitory action on the growth of *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae* and *Bacillus subtilis* at 100 mg/ml. A methanol extract of the aerial parts showed moderate antiplasmodial activity. A leaf extract showed significant nematicidal activity against *Meloidogyne graminicola*. An extract of the aerial parts given orally to goats showed moderate activity against several intestinal nematodes, such as *Haemonchus*, *Trichostrongylus*, *Bunostomum* and *Oesophagostomum*.
Extracts from the fresh shoots produced inhibitory effects on the early seed germination of tomato, pepper and cowpea.

Description Monoecious, annual, sparsely branched herb up to 100 cm tall; stems often tinged red towards the apex, with copious latex. Leaves arranged spirally, crowded at stem apex, simple; stipules modified into purplish glands; petiole up to 2(–4) cm long; blade ovate to lanceolate, up to 12 cm × 6 cm, base cuneate, apex obtuse to slightly acuminate, margins with minute gland-tipped teeth, glabrous to sparsely hairy on the main veins; upper leaves often with whitish or reddish base. Inflorescence a compact axillary or terminal cyme consisting of clusters of flowers, each cluster called a 'cyathium', forking c. 5 times, rays becoming progressively shorter; basal bracts similar to the leaves but paler green, progressively smaller and more lanceolate, almost sessile; cyathia almost sessile, c. 3.5 mm × 2.5 mm, with an urn-shaped involucre, lobes circular, c. 1.5 mm long, toothed, margin hairy; gland 1, peltate, funnel-shaped, c. 1 mm in diameter, red-rimmed, each involucre containing 1 female flower surrounded by many male flowers. Flowers unisexual; male flowers sessile, bracteoles few, fringed, perianth absent, stamen c. 4 mm long; female flowers with pedicel c. 6 mm long in fruit, perianth a rim, ovary superior, glabrous, 3-celled, styles 3, c. 1 mm long, 2-fid.



Euphorbia heterophylla – 1, flowering branch; leaf showing variability in shape; 3, cyathium; 4, seed.
Source: PROSEA

Fruit a deeply 3-lobed capsule c. 4.5 mm × 5.5 mm, glabrous, 3-seeded. Seeds ovoid, c. 2.5 mm in diameter, warty, blackish brown. Seedling with epigeal germination; cotyledons elliptical, c. 1.5 cm long, apex acute; hypocotyl, up to 4 cm long; first leaves nearly opposite, lanceolate, later alternate, toothed or not.

Other botanical information *Euphorbia* comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150 species in Madagascar and the Indian Ocean islands. *Euphorbia heterophylla* belongs to the subgenus *Poinsettia*, section *Poinsettia*, a group of herbs or shrubs, with stipules modified into glands, further characterized by cyathia in densely branching cymes, large and leafy bracts, 1 funnel-shaped involucral gland with 5 lobes, capsules exserted on reflexed pedicels and seeds without a caruncle. Several species from this section are planted as ornamentals because of the brightly coloured bracts. *Euphorbia heterophylla* and *Euphorbia cyathophora* Murray, also originating from tropical America, are now regarded as two distinct species, but have not been treated as such in older

literature. Therefore much of the older literature cannot be regarded as referring to either of these species. *Euphorbia cyathophora* is grown as an ornamental, especially in the United States. In Brazil, the red-coloured leaves are used as a dye.
The leaves of *Euphorbia heterophylla* occurring in East Africa show little of the variation characteristic of this widespread species. Elsewhere in tropical Africa more variation in leaf shape is present.

Growth and development *Euphorbia heterophylla* is an annual with a life cycle of 45–50 days, and is thus capable of several life cycles per rainy season. It can be found flowering and fruiting throughout the year if enough water is available.

Ecology *Euphorbia heterophylla* grows in disturbed localities, as a weed of cultivation and waste land, in gardens and along roadsides, from sea-level up to 3000 m altitude. It prefers full sun but is shade-tolerant.

Propagation and planting *Euphorbia heterophylla* is propagated by seed. Fresh seed germinates readily under tropical conditions, but remains dormant under temperate circumstances. Both light and temperature influence the breaking of dormancy. The turning of soil favours germination and seeds germinate even when at a depth of 10 cm in the soil.
Experiments with the post-emergence herbicide glyphosate, sprayed on top of potted soil did not affect the emergence of seeds planted 2 cm deep; glyphosate at 1.5 kg/ha even stimulated the emergence of seeds on the soil surface. This stimulatory effect of direct contact with glyphosate on germination of the seeds was confirmed in laboratory tests.

Management *Euphorbia heterophylla* is a common and troublesome, nitrophilic weed in arable land in tropical Africa, and should be controlled. Hand weeding is commonly used, as chemical control is too costly.
Sphaceloma poinsettiae, a scab-causing fungus that attacks *Euphorbia heterophylla*, could be used as a mycoherbicide, as on several occasions this fungus has been observed to cause devastating epidemics in the field on this host.

Diseases and pests *Euphorbia heterophylla* is a host of several crop viruses, including cassava common mosaic potexvirus (CsCMV), Euphorbia mosaic bigeminivirus (EuMV), tomato yellow leaf curl virus (TYLCV) and mungbean yellow mosaic virus (MYMV). It is moderately susceptible to root-knot nematodes, *Meloidogyne* spp.

Handling after harvest The leaves may be dried, powdered and kept for future use.

Genetic resources *Euphorbia heterophylla* has a large area of distribution and is a weed; it is therefore not under threat of genetic erosion.

Breeding *Euphorbia heterophylla* is sometimes cultivated as an ornamental with brightly coloured upper leaves and bracts.

Prospects Although *Euphorbia heterophylla* is an important medicinal plant in Africa, it is considered a noxious weed and, as such, it is often weeded. More research on its chemistry and pharmacology is needed to fully evaluate its potential.

Major references Burkill, 1994; Carter & Leach, 2001; Falodun & Agbakwuru, 2004; Falodun, Okunrobo & Uzoamaka, 2006; Hamill et al., 2000; Kokwaro, 1993; Nechet, Barreto & Mizubuti, 2004; Nguyen Nghia Thin & Sosef, 1999; SEPASAL, 2008d; Vamsidhar et al., 2000.

Other references Aarestrup, Karam & Fernandes, 2008; Aarestrup, Karam & Fernandes, 2008; Adedapo, Abatan & Olorunsogo, 2004; Adjanohoun et al., 1989; Adjanohoun et al., 1993; Akah, 1989; Bannon, Baker & Rogers, 1978; Clarkson et al., 2004; Eke & Okereke, 1996; Eniola-Tijani & Fawusi, 1991; Falodun, Agbakwuru & Ukoh, 2003; Gill, 1992; Gurib-Fakim, Guého & Bissoondoyal, 1996; Ipou, 2005; Latham, 2005; Le Bourgeois & Merlier, 1995; Nsimba-Lubaki, Peumans & Carlier, 1983; Saimo et al., 2003; Suda & Giorgini, 2003; Tabuti, Lye & Dhillion, 2003; Wome, 1985.

Sources of illustration Nguyen Nghia Thin & Sosef, 1999.

Authors D.M. Mosango

EUPHORBIA HIRTA L.

Protologue Sp. pl. 1: 454 (1753).

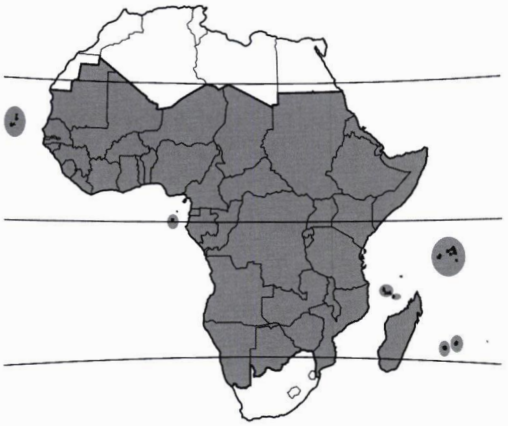
Family Euphorbiaceae

Chromosome number $2n = 18, 20, 22, 32$

Synonyms *Euphorbia pilulifera* L. (1753), *Chamaesyce hirta* (L.) Millsp. (1909).

Vernacular names Snakeweed, pill-bearing spurge, asthma herb (En). Jean Robert, malnommée, euphorbe pilulifère (Fr). Erva de Santa Luzia, luzia, burra leiteira, erva andorinha (Po). Mziwaziwa, kinywele, kitadali, kitapiaroho, kiziwa, mwache, wiza (Sw).

Origin and geographic distribution *Euphorbia hirta* is native to Central America and a very common weed of the tropics and sub-



Euphorbia hirta – naturalized

tropics; it occurs throughout tropical Africa and also in South Africa.

Uses *Euphorbia hirta* is an important medicinal herb used throughout its distribution area, including tropical Africa. It is held in high esteem, as a decoction or infusion, to treat gastrointestinal disorders, including intestinal parasites, diarrhoea, peptic ulcers, heartburn, vomiting and amoebic dysentery. It is also regarded as an outstanding medication to treat respiratory system disorders, including asthma, bronchitis, hay fever, laryngeal spasms, emphysema, coughs and colds. The leaves are mixed with those of *Datura metel* L. in preparing 'asthma cigarettes'. Other principal uses are as a diuretic to treat uro-genital diseases, such as kidney stones, menstrual problems, sterility and venereal diseases. The plant is also used to treat affections of the skin and mucous membranes, including warts, scabies, tinea, thrush, aphthae, fungal afflictions, measles, Guinea-worm and as an antiseptic to treat wounds, sores and conjunctivitis. The plant has a reputation as an analgesic to treat severe headache, toothache, rheumatism, colic and pains during pregnancy. It is used as an antidote and pain relief of scorpion stings and snakebites. It is antipyretic and anti-inflammatory. The use of the latex to facilitate removal of thorns from the skin is common. Its use in the treatment of jaundice, hypertension, oedema, anaemia and malaria, as an aphrodisiac, and to facilitate childbirth has also been reported. In West Africa the plants are widely used as a galactagogue, and in Nigeria they are marketed for this purpose. In Uganda whole plants are chewed to induce labour during childbirth.

Euphorbia hirta is included in the African pharmacopoeia of the Organization of African Unity as a dysentery medication.

In Java and India the tender shoots serve as famine food, raw or steamed, but they may cause intestinal complaints. In West Africa *Euphorbia hirta* is used as a livestock fodder.

Production and international trade Dried plants, seeds and tinctures made from *Euphorbia hirta* are sold in local markets and through the internet.

Properties Important constituents of the aerial parts are terpenoids, including triterpenes: α-amyrin, β-amyrin, friedelin, taraxerol, and esters of it: taraxerone, 11α,12α-oxidotaraxerol, cycloartenol, 24-methylene-cycloartenol, and euphorbol hexacosoate. The aerial parts and roots also contain diterpene esters of the phorbol type and ingenol type, including 12-deoxyphorbol-13-dodecanoate-20-acetate, 12-deoxyphorbol-13-phenylacetate-20-acetate, ingenol triacetate, as well as the highly toxic tinyatoxin, a resiniferonol derivative. Other terpenoids isolated are sterols including β-sitosterol, campesterol, cholesterol and stigmasterol. Tannins isolated include the dimeric hydrolysable dehydroellagitannins euphorbins A, B, C, E and terchebin, the monomeric hydrolysable tannins geraniin, 2,4,6-tri-O-galloyl-β-D-glucose and 1,2,3,4,6-penta-O-galloyl-β-D-glucose and the esters 5-O-caffeoylquinic acid (neochlorogenic acid) and 3,4-di-O-galloylquinic acid, and benzyl gallate. Acids isolated include ellagic acid, gallic acid, tannic acid, maleic acid and tartaric acid. Flavonoids isolated include quercetin, quercitrin, quercitol and derivatives containing rhamnose, quercetin-rhamoside, a chlorophenolic acid, rutin, leucocyanidin, leucocyanidol, myricitrin, cyanidin 3,5-diglucoside, pelargonium 3,5-diglucoside and camphol. The flavonol glycoside xanthorhamnin was also isolated. The stems contain the hydrocarbon hentriacontane and myricyl alcohol. The latex contains inositol, taraxerol, friedelin, β-sitosterol, ellagic acid, kaempferol, quercitol and quercitrin. The mineral content of a sample of the dried leaves was: Ca 1.1%, P 0.3%, Fe 0.03%, Mg 0.5%, Mn 0.01%, Zn 0.01% and Cu 0.002%. Fresh leaves from *Euphorbia hirta* plants of Nigerian origin were found to contain high levels of Mn (189 ppm), Cu (30.5 ppm), Zn (152 ppm), and NO_3 (4600 ppm). Varying proportions of Fe, Mg, K, Ca and Na were found. The levels of chemicals are high enough to constitute a source of toxicosis to animals consum-

ing the plants and should also be a source of concern in medicinal use.

Few toxic effects have been documented for *Euphorbia hirta*. An ether extract was found to be toxic in a brine shrimp lethality test, whereas ethyl acetate and aqueous extracts were within safe limits. In another test, however, an aqueous crude extract was found to cause testicular degeneration in sexually mature male rats as well as a reduction in the mean seminiferous tubular diameter. Several other extracts given orally to rats caused dullness and anorexia and induced a 20% mortality rate. Some fractions from the ethanolic extract showed potentially deleterious effects on the blood serum chemistry of rats. In feeding experiments with rats however, no difference in the blood serum was found after a prolonged period of adding *Euphorbia hirta* to the diet. It was also found that drying *Euphorbia hirta* prior to extraction considerably reduces the cytotoxic activity of certain of its extracts.

Several of the traditional medicinal uses of *Euphorbia hirta* have been supported by in-vitro studies. An aqueous extract of the whole plant acts as an antidiarrhoeic agent by anti-amoebic, antibacterial and antispasmodic activities. The antidiarrhoeal activity is attributed to quercitrin through the release of the aglycone quercetin in the intestine. Quercitrin showed antidiarrhoeic activity at doses of 50 mg/kg in mice.

A crude plant extract and an ethanolic extract had significant anti-amoebic activity against *Entamoeba histolytica* in vitro at 35 mg/ml. An aqueous lyophilysate of the whole plant showed higher activity against *Entamoeba histolytica* than either the ethyl acetate or methanol extracts, at 30 mg/ml. An aqueous plant extract showed concentration-related activity against non-pathogenic amoebae of the *Amoeba proteus* type. Different extracts from the aerial parts showed antibacterial activity against a wide spectrum of both gram-positive and gram-negative bacteria. Extracts of the aerial parts showed strong antibacterial activity against *Shigella dysenteriae*, a causal agent for dysentery in humans. The active compound was found to be ethyl gallate, which has broad spectrum antibiotic activity at non-toxic doses. A crude ethanol extract of the whole plant showed dose-dependent activity against *Candida albicans*, but not against several other pathogenic fungi. Some of the isolated antibacterial compounds were taraxerone and 11α,12α-oxidotaraxerol, which showed low cytotoxicity.

Ethanol, petroleum ether and dichloromethane extracts of whole plants showed significant in-vitro antiplasmodial activity (IC_{50} = 3 μg/ml) and decreased growth of *Plasmodium falciparum* by 89–100% at a test concentration of 6 μg/ml. In-vivo, the extracts reduced parasitaemia in mice infected with *Plasmodium berghei berghei* at oral doses of 100–400 mg/kg per day. From a methanolic extract of the aerial parts the flavonol glycosides afzelin, quercitrin and myricitrin were isolated, which showed proliferation inhibition of *Plasmodium falciparum*, with IC_{50} values of 1.1, 4.1, 5.4 μg/ml respectively, while they exhibited little cytotoxic effect against human epidermoid carcinoma KB 3–1 cells. An ethanolic extract was active in selectively inhibiting Herpes simplex virus type-1 (0.001–0.1 mg/ml).

A lyophilized aqueous extract of the aerial parts has been evaluated for analgesic, antipyretic and anti-inflammatory properties in mice and rats. The extract exerted central analgesic properties at doses of 20 and 25 mg/kg, and antipyretic activity at doses of 100 and 400 mg/kg, whereas anti-inflammatory effects against carrageenan-induced oedema in rats were observed at a dose of 100 mg/kg. The aqueous extract of the aerial parts has been found to strongly reduce the release of prostaglandins, and thus depress inflammation. An ethanolic extract of the aerial parts was found to possess a prominent anti-anaphylactic activity and also showed significant antihistaminic, anti-inflammatory and immunosuppressive properties in various animal models.

Water and ethanolic leaf extracts produced a time-dependent increase in urine output in rats. A methanol extract of leaves and stems inhibited the activity of angiotensin–converting enzyme by 90% at 500 μg and 50% at 160 μg. The extract (10 mg/100 g, intraperitoneally) significantly decreased the amount of water consumed by rats. An ethanolic extract of the whole plant showed a dose-dependent ulcer protective effect in rats. The active compound was found to be quercetin, which had an anti-ulcer activity ranging from 48–64% comparable to 61–80% of the standard drug ranitidine. An ethanolic extract of the aerial parts showed significant hepatoprotective activity in rats. Extracts of whole plant material have oestrogenic activity in female guinea pigs, when given orally.

In organ bath tests with ileum preparations, shikimic acid and choline extracted from the

aerial parts had relaxing and contracting properties, respectively. Shikimic acid also has acute toxicity, mutagenicity and carcinogenicity.

The aqueous crude extract significantly reduced the faecal egg count of helminths in dogs.

Several of the extracts of *Euphorbia hirta* showed potential for controlling plant diseases and pests. For example, a whole plant extract inhibited growth of vascular wilt (*Fusarium oxysporum*) and the causal agent of sheath rot of rice, *Sarocladium oryzae*; aqueous extracts of the aerial parts inhibited aflatoxin production by *Aspergillus parasiticus* on agricultural crops, including rice, wheat, maize and groundnuts. Leaf extracts completely inhibited soft rot infection caused by the bacteria *Erwinia carotovora* pv. *carotovora*. The infectivity of tobacco mosaic virus on *Nicotiana glutinosa* L. was strongly inhibited (>80%) by tannins extracted from the aerial parts. The latex inhibited sugarcane mosaic virus-A by 78.5% and sugarcane mosaic virus-F by 80%.

Root and leaf extracts showed nematicidal activity against *Meloidogyne incognita*; a whole plant extract effectively reduced hatching in the nematode *Heterodera avenae*. A 10% ethanol crude extract showed significant larvicidal action against the larvae of the tick *Boophilus microplus*.

Aqueous stem, latex and leaf extracts have potent molluscicidal activity against the freshwater snails *Lymnaea acuminata* and *Indoplanorbis exustus*, both intermediate hosts of *Fasciola hepatica* and *Fasciola gigantica*, which cause endemic fascioliasis in cattle and livestock. Toxicity of the extracts was time dependent and dose dependent against both snails. The doses that can be used for killing 90% of the *Lymnaea acuminata* populations are safe for the fish *Channa punctatus*.



Euphorbia hirta – 1, plant habit; 2, young cyathium; 3, mature cyathium; 4, seed.
Source: PROSEA

Description Annual, branched herb, prostrate to ascending, with branches up to 50 cm long, with latex; all parts short-hairy and with sparse yellow hairs c. 1.5 mm long. Leaves opposite, distichous, simple; stipules linear, up to 2.5 mm long; petiole up to 3.5 mm long; blade ovate, 1–4 cm × 0.5–2 cm, base very unequal, one side cuneate, the other side rounded, apex almost acute, margin finely toothed, often with a purple blotch near the midvein. Inflorescence a terminal or axillary cluster of flowers, called a 'cyathium', with several cyathia densely clustered into a cyme c. 15 mm in diameter; peduncle up to 15(–20) mm long; cyathia with a cup-shaped involucre c. 1 mm in diameter, tinged purple, lobes triangular, fringed, glands 4, tiny, elliptical, green or purplish, with minute white to pink appendages, each involucre containing 1 female flower surrounded by many male flowers. Flowers unisexual; male flowers sessile, bracteoles linear, fringed, perianth absent, stamen 1, c. 1 mm long; female flowers with short pedicel, perianth a rim, ovary superior, short-hairy, 3-celled, styles 3, minute, apex 2-fid. Fruit a just exserted, acutely 3-lobed capsule c. 1 mm in diameter, base truncate, short-hairy, 3-seeded. Seeds oblong-conical, c. 1 mm long, slightly wrinkled, pinkish brown, without caruncle.

Other botanical information *Euphorbia* comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150 species in Madagascar and the Indian Ocean islands. *Euphorbia hirta* belongs to subgenus *Chamaesyce* section *Hypericifoliae*, a group of annual herbs with obvious stipules, which is further characterized by the main stem aborting at the seedling stage and the plant thus

consisting of an expanded, dichotomously branching inflorescence, with the floral bracts appearing as normal leaves, cyathia clustered into 10 or more stalked, head-like cymes, 4 involucral glands with petal-like appendages or entire and conical seeds without a caruncle.

Growth and development Ants may be dispersal agents of *Euphorbia hirta* seeds.

Ecology *Euphorbia hirta* grows in cultivated fields, gardens, roadsides and waste places, from sea-level up to 2000 m altitude.

Propagation and planting *Euphorbia hirta* produces up to 3000 seeds per plant, which show a germination rate of up to 92%. Seeds can be dried without damage to low moisture contents, usually much lower levels than normally reached in nature. Over a wide range of storage environments, their longevity increases with reduction in both moisture content and temperature. Regeneration can also be achieved from leaf explants or stem segments.

Management *Euphorbia hirta* is considered a weed, and can be a nuisance in crops due to the large number of seedlings.

Diseases and pests *Euphorbia hirta* is a host to many fungal pathogens and may as such act as a reservoir of pathogenic fungi, which can infect nearby susceptible crops. Trypanosomatid flagellates (*Phytomonas* spp.) were detected in *Euphorbia hirta* plants in coconut plantations. *Euphorbia hirta* also acts as a host to several insect vectors, including the aphid *Aphis craccivora*, a vector of the rosette virus disease of groundnut, and *Aphis gossypii*.

Handling after harvest All parts of *Euphorbia hirta* are usually used fresh, but sometimes they are dried for future use.

Genetic resources *Euphorbia hirta* is a very common weed and has a very large area of distribution. Therefore there is no risk of genetic erosion.

Prospects Considering that the pharmacological action of *Euphorbia hirta* for the treatment of many ailments has been validated, and that the plant is reasonably safe to use, this plant has not received sufficient promotion for use as herbal medicine. Its development will be important in the improved delivery of primary health care in developing countries. *Euphorbia hirta* may find potential use in integrated pest management as a simple, cheap and safe natural product insecticide.

Major references Anuradha et al., 2008; Burkill, 1994; Carter & Radcliffe-Smith, 1988; Gurib-Fakim, Guého & Bissoondoyal, 1996; Lanhers et al., 1991; Lui et al., 2007; Neuwinger, 1996; Neuwinger, 2000; Nguyen Nghia Thin & Sosef, 1999; Youssouf et al., 2007.

Other references Abu Sayeed et al., 2005; Adedapo et al., 2005; Adjanohoun, 1986; Edwin et al., 2007; Hiermann & Bucar, 1994; Johnson et al., 1999; Lanhers et al., 1990; Masood & Ranjan, 1991; Ogbulie, 2007; Oyewale, Mika & Peters, 2002; Rao et al., 2003; Sawadogo et al., 1988; Singh et al., 2006; Singh et al., 2005; Somchit et al., 2001; Tabuti, Lye & Dhillion, 2003; Tona et al., 2004; Wallace et al., 1990; Wome, 1984.

Sources of illustration Nguyen Nghia Thin & Sosef, 1999.

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EUPHORBIA HYPERICIFOLIA L.

Protologue Sp. pl. 1: 454 (1753).

Family Euphorbiaceae

Chromosome number $n = 7, 8, 16, 28$; $2n = 16, 18, 22, 32$

Synonyms *Chamaesyce hypericifolia* (L.) Millsp. (1909).

Vernacular names Graceful sandmat, graceful spurge, large spotted spurge (En). Herbe colique (Fr). Lechosa, lecheleche, yerba golondrina, canchlagua (Po).

Origin and geographic distribution *Euphorbia hypericifolia* originates from tropical and subtropical America and has spread to tropical Africa and India. Its distribution in tropical Africa is not clear as it is confused with *Euphorbia indica* Lam. It occurs with certainty in West Africa, Burundi and on Mauritius.

Uses In West Africa and Burundi the latex is applied as a caustic on cuts and wounds; in West Africa the latex is taken in water as a purgative. In Burundi a vapour bath of the leaf decoction is applied to treat headache. In Mauritius a plant decoction is taken to treat diarrhoea, dysentery and colic. The plant is considered astringent and calming.

The principal use of *Euphorbia hypericifolia* in tropical and subtropical America is in a decoction or infusion of the leaves and roots for the treatment of a wide variety of gastro-intestinal disorders with watery and mucous discharges. *Euphorbia hypericifolia* is also used in the treatment of gonorrhoea, menorrhagia, leucorrhoea, pneumonia and bronchitis. The leaves have a sweetish taste, followed by a sensation

of harshness.

Production and international trade *Euphorbia hypericifolia* is widely traded in the United Stated in tablets and powders, mainly to treat bowel disorders. It is traded internationally through the internet.

Properties From the aerial parts aliphatic alcohols have been isolated as have the sterols taraxerol, β-sitosterol, stigmasterol, campestol and the flavonoids kaempferol, quercetin, quercetrin (quercetin-3-rhamnoside), rhamnetin-3-galactoside, rhamnetin-3-rhamnoside and ellagic acid.

Leaf extracts showed significant growth inhibitory effect against *Aspergillus flavus* in vitro, and also inhibited the production of aflatoxins almost completely, with greater inhibition at higher concentrations.

Botany Glabrous annual, branched herb, spreading or erect, up to 60 cm tall, apex of branches drooping, with latex. Leaves opposite, simple; stipules triangular, 1–2 mm long, one pair often fused, hairy at margins; petiole 1–2 mm long; blade elliptical-oblong to oblong, 1–2(–3.5) cm × 0.5–1(–1.5) cm, base cuneate, asymmetric, apex obtuse, margin obscurely toothed. Inflorescence an axillary cluster of flowers, called a 'cyathium', cyathia densely clustered into a head c. 1.5 cm in diameter; peduncle up to 3 cm long; cyathia almost sessile, c. 1 mm long, with a cup-shaped involucre, lobes triangular, minute, glands 4, tiny, almost round, stiped, with circular, white to pink appendage, each involucre containing 1 female flower surrounded by many male flowers. Flowers unisexual; male flowers sessile, bracteoles linear, perianth absent, stamen c. 0.5 mm long; female flowers with short pedicel, perianth a rim, ovary superior, glabrous, 3-celled, styles 3, minute. Fruit a 3-lobed capsule c. 1.5 mm in diameter, 3-seeded. Seeds ovoid, c. 1 mm long, 4-angled, slightly wrinkled, greyish purple, without caruncle.

Pollination of *Euphorbia hypericifolia* is probably effected by small insects and the seeds have been seen to be dispersed by ants.

Euphorbia comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150 species in Madagascar and the Indian Ocean islands. *Euphorbia hypericifolia* belongs to subgenus *Chamaesyce* section *Hypericifoliae*, a group of annual herbs with obvious stipules, further characterized by the main stem aborting at the seedling stage. The plant thus consists of an expanded dichotomously branching inflorescence, with the floral bracts appearing as normal leaves, cyathia clustered 10 or more in stalked, head-like cymes, 4 involucral glands with petal-like appendages or entire and conical seeds without a caruncle. *Euphorbia indica* Lam. also belongs to section *Hypericifoliae*. It originates from India and Sri Lanka and has been introduced as a weed in East and southern Africa, as well as in Réunion and Mauritius. It was mistakenly considered to be synonymous with *Euphorbia hypericifolia* L., but it differs by having stipules that are not fused and a hairy fruit. In East Africa the latex is used as a purgative and as a caustic on skin lesions. In Kenya the latex is applied to the eyes to treat eye infections and catarrh. In Tanzania ground plants are added to bath water to treat oedema. In Mauritius a plant decoction is taken to treat diarrhoea and dysentery.

Ecology *Euphorbia hypericifolia* occurs along roadsides, stony river sides, in waste places and as a weed in cultivation, from sea-level up to 600 m altitude.

Genetic resources and breeding *Euphorbia hypericifolia* has a large area of distribution and is weedy of nature. Therefore it is not threatened by genetic erosion.

Prospects *Euphorbia hypericifolia* has considerable value as a medicinal plant, although more research needs to be done to evaluate its chemistry and pharmacology.

Major references Burkill, 1994; Gurib-Fakim, Guého & Bissoondoyal, 1996; Hasan & Abdel Mallek, 1994; Neuwinger, 2000.

Other references Ehrenfeld, 1976; Ehrenfeld, 1979; Watt & Breyer-Brandwijk, 1962.

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EUPHORBIA INGENS E.Mey. ex Boiss.

Protologue A.DC., Prodr. 15(2): 87 (1862).

Family Euphorbiaceae

Chromosome number $2n = 40$

Synonyms *Euphorbia similis* A.Berger (1907).

Vernacular names Candelabra tree, common tree euphorbia (En).

Origin and geographic distribution *Euphorbia ingens* occurs from the Caprivi strip (Namibia), Zambia and Botswana east to Mozambique and south to eastern South Africa and Swaziland.

Uses The latex is very toxic, causing intense

irritation and blistering to the skin and mucous membranes. If the latex comes into contact with the eyes, it causes temporary or even permanent blindness. Medicinally, the latex is taken in very small amounts, often on sugar, as a drastic purgative and to treat alcohol dependency. Pulverized root or a few drops of latex in porridge is eaten to treat bronchitis. In Zimbabwe the stems of *Brachystegia spiciformis* Benth. are chewed and the fibres dipped in the latex of *Euphorbia ingens*; the fibres are then dried and burnt and the smoke inhaled to treat asthma and bronchitis. In South Africa the Venda people use the latex to treat chronic ulcers, warts and cancer. There are several cases recorded of overdoses, causing vomiting, violent abdominal pain and excessive purging, and even death.

In Zimbabwe and South Africa a bundle of grass soaked in latex is thrown into water as a fish poison.

The wood is light and tough and is used to make boats, planks and doors. Before cutting, the trunk is scorched to prevent the toxic latex from splashing. The flowers of *Euphorbia ingens* and several other tree-sized *Euphorbia* spp. produce much nectar, but the honey, known as 'noors honey', causes a burning sensation in the mouth, which is intensified by drinking water. *Euphorbia ingens* is planted as an ornamental in succulent gardens or rock gardens in South Africa and the United States.

Properties The latex and roots of *Euphorbia ingens* contain ingenol, a tetracyclic diterpene ester of the ingenane type, based on the parent alcohol 16-hydroxyingenol and several derivatives. Ingenol and its derivatives show tumour-promoting, anti-HIV and anti-leukaemia activities. Much research is directed toward synthesis and biological evaluation of ingenol analogs and derivatives. The irritant ingenol esters of the latex have ID_{50} values of 0.004–0.02 µg in mice-ear tests.

An extract of the pounded branches in water was given to chickens before or during Newcastle disease outbreaks. The rate of mortality reduction ranged between 38% for chickens given the extract during a Newcastle disease outbreak as a therapeutic measure and 100% for chickens given the extract as a prophylactic measure.

Different concentrations of latex were used in mortality tests with several aquatic animals. The latex was found to be a short-lived and effective fish poison. Within 12 hours all the fish and half the frogs died, whereas crabs and snails appeared not to suffer any detrimental effects. The poison degraded and became harmless to fish within 48 hours.

Botany Monoecious, succulent small tree up to 12(–15) m tall, with abundant latex; bole stout; bark grey, roughly fissured; branches persistent from c. 3 m upwards, almost erect, rebranching, forming a large, broadly rounded crown; terminal branches fleshy, 6–12 cm in diameter, constricted at irregular intervals into oblong segments 10–15 cm long, 4-angled, wings up to 3 cm wide, margins of angles straight to wavy, with shallow tubercles 1–2 cm apart; spine shields obtusely triangular, c. 6 mm × 5 mm, soon becoming corky, with 2 pairs of spines, 1 pair stout, c. 5 mm long, 1 (stipular) pair triangular, c. 1.5 mm long, flexible, soon falling. Leaves at the end of branches, in 4 rows, sessile; stipules transformed into small spines; blade obovate, c. 3 mm × 3 mm, soon falling, in young plants up to 8 cm × 2 cm. Inflorescence an axillary cyme, 1–3 together crowded at the end of branches, consisting of clusters of flowers, each cluster called a 'cyathium', peduncle 8–20 mm long, branches 2, c. 5 mm long; bracts 2, c. 5 mm long; cyathia c. 5 mm × 10 mm, with a cup-shaped involucre, lobes c. 2.5 mm long, glands 5, transversely elliptical, c. 2 mm × 4 mm, golden-yellow, each involucre containing 1 female flower surrounded by many male flowers. Flowers unisexual; male flowers sessile, perianth absent, stamen c. 5.5 mm long; female flowers with pedicel c. 5 mm long in fruit, perianth irregularly 3-lobed, lobes filiform, 2–4 mm long, ovary superior, glabrous, 3-celled, styles 3, 3–3.5 mm long, fused at base, apex 2-fid. Fruit an obtusely 3-lobed capsule c. 7 mm × 10 mm, fleshy, green becoming red, hardening before dehiscence, 3-seeded. Seeds almost globose, c. 4 mm × 3 mm, greyish brown speckled with pale brown, smooth.

The flowers of *Euphorbia ingens* are pollinated by butterflies, bees and other insects, and the seeds are dispersed by birds, which feed on the fruits. Birds also like nesting in these trees; hole-nesting birds such as woodpeckers often use dead sections.

Euphorbia comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150 species in Madagascar and the Indian Ocean islands. *Euphorbia ingens* belongs to section *Euphorbia*, a large group which is characterized by succulent, usually angular stems, stipules modified into small spines (or

absent), a spine shield with an additional pair of spines (sometimes fused into a single spine), axillary inflorescences and seeds without a caruncle. *Euphorbia ingens* is very similar to *Euphorbia candelabrum* Trémaux ex Kotschy from East and northeastern Africa, and may be conspecific. The branches of trees in southern Africa are usually more distinctly and shortly segmented, the tubercle teeth along the angles are usually further apart and the branch tips are fewer-flowered.

Euphorbia conspicua N.E.Br. is a small tree up to 15 m tall endemic to western Angola; it is also very similar to *Euphorbia candelabrum*. The latex is taken as a purgative to treat constipation, and also to treat breast inflammation, epilepsy, coughs and tuberculosis.

Ecology *Euphorbia ingens* occurs in dry mopane and wooded grassland, often on rocky outcrops, from sea-level up to 1600 m altitude. It can survive in areas that go through long periods of drought or are generally very dry.

Management As an ornamental *Euphorbia ingens* is a hardy succulent and needs little or no maintenance. It does best in the open sun.

Genetic resources and breeding *Euphorbia ingens* is relatively common in its distribution area; small trees are only browsed by rhinoceros, and therefore it is not threatened by genetic erosion. All succulent *Euphorbia* spp. are listed in CITES appendix 2.

Prospects The latex of *Euphorbia ingens* is highly poisonous and medicinally it should therefore be used with great care. Only few chemical analyses have been done, and virtually no pharmacological tests. Because the latex contains ingenol and derivatives more research is warranted.

Major references Carter & Leach, 2001; Coates Palgrave, 1983; Kellerman, Coetzer & Naudé, 1988; Neuwinger, 2000; van Wyk, van Heerden & van Oudtshoorn, 2002.

Other references Bossard, 1996; Carter, 1985; Grace et al., 2002; Kaoma & Chiteta, 2001; Le Roux, 2004; Opferkuch et al., 1981; Opferkuch & Hecker, 1982; Ross & Steyn, 2004; SEPASAL, 2008f; van Wyk & Gericke, 2000.

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EUPHORBIA LUGARDIAE (N.E.Br.) Bruyns

Protologue Taxon 55(2): 413 (2006).
Family Euphorbiaceae
Chromosome number $n = 17$

Synonyms *Monadenium lugardiae* N.E.Br. (1909).

Origin and geographic distribution *Euphorbia lugardiae* occurs in Malawi, Zambia, Botswana, Zimbabwe, Mozambique and South Africa.

Uses In Zimbabwe and South Africa a few drops of stem or root latex are mixed in porridge or milk and taken to treat ascites, stomach-ache, chest pain, headache, measles, pneumonia and asthma; the latex is also taken as an abortifacient. The latex is a violent purgative, and can cause vomiting and haemorrhagic gastroenteritis, cirrhosis of the liver and sometimes death. It is also used to expel worms in dogs. The latex taken together with plant sap of *Portulaca quadrifida* L. has been applied as a remedy for gonorrhoea. In South Africa plant ash is rubbed into scarifications to treat rheumatic pain. Consumption of the root can cause hallucinations and delirium, and a piece of the root is taken by diviners to see visions and to make prophecies. Eating the raw root produces a burning sensation in the mouth and gullet.

Euphorbia lugardiae is grown as an ornamental pot plant.

Properties The latex from the aerial parts and a methanol extract from the stem had a dualistic effect on isolated guinea-pig ileum, as they had contractile activity at lower concentrations, but an inhibitory effect on the contractions at higher concentrations.

When 1 ml of pure or water-diluted latex from the aerial parts (at concentrations of 10% or 1%) was given orally to 3-month-old rats, all rats died within 20 minutes. Concentrations of 0.1% or 0.01% caused severe diarrhoea lasting 7 days and a 10–15% loss in weight. The latex is very acid, with a pH of as low as 2, and can cause dermatitis. The latex also showed significant insecticidal activity in vitro.

Botany Monoecious, succulent shrub up to 60 cm tall, branching from the base, erect or slightly decumbent; roots thick and fleshy; stems cylindrical, up to 3 cm in diameter, with flattened tubercles c. 1.5 cm × 1 cm in a diamond-shaped pattern, with circular leaf scars c. 2 mm in diameter at apex. Leaves arranged spirally, crowded towards the stem apex, simple, almost sessile; stipules modified into a cluster of 3–5 soft spines up to 2 mm long, soon falling; blade obovate, up to 9 cm × 4 cm, base cuneate, apex rounded, margins wavy, fleshy, minutely short-hairy, pinnately veined. Inflorescence an axillary cyme, consisting of clus-

ters of flowers, each cluster called a 'cyathium'; peduncle 5–8 cm long and branches 2–4 mm long; bracts fused into a cup c. 7 mm × 7 mm, shortly notched between acute lobes, with prominent midveins, often tinged pinkish; cyathia c. 4 mm in diameter, with cup-shaped involucre, cream with yellow rim, 5-lobed with lobes c. 1 mm × 1.5 mm, toothed, with 1 horseshoe-shaped gland c. 2 mm long, each involucre containing 1 female flower surrounded by many male flowers. Flowers unisexual; male flowers sessile with bracteoles c. 2.5 mm long, fringed, perianth absent, stamen c. 4 mm long; female flowers with pedicel up to 8 mm in fruit, perianth 3-lobed, c. 2.5 mm in diameter, ovary superior, 3-celled, styles 3, c. 1.5 mm long, fused at base, deeply bifid at apex. Fruit a 3-lobed capsule c. 6 mm × 6 mm, with a pair of fleshy crested ridges along the ribs, 3-seeded. Seeds oblong, c. 3.5 mm × 1.5 mm, 4-angled, minutely rough, pale brownish grey, caruncle cap-shaped, c. 1 mm in diameter, on a short, thin stalk.

Euphorbia comprises about 2000 species and has a worldwide distribution. *Monadenium* (about 70 species in continental Africa) had always been kept separate from *Euphorbia*, but recent molecular analyses found *Monadenium* to be nested within *Euphorbia*, and it is therefore included within *Euphorbia*, as section *Monadenium* in subgenus *Euphorbia*.

Ecology *Euphorbia lugardiae* occurs on granite outcrops, in sandy soil among rocks in wooded grassland and open *Brachystegia* woodland, and also in shade on termite mounds, often in colonies, at 100–1100 m altitude.

Management As a pot plant *Euphorbia lugardiae* needs full sun to light shade, and a well-drained soil mix consisting of 2 parts sand to 1 part loam and 1 part peat moss. After watering the plants should be allowed to dry thoroughly before watering again. A single fertilizer application is recommended during the growing season. Too much water and fertilizer will cause root rot. During the cold season, only enough water should be given to keep the leaves from shrivelling and dropping off.

Euphorbia lugardiae is mainly propagated from stem cuttings; stem tips 10–15 cm long are used. After cutting, the stems are dipped in charcoal dust to seal the cut and then left to form callus for a week before inserting the cutting into the soil. Cuttings should root in 6–8 weeks.

Genetic resources and breeding *Euphorbia lugardiae* is rather uncommon in its distribution area, but there are no signs that it is threatened by genetic erosion.

Prospects *Euphorbia lugardiae* has several medicinal uses, but chemical analyses and pharmacological evidence of its usefulness is lacking. Additional research is therefore warranted.

Major references Bruyns, Mapaya & Hedderson, 2006; Carter & Leach, 2001; Gundidza, 1993; Neuwinger, 2000; van Wyk & Gericke, 2000.

Other references De Smet, 1996; Gelfand et al., 1985; Gundidza, 1986; Gundidza, 1990; Gundidza, 1991; Lemke, 2005; Steenkamp, 2003; Steinmann & Porter, 2002.

Authors G.H. Schmelzer

EUPHORBIA MAINTY (Poiss.) Denis ex Leandri

Protologue Cat. Pl. Madag., Euphorb.: 16 (1935).

Family Euphorbiaceae

Origin and geographic distribution *Euphorbia mainty* is endemic to south-eastern Madagascar.

Uses The latex is taken in water as a vermifuge, despite its toxicity. The use is well-known and people are careful about the quantities used.

The latex was formerly mixed with fibres from other plants to make wooden boats watertight; it was also made into varnish to make boats water resistant. The latex is mixed with latex from other plants to make a rubber. The plants are browsed by cattle. *Euphorbia mainty* is grown as a pot plant in Europe and the United States.

Botany Monoecious, glabrous, much-branched shrub up to 8 m tall, most of the time leafless; branches slender, cylindrical, with compressed tips, green; stems with white latex. Leaves arranged spirally, simple and entire, almost sessile, on new growth only, soon deciduous; blade oblong, up to 15 mm × 3 mm, base cuneate, apex rounded. Inflorescence a cyme near the end of branches, hairy, consisting of clusters of flowers, each cluster called a 'cyathium'; cyathium unisexual, c. 4 mm in diameter, developing only male flowers or a single female flower; nectar producing glands yellow. Flowers unisexual; male flowers consisting of a single stamen; female flowers with superior ovary, 3-celled. Fruit an almost globose capsule, c. 8 mm in diameter, on reflexed

pedicel c. 1 mm long, 3-seeded. Seed ovoid, c. 3.5 mm × 2.5 mm.

Euphorbia comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150 species in Madagascar and the Indian Ocean islands. Most species present in Madagascar are endemic to the island. Several other *Euphorbia* spp. with small leaves and photosynthetic stems, endemic to Madagascar, are locally used. The steam of leafy twigs in boiling water of *Euphorbia plagiantha* Drake (synonym: *Euphorbia fiha* Decary) is inhaled to treat asthma. The thick latex is used as glue for wood and paper. The very corrosive latex of the crushed stems of *Euphorbia enterophora* Drake, *Euphorbia decorsei* Drake and *Euphorbia plagiantha* are all used as fish poison. The trunk of *Euphorbia enterophora* is covered with a wax, which was formerly harvested for polishing. *Euphorbia enterophora* is also planted as a pot plant and sold as such on the internet.

Ecology *Euphorbia mainty* occurs in dry thickets and open forest, from sea-level up to 500 m altitude.

Genetic resources and breeding As *Euphorbia mainty* is common there are no threats to its genetic diversity. As a (semi-)succulent *Euphorbia* species, its trade is controlled under CITES appendix 2.

Prospects *Euphorbia mainty* will probably remain of local importance as a medicinal plant.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Debray, Jacquemin & Razafindrambao, 1971; Eggli, 2002.

Other references Cremers, 1977; Cremers, 1978; Neuwinger, 2000.

Authors G.H. Schmelzer

EUPHORBIA MATABELENSIS Pax

Protologue Ann. Naturhist. Mus. Wien 15: 51 (1900).

Family Euphorbiaceae

Vernacular names Three-forked euphorbia (En).

Origin and geographic distribution *Euphorbia matabelensis* occurs in Somalia, southern Kenya, Tanzania and throughout southern Africa.

Uses In Malawi a root decoction together with leaves of *Dichrostachys cinerea* (L.) Wight & Arn. is drunk to treat depression, high blood pressure and swollen lymph glands. In Zimbabwe root powder is rubbed into scarifications on the breasts as a galactagogue for foster mothers. A decoction of the chopped roots or latex is taken as a purgative in case of poisoning and to induce abortion. The latex is put into drinking water of chickens to treat diarrhoea and Newcastle disease.

In Tanzania the boiled latex is used as birdlime or sometimes as chewing gum.

Properties An ingenol diterpene isolated from the latex exhibited irritant activity in the mouse ear test.

Botany Monoecious, slightly succulent, deciduous shrub up to 3(–8) m tall with abundant latex; bark greyish brown, peeling; branches ascending, drooping at apex, young branches densely short-hairy, usually spine-tipped, branching trichotomous at apex. Leaves arranged spirally or crowded at branch apex, simple and entire; stipules glandular, minute; petiole 1–5 mm long; blade oblanceolate to obovate, c. 5.5 mm × 2.5 mm, base cuneate, apex rounded, lower surface short-hairy when young. Inflorescence an axillary cyme consisting of clusters of flowers, each cluster called a 'cyathium', in 3–7-branched umbels; branches up to 10 mm long; bracts leaf-like, c. 5 mm long, yellowish green; cyathia almost sessile or central one of an umbel on a peduncle up to 5 mm long, c. 3.5 mm × 6 mm, with a cup-shaped involucre, lobes c. 1.5 mm long, rounded, deeply fringed, glands 5, shallowly saucer-shaped, 2–2.5 mm in diameter, yellow, each involucre containing 1 female flower surrounded by many male flowers. Flowers unisexual; male flowers sessile, bracteoles fringed, perianth absent, stamen c. 4.5 mm long; female flowers with pedicel c. 5 mm long in fruit, ovary superior, densely short-hairy, 3-celled, styles 3, c. 2 mm long, fused at base, apex 2-fid. Fruit an obtusely 3-lobed capsule c. 7 mm × 8 mm, densely short-hairy, green becoming red, 3-seeded. Seeds globose, c. 3.5 mm in diameter, smooth, brown, obscurely speckled.

Euphorbia comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150 in Madagascar and the Indian Ocean islands. *Euphorbia matabelensis* belongs to section *Lyciopsis*, a group of tuberous herbs or shrubs, characterized by glandular stipules, terminal or axillary cymes in large umbels, almost sessile capsules and seeds without a caruncle. Several other species with medicinal uses belong to this section or occur in the region. *Euphorbia cuneata* Vahl occurs from

Guinea east to Somalia and south through East Africa to Mozambique; it also occurs throughout the Arabic Peninsula. In East Africa the latex is applied to warts, wounds and sores. The latex in water is given to calves with hepatitis. A decoction of the stem bark and roots is given to cattle for the expulsion of a retained placenta. The plants are sometimes browsed by camels, goats and sheep. The stem is used to make earrings and knife handles. The stems are used for fencing during ceremonies. The sticky latex is used to remove dust from the eye. *Euphorbia espinosa* Pax is a shrub from Kenya, Tanzania and southern Africa. Latex in milk, porridge or egg is taken as an emetic in case of suspected poisoning or indigestion. *Euphorbia joyae* Bally & S.Carter is a shrub endemic to Kenya, where the Boran people take a root decoction to treat coughs. *Euphorbia namibiensis* Marloth has a short, strongly tuberculate, succulent stem with short branches and occurs in Namibia and Botswana. In Botswana a decoction of the aerial parts is taken to treat venereal diseases and stomach-ache, or smoke of the burning plant is inhaled for these purposes. A root decoction is taken to induce vomiting after ingestion of poison. *Euphorbia radiifera* L.C.Leach has annual stems arising from an elongate tuber; it is endemic to Angola. Painful legs are massaged with the crushed plant and hot water.

Ecology *Euphorbia matabelensis* occurs in open deciduous woodland, in sandy soils, often on rocky outcrops and hillsides, at 450–1900 m altitude.

Genetic resources and breeding There are no signs that *Euphorbia matabelensis* is threatened by genetic erosion. As a succulent *Euphorbia* species, its trade is controlled under CITES appendix 2.

Prospects Ingenol diterpenes can cause skin irritation and have tumour promoting properties. The use of the latex of *Euphorbia matabelensis* for medicinal purposes should therefore be discouraged.

Major references Carter & Leach, 2001; Gelfand et al., 1985; Gundidza, Sorg & Hecker, 1993; Neuwinger, 2000; SEPASAL, 2008g.

Other references Beentje, 1994; Bossard, 1996; Chinemana et al., 1985; Eggli, 2002; Heine & Heine, 1988b; Ichikawa, 1987; Kerharo, Guichard & Bouquet, 1961; Kokwaro, 1993; Minja, 1999; SEPASAL, 2008i.

Authors G.H. Schmelzer

EUPHORBIA PAGANORUM A.Chev.

Protologue Rev. Int. Bot. Appl. Agric. Trop. 13: 556 (1933).

Family Euphorbiaceae

Origin and geographic distribution *Euphorbia paganorum* occurs from Senegal east to northern Nigeria, in Gabon and possibly also in southern Sudan. It is confused with *Euphorbia sudanica* A.Chev. and part of its distribution area may need to be attributed to this last species.

Uses The uses of *Euphorbia paganorum* also apply to *Euphorbia sudanica*, a very similar species. In Senegal and northern Côte d'Ivoire a decoction of the stem ash, together with leaves of *Sarcocephalus latifolius* (Sm.) E.A.Bruce, is used to wash the body to treat leprosy. Stem or root decoctions or latex are applied to wounds and sores, but in general *Euphorbia paganorum* is considered too poisonous for medicinal use. The very caustic latex is used as an ingredient of arrow poison and in bait for trapping animal pests.
In Mali *Euphorbia paganorum* is planted in villages as a fetish plant. The flowers are much-visited by bees.

Properties A preliminary test of the latex showed the presence of diterpene esters of the alcohol 12-deoxyphorbol.

Botany Monoecious, deciduous, succulent shrub up to 1.5(–2) m tall, much-branching from the base; stem cylindrical, 2–5 cm in diameter, green to grey, smooth, with abundant latex; spine shields triangular on small tubercles, with 1 pair of spines 5–12 mm long, sturdy, fewer on old stems. Leaves arranged spirally at the end of branches, sessile; stipules a pair of tiny spines or absent; blade obovate to obtriangular, 2–8 cm × 1–5 cm, fleshy, base tapering, apex acute and toothed. Inflorescence an axillary, simple cyme, consisting of clusters of flowers, each cluster called a 'cyathium', at the end of branches; peduncle c. 3 mm long, branches 2, often aborting; bracts 2, tiny; cyathia c. 5 mm in diameter, with a shortly cup-shaped involucre, green, 5-lobed, glands 5, oblong, yellow, each involucre containing 1 female flower surrounded by many male flowers. Flowers unisexual; male flowers sessile, perianth absent, stamen 1; female flowers with pedicel 4–6 mm long in fruit, perianth 3-lobed, ovary superior, glabrous, 3-celled, styles 3, fused at base. Fruit a 3-lobed capsule c. 15 mm × 12 mm, glabrous, grey to pale brown, 3-seeded. Seeds oblong, c. 8 mm × 3 mm.

Leaves are only present for about 3 months, during the rainy season; flowers appear at the end of the dry season, on bare branches.

Euphorbia comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150 in Madagascar and the Indian Ocean islands. *Euphorbia paganorum* belongs to section *Euphorbia*, a large group which is characterized by succulent, usually angular stems, stipules modified into small spines (or absent), a spine shield with an additional pair of spines (sometimes fused into a single spine), axillary inflorescences and seeds without a caruncle. *Euphorbia paganorum* and the following species belong to a group of much-branched, succulent shrubs up to 3 m tall, with branches more than 1.5 cm in diameter and with (2–)4 spines per spine shield.

Euphorbia sudanica occurs from Senegal east to Sudan. The main difference with *Euphorbia paganorum* is that it has thinner branches, 1–2 cm in diameter. It has similar uses as *Euphorbia paganorum*. The caustic latex is applied to peanuts to prevent them being eaten by monkeys and birds. In Niger *Euphorbia sudanica* is planted as a boundary marker. *Euphorbia breviarticulata* Pax occurs from Ethiopia and Somalia south to Tanzania. In Tanzania latex is applied topically to treat haemorrhoids. Latex mixed with ground fresh leaves of *Acacia edgeworthii* T.Anderson and honey is applied to wounds and sores caused by filariasis. *Euphorbia heterochroma* Pax occurs in Kenya, Uganda and Tanzania. A latex infusion or root decoction is taken to treat venereal diseases. In Uganda latex mixed with clay is applied to the skin or in incisions to treat syphilis. In Kenya an infusion of the latex or of the roasted stems is taken to treat fever, diarrhoea, cough, tuberculosis and pneumonia. A leaf decoction is taken to treat stomach-ache. In Uganda the latex is applied to incisions to treat pyomyositis. Latex is used as nose drops to treat migraine and insanity. In Kenya a root or stem infusion is given to camels to drink to treat persistent cough and haemorrhagic septicaemia. The boiled stem of *Euphorbia heterospina* S.Carter from Kenya and Uganda is drunk with soup or milk to treat diarrhoea. *Euphorbia polyacantha* Boiss. (synonym: *Euphorbia thi* Schweinf.) occurs from Sudan to Eritrea, Somalia and Yemen. In Eritrea the stem is crushed in water and applied to crops as an insecticide. *Euphorbia polyacantha* is planted as an ornamental in home gardens, as a live fence and for soil conservation purposes. In Sudan the crushed stems are applied to scorpion stings. *Euphorbia quadrangularis* Pax is endemic to Tanzania. Latex is rubbed into scarifications on the eyebrows to treat headache, and the roots are used to ease backache and chest and rib pain.

Ecology *Euphorbia paganorum* occurs on rocky soils in arid savanna, often gregarious, up to 600 m altitude.

Management *Euphorbia paganorum* is easily and quickly propagated by stem cuttings, which should be at least 20 cm long and preferably cut from the woody base of a branch. After cutting they need to dry in the shade for at least two weeks for callus to form on the cut end. *Euphorbia paganorum* can also be grown from seed.

Genetic resources and breeding There are no indications that *Euphorbia paganorum* is threatened by genetic erosion. As a succulent *Euphorbia* species, its trade is controlled under CITES appendix 2.

Prospects As almost no chemical or pharmacological research has been done on *Euphorbia paganorum*, it is not clear whether the latex contains pharmacologically important compounds. Other *Euphorbia* spp. containing diterpenes of the tigliane type show promising results, thus more research is warranted. As it is not clear whether *Euphorbia paganorum* and *Euphorbia sudanica* are really different species, taxonomical research is needed to elucidate their status.

Major references Burkill, 1994; Eggli, 2002; Evans & Kinghorn, 1977; Keay, 1958a; Neuwinger, 1996.

Other references Arbonnier, 2002; Baerts & Lehmann, 2008b; Bein et al., 1996; Chevalier, 1933; Chevalier, 1948; Inngjerdongen et al., 2004; ITDG & IIRR, 1996; Kamuhabwa, Nshimo & de Witte, 2000; Newton, 1992; Tabuti, Lye & Dhillion, 2003.

Authors L.E. Newton

EUPHORBIA PEPLUS L.

Protologue Sp. pl. 1: 456 (1753).

Family Euphorbiaceae

Chromosome number $2n = 16$

Vernacular names Petty spurge, radium weed, cancer weed, milkweed, wartweed, radium plant (En). Euphorbe omblette, herbe de lait, esule ronde, euphorbe des vignes, réveille-matin des vignes, euphorbe des jardins (Fr).

Leitaria, ésula redonda, trovisco (Po).

Origin and geographic distribution *Euphorbia peplus* originates from Europe, temperate Asia and northern Africa, and is now widespread in temperate, subtropical and tropical regions of the world. In tropical Africa it occurs from Sudan, Eritrea and Somalia south to Zimbabwe, and also in Réunion and Mauritius.

Uses *Euphorbia peplus* is one of a number of plants in the *Euphorbiaceae* family that has attracted attention as a home remedy for skin cancer, particularly basal cell carcinomas. The milky latex is toxic and irritant and is widely known as a therapeutic agent for the removal of warts and sun-spots on the skin. The plant is also used for its expectorant, anthelmintic, antipyretic and anti-inflammatory activities. In Mauritius a leaf decoction is taken to treat diarrhoea and dysentery.

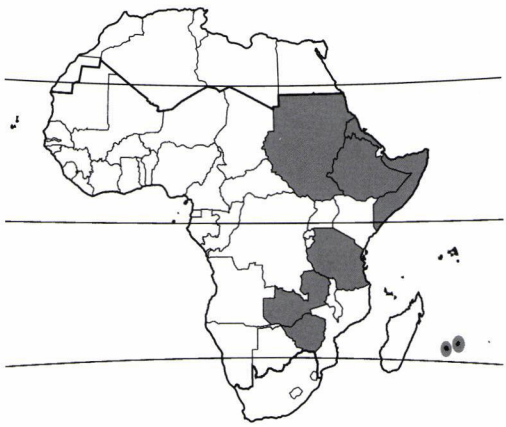
In Europe and Australia the latex is used in local medicine against corns and waxy growths, and an infusion of the aerial parts is taken to treat asthma, catarrh and as a purgative. In Saudi Arabia an infusion of the aerial parts is applied for the lowering of blood pressure. *Euphorbia peplus* was widely used in the Ukraine in the 1990s as a treatment for cancer of the stomach, liver and uterus.

The latex causes irritation of the skin, eyes and mucous membranes. Due to the toxicity of the latex, it is advised to use the plant topically only.

Production and international trade *Euphorbia peplus* is grown in Australia for extraction of its anti-cancer compounds, but quantities are unknown.

Properties *Euphorbia peplus* latex yields mostly diterpenes of the jatrophane, pepluane and ingenane types. Jatrophane and pepluane diterpenes are non-inflammatory, whereas ingenane diterpenes, including ingenol 3-angelate (PEP005) and ingenol, are responsible for the irritant and tumour-promoting properties of the latex. Of the pepluane esters, pepluanone showed significant anti-inflammatory activity in vivo on carrageenan-induced rat paw oedema. Of the ingenane compounds, 5-deoxyingenol, 20-deoxyingenol 3-O-angelate and ingenol 20-O-octanoate exhibited strong inflammatory activities on mice skin, but less strong and more prolonged than several phorbol esters of related *Euphorbia* species. In addition to these diterpenes, the latex contains the triterpenoids obtusifoliol, cycloartenol, 24-methylenecycloartanol, and the 24-acyclic triterpene alcohol, peplusol, the steroids cholesterol, campesterol, stigmasterol, β-sitosterol, 28-isofucosterol, the flavonoids quercetine, quercetin-3-galactoside, kaempferol, kaempferol-3-galactoside and rhamnetin-3-galactoside, tannins and anthraquinones. From air-dried powdered whole plants simiarenone, nepehinol, alangidiol, cycloartenone, cycloartenol, 24-methylenecycloartanol, obtusifoliol and stigmastanol were isolated. The epicuticular leaf wax contains large amounts of pentacyclic triterpenoids in addition to the common lipid wax constituents: alkanes, wax esters, aldehydes, primary alcohols and fatty acids. Most of the triterpenoids were triterpenols, as well as their acetates, fatty acid esters and the corresponding ketones.

The most active compound is a hydrophobic diterpene ester, ingenol 3-angelate (PEP005), an irritant compound, which possesses topical anti-tumour activity against human cancer cell lines grown as subcutaneous tumours in mice. It has given more than 90% complete responses on different skin cancers in a Phase II clinical trial. The LD_{90} for PEP005 for a panel of tumour cell lines was 180–220 μM. PEP005 thus emerges as a potential new topical anti-skin cancer agent that has a novel mode of action involving plasma membrane and mitochondrial disruption, primary necrosis and potent activation of protein kinase C. PEP005 also has potent antileukaemic effects, inducing apoptosis in myeloid leukaemia cell lines. It also had powerful inhibitory activity against a wide range of other tumours tested, including breast cancer cells. In preclinical studies it was also shown to have activity against human melanoma xenografts in mice. The intellectual property on the use of ingenane, jatrophane



Euphorbia peplus – naturalized

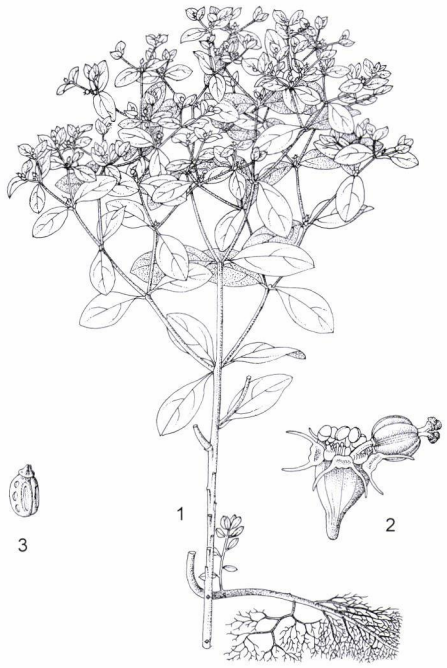
and pepluane type diterpenes, which are being used as anti-neoplastic differentiation control agents, is the subject of several patent applications.

Several diterpenes exhibited a pronounced or moderate anti-herpes virus effect (IC_{50} of 2.5–8.3 µg/ml) in vitro. The observed HSV-2 inhibitory activities were not associated with virucidal effects.

A crude chloroform extract and hot water extract of the aerial parts showed significant molluscicidal activity against *Biomphalaria alexandrina* and *Bulinus truncatus*. An acetone extract showed larvicidal activity against the mosquito *Culex pipiens*. A methanolic leaf extract inhibited the growth of *Aspergillus flavus*, and also inhibited the production of aflatoxins (73–100%), with greater inhibition at higher concentrations.

Experimental feeding of *Euphorbia peplus* caused blood-stained faeces and excessive salivation in calves. Lactating goats, which fed on the aerial parts mixed with their usual green fodder, showed symptoms of general poisoning; the main toxic effects were seen in the heart, lung and liver. Histopathological examinations revealed that the primary toxic effects originated from degenerative changes in parenchymal and endothelial cells. The milk of the goats fed on *Euphorbia peplus*, consumed by their offspring, caused poisoning and even death, with signs similar to those observed in the adults. The toxicity is caused by ingenane type diterpenes.

Description Monoecious, annual, erect herb up to 30 cm tall, glabrous, with latex in aerial parts. Leaves alternate in lower part of the stem, opposite in upper part, simple and entire; stipules absent; petiole up to 1 cm long; blade obovate, up to 2.5 cm × 1.5 cm, base cuneate, apex rounded. Inflorescence an axillary or terminal cyme consisting of clusters of flowers, each cluster called a 'cyathium', in 3-branched umbels; branches up to 3.5 cm long; bracts similar to the leaves, sessile; cyathia almost sessile, c. 1 mm × 1 mm, with a cup-shaped involucre, lobes rounded, minute, margin hairy; glands 4, transversely oblong, c. 0.5 mm long, with 2 horns up to 1 mm long, each involucre containing 1 female flower surrounded by male flowers. Flowers unisexual; male flowers sessile, bracteoles linear, fringed, perianth absent, stamen c. 1 mm long; female flowers with pedicel c. 3 mm long in fruit, ovary superior, glabrous, 3-celled, styles 3, c. 0.5 mm long, spreading. Fruit a deeply 3-lobed capsule c. 2 mm in diameter, base truncate, with fleshy longitudinal ridges, 3-seeded. Seeds oblong-ovoid, c. 1.5 mm × 1 mm, warty, reddish brown becoming grey; caruncle c. 0.3 mm in diameter.



Euphorbia peplus – 1, plant habit; 2, cyathium; 3, seed.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Euphorbia* comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150 species in Madagascar and the Indian Ocean islands. *Euphorbia peplus* belongs to section *Esula*, a group of annual or perennial herbs characterized by absence of stipules, cyathia in axillary and terminal umbel-like cymes, leafy or deltoid bracts, 4 involucral glands, entire or with 2 horns, fruits exserted on reflexed pedicel and seeds with a caruncle. Several other species from this section are medicinally used, 3 of them are mentioned hereafter.

Euphorbia cyparissioides Pax occurs from Nigeria east to Ethiopia and throughout east and southern Africa. In East Africa root powder is eaten with porridge as a strong purgative.

Euphorbia petitiana A.Rich. occurs in Ethiopia and Yemen. In Ethiopia an infusion of the aerial parts is taken as an anthelmintic. *Euphor-*

bia ugandensis Pax & K.Hoffm. occurs in Kenya, Uganda and Tanzania. In Kenya the Maasai people take a leaf infusion as an emetic to treat colds and cough.

Growth and development *Euphorbia peplus* can be found flowering throughout the year if enough water is available. The plant develops rapidly as it matures in 12–14 weeks.

Ecology *Euphorbia peplus* occurs in disturbed localities, gardens, pavements, waste places and pastures, from sea-level up to 1500 m altitude. It prefers shaded localities.

Propagation and planting The seeds of *Euphorbia peplus* are small (about 1700 per g) and have a germination rate of more than 70%.

Management In Australia *Euphorbia peplus* is grown in small plots for latex production. As the plants can be easily killed by herbicides, and because they do not spread beyond shade, the risk that it will become an invasive weed is small. It is potentially suitable for large-scale agricultural production.

Diseases and pests Rust and other fungal diseases may become a problem of *Euphorbia peplus* in the maturing stages. It can also be attacked by viruses and is a host of cabbage whitefly (*Aleyrodes proletella*), a possible reservoir of cabbage black ring virus.

Harvesting If enough water is available throughout the year, *Euphorbia peplus* grows and produces seeds all year round and can be harvested for latex or seed whenever the need arises.

Yield In Australia the fresh plant yield of *Euphorbia peplus* is 1–1.5 kg/m^2, and latex yield is 100–300 mg/kg freshly harvested plant parts.

Handling after harvest In Africa the latex of *Euphorbia peplus* is usually used fresh; in Australia active compounds are extracted industrially.

Genetic resources *Euphorbia peplus* has a very large area of distribution, has a short life cycle and produces many seeds. Therefore, there is no risk of genetic erosion.

Breeding There are currently no breeding programmes of *Euphorbia peplus* to increase the amount of diterpenes in the latex.

Prospects Several of the active compounds of *Euphorbia peplus* are good candidates to be developed into anticancer drugs considering the promising pharmacological studies and clinical trials results. As the active compounds are complex molecules, they have not yet been chemically produced, and can only be obtained directly from the plant. More research into large-scale production and mechanisation of cultivation and latex extraction is needed.

Major references Carter & Leach, 2001; Challacombe et al., 2006; Corea et al., 2005; Davis & Parsons, 2002; Gillespie, Zhang & Hersey, 2004; Green & Beardmore, 1988; Hampson et al., 2005; Hemmers, Gülz & Marner, 1988; Nawito et al., 1998; Ogbourne et al., 2004.

Other references Beentje, 1994; Burkill, 1994; Corea et al., 2004; Giner, Berkowitz & Andersson, 2000; Gayar, Shazli & Abbassy, 1971; Gurib-Fakim, Guého & Bissoondoyal, 1996; Hartwell, 1970; Hasan & Abdel Mallek, 1994; Hohmann et al., 2000; Hohmann et al., 1999a; Hohmann et al., 1999b; Jakupovic et al., 1998; Jansen, 1981; Lotfy & Abdel Gawad, 2000; Mucsi et al., 2001; Neuwinger, 2000; Rizk et al., 1985; Scott, 1982; Shoeb, El-Eman & Osman, 1982.

Sources of illustration Ross-Craig, 1970.

Authors A.T. Tchinda

EUPHORBIA PERESKIIFOLIA Houllet ex Baill.

Protologue Adansonia 1: 105 (1861).

Family Euphorbiaceae

Synonyms *Synadenium pereskiifolium* (Houllet ex Baill.) Guillaumin (1935).

Vernacular names Kiyuyu (Sw).

Origin and geographic distribution *Euphorbia pereskiifolia* occurs in Kenya and Tanzania.

Uses In Kenya *Euphorbia pereskiifolia* is used by traditional doctors in the preparation of an anti-asthma drug. Although it is a highly poisonous plant, traditional doctors have used a leaf decoction, mixed with lemon juice, baking soda and honey, effectively in the treatment of asthma for decades with no adverse effects. The leaves are reported to be a strong purgative. In Tanzania women suffering from excessive menstruation drink the juice of fresh crushed leaves. Leprosy is treated with the ash of dried burnt leaves. The latex is highly irritating to the skin and mucous membranes, causing blisters and pain. Several peanuts dipped into the latex are eaten as a drastic purgative. Boils are treated with the latex. Roots also contain the strong latex, and a cold water extract of peeled roots is mixed with sugar and left standing for three days, after which it is drunk against heavy coughs and tuberculosis.

In addition to medicinal uses, the latex is an

ingredient in arrow poison in Kenya. In Kenya and Tanzania the latex is used as fish poison.

Properties Preliminary phytochemical screening of the aqueous extract of the leaves and stems revealed the presence of glycosides, terpenoids, flavonoids and other phenolic compounds.

An aqueous extract of the stems and leaves contracted the isolated guinea pig ileum. A glycoside, 2-O-β-D-glucopyranosyl-L-malic acid was isolated from the aqueous extract, but this was found to be inactive.

Botany Monoecious, succulent shrub up to 5 m tall, laxly branched; stems cylindrical, with copious latex. Leaves arranged spirally, simple and usually entire; stipules modified into small brown glands; petiole winged, c. 1 cm long; blade obovate, up to 19 cm × 10 cm, base cuneate, apex obtuse to rounded, fleshy, glabrous, pinnately veined, midvein prominent beneath. Inflorescence an axillary false umbel, composed of 2–5 cymes, consisting of clusters of flowers, each cluster called a 'cyathium'; peduncle up to 4 cm long and branches c. 2 cm long; bracts broadly ovate, c. 3.5 mm × 3 mm, short-hairy; cyathia with a funnel-shaped involucre c. 2.5 mm × 6 mm, densely short-hairy below, glandular rim c. 1 mm wide, deeply furrowed, greenish yellow, lobes c. 1.5 mm in diameter, margin hairy, each cyathium containing 1 female flower surrounded by several male flowers. Flowers unisexual; male flowers sessile with fan-shaped, fringed bracteoles, perianth absent, stamen c. 3 mm long; female flowers with pedicel up to 6 mm in fruit, perianth obtusely 3-lobed, ovary superior, 3-celled, styles 3, c. 2 mm long, fused to halfway, deeply bifid at apex. Fruit a 3-lobed capsule c. 7 mm × 7 mm, short-hairy, 3-seeded. Seeds ovoid, c. 2.5 mm × 2 mm, obtusely 4-angled, minutely rough, pale brownish grey, caruncle minute.

Euphorbia comprises about 2000 species and has a worldwide distribution. *Synadenium* (about 15 species in continental Africa) has classically been kept separate from *Euphorbia*, mainly because the glands of the cyathia form a ring in *Synadenium*, whereas the glands in *Euphorbia* are separate or only touching. However, recent molecular analyses found *Synadenium* to be nested within *Euphorbia*, section *Monadenium*, and it is therefore now included in *Euphorbia*. Several other *Euphorbia* spp., belonging to section *Monadenium*, have medicinal uses. *Euphorbia cupularis* Boiss. ('dead man's tree'; synonym: *Synadenium cupulare* (Boiss.) L.C.Wheeler) occurs in Mozambique and South Africa. The latex is extremely toxic, irritant and blistering, and never taken internally. In South Africa ground dry leaves or ground leaves in water are sniffed to treat headache, catarrh and flu. Dried leaves are eaten to treat asthma. Latex is placed in a hollow tooth to treat toothache; latex is also rubbed on infected wounds. The burnt roots are used with other plants to treat paralysis. The bark is employed in a potent sorcery charm. An ethanolic leaf extract significantly inhibited prostaglandin-synthesis. *Euphorbia neoglaucescens* Bruyns (synonym: *Synadenium glaucescens* Pax) is a succulent tree endemic to Tanzania and morphologically similar to *Euphorbia pereskiifolia*; it has similar medicinal uses. The juice of fresh, crushed leaves is drunk to treat excessive menstruation and as a purgative; a leaf decoction with lime juice, baking soda and honey added is drunk to treat asthma. The ashes of dried leaves are mixed with water and applied to treat leprosy. A root bark extract is taken with sugar to treat severe cough and tuberculosis; a root extract is used as ear drops to treat earache. A few drops of latex are put on 1–2 peanuts and eaten as a purgative. The latex is also used as a fish poison.

Ecology *Euphorbia pereskiifolia* occurs on sandy soil or on rocks in coastal or riverine woodland, from sea-level up to 250 m altitude.

Management *Euphorbia pereskiifolia* is easily and quickly propagated by stem cuttings, which should be at least 20 cm long. After cutting they should be allowed to lie in a shaded place for at least a week for a callus to form on the cut end. Care should be taken that the latex does not touch the skin or mucous membranes because of its irritating properties. *Euphorbia pereskiifolia* can also be grown from seed. Mostly wild plants are used, or a few trees planted near villages, and no management practices are required.

Genetic resources and breeding Although *Euphorbia pereskiifolia* only occurs in Kenya and Tanzania, there are no signs that it is threatened by genetic erosion. As a (semi-)succulent *Euphorbia* species, its trade is controlled under CITES appendix 2.

Prospects The use of *Euphorbia pereskiifolia* as a medicinal plant is not recommended because of its very toxic latex. Unless interesting pharmacological compounds are isolated, the species will remain of local importance as a medicine against asthma.

Major references Bruyns, Mapaya & Hed-

derson, 2006; Carter & Radcliffe-Smith, 1988; Eggli, 2002; Neuwinger, 1996; Neuwinger, 2000.

Other references Chhabra, Mahunnah & Mshiu, 1990; Chhabra, Uiso & Mshiu, 1984; Grace et al., 2002; Hedberg et al., 1983a; Hermansson et al., 1990; Jäger, Hutchings & van Staden, 1996; Neuwinger, 2004; Powys & Duckworth, 2006; Watt & Breyer-Brandwijk, 1962.

Authors L.E. Newton

EUPHORBIA POISSONII Pax

Protologue Bull. Mus. natn. Hist. nat., Paris 8: 62 (1902).

Family Euphorbiaceae

Vernacular names Candle plant (En).

Origin and geographic distribution *Euphorbia poissonii* occurs from southern Burkina Faso and Ghana east to Cameroon. It possibly also occurs in Guinea, Côte d'Ivoire and Mali.

Uses The latex of *Euphorbia poissonii* is very caustic and toxic, and very irritating to the skin and mucous membranes. It can cause blindness when in contact with the eyes. Despite its toxicity, it is used medicinally. In Nigeria a few drops of latex are applied to Guinea-worm sores and to skin papilloma. A few drops of latex with sugar cane or in palm wine or soup are taken as a purgative. In Cameroon the latex extracted from the leaves is applied to treat lumbago. It is also placed in a carious tooth to relieve toothache or to help to loosen the tooth and render extraction easier.

Throughout West Africa the latex is used as fish poison. A piece of stem is mixed with the seeds of *Strophanthus* to prepare arrow poison. In Nigeria the latex is said to be added sometimes to tobacco snuff to increase its pungency. The Hausa people use the latex on cereals to catch guinea fowl. The latex is also used in bait to kill rodents and birds, and is used for removing hairs from hides. The latex is applied as glue on branches to capture birds. The latex is highly poisonous when added to food, drinking water and kola nuts, and in Nigeria homicides are sometimes committed through *Euphorbia poissonii* poisoning.



Euphorbia poissonii – wild

In West Africa *Euphorbia poissonii* is sometimes planted in gardens as an ornamental plant or as a hedge around fields and graveyards. In Europe and the United States it is kept as a pot plant in succulent collections. The flowers are much visited by bees and other insects.

Euphorbia poissonii closely resembles *Euphorbia unispina* N.E.Br., and they have similar uses.

Production and international trade Several compounds isolated from *Euphorbia poissonii* are internationally traded. Resiniferatoxin was sold on the internet in 2007 for US$ 35 (1 mg) to US$ 525 (25 mg); tinyatoxin was sold for US$ 60 (1 mg) to US$ 240 (5 mg). *Euphorbia poissonii* is also traded on the internet as an ornamental plant.

Properties The latex of *Euphorbia poissonii* contains esters of the diterpene tigliane type alcohols 12-deoxyphorbol and 12-deoxy-16-hydroxyphorbol, the diterpene daphnane type alcohol resiniferonol, and several esters of the macrocyclic diterpene alcohol 19-hydroxyingol, e.g. the pentacyclic euphorianin. Most compounds isolated are mono- and di-esters of 12-deoxyphorbol. Daphnane esters are generally known for their potent skin irritant properties, whereas tigliane esters are toxic and tumour promoters; however, some of the tigliane compounds, especially 12-deoxyphorbol derivatives, possess anticancer activities.

The variety of irritant compounds present in high concentrations is reflected by the irritant activity of the latex, which is more than 30 times stronger in *Euphorbia poissonii* latex (ID_{50} = 0.1 µg / 5 µl) than in the latex of e.g. *Euphorbia unispina*, although after 24 hours both activities have almost the same value. The isolated aromatic esters of the daphnane type are more potent irritants in mouse ear tests than the aromatic tigliane esters, especially resiniferatoxin (ID_{50} = 0.00021 nMol / 5

µg) and tinyatoxin (ID_{50} = 0.0012 nMol / 5 µg). Of the 6 isolated aromatic tigliane esters, the highly irritant 12-deoxyphorbol-13-O-phenylacetate-20-O-acetate (ID_{50} = 0.075 nMol / 5 µg) is the major compound; candletoxin A, candletoxin B and DPP (12-deoxyphorbol 13-phenylacetate) are also strongly irritant. The irritant activity of resiniferatoxin and tinyatoxin is rapid. It reaches a maximum within 4 hours and then fades to inactivity after 24 hours.

Resiniferatoxin and tinyatoxin are highly toxic, as they bind to pain receptors in the same way as capsaicin, but much more powerfully. They stimulate the neurons to fire repeatedly until the neuron dies, causing searing pain and sending the victim into severe anaphylactic shock. Resiniferatoxin is used in the treatment of incontinence associated with an overactive bladder. It also has antifeedant and analgesic properties. Efforts have been made to synthesize this compound. In laboratory tests, DPP induced the expression of HIV-1 in latently infected T cells and rendered them sensitive to killing by an immunotoxin. DPP is 20- to 40-fold more potent than the related phorbol ester prostratin, and the combination of high potency and antitumour promoting activity makes DPP an attractive candidate for therapy of HIV-1 infection.

During further phytochemical studies on the latex, derivatives of 19-hydroxyingol were isolated. These compounds showed cytotoxic activities against 6 human solid tumour cell lines (lung carcinoma, breast carcinoma, colon adrenocarcinoma, kidney carcinoma, prostate adenocarcinoma and pancreatic carcinoma). Moreover, most of the 12-deoxyphorbol ester derivatives showed selective cytotoxicity for the human kidney carcinoma cell line with potencies for one compound exceeding those of the anticancer drug adriamycin by 10,000 times.

A root extract of Nigerian material, screened for molluscicidal activity on the freshwater snail *Bulinus globulus*, was reported as being inert.

Description Monoecious, candelabriform shrub up to 2 m tall; branches cylindrical, 3–3.5(–4) cm in diameter, silvery grey, covered with prominent rounded tubercles and horny spine shields up to 8 mm in diameter, grey, with 1 spine on young plants or spine rudimentary, with white latex. Leaves arranged spirally at stem apex in 8–10 ranks, simple and entire, soon falling; stipules, if present, modified into small spines, soon falling; petiole short, thick; blade obovate to spoon-shaped, 5–14 cm × 3–7 cm, base long-cuneate, apex deeply notched, fleshy, glabrous, pinnately veined. Inflorescence an axillary cyme, numerous at the ends of branches, consisting of clusters of flowers, each cluster called a 'cyathium'; peduncle and branches short; bracts 2, ovate, c. 2 mm long, membranous; cyathia c. 8 mm in diameter, with a shortly funnel-shaped involucre, green, 5-lobed with broadly ovate, fringed lobes, glands 5, elliptical, touching, green, each involucre containing 1 female flower surrounded by many male flowers. Flowers unisexual; male flowers sessile, perianth absent, stamen shortly exserted, red; female flowers with curved pedicel 5–12 mm long in fruit, perianth 3-lobed, ovary superior, glabrous, 3-celled, styles 3. Fruit a deeply 3-lobed capsule 5–6 mm in diameter, lobes almost globose, glabrous, 3-seeded. Seeds ovoid, c. 2 mm long, smooth, pale grey with a few darker markings.

Other botanical information *Euphorbia* comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150 species in Madagascar and the Indian Ocean islands. *Euphorbia poissonii* belongs to subgenus *Euphorbia* section *Euphorbia*, a large group which is characterized by succulent, angular stems, stipules modified into small spines, a spine shield with a pair of spines (sometimes fused into a single spine), axillary inflorescences and seeds without caruncle. *Euphorbia poissonii* closely resembles *Euphorbia unispina* N.E.Br., and they have overlapping medicinal uses.

Euphorbia sapinii De Wild. occurs from Cameroon and the Central African Republic south to western DR Congo, and is closely related to *Euphorbia poissonii* and *Euphorbia unispina*. In the Central African Republic and DR Congo the latex is rubbed onto the skin of dogs to treat scabies. The latex is also an ingredient for spear poison; it is used as a fish poison and sometimes as an ordeal poison in the form of eye drops.

Growth and development *Euphorbia poissonii* flowers at the end of the dry season, before new leaves are formed.

Ecology *Euphorbia poissonii* occurs on rocks and dry stony soils, usually in open woodland with grass, at 400–700 m altitude.

Propagation and planting *Euphorbia poissonii* can be propagated by seed or by stem cuttings. Stem cuttings should be at least 20 cm long and preferably cut from the base of a branch where the cut surface is woody. After

cutting they should be allowed to dry for at least 2 weeks for a callus to form on the cut end.

Management *Euphorbia poissonii* latex is harvested from wild plants or from those planted near villages.

Harvesting Harvesting of the leaves is seasonal because the plants are leafless in the dry season.

Genetic resources *Euphorbia poissonii* has a relatively large area of distribution and is locally common. Therefore it is not likely to be threatened by genetic erosion. Trade in all succulent *Euphorbia* spp. is controlled under CITES appendix 2.

Prospects Although *Euphorbia poissonii* has useful biological activities, its use for medicinal purposes is limited by the toxicity of the latex. However, the prospects of some of its compounds are good; for example, resiniferatoxin is going through phase II clinical trials and DPP can be used in the therapy of persistent HIV-1 infection.

The taxonomy and distribution areas of *Euphorbia poissonii*, *Euphorbia unispina* and some other closely related species need to be reviewed as they resemble each other closely.

Major references Adjanohoun et al., 1996; Arbonnier, 2002; Burkill, 1994; Brown, Hutchinson & Prain, 1909–1913; Dalziel, 1937; Evans & Schmidt, 1977; Evans & Schmidt, 1979; Keay, 1958a; Neuwinger, 1996.

Other references Aubréville, 1950; Eggli, 2002; Fakunle & Ekong, 1978; Fakunle, Connolly & Rycroft, 1989; Fatope et al., 1996a; Fatope et al., 1996b; Graham et al., 2000; Neuwinger, 2000; Schmidt & Evans, 1976; Schmidt & Evans, 1977; Schmidt & Evans, 1978; Smith & Evans, 1980.

Authors A.T. Tchinda

EUPHORBIA PROSTRATA Aiton

Protologue Hort. kew. 2 : 139 (1789).

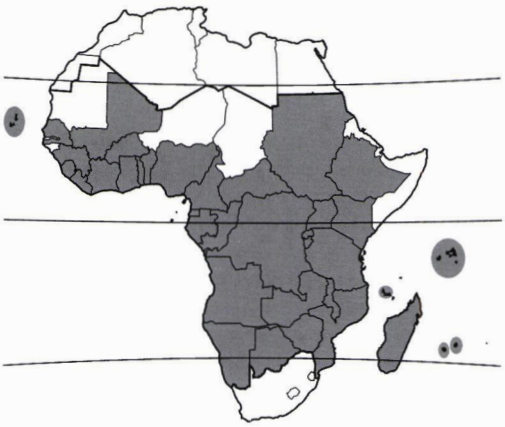
Family name Euphorbiaceae

Chromosome number $2n = 18, 20$

Synonyms *Chamaesyce prostrata* (Aiton) Small (1903).

Vernacular names Prostrate spurge, prostrate sandmat, trailing red spurge (En). Rougette, rosette, petit trèfle, petite teigne noire (Fr).

Origin and geographic distribution *Euphorbia prostrata* is native to the West Indies, but is now widely distributed throughout the tropics and subtropics. It occurs throughout tropical Africa and the Indian Ocean islands.



Euphorbia prostrata – naturalized

Uses All parts of *Euphorbia prostrata* are widely used in African traditional medicine. In Burkina Faso the leaves are rubbed onto wasp stings and scorpion stings. In Togo a leaf decoction is drunk to treat threatened abortion. Small balls of ground plants are inserted into the vagina to treat female sterility and painful menstruation. In Benin the pounded aerial parts with pounded shells are taken to treat irregular menstruation. Ground leaves in water are administered against difficult childbirth. In Nigeria a plant decoction is taken for its astringent, vulnerary and anthelmintic properties, and crushed plants are used by the Igbo people as a poultice for broken arms. In Cameroon crushed leaves are eaten to treat amoebic dysentery. In Gabon a leaf extract is applied as an enema to treat inflammations. Leaf powder mixed with palm oil is rubbed on the head to treat headache. In DR Congo the whole plant or only the leaves are warmed over a fire, crushed and squeezed on the body to cure insect bites and fungal infection. An infusion or decoction of the leaves is also taken orally to treat fungal infections. The crushed whole plant is eaten with bread against kidney stones. In Kenya Maasai people chew the plant to treat gonorrhoea. In Uganda crushed fresh leaves in water are used as a mouthwash and gargle to treat oral sores. Pregnant women eat the boiled shoots, mixed with sesame, to reduce the risk of miscarriage. Plant juice is taken to induce labour during childbirth. A bath of the plant infusion is recommended to treat insanity. In Angola a vapour bath of the whole plant

is taken to treat scabies; the plant is also crushed and applied on the affected spots. Throughout the Indian Ocean islands an infusion of the leaves or aerial parts is taken either alone or combined with other plants to treat diarrhoea, dysentery and stomach-ache. In the Comoros, the plant is used in association with other plants to treat deformations of the spinal column. In Réunion a bath with the whole plant is taken to facilitate healing of measles and other skin eruptions. In Mauritius a decoction of the whole plant is taken orally to treat painful menstruation and used as an eye wash against conjunctivitis.

The latex is applied to warts and abscesses. It is also used as an arrow poison.

Similar uses as above have been reported from other parts of the world. In the United States the latex is applied to snakebites, in Mexico and Venezuela to tumours and in India the latex is used to treat diabetes, as it is considered to have hypoglycaemic and anti-inflammatory activities. The plant is also used to treat asthma and an infusion is taken as a blood purifier. In French Guyana the aerial parts in decoction are taken as a bitter diuretic. Crushed fresh plants are applied as an embrocation to heal sprains and strains.

Properties The latex is irritant and blistering to the skin and mucous membranes and is reported to cause blindness. From different fractions of extracts of the dried leaves a range of hydrolyzable ellagitannins were isolated, including prostratins A, B and C, euphorbins G and H, tellimagradin I and II, and rugosins A, D, E and G. Flavonoids isolated from the aerial parts include: kaempferol, cosmosiin (apigenin-7-glucoside), rhamnetin-3-galactoside, quercetin and quercetin-3-rhamnoside. Other constituents of the aerial parts include the sterols β-amyrine acetate, β-sitosterol, campesterol, stigmasterol and cholesterol. The aerial parts also contain the terpene alcohol β-terpineol, gallic acid, corilagin, 1,2,3-tri-O-galloyl-D-glucose, geraniin, and various amino acids, including n-valeramide and N,N-dimethyl-4-benzoxybutylamine. From the roots a myricylic alcohol and two triterpenes, taraxerol and tirucallol, have been isolated. Both flavonoids and tannins have been reported to have anti-inflammatory, analgesic, haemostatic, antithrombic and vasoprotective actions. The flavonoids furthermore have antiviral, anti-allergic, antiplatelet, antitumour and antioxidant properties.

The ethanol and water extracts of the whole plant showed significant antifungal activity against the dermatophytes *Trichophyton mentagrophytes*, *Trichophyton simii* and *Microsporum gypseum* in vitro and in vivo in goats and rabbits. The extracts cured the lesions caused by these fungi in 3–4 weeks and were as effective as benzoic acid. A water extract inhibited growth, spore formation, and enterotoxin production of *Clostridium perfringens* type A. Ethanolic extracts from the aerial parts showed significant antibacterial activity against *Escherichia coli* and *Bacillus subtilis*. An aqueous ethanol extract showed significant antibacterial activity in vivo against *Shigella dysenteriae* in tests with rats. A methanol extract of the leaves showed considerable inhibitory effects against HIV-1 protease, and a water extract against hepatitis C virus protease.

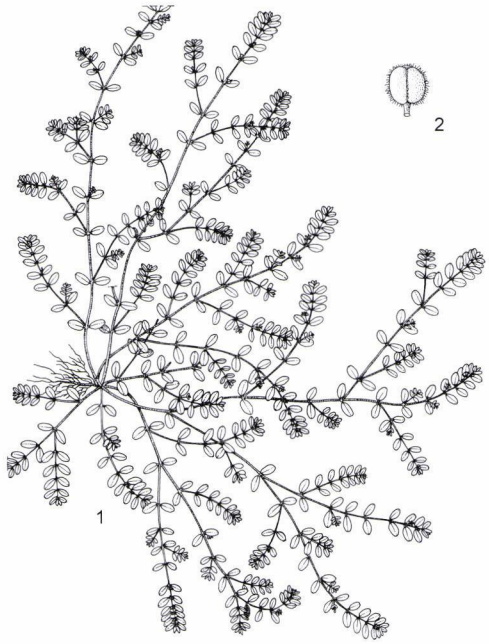
The ethyl acetate fraction of the ethanol extract administered orally to rats at 200 mg/kg inhibited 76% of acute carrageenin-induced paw oedema and showed significant anti-inflammatory activity when applied topically in carrageenin-induced paw oedema in mice.

Various doses of powdered plants as well as methanol extracts administered orally to rabbits produced significant hypoglycaemic effects in normal rabbits, but had no effect in alloxan-diabetic rabbits.

Euphorbia prostrata shows strong seed germination inhibiting effects on wheat and a range of horticultural crops, including carrot, tomato, lettuce and onion.

Adulterations and substitutes *Euphorbia prostrata* resembles *Euphorbia thymifolia* L. and has similar medicinal uses.

Description Monoecious, prostrate, annual herb with branches up to 20 cm long, tinged purplish, with numerous adventitious roots; stems with latex. Leaves opposite, distichous, simple; stipules triangular, c. 1 mm long, 2-toothed; petiole up to 1 mm long; blade ovate, up to 8 mm × 5 mm, base unequal, one side cuneate, the other side rounded, apex rounded, margins shallowly toothed, glabrous above, sparsely hairy beneath. Inflorescence a terminal or axillary cluster of flowers, called a 'cyathium', on short leafy shoots; cyathia almost sessile, c. 1 mm × 0.5 mm, with a barrel-shaped involucre, lobes triangular, minute, margin hairy; glands 4, minute, transversely elliptical, red, with very small pink or white appendages, each involucre containing 1 female flower surrounded by few male flowers. Flowers unisexual; male flowers sessile, bracteoles hair-like, perianth absent, stamen c. 1 mm long; female flowers with pedicel c. 1.5 mm long and re-



Euphorbia prostrata – 1, plant habit; 2, fruit. Redrawn and adapted by Achmad Satiri Nurhaman

flexed in fruit, perianth a rim, ovary superior, glabrous, 3-celled, styles 3, minute, 2-fid. Fruit an acutely 3-lobed capsule c. 1.5 mm × 1.5 mm, base truncate, sutures purplish and hairy, 3-seeded. Seeds oblong-conical, c. 1 mm × 0.5 mm, acutely 4-angled, transversely wrinkled, grey-brown, without caruncle.

Other botanical information *Euphorbia* comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150 species in Madagascar and the Indian Ocean islands. *Euphorbia prostrata* belongs to subgenus *Chamaesyce* section *Chamaesyce*, a group of annual or sometimes perennial herbs with obvious stipules, further characterized by a main stem aborting at the seedling stage. The plant thus consists of an expanded, dichotomously branching umbel-like inflorescence, with the floral bracts appearing as normal leaves, cyathia solitary or up to 5 together in congested leafy cymes, 4 involucral glands with petal-like appendages or entire and conical seeds without a caruncle.

Several other *Euphorbia* spp. belonging to section *Chamaesyce* are medicinally used. *Euphorbia inaequilatera* Sond. occurs from Mauritania and Senegal east to Eritrea and Somalia and south to South Africa. It also occurs in the Arabian Peninsula and Pakistan. In DR Congo the pounded plant is applied to wounds and burns. In Rwanda an extract of the plant is used as eye bath to treat eye infections. In East Africa plant powder is applied to wounds. The aerial parts are chewed to treat gonorrhoea. In Namibia leaf sap is applied to wounds. Tea from the leaves is drunk as a blood purifier. Leaf pulp is applied to skin rashes. A leaf and root infusion is drunk to accelerate birth giving. Powdered dried plants are eaten as a cardiac medicine. The roots are used as a fish poison. The plant is browsed by camels, goats and sheep.

Growth and development *Euphorbia prostrata* grows rapidly and flowers and fruits 12–14 weeks after germination. It can be found flowering and fruiting throughout the year if enough water is available.

Ecology *Euphorbia prostrata* grows in gardens, on disturbed ground, in cultivated land and roadsides, especially in sandy soils, from sea-level up to 2050 m altitude.

Propagation and planting *Euphorbia prostrata* is a prolific seed producer. Most seeds will germinate at the same time when ecological conditions are favourable, especially during the rainy season.

Management *Euphorbia prostrata* is considered a weed, and can be a nuisance in crops due to the large number of seedlings. It is known to accumulate heavy metals from the soil.

Diseases and pests *Euphorbia prostrata* is a host of the root-knot nematodes *Meloidogyne incognita* and *Meloidogyne javanica*.

Handling after harvesting *Euphorbia prostrata* is usually used fresh for medicinal purposes.

Genetic resources *Euphorbia prostrata* has a very large area of distribution and is weedy, and is thus not at risk of genetic erosion.

Prospects *Euphorbia prostrata* has many local medicinal use and showed antibacterial activities as well as inhibitory effects against HIV-1 protease and hepatitis C virus protease. Although considerable chemical and pharmacological research has been done, more research is still needed to evaluate its potential.

Major references Alarcon-Aguilara et al., 1998; Bouquet & Debray, 1974; Carter & Leach, 2001; Gurib-Fakim, Guého & Bissoondoyal, 1996; Hussein et al., 2000; Hussein et al., 1999; Kamgang et al., 2007; Neuwinger,

2000; Nguyen Nghia Thin & Sosef, 1999; Singla & Pathak, 1989.

Other references Akhtar, Khan & Khaliq, 1984; Burkill, 1994; El Mahy, 2004; Garcia et al., 2002; Holm et al., 1977; Ivens, 1967; Kamatenesi-Mugisha & Oryem-Origa, 2007; Kokwaro, 1993; Lavergne & Véra, 1989; Nacoulma-Ouédraogo, Millogo-Rasolodimby & Guinko, 1998; Noumi & Yomi, 2001; Ogwal, 1996; Pal & Gupta, 1979; SEPASAL, 2008e; Singla & Pathak, 1990; Singla & Pathak, 1991; Tabuti, Lye & Dhillion, 2003; Watt & Breyer-Brandwijk, 1962; Wome, 1985; Yoshida et al., 1990.

Sources of illustrations Berhaut, 1975a.

Authors D.M. Mosango

EUPHORBIA PSEUDOGRANTII Bruyns

Protologue Taxon 55(2): 414 (2006).

Family Euphorbiaceae

Chromosome number $2n = 36$

Synonyms *Synadenium grantii* Hook.f. (1867).

Vernacular names African milkbush, coat-of-many-colours (En). Kinyunywa (Sw).

Origin and geographic distribution *Euphorbia pseudograntii* occurs from Ethiopia south to eastern DR Congo and Tanzania and probably also in Malawi, Zambia and Zimbabwe.

Uses In DR Congo the latex of *Euphorbia pseudograntii* is applied to warts, and leaf sap to treat cardiac problems. The powder from dried young stems mixed with salt is licked to soothe cough. In Rwanda and Burundi the latex is applied to cure syphilis. In Burundi several drops of latex from warmed leaves are taken to expel intestinal parasites and sometimes tapeworm. In Uganda and Tanzania the latex is applied to abscesses to mature them. Leaf sap is taken to treat excessive menstruation. In East Africa leaf preparations are externally applied to psoriasis and impetigo. A decoction of the stem bark or the latex is taken to expel a retained placenta, whereas a leaf decoction is drunk as an abortifacient. Pulverized leaves are rubbed into scarifications to treat backache. Leaf ash is taken in water to treat a sore throat. Pulverized leaves are applied to wounds. A root extract or sap from the crushed stem is used as ear drops to treat earache. In Tanzania a root preparation is used as a malaria remedy.



Euphorbia pseudograntii – wild

In Kenya the roots, in a mixture with parts of other plants, are boiled and the liquid is given to drink to cattle suffering from anthrax or blackquarter. The latex is also used as a blistering remedy on swollen glands caused by East Coast Fever in cattle.

In DR Congo the latex of young stems and leaves is used for tattooing. The latex can be fatal if ingested and is also used as a fish poison. In Rwanda the latex is an ingredient of arrow poison. In Kenya and Tanzania the plant is sometimes used for criminal purposes.

Euphorbia pseudograntii is sometimes cultivated as a greenhouse plant in temperate regions or as a garden plant in Kenya.

Properties *Euphorbia pseudograntii* has long been recognized as being very toxic and irritant. Contact of the latex with the skin or mucous membranes will cause a burning sensation, dermatitis and blisters. Symptoms may not be developed immediately and can be delayed for hours.

The latex of *Euphorbia pseudograntii* yields several diterpene esters of the tigliane type derived from 4-desoxyphorbol, of which 4-deoxyphorbol-13-phenylacetate-12-tigliate showed very strong skin irritant activity, with an ID_{50} of 0.000064 nMol/ear in mice. As a comparison, the standard irritant TPA (12-O-tetradecanoylphorbol-13-acetate) has an ID_{50} of 0.016 nMol/ear. The tumour-promoting activity of the isolated diester was found to be low. The other esters were relatively unstable and had only slight irritant activities. Subcutaneous injection of 0.5–1 ml latex into guinea pigs resulted in 40% mortality after 48–72 hours, the surviving animals developed severe oedema, skin lesions and necrosis. An ethanolic extract of the latex induced significant, dose-

dependent reversible hypothermia when injected intraperitoneally in rats and rabbits. In anaesthetized dogs, a slight rise in blood pressure with diuresis was induced by low doses, whereas high doses caused a severe to fatal drop in blood pressure, and several other effects.

The triterpenoids euphol, euphorbol and tirucallol were isolated from the acetone extract of the latex. Intravenous administration of euphol caused hypotensive activity in normotensive anaesthetized dogs and rats. The LD_{50} is 1.5 g/kg in mice intraperitoneally and more than 2 g/kg orally.

The latex also contains rubber (cis-1,4 linked polyisoprene) and ionol, an antioxidant which could play a role in the stabilization of *Euphorbia pseudograntii* latex. Furthermore, several acetylcholinesterase isozymes and proteolytic enzymes were purified from the latex, one of them with fibrinolytic and fibrinogenolytic properties, as well as several lectins, one of them exhibiting maximum agglutinating activity towards human O-group erythrocytes.

The acetone extract of dried latex showed high molluscicidal activity against the freshwater snails *Biomphalaria alexandrina* and *Bulinus truncatus*. The latex also has some acaricidal properties; in a trial in Uganda, the extract killed 62% of ticks. The latex showed significant nematicidal activity against *Meloidogyne javanica* infecting sunflower under greenhouse conditions.



Euphorbia pseudograntii – flowering branch. Redrawn and adapted by Achmad Satiri Nurhaman

Description Monoecious, rather succulent shrub or small bushy tree up to 5(–10) m tall; stems cylindrical, older stems pale grey, with prominent leaf scars on green stems and copious latex. Leaves arranged spirally, simple and entire; stipules modified into small brown glands; petiole up to 8 mm long; blade elliptical to oblanceolate, up to 15 cm × 6(–8) cm, base long-cuneate, apex obtuse to short-acuminate, fleshy, margin curled down, nearly glabrous, pinnately veined, midvein prominent below, rounded, green or sometimes tinged red beneath. Inflorescence a lax axillary cyme, consisting of clusters of flowers, each cluster called a 'cyathium'; peduncle up to 5 cm long, short-hairy, branches 1–3 cm long; bracts 2, c. 4 mm × 4 mm, short-hairy, reddish green, persistent; cyathia c. 3 mm × 6.5 mm, with a funnel-shaped involucre, bright red, 5-lobed with lobes c. 2 mm × 2 mm, with glandular rim c. 1 mm wide, deeply furrowed, red, each cyathium containing 1 female flower surrounded by male flowers. Flowers unisexual; male flowers sessile with linear bracteoles, fringed, with red tips, perianth absent, stamen c. 4 mm long, shortly exserted; female flowers with pedicel up to 5(–9) mm in fruit, perianth a 3-lobed rim, ovary superior, densely short-hairy, 3-celled, styles 3, c. 2 mm long, fused at base, bifid at apex. Fruit a 3-lobed capsule c. 7 mm × 8 mm, short-hairy, red, 3-seeded. Seeds ovoid, c. 2.5 mm × 2 mm, pale brownish grey, minutely tuberculate, caruncle rudimentary.

Other botanical information *Euphorbia* comprises about 2000 species and has a worldwide distribution. *Synadenium* (about 15 species in continental Africa) has classically been kept separate from *Euphorbia*, mainly because the glands of the cyathia form a ring, whereas the glands of *Euphorbia* species are separate or only touching. However, recent molecular analyses found *Synadenium* to be nested within *Euphorbia* section *Monadenium*, and therefore it is now included in *Euphorbia*. *Euphorbia pseudograntii* Bruyns is an invalid name as *Euphorbia pseudograntii* Pax already existed for another species, a fact overlooked by Bruyns. This is in the process of being corrected. The specimens of *Euphorbia pseudograntii* Bruyns in southern Africa might belong to *Euphorbia kirkii* (N.E.Br.) Bruyns (syno-

nym: *Synadenium kirkii* N.E.Br.), which has hairy leaf margins and lower midvein, a yellow glandular involucre ring and seeds with an obvious caruncle.
The name *Synadenium grantii* is internationally used for an ornamental plant, but this usually concerns *Euphorbia bicompacta* Bruyns. Especially *Euphorbia bicompacta* var. *rubra* (S.Carter) Bruyns is a widespread ornamental and hedge plant in subtropical gardens and a pot plant in Europe and the United States. It mainly differs from *Euphorbia pseudograntii* by having broadly obovate, sparsely toothed leaves, a prominent, sharp midvein below, blade usually with a red blotch below, and short, reddish-purple inflorescences. *Euphorbia bicompacta* occurs wild or cultivated in Ethiopia, Kenya, Rwanda and Tanzania. In Kenya, plant sap is used for treating East Coast fever in cattle. A decoction of its leaves and stem bark is given to drink to cattle to control ticks. *Euphorbia triangolensis* Bruyns (synonym: *Synadenium angolense* N.E.Br.) occurs in Malawi, Zambia and Angola. In Angola a root infusion is drunk to treat pain in the hips and madness. An infusion of unspecified plant parts is taken to treat stomach-ache, dropsy, stitch, urogenital problems, excessive menstruation, tuberculosis and cardiac palpitations. The latex is used as fish poison.

Growth and development In cultivation *Euphorbia pseudograntii* is moderately slow-growing, growing faster in warm tropical conditions with abundant rainfall. Under garden conditions at high altitudes, it can reach 3 m in height in 5 years.

Ecology *Euphorbia pseudograntii* is xerophytic and thrives on rocky hills with dry open woodland in the east African uplands, at 900–2100 m altitude and an annual rainfall of 600–900 mm.

Propagation and planting *Euphorbia pseudograntii* is easily propagated from seed, stem cuttings and root cuttings. Fresh cuttings should be dipped in charcoal dust to stop the leaking of latex and should be planted in sand to root.

Diseases and pests Excessive rainfall and cold conditions cause the stem to rot.

Handling after harvest One should take great care to avoid latex falling on skin, lips and eyes, and gloves are recommended for handling.

Genetic resources *Euphorbia pseudograntii* is relatively common in its distribution area and there are no signs that it is threatened by genetic erosion. As a (semi-)succulent *Euphorbia* species, its trade is controlled under CITES appendix 2.

Prospects The use of *Euphorbia pseudograntii* as a medicinal plant is not recommended because of its very toxic latex. The tigliane diterpene esters isolated from the latex have not yet yielded interesting pharmacological compounds. The enzymes and lectins isolated from the latex might have some potential in future, but more research is required.

Major references Bruyns, Mapaya & Hedderson, 2006; Carter, 1987; Carter & Radcliffe-Smith, 1988; ITDG & IIRR, 1996; Neuwinger, 1996; Rajesh et al., 2006; Steinmann & Porter, 2002; Watt & Breyer-Brandwijk, 1962.

Other references Bagavathi, Sorg & Hecker, 1988; Banderembako & Ntitangirageza, 1978; Beentje, 1994; Bossard, 1993; Chifundera, 2001; El Sayed, 1993; Govindappa et al., 1987; Kinghorn, 1980; Mrinalini et al., 2002; Neuwinger, 2000; Nielsen et al., 1979; Olivier et al., 1992; Okello-Onen et al., 2004; Premaratna, Shadaksharaswamy & Nanjappa, 1981; Shoeb et al., 1990; Tabuti, Lye & Dhillion, 2003; Unnikrishnan, Desai & Guruswamy, 1987; Uzabakiliho, Largeau & Casadevall, 1987; Van Puyvelde et al., 1983; van Wyk, van Heerden & van Oudtshoorn, 2002.

Sources of illustration Carter & Radcliffe-Smith, 1988.

Authors M.J. Nicholson

EUPHORBIA QUINQUECOSTATA Volkens

Protologue Notizbl. Bot. Gart. Berlin-Dahlem 2: 266 (1899).

Family Euphorbiaceae

Vernacular names Mchorongo (Sw).

Origin and geographic distribution *Euphorbia quinquecostata* occurs in Kenya, Tanzania and Mozambique.

Uses In Tanzania a stem infusion is given to children to expel intestinal worms; it is also taken to treat stomach-ache and is externally applied to heal wounds. The latex is rubbed into the skin in case of pain in the ribs, but this should be done with caution as it causes blisters.
In the Tanga region of Tanzania the latex is used as bird lime.

Properties An ethyl acetate extract of the wood of *Euphorbia quinquecostata* using a phorbol dibutyrate receptor-binding assay sys-

tem as a monitor yielded 4 inhibitory compounds; 2 were ingenane ester derivatives, 17-hydroxyingenol 20-hexadecanoate and ingenol 20-hexadecanoate, and the other 2 were entatisane derivatives. Also isolated from this extract were constituents inactive in this bioassay, including xanthoxylin, 6-hydroxy-7-methoxycoumarin (isoscopoletin), lupeol acetate, β-sitosterol, sitosterol-β-D-glucopyranoside, 6,7,8-trimethoxycoumarin, 3,4-dimethoxycinnamaldehyde, N-butylaniline and vanillin. A later isolated ent-isopimarane-type diterpene and a dihydrobenzofuran neolignan were inactive in assays for the induction of quinone reductase in hepatoma cells and for the inhibition of the transformation of murine cells, but 3,4-dimethoxycinnamaldehyde was significantly active in these assays.

Botany Monoecious, succulent small tree up to 10(–15) m tall with abundant latex; bole simple, up to 50 cm in diameter, with loosely spiraled rows of spines and scars of fallen branches; bark grey-brown, flaking; primary branches 2–4 m long, with whorls of secondary branches, directing upwards, forming a rounded crown; terminal branches fleshy, (3–)5(–6)-angled, 2–4(–7) cm in diameter, constricted at irregular intervals into oblong segments 5–15 cm long, margins of angles straight to toothed, with teeth 5–15 mm apart; spine shields oblong-triangular, c. 1.5 mm × 2 mm, with 1 pair of spines 2–8(–10) mm long. Leaves at the end of branches, in 4 rows, sessile; stipules absent; blade deltoid, c. 2 mm × 2 mm, soon falling. Inflorescence an axillary cyme, 1–3 together in a horizontal row, consisting of clusters of flowers, each cluster called a 'cyathium', crowded at the end of branches; peduncle 2–3 mm long, branches 2, short; bracts 2, c. 2 mm long; cyathia c. 2.5 mm × 4 mm, with a cup-shaped involucre, lobes c. 1 mm long, glands 5, transversely oblong, c. 1 mm × 2 mm, golden-yellow, each involucre containing 1 female flower surrounded by many male flowers. Flowers unisexual; male flowers sessile, perianth absent, stamen c. 4 mm long; female flowers with pedicel c. 7 mm long in fruit, perianth 3-lobed, ovary superior, glabrous, 3-celled, styles 3, c. 1 mm long, fused at base, apex 2-fid. Fruit a deeply 3-lobed capsule c. 4.5 mm × 7 mm, fleshy, 3-seeded. Seeds almost globose, c. 2.5 mm × 2 mm, grey-mottled, smooth.

Euphorbia comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150 species in Madagascar and the Indian Ocean islands. *Euphorbia quinquecostata* belongs to section *Euphorbia*, a large group which is characterized by succulent, usually angular stems, stipules modified into small spines (or absent), a spine shield with an additional pair of spines (sometimes fused into a single spine), axillary inflorescences and seeds without a caruncle.

Some other species from this section are medicinally used in tropical Africa. *Euphorbia robecchii* Pax occurs in Ethiopia, Somalia, Kenya and Tanzania. In Somalia the latex is widely used in the treatment of cattle diseases, including foot rot, foot abscesses, mange, ringworm and ticks. In Tanzania dried stem bark is boiled with butter and coffee beans, and the decoction is rubbed onto inflamed lymph nodes. The latex is applied to the skin of camels to treat contagious skin necrosis.

Euphorbia teke Schweinf. ex Pax (synonym: *Euphorbia tisserantii* A.Chev. & Sillans) occurs from the Central African Republic and southern Sudan south to Congo and DR Congo and east to Uganda and Tanzania. In the Central African Republic the latex is boiled with an egg and taken as a strong purgative to treat gonorrhoea.

Ecology *Euphorbia quinquecostata* occurs on rocky hillsides, and is usually the dominant tree in mixed deciduous woodland, at 600–1250 m altitude.

Genetic resources and breeding There are no signs that *Euphorbia quinquecostata* is threatened by genetic erosion. All succulent *Euphorbia* spp. are listed in CITES appendix 2.

Prospects *Euphorbia quinquecostata* yields several interesting compounds, which merit further research into their anticancer activities.

Major references Carter & Radcliffe-Smith, 1988; Elia, 2007; Kokwaro, 1993; Mbwambo et al., 1996.

Other references Catley & Mohammed, 1996; ITDG & IIRR, 1996; Neuwinger, 2000; Su et al., 2002.

Authors G.H. Schmelzer

EUPHORBIA SCHIMPERIANA Scheele

Protologue Linnaea 27: 344 (1843).

Family Euphorbiaceae

Chromosome number $2n = 20$

Origin and geographic distribution *Euphorbia schimperiana* occurs in Cameroon and from Eritrea south through East Africa, Rwanda, Burundi and eastern DR Congo to

Zimbabwe and Mozambique. It also occurs in Madagascar and Rodrigues (Mauritius), and on the Arabian Peninsula.

Uses In Rwanda the latex is used as ear drops to treat otitis. Leaf powder is applied to impetigo and stubborn skin infections. In Ethiopia an infusion of the aerial parts is taken as a purgative, to treat venereal diseases and as an anthelmintic. The fruits, crushed together with roots of *Cyathula polycephala* Baker, and mixed with water are taken to treat anthrax in cattle. In Kenya and Tanzania leaf paste in water is taken to treat coughs and colds. In Tanzania a leaf and root decoction is taken as a purgative. The latex is applied externally to treat snakebites.

In Kenya the plants are grazed by all domestic animals.

Properties The methanol extract of dry stems showed strong molluscicidal activity (LD_{50} = 5.7 ppm) against *Biomphalaria pfeifferi*, a vector of schistosomiasis. This activity was associated with terpenoids and phenolics. The effects of the extract on various snail tissues (gut, digestive gland and epidermal layer) were time and concentration dependent, and the results show that the epithelium layer is probably the primary site affected. The toxic and mutagenic activities of the methanol extract of the stems were investigated in mice, and showed slight toxicity to the skin and moderately irritant activity to the ocular tissue. The extract significantly increased the frequency of micronuclei division, especially at high concentrations, indicating that it has mutagenic activity.

Botany Monoecious, much-branched, annual or short-lived perennial herb up to 2 m tall, glabrous or with long, crisped hairs on the stem below the leaves or on the fruit; stems with conspicuous leaf scars, with latex. Leaves alternate, simple and entire, sessile, crowded; stipules absent; blade ovate-lanceolate to lanceolate, up to 15 cm × 2 cm, base cuneate, apex with short point, midvein winged on lower surface. Inflorescence an axillary or terminal cyme consisting of clusters of flowers, each cluster called a 'cyathium', in 3–15-branched umbels; branches up to 15 cm long; bracts sessile, deltoid, 1–4 cm long, long-acuminate; cyathia with peduncle up to 3 mm long, c. 2 mm × 2 mm, with a cup-shaped involucre, lobes quadrangular, c. 0.5 mm long, shallowly 2-lobed, hairy at margin; glands 4, transversely elliptical, c. 1 mm × 1.5–2 mm, 2-horned, horns up to 1.5 mm long, green turning brownish red, each involucre containing 1 female flower surrounded by many male flowers. Flowers unisexual; male flowers sessile, bracteoles linear, fringed, perianth absent, stamen c. 4.5 mm long; female flowers with pedicel up to 5.5 mm long, ovary superior, glabrous or hairy, 3-celled, styles 3, up to 2.5 mm long, fused at base, apex 2-fid, spreading. Fruit a deeply 3-lobed capsule c. 4 mm × 4.5 mm, base truncate, 3-seeded. Seeds oblong, slightly compressed, 2–2.5 mm × 1.5–2 mm, smooth, shiny black becoming grey; caruncle 0.5 mm in diameter, wrinkled, yellowish.

Euphorbia comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150 in Madagascar and the Indian Ocean islands. *Euphorbia schimperiana* belongs to section *Esula*, a group of annual or perennial herbs characterized by the absence of stipules, cyathia in terminal umbel-like cymes, leafy or deltoid bracts, 4 involucral glands, entire or with 2 horns, fruits exserted on reflexed pedicel and seeds with a caruncle. In *Euphorbia schimperiana* 3 varieties have been recognized: var. *schimperiana*, which is completely glabrous, var. *pubescens* (N.E.Br.) S.Carter, with short-hairy stem below the leaves and var. *velutina* N.E.Br. with hairy fruits.

Euphorbia depauperata Hochst. ex A.Rich. is a variable perennial herb which also belongs to section *Esula* and which occurs in West, East and southern Africa. In Ethiopia a leaf or root infusion is taken as an anthelmintic and purgative. In Kenya the plant is grazed by all domestic animals.

Ecology *Euphorbia schimperiana* occurs in grassland, evergreen bushland and montane forest, at 1350–3000 m altitude. It is also a weed in cultivation.

Genetic resources and breeding *Euphorbia schimperiana* is a widespread and variable species with a tendency to form distinctive local variants.

Prospects *Euphorbia schimperiana* is promising as a molluscicide, but more research is needed to identify the chemical compounds responsible for this activity.

Major references Burkill, 1994; Carter & Radcliffe-Smith, 1988; Ekram & Najia, 2006; Neuwinger, 2000.

Other references Al Zanbagi, Banaja & Barrett, 2000; Al Zanbagi, Banaja & Barrett, 2002; Al Zanbagi, Barrett & Banaja, 2000; Jansen, 1981; Yineger et al., 2007.

Authors G.H. Schmelzer

EUPHORBIA SUBSALSA Hiern

Protologue Cat. afr. pl. 1(4): 948 (1900).
Family Euphorbiaceae
Origin and geographic distribution *Euphorbia subsalsa* occurs in Angola and Namibia.

Uses A powder is prepared by pounding the sun-dried stem, from which the thorns are burnt off. This powder is smeared on incisions of the skin to ease pain when making tattoos. In northern Namibia latex of *Euphorbia subsalsa* is occasionally added to arrow poison made from the bitter root sap or latex of *Adenium boehmianum* Schinz, or arrow or spear poison made from the seeds or latex of *Fockea multiflora* K.Schum. to increase their efficacy. The Himba people of Namibia mainly use the latex to kill wild animals by poisoning the drinking water.

Botany Monoecious shrub up to 60(–120) cm tall, branching from the base; branches 4-angled, angles with wavy teeth up to 2 cm apart; stem up to 1 cm in diameter, not or distantly constricted into segments, pale green with a longitudinal stripe, with white latex; spine shield elongated, often joined into a horny margin, with 2 pairs of spines closely set on each spine shield, the lower pair 6–16 mm long, sturdy, the upper pair 2–5 mm long, brown or dark grey. Leaves rudimentary, scale-like, minute, soon falling; stipules modified into small spines on the upper part of the spine shield. Inflorescence an axillary, almost sessile, simple cyme, consisting of clusters of flowers, each cluster called a 'cyathium'; cyme branches 0–2, short; bracts 2; cyathia c. 3 mm in diameter, with a shortly cup-shaped involucre, green, 5-lobed with broadly ovate, fringed, emarginate lobes, glands 5, elliptical, not touching, yellow, female flower 1, surrounded by many male flowers. Flowers unisexual; male flowers sessile, perianth absent, stamen shortly exserted; female flowers almost sessile, perianth 3-lobed, ovary superior, glabrous, 3-celled, styles 3, fused at base. Fruit an almost sessile, obtusely 3-lobed capsule 2.5–3.5 mm in diameter, glabrous, brown, 3-seeded. Seeds ovoid, c. 2 mm long, with small warts.

Euphorbia comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150 species in Madagascar and the Indian Ocean islands. *Euphorbia subsalsa* belongs to subgenus *Euphorbia*, section *Euphorbia*, a large group which is characterized by succulent, angular stems, stipules modified into small spines, a spine shield with an additional pair of spines (sometimes fused into a single spine), axillary inflorescences and seeds without a caruncle. *Euphorbia subsalsa* and the species mentioned below are characterized by the small size of the plants and the branched, 4-angled, succulent stems with 4 spines per spine shield and almost sessile fruits.

Euphorbia kaokoensis (A.C.White, R.A.Dyer & B.Sloane) L.C.Leach is endemic to Namibia. It was formerly considered a variety of *Euphorbia subsalsa*, but is distinguished by its 5–7-ribbed branches, longer and more densely set spines; its medicinal uses are similar to those of *Euphorbia subsalsa*. *Euphorbia tenuispinosa* Gilli occurs in Kenya and Tanzania; the Galla people in Kenya use the latex as the main ingredient of arrow poison. *Euphorbia schinzii* Pax occurs in Botswana, Zimbabwe and northern South Africa; references to its presence in Kenya probably concern *Euphorbia angustiflora* Pax. In Zimbabwe root powder is rubbed into scarifications on the breasts as a galactagogue. *Euphorbia uhligiana* Pax occurs in Kenya and Tanzania. A stem decoction is drunk to treat colds. Sap is applied to wounds to heal them. In Kenya a bitter root and stem decoction is taken to treat fever, including malaria. *Euphorbia virosa* Willd. occurs in Angola, Namibia and the Cape Province of South Africa. In northern Namibia latex is added to arrow poison made from the bitter root sap or latex of *Adenium boehmianum* Schinz. Latex or powder of dried branches is used to poison hyenas and jackals, and also to poison waterholes. Black rhinoceros is reported to browse the plant. The latex contains esters of diterpene alcohols of the tigliane type. Honey from *Euphorbia virosa* is unpalatable because it causes a burning sensation when eaten.

Ecology *Euphorbia subsalsa* occurs in shrubland, often dominated by mopane (*Colophospermum mopane* (Benth.) J.Léonard), at about 1000 m altitude. It occurs mainly on calcareous soils.

Management *Euphorbia subsalsa* is only harvested from the wild.

Genetic resources and breeding Although *Euphorbia subsalsa* occurs in a relatively small area, there are no signs that it is threatened by genetic erosion. As a (semi-)succulent *Euphorbia* species, its trade is controlled under CITES appendix 2.

Prospects The latex of *Euphorbia subsalsa*

is apparently very poisonous and it will remain of local importance only, unless chemical or pharmacological research demonstrates interesting properties.

Major references Eggli, 2002; Neuwinger, 1996; SEPASAL, 2008j; van Wyk & Gericke, 2000.

Other references Beentje, 1994; Brown, Hutchinson & Prain, 1909–1913; Gelfand et al., 1985; Heine & Heine, 1988b; Kokwaro, 1993; SEPASAL, 2008l.

Authors G.H.Schmelzer

EUPHORBIA THYMIFOLIA L.

Protologue Sp. pl. 1: 454 (1753).

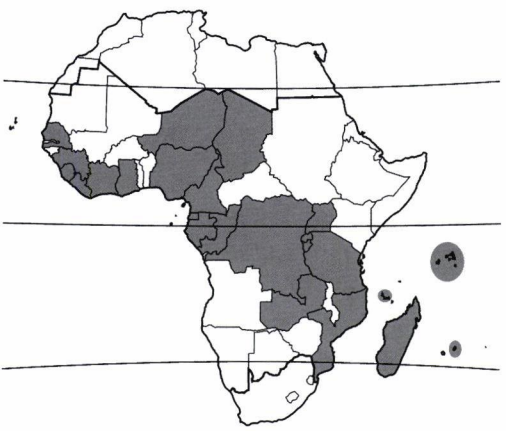
Family Euphorbiaceae

Chromosome number $2n = 18$

Vernacular names Thyme-leaf spurge, Gulf sandmat, chamber bitter (En). Petite rougette, euphorbe à feuilles de thym (Fr).

Origin and geographic distribution *Euphorbia thymifolia* is native to tropical America and is now widely distributed throughout the tropics and subtropics. It is widespread in West Africa and the Indian Ocean islands, and advancing in eastern and southern Africa.

Uses *Euphorbia thymifolia* is widely used in Africa in decoction or infusion against dysentery, enteritis, diarrhoea and venereal diseases. The dried leaves and seeds are slightly aromatic and are used as a stimulant, astringent, anthelmintic and laxative. A decoction of fresh aerial parts is applied externally to treat dermatitis, eczema and skin inflammations. An infusion of the leafy stems is taken as a bitter diuretic. Women with heavy menstruation drink the latex as a tonic. Fresh crushed plants are applied as a plaster for healing sprains. The latex is applied to warts. In Sierra Leone the leaves are pulped with water and applied to the head to treat headache. The leaves are used in a decoction to treat cystitis and kidney ailments. In Côte d'Ivoire and Congo a decoction of the whole plant is drunk to treat lung problems. In Congo ground fresh leaves are rubbed in to treat intercostal pain. A maceration of the dried leaves is drunk for facilitating childbirth; it is claimed to stimulate contractions of the uterus.



Euphorbia thymifolia – naturalized

In Mauritius plant and seed decoctions are also taken as a galactagogue, and to treat hypertension and venereal diseases. A decoction of the whole plant is taken to treat absence of menstruation and applied externally as an eye wash to treat conjunctivitis. On Rodrigues the crushed plant is applied to measles and other skin eruptions.

In South America and continental Asia similar medicinal uses as above are recorded. In southern India the latex is applied as a remedy for ringworm and scabies. The plant is also used in the treatment of impotence. Crushed plants are rubbed on the scalp for strengthening the skull bones of children to enable them to carry loads on their heads as adults, and also as mild irritating rubefacient products to treat alopecia. In Trinidad a decoction of the plant is taken to treat fever, influenza, hypertension and venereal diseases.

In East Africa the latex is applied to treat scabies in sheep.

Properties From an aqueous acetone extract of the dried whole plant a range of hydrolysable tannins, including ellagitannins and gallotannins, were isolated. These tannins are pedunculagin, 1-desgalloyleugeniin, eugeniin, rugosin B, corilagin, geraniin, bixanin, 5-desgalloylstachyurin, casuariin, several derivatives of galloyl-β-D-glucose, several derivatives of hexahydroxydiphenoyl-D-glucose, mallotinic acid, as well as 1-O-galloyl-3,6-(R)-valoneayl-β-D-glucose, an isomer of mallotinic acid. Flavonoids isolated from the aerial parts include: kaempferol, cosmosiin (apigenin-7-glucoside), quercetin, quercetin-3-β-galactoside, quercetin-3-rhamnoside as well as β-amyrine, β-sitosterol, campesterol, stigmasterol, epitaraxerol, n-hexacosanol, euphorbol, 24-methylene cycloartenol and cholesterol. Furthermore, the following compounds were isolated from the aerial parts: 12-deoxy-4-β-hydroxyphorbol-13-dodecanoate-20-acetate, 12-deoxy-4-β-hydroxy-

phorbol-13-phenylacetate-20-acetate and 12-deoxyphorbol-13,20-diacetate. Both flavonoids and tannins have been reported to have anti-inflammatory, analgesic, haemostatic, antithrombic, antioxidant and vasoprotective actions. The flavonoids furthermore have antiviral, anti-allergic, anti-inflammatory, and antitumour properties. The essential oil from the leaves has a pungent odour and irritating taste, and contains cymol, carvacrol, limonene, sesquiterpenes and salicylic acid. The essential oil is put into medicinal soaps for treatment of erysipelas, sprays to keep off flies and mosquitoes, and a vermifuge for dogs.

An extract prepared with 1.5% HCl inhibited the growth of gram-positive (*Bacillus subtilis*) and gram-negative (*Escherichia coli*) bacteria. Ethyl acetate and chloroform extracts of the aerial parts inhibited the growth of *Escherichia coli* and *Shigella flexneri* in vitro. The ethyl acetate extract was also found to be active against *Shigella flexneri* in vivo; 80% of the infected mice were cured when given 1500 µg/day orally. The ethanol and water extracts of the whole plant showed significant antifungal activity against the dermatophytes *Trichophyton mentagrophytes* and *Trichophyton verrucosum* in vitro and in vivo in calves. The ether extract of the whole plant showed significant activity against the *Sarcoptes scabei* mite, which causes scabies.

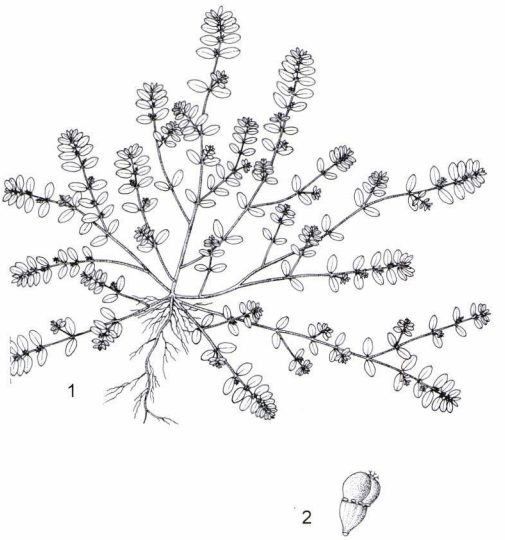
Several extracts from the whole plant as well as pure compounds (3-O-galloyl-4,6-(S)- hexahydroxydiphenoyl-D-glucose, rugosin B and 1,3,4,6-tetra-O-galloyl-K-β-D-glucose) possessed antioxidant activities. In addition, 3-O-galloyl-4,6-(S)-hexahydroxydiphenoyl-D-glucose and the ethyl acetate fraction of the extract also showed significant activity against Herpes simplex virus type 2 in vitro in a dose-dependent manner. The ethyl acetate extract significantly reduced virus infectivity at a concentration of 4 µg/ml, whereas 3-O-galloyl-4,6-(S)-hexahydroxydiphenoyl-D-glucose obviously diminished virus infectivity at a concentration of 0.5 µg/ml. Several derivatives of galloyl-β-D-glucose show significant cytotoxicity against a range of human tumour cell lines.

In pot tests, infection of *Vigna radiata* (L.) R.Wilczek by tomato spotted wilt virus (TSWV) was prevented by spraying the plants first with water extracts of whole *Euphorbia thymifolia* plants.

Adulterations and substitutes *Euphorbia thymifolia* resembles *Euphorbia prostrata* L. and has similar medicinal uses.

Description Monoecious, prostrate, annual herb with branches up to 25 cm long, with numerous adventitious roots; stems with latex. Leaves opposite, distichous, simple; stipules linear, c. 1 mm long, deeply 2–3-toothed; petiole c. 0.5 mm long; blade ovate, up to 8 mm × 4 mm, base unequal, one side cuneate, the other side rounded, apex rounded, margins shallowly toothed, glabrous above, sparsely long-hairy beneath. Inflorescence a terminal or axillary cluster of flowers, called a 'cyathium', on short leafy shoots; cyathia almost sessile, c. 0.5 mm × 0.5 mm, with a funnel-shaped involucre, lobes triangular, minute, margin hairy, glands 4, minute, almost circular, red, with very small red appendages, each involucre containing 1 female flower surrounded by few male flowers. Flowers unisexual; male flowers sessile, bracteoles hair-like, perianth absent, stamen c. 1 mm long; female flowers almost sessile, perianth a rim, ovary superior, glabrous, 3-celled, styles 3, minute, 2-fid. Fruit an acutely 3-lobed, almost sessile capsule c. 1 mm × 1 mm, base truncate, short-hairy, 3-seeded. Seeds conical, c. 0.5 mm in diameter, acutely 4-angled, shallowly transversely wrinkled, reddish brown, without caruncle.

Other botanical information *Euphorbia* comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150



Euphorbia thymifolia – 1, plant habit; 2, fruit. Redrawn and adapted by Achmad Satiri Nurhaman

species in Madagascar and the Indian Ocean islands. *Euphorbia thymifolia* belongs to subgenus *Chamaesyce*, section *Chamaesyce*, a group of annual or sometimes perennial herbs with obvious stipules, further characterized by a main stem aborting at the seedling stage, the plant thus consisting of an expanded dichotomously branching umbel-like inflorescence, with the floral bracts appearing as normal leaves, cyathia solitary or up to 5 together in congested leafy cymes, 4 involucral glands with petal-like appendages or entire and conical seeds without a caruncle. Several other *Euphorbia* spp. belonging to this section are medicinally used. *Euphorbia glanduligera* Pax occurs in Namibia, Botswana and South Africa. In Namibia fresh or sun-dried leaves are pounded and rubbed into scarifications in the chest to increase milk flow in lactating women. *Euphorbia polycnemoides* Hochst. ex Boiss. occurs from Senegal east to Somalia and south to Malawi and Zambia. It also occurs on the Arabian Peninsula. In Nigeria the medicinal uses are similar to those of *Euphorbia convolvuloides* Hochst.; crushed leaves, mixed with palm oil, are applied to dry up the rashes associated with measles, chickenpox and formerly smallpox. The crushed leaves are taken to treat diarrhoea and an infusion of the dried leaves is taken against dysentery. In contrast, an infusion of the whole plant is taken orally or as an enema for its laxative effects. An extract of the plant is taken to treat coughs, a sore throat, asthma and bronchitis. In Tanzania a decoction of the whole plant, together with the whole plant of *Euphorbia convolvuloides*, is taken to treat dysentery. The latex is rubbed on the breasts to stimulate milk flow. The plant is browsed by sheep and camels.

Growth and development *Euphorbia thymifolia* grows very rapidly and completes its life cycle in 3–4 months; it can be found flowering and fruiting throughout the year in warm tropical conditions. Pollination is effected by insects.

Ecology *Euphorbia thymifolia* is a common weed of cultivated and waste ground, often on sandy or gravelly soils, up to 1650 m altitude.

Propagation and planting Seed germination of *Euphorbia thymifolia* occurs at the start of rainy season, or throughout the year if enough water is available.

Diseases and pests *Euphorbia thymifolia* is a host to the root-knot nematodes *Meloidogyne javanica* and *Rotylenchulus reniformis*.

Handling after harvesting Plant material is washed and used fresh, or dried for later use.

Genetic resources *Euphorbia thymifolia* has a pantropical distribution and is weedy; therefore it is not threatened by genetic erosion.

Prospects *Euphorbia thymifolia* has many local medicinal uses and showed antibacterial and antifungal activities as well as inhibitory effects against Herpes virus type 2. Although considerable chemical and pharmacological research has been done so far, more research is still needed to evaluate its potential.

Major references Adjanohoun et al. (Editors), 1988; Agarwal & Baslas, 1981; Bouquet & Debray, 1974; Burkill, 1994; Carter & Leach, 2001; Lee et al., 1997; Lin et al., 2002; Phuong et al., 2006; Yang et al., 2005.

Other references Gurib-Fakim, Guého & Bissoondoyal, 1996; Gurib-Fakim et al., 1993; Jabbar & Khan, 1965; Khan, Rahman & Nur-e-Kamal, 1988; Kokwaro, 1993; Lavergne & Véra, 1989; Lee et al., 1990; Manickam & Rajappan, 1998; Manickam & Rajappan, 1999; Nguyen Nghia Thin & Sosef, 1999; Oliver-Bever, 1986; Pal & Gupta, 1979; Sarkar, 1986; SEPASAL, 2008c; Sofowora, 1982; Stäuble, 1986; Wome, 1985.

Sources of illustration Berhaut, 1975a.

Authors D.M. Mosango

EUPHORBIA TIRUCALLI L.

Protologue Sp. pl. 1: 452 (1753).

Family Euphorbiaceae

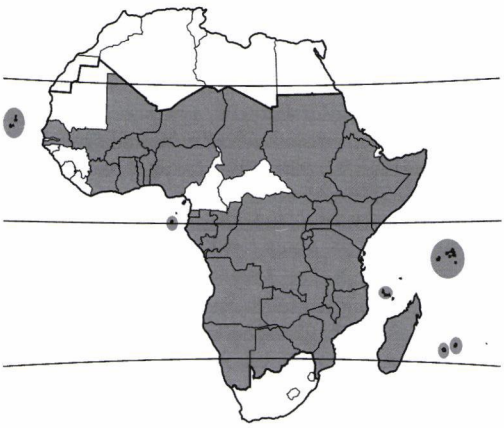
Chromosome number $2n = 10, 20$

Synonyms *Euphorbia laro* Drake (1899).

Vernacular names Finger tree, finger euphorbia, petroleum plant, pencil tree, rubber hedge euphorbia, rubber euphorbia, African milkbush (En). Euphorbe effilée, tirucalli (Fr). Almeidinha (dried latex), cassoneira, aveloz, euforbia (Po). Mtupa mwitu, malangili, mwasi, mchakaazi, mtovua macho (Sw).

Origin and geographic distribution *Euphorbia tirucalli* originates in eastern tropical Africa, and has long since become naturalized in other parts of Africa, including South Africa and the Indian Ocean islands. It is widely naturalized and planted as an ornamental throughout the tropics and subtropics and is grown as a pot plant in temperate regions.

Uses In Africa including Madagascar the latex of *Euphorbia tirucalli* is used for its potent purgative and emetic properties to treat stomach complaints, constipation, intestinal



Euphorbia tirucalli – wild, planted and naturalized

worms, headache, asthma, epilepsy, palpitations, poisoning and snakebites. A few drops of latex are reportedly sufficient to cause vomiting, and are taken in milk as an antidote to poisoning or snakebites. Anecdotal evidence suggests that the risks of a lethal overdose are high, particularly when treating children. The latex has severely irritant effects on the skin and mucosa. It causes painful blistering and inflammation, and may cause blindness if it comes into contact with the eyes. Heated branches are chewed and the latex is swallowed to relieve a sore throat and dry cough, but also to induce labour during childbirth. The latex is externally applied to warts, wounds, skin complaints, swollen glands, oedema, haemorrhoids, rheumatism, toothache, earache and tumours. In Brazil the latex is widely used to treat cancer, but in some areas where it is commonly used, tumours of the nose are prevalent and thought to be related to this use. The roots of *Euphorbia tirucalli* are widely taken alone or in a mixture to treat schistosomiasis and sexually transmitted diseases. In Mauritius a root and bud decoction is taken as a laxative, and to treat coughs and pectoral pain. Ash from burned branches and stems is used to treat whooping cough and is externally applied as a caustic to open abscesses. Pulped twigs are applied to oedema of the legs.

The latex is taken in therapy of sexual impotence and sterility in East Africa, and elsewhere as a sexual stimulant, and it is also said to promote breast enlargement. In East Africa the latex is commonly used as arrow poison and as an ingredient for bait to kill rodents and other wild animals; the pulped stems are thrown in water as fish poison. In south-western DR Congo the latex has been used in high doses as a trial by ordeal poison; in various countries it is used as criminal poison. The latex is also used as a fly repellent in West Africa and a mosquito and termite repellent in Tanzania. In India the latex is used as an insecticide.

Goats and sheep browse the green parts of the plant. The toxicity of the latex is considered seasonal or reduced in young plant parts, and young branches are even roasted and chewed. *Euphorbia tirucalli* is widely planted as an ornamental in gardens and as a pot plant, and a golden-stemmed cultivar exists. It is widely cultivated as a hedge and around cattle enclosures, as it is considered impenetrable, due to the poisonous latex and dense growth; it is also planted as a firebreak and boundary marker. The plants are used to control soil erosion, to stabilize sand dunes, and, in some parts of Africa, as grave-markers. In agriculture *Euphorbia tirucalli* is used for mulch and as pesticide. It is unsuitable for intercropping as the plants suppress undergrowth, including crops. In South Africa it is reported to keep moles away. The white wood is used to make rafters, granary floors, house posts, toys and veneer. It is also used as firewood when no other fuel is available. Gunpowder for fireworks has been produced from the charcoal. The latex is a source of natural rubber, but its resin content is too high for economic use. Resin from the latex appeared useful for application in linoleum, oilskin and leather cloth industries, but is not durable as a varnish. Biomass can be converted into gas, liquid fuels and solid fuels such as pellets, briquettes and charcoal. The latex has strong fixative properties and is used in coastal East Africa to fix knife-blades to wooden handles and spear-heads to shafts. In Malawi the latex is used as bird lime to trap birds. Zulu warriors used it to make headdresses. In Gabon and the Seychelles *Euphorbia tirucalli* is planted in villages as a medico-magical plant.

Production and international trade In the 1980s *Euphorbia tirucalli* was planted in Senegal, East Africa, Brazil and Japan as a potential energy crop; later trials concentrated on biogas production, but no recent information is available. *Euphorbia tirucalli* is widely traded on the internet as an ornamental.

Properties The chemical composition of *Euphorbia tirucalli* has been subject to many

investigations, and from all plant parts a wide range of diterpene esters has been isolated. These diterpenes are of the tigliane, ingenane and daphnane types, and are based on the parent alcohols ingenol, phorbol, resiniferonol, 12-deoxyphorbol and the rare 4-deoxyphorbol and 12-deoxy-4β-hydroxyphorbol. The latex is an emulsion of about 30% terpenes in water. Several chemical races exist with different diterpene profiles, e.g. from East Africa, Madagascar, South Africa, India and South America. Samples of latex from South Africa and Colombia, for instance, contained predominantly irritant and tumour-promoting esters of 4-deoxyphorbol and highly unsaturated aliphatic acids. The main irritants in samples from Madagascar were 3-acylates of ingenol and diesters of phorbol containing an acetate group and a long-chain highly unsaturated acyl group. The acyl groups were similar to those in latex from South Africa, while esters of 4-deoxyphorbol were completely absent from the Madagascan material. Latex from greenhouse plants in Germany did not contain tigliane- or ingenane-type diterpene esters and did not exhibit irritant activity.

Other terpenes isolated from latex of different origins are the diterpenes euphol and its stereoisomer tirucallol, the highly toxic daphnane diterpene ester tinyatoxin, the triterpenoids euphorbinol, cycloeuphorbinol, euphorone and the 31-nortriterpene cycloeuphordenol and the macrocyclic diterpene tirucalicine. The latex also contains an isoquinoline alkaloid as well as the sterols taraxasterol, phorbosterol, euphorbosterol, α-amyrine and cycloartenol. Four trypsine-like proteolytic enzymes, euphorbains t1–t4, have also been isolated. The twigs have yielded taraxasterol, β-sitosterol, ellagic acid, kaempferol, glucose and the hydrocarbon hentriacontane, as well as an alcoholic analogue. The whole plant contains 7.4% citric acid with some malonic and succinic acid. The stem bark yielded the following compounds: cycloartenol, 24-methylene cycloartenol, β-sitosterol, α-taraxerol, euphorbol, euphorbol-hexacosonoate, taraxerone as well as diterpene esters, including ingenol triacetate, the pentacyclic triterpene euphorcinol and the taraxerane type triterpene euphorginol. Several diterpene esters, tiglianes and daphnanes have been isolated from the roots, based on 12-deoxyphorbol, 12-deoxy-16-hydroxyphorbol and resiniferol, including tinyatoxin and candletoxin A. Two anthocyanins were also isolated from the roots.

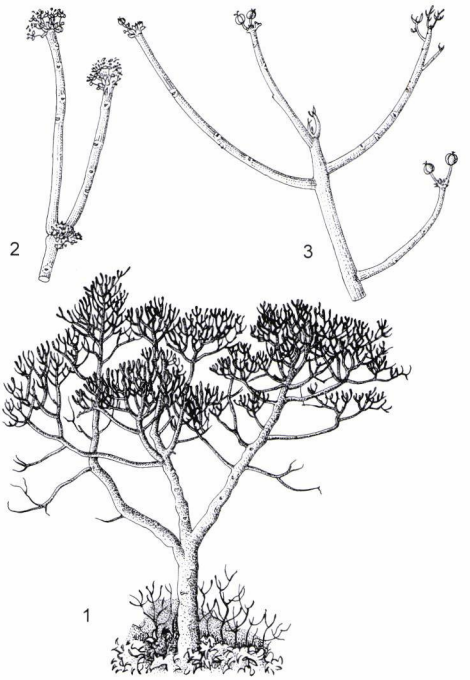
A biopolymeric fraction of the aerial parts showed dose dependent anti-arthritic activity in vitro and also showed immunomodulatory capacity in both rats and mice. The LD_{50} in healthy mice and rats exceeded 2000 mg/kg. In-vivo mammal bioassays have demonstrated dose-dependent anti-inflammatory activity of aqueous extracts, which inhibited oedema by up to 68%.

Euphorbia tirucalli is a cause of Burkitt's lymphoma, a highly aggressive tumour endemic to children in the Central African Region, where *Euphorbia tirucalli* is widely used in traditional medicine. The epidemiology of Burkitt's lymphoma is unclear, but has been associated with plant species such as *Euphorbia tirucalli* and *Jatropha curcas* L., as well as with malaria and Epstein-Barr virus (EBV); these associations are generally weak in areas of low incidence. The diterpene esters from the latex of *Euphorbia tirucalli* activate latent EBV within a cell, and a plant extract induces continuous mitosis and chromosomal rearrangements in EBV infected B-lymphocytes in vitro. The cocarcinogenic compound, a 4β-deoxyphorbol ester isolated from the latex, was found to reduce the EBV-specific cytotoxic T-cell function. These activities of the 4β-deoxyphorbol ester suggest that it plays a role in the modification of human retroviral infections in vivo, including AIDS and human T-cell leukaemia virus type 1 (HTLV-1) associated diseases. An ethanol extract of the dried aerial parts given orally to tumour-bearing mice showed myelosuppression in bone marrow and enhanced resistance by significantly reducing tumour growth in the peritoneal cavity.

Extracts of *Euphorbia tirucalli* have exhibited in-vitro antimicrobial activity against gram-negative and gram-positive bacteria, certain fungal plant pathogens, and the Herpes simplex virus, the latter in the absence of cytotoxicity (therapeutic index >7.1). An aqueous extract also showed significant antibacterial activity against the crop pathogens *Erwinia carotovora*, *Xanthomonas campestris* and *Pseudomonas solanacearum*. Extracts of the latex and stem bark have shown larvicidal activity against larvae of the mosquito *Culex quinquefasciatus*, nematicidal effects against the parasitic nematode *Heterodera cajani* and also against *Hoplolaimus indicus*, *Helicotylenchus indicus* and *Tylenchus filiformis* in vitro. The aqueous latex extracts showed significant molluscicidal activity against the freshwater snails *Lymnaea acuminata*, *Lymnaea natalensis*,

Biomphalaria glabrata and *Bulinus guernei*.
Rubber produced from the latex of *Euphorbia tirucalli* is limited in quality by its high resin content, which can be up to 82%. The rubber content of the latex is very variable; fresh latex contains on average 13% rubber, but may be as low as 1.6%.
Euphorbia tirucalli may become an important biofuel plant. Initial attention focussed on the latex for the conversion of the terpenoids into biopetrol. However, experimental plantations for biopetrol production were not economically viable, as the production cost per barrel of oil was estimated to be between US$ 150 and US$ 200. Attention later shifted to the conversion of the whole biomass into methane.
Estimates of the gross energy value of *Euphorbia tirucalli* dry biomass range from 15,900 kJ/kg to 17,600 kJ/kg, fresh material containing about 85% water. Fermentation of chopped, fresh aerial parts gives yields of biogas comparable to other agro-industrial wastes. *Euphorbia tirucalli* could be an appropriate plant for methane production in the Sahel where food crops do not yield well, since it is well adapted to poor soils. In other experiments, *Euphorbia tirucalli* stems increased yields of biogas from fermented cattle manure. Optimal methanization occurs on freshly chopped material at about 48°C.
The latex shows similarity in composition and activity to the highly poisonous croton seed oil from *Croton tiglium* L. When ingested, the latex causes congestion in the stomach, intestines, kidneys and spleen. A 400 µl dose of diluted latex given to rats is sufficiently potent to cause stomach perforation and death. Doses of up to 30 g/kg fresh *Euphorbia tirucalli* fed to cattle reportedly cause mild symptoms of poisoning. Neither genotoxic nor anti-genotoxic effects were established in tests of aqueous latex solutions using the fruitfly *Drosophila melanogaster*.
Euphol is present in large amounts in the latex, but tirucallol predominated in greater quantities in explants and callus cultures indicating synthesis and/or accumulation of tirucallol by cells other than the laticifer cell. Sterol production was significantly enhanced by certain nutrient media, as well as indole-3-acetic acid, and depressed by benzyladenine.
The wood is pale, hard and with a fine texture, and is rarely attacked by insects.

Description Succulent, much-branched, monoecious or more often dioecious shrub to 4 m tall or small tree up to 10(–15) m tall;



Euphorbia tirucalli – 1, habit; 2, part of branch with male inflorescences; 3, part of branch with fruits.
Redrawn and adapted by Achmad Satiri Nurhaman

branchlets rounded, c. 7 mm in diameter, often produced in whorls, brittle, green with longitudinal fine stripes and very small leaf scars, the extreme tips of young leafy branchlets sparsely short-hairy, with copious white to yellowish latex. Leaves arranged spirally, present only at the tips of young branchlets and quickly falling, simple and entire, almost sessile; stipules minute, glandular, dark brown; blade linear-lanceolate, c. 15 mm × 2 mm, fleshy. Inflorescence a terminal umbel-like cyme, 2–6 together at the apex of branchlets, each forking 2–4 times, composed of dense clusters of flowers, each cluster called a 'cyathium', developing only male flowers (sometimes with a few female flowers), or only female flowers; bracts c. 2 mm long, rounded; cyathia almost sessile, c. 3 mm × 4 mm, involucre cup-shaped, glands 5, up to 1.5 mm × 2 mm, bright yellow, lobes triangular, c. 0.5 mm long. Flowers unisexual; male flowers with linear bracteoles, plumose at apex, stamen c. 4.5 mm long; female flowers with small bracteoles, pedicel up to 10 mm long in fruit, hairy, perianth distinctly 3-lobed, lobes

c. 0.5 mm long, ovary superior, 3-celled, styles c. 2 mm long, fused at base, with thickened deeply bifid recurved stigma. Fruit a nearly globose capsule c. 8 mm × 8.5 mm, almost glabrous, 3-seeded. Seeds ovoid, c. 3.5 mm × 3 mm, smooth, speckled with brown and with a dark brown ventral line; caruncle 1 mm across.

Other botanical information *Euphorbia* comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150 in Madagascar and the Indian Ocean islands. *Euphorbia tirucalli* belongs to section *Tirucalli*, a group which is characterized by cylindrical, succulent branches with copious latex, small, quickly falling leaves, cyathia in terminal umbel-like cymes, 5 glands, an exserted fruit and seeds with a caruncle. The species mentioned below also belong to this section.

Euphorbia damarana L.C.Leach is endemic to Namibia; the toxic latex is used to pollute water holes to poison and catch game drinking from them. The latex is highly irritating to the skin and mucous membranes. *Euphorbia gossypina* Pax occurs from Somalia south to Zimbabwe. In Kenya a decoction of the pounded stems is drunk to treat swollen legs and general body pain. In Tanzania the latex is applied as eye drops to treat conjunctivitis, as ear drops to treat oral infections and also to warts that have first been cut open. The diluted latex of small twigs is taken to treat laryngitis. In Somalia the latex is applied to mange in livestock. *Euphorbia spartaria* N.E.Br. is endemic to Namibia; the latex is applied to warts.

Growth and development *Euphorbia tirucalli* is a rare example of a species in which the physiological mechanisms of Crassulacean Acid Metabolism (CAM) in the stems are combined with C_3 photosynthesis in the leaves. Other adaptations to drought include succulent stems and sunken stomata. Salt tolerance in *Euphorbia tirucalli* is attributed to adaptations that limit the uptake of salt ions by the roots, and store the ions in the roots and stems. *Euphorbia tirucalli* grows vigorously once established. Leaves are only present during the rainy season and flowering starts at the end of the dry season before new leaves are formed. Pollination is by insects.

Ecology *Euphorbia tirucalli* is very well adapted to semi-arid conditions, but also occurs in both dry and moist forest, savanna and shrub land, and withstands salt stress associated with coastal conditions, but no frost. It occurs from sea-level up to 2500 m altitude. It grows well on a wide variety of light-textured, neutral to acidic soils. It is commonly associated with human settlements and becomes naturalized rapidly. It is locally common and often occurs in groups.

Propagation and planting *Euphorbia tirucalli* is sometimes propagated by seed, but usually by stem or root cuttings, and establishes quickly on almost any soil. Cuttings should be at least 10 cm long and should be left to dry for at least 24 hours before planting. For ornamental purposes, cuttings of 35–40 cm long are usually taken and for hedges cuttings of up to 1 m long. *Euphorbia tirucalli* can also be propagated through micro-propagation.

When grown as a fuel crop, cuttings can be planted very densely depending on the climatic and edaphic conditions, at 10,000–20,000 plants/ha. In Kenya freshly planted cuttings are protected from browsing and sun by *Acacia* branches. Planting can start at the beginning of the rainy season. Weeding is necessary only as seedlings become established; later, weeds are suppressed by litter from the crop.

Management *Euphorbia tirucalli* may be coppiced, trimmed and top-pruned to establish a living fence or hedge. As it is well adapted to semi-arid conditions and can be grown on marginal land, plantations were established for use as energy crop. Application of single-nutrient or compound fertilizer results in increased growth. In Zimbabwe, plantations of *Euphorbia tirucalli* have succeeded in some instances on the spoil mounds of arsenic mines.

Diseases and pests In India several diseases occur including stem rot caused by *Phoma sorghina* and necrotic spots by *Alternaria* sp.; *Nectria euphorbiana* was found on dead stem material. In Pakistan *Euphorbia tirucalli* is a host of *Botryodiplodia theobromae* and also of *Cuscuta* spp. *Euphorbia tirucalli* can be severely affected by nematodes, including *Meloidogyne* spp. Aphids, mealy bugs and grasshoppers feed on the plants, whereas mites occur on leaves and young growth, especially in greenhouses.

Harvesting Branches of *Euphorbia tirucalli* can be cut for medicinal use whenever the need arises. In biofuel plantations the plants can be cut at 20–30 cm above the ground.

Yield Yield of *Euphorbia tirucalli* stems for biofuel production varies greatly with density of planting, number of cuttings per year, annual rainfall and soil type. In Thailand yields varied between 150 t/ha fresh weight and 2.3 t/ha dry weight for high-density plots (10,000

plants/ha) with 6 harvests, and 25.5 t/ha fresh weight for low density plots (1600 plants/ha) with one harvest.

In biogas production, the low N content and easily decomposed stem pieces of *Euphorbia tirucalli* result in high methane output rates. In an experiment in India, 375 g fresh stem cuttings and 375 g fresh cattle manure were fermented in 750 ml water and yielded 19.2 l gas. A field producing 500 t/ha/y of biomass would result in 137 kg/dry matter/day and 31 m^3 methane per day or about 20 kg methane per day.

Handling after harvest In medicine, the harvested parts of *Euphorbia tirucalli* are usually used fresh.

Genetic resources *Euphorbia tirucalli* is widely planted and naturalized and is therefore not threatened by genetic erosion. As a succulent *Euphorbia* species, its trade is controlled under CITES appendix 2.

Prospects *Euphorbia tirucalli* is an important multi-purpose plant. It has many medicinal uses, which are partly confirmed by pharmacological tests. As the latex has tumour-promoting properties and is implicated in the epidemiology of Burkitt's lymphoma, its use in traditional medicine should be discouraged. Further research is warranted to clarify its antibacterial and anti-arthritic activities.

Euphorbia tirucalli is a unique example of a plant combining permanent crassulacean acid metabolism (CAM) stems with short-lived C_3 leaves. During humid spells when leaves are present, this combination allows high CO_2 uptake and, thus, elevated growth rates. It is a low-input plant, with high drought and salinity stress tolerance that can be grown on land that is not suitable for crops. It has the potential to provide semi-arid zone inhabitants with an energy solution in the form of a biomass that can be converted to gaseous, liquid or solid biofuels. More research is needed and should cover crop genetic improvement, improved farming techniques to intensify production, improve the product quality, and develop efficient technologies to extract and use the biofuels.

Major references Bani et al., 2007; Burkill, 1994; Cardy, Sharp & Little, 2001; Carter & Radcliffe-Smith, 1988; MacNeil et al., 2003; Neuwinger, 1996; Neuwinger, 2000; Nguyen Nghia Thin & Sosef, 1999; Valadares et al., 2006; van den Bosch, 2004.

Other references Arbonnier, 2004; Declerck et al., 1985; De Oliveira & Nepomuceno, 2004; Furstenberger & Hecker, 1986; Gurib-Fakim & Brendler, 2004; Hecker, 1977; Kajikawa et al., 2005; Kamar, 1994; Katende, Birnie & Tengnäs, 1995; Leach, 1973; Passilongo-Silva et al., 2007; Rajasekaran, Swaminatha & Jayapragasm, 1989; Ralantonirina, 1993; Razanamparany, 1986; Samuelsson et al., 1992; SEPASAL, 2008k; Sow et al., 1989; Tiwaru & Singh, 2005; Van Damme, 1990; Yadav et al., 2002.

Sources of illustration Carter & Radcliffe-Smith, 1988; Coates Palgrave, 1983.

Authors O.M. Grace

EUPHORBIA UNISPINA N.E.Br.

Protologue Dyer, Fl. trop. Afr. 6(1): 561 (1911).

Family Euphorbiaceae

Vernacular names Candle plant (En).

Origin and geographic distribution *Euphorbia unispina* occurs from Guinea and Mali east to southern Sudan.

Uses The latex of *Euphorbia unispina* is very caustic and toxic, and very irritating to the skin and mucous membranes. It can cause blindness when in contact with eyes. Despite its toxicity, it is medicinally used. In Guinea, Mali and Côte d'Ivoire the latex is applied to the neck to cure sleeping sickness, because it is believed that the disease is caused by ganglia in the neck. In Côte d'Ivoire and Nigeria the latex is applied to leprosy sores. Two drops of latex on an egg are eaten as an anthelmintic. In Benin stem ash is inhaled to treat asthma; palm oil with latex is taken to treat constipation and colic; a macerate of the cut stems in water is applied to skin diseases and haemorrhoids. In northern Nigeria the latex is rubbed onto the body to treat mental illness. In Cameroon the latex is placed in a carious tooth to relieve toothache or to help to loosen the tooth and render extraction easier. Dried leaves are smoked in a pipe to treat bronchitis.

In addition to medicinal uses, the latex is widely used in the preparation of arrow poison, though always mixed with other ingredients, such as seeds of *Strophanthus* species. It is also used in fish poison and animal traps. In northern Nigeria the latex is reported to be used as a poison to commit murder and suicide. The latex is applied to scarifications to thicken them. In West Africa *Euphorbia unispina* is sometimes planted in gardens as an ornamental plant or as a hedge around fields and graveyards. In

Europe and the United States it is a rare pot plant in succulent collections.

Euphorbia unispina closely resembles *Euphorbia poissonii* Pax, and they have similar uses.

Production and international trade Some compounds isolated from *Euphorbia unispina* are sold on the internet. Resiniferatoxin was sold in 2007 for US$ 35 (1 mg) to US$ 525 (25 mg); tinyatoxin was sold for US$ 60 (1 mg) to US$ 240 (5 mg). *Euphorbia unispina* is also traded on the internet as an ornamental plant.

Properties The latex of *Euphorbia unispina* contains esters of diterpene alcohols of the tigliane type, 12-deoxyphorbol and 12-deoxy-16-hydroxyphorbol, and the daphnane type, resiniferonol, as well as several macrocyclic esters of the diterpene alcohol 18-hydroxyingol. Daphnane esters are generally known for their potent skin irritant properties whereas tigliane esters are toxic and tumour promoters; some tigliane esters, however, possess anticancer activities.

Euphorbia unispina contains a smaller variety of chemical compounds than *Euphorbia poissonii* and also in lower concentrations. This is reflected by the irritant activity of the latex, which is more than 30 times less than in *Euphorbia poissonii* latex, although after 24 hours both activities have almost the same value. The isolated aromatic esters of the daphnane type are more potent irritants in mouse ear tests than the aromatic tigliane esters, especially resiniferatoxin (ID_{50} = 0.00021 nMol / 5 µg) and tinyatoxin (ID_{50} = 0.0012 nMol / 5 µg), whereas proresiniferatoxin is almost inactive. The isolated aromatic tigliane esters, candletoxin A (ID_{50} = 0.48 nMol / 5 µg) and candletoxin B (ID_{50} = 0.19 nMol / 5 µg), as well as DPP (12-deoxyphorbol 13-phenylacetate; ID_{50} = 0.064 nMol / 5 µg) were also strongly irritant. The major compound isolated from *Euphorbia poissonii*, the highly irritant 12-deoxyphorbol-13-O-phenylacetate-20-O-acetate, was not isolated from *Euphorbia unispina*. The irritant activity of resiniferatoxin and tinyatoxin is rapid and reaches a maximum within 4 hours and then fades to inactivity after 24 hours. Resiniferatoxin is highly toxic, as it binds to pain receptors in the same way as capsaicin but much more powerfully. It stimulates the neurons to fire repeatedly until the neuron dies, causing searing pain and sending the victim into severe anaphylactic shock. It is used in the treatment of incontinence associated with an overactive bladder. It also has antifeedant and analgesic properties. Efforts are being made to synthesize this compound, as it will be of use in the elucidation of the binding characteristics of resiniferatoxin to its receptor sites.

Botany Monoecious, candelabriform, sparsely branching shrub up to 3.5 m tall; branches cylindrical, up to 2.5 cm in diameter, silvery grey, covered with shallow tubercles and horny spine shields up to 1 cm in diameter, grey, with 1 spine, with white latex. Leaves arranged spirally at stem apex in 4–5 ranks, simple, soon falling; stipules modified into 2 stout spines 6–10 mm long; petiole short, thick; blade oblong to spoon-shaped, 5–12 cm × 1.5–5 cm, base long-cuneate, apex notched and fringed, acute or rounded, almost entire, fleshy, glabrous, pinnately veined. Inflorescence an axillary cyme at the ends of branches, consisting of clusters of flowers, each cluster called a 'cyathium'; peduncle short; cyme branches c. 2, short; bracts 2, ovate, c. 2 mm long, membranaceous; cyathia c. 4 mm in diameter, with a shortly funnel-shaped involucre, green, 5-lobed with broadly ovate, fringed lobes, glands 5, elliptical, touching, red, each cyathium containing 1 female flower surrounded by many male flowers. Flowers unisexual; male flowers sessile, perianth absent, stamen shortly exserted, red; female flowers with curved pedicel 4–8 mm long in fruit, perianth 5-lobed, ovary superior, 3-celled, glabrous, styles 3, up to 2 mm long, slender, fused at base, bifid at apex. Fruit an obtusely 3-lobed capsule c. 6 mm in diameter, glabrous, 3-seeded. Seeds ovoid.

Euphorbia comprises about 2000 species and has a worldwide distribution, with at least 750 species occurring in continental Africa and about 150 species in Madagascar and the Indian Ocean islands. *Euphorbia unispina* belongs to subgenus *Euphorbia*, section *Euphorbia*, a large group which is characterized by succulent, angular stems, stipules modified into small spines, a spine shield with a pair of spines (sometimes fused into a single spine), axillary inflorescences and seeds without caruncle. Plants of *Euphorbia poissonii* Pax having small spines resemble *Euphorbia unispina* closely. The former may be distinguished from *Euphorbia unispina* by the stouter flowering branches, with leaves in 8–10 ranks instead of 4–5, by the usually rudimentary spines, and by the numerous inflorescences densely clustered at the end of the shoots.

Euphorbia unispina flowers at the end of the dry season, before new leaves are formed.

Several other *Euphorbia* species closely related

to *Euphorbia unispina* have medicinal uses. *Euphorbia meridionalis* P.R.O.Bally & S.Carter occurs in Kenya and Tanzania; in Kenya the Maasai people drink water or soup in which slices of stem are boiled, to induce diarrhoea to treat malaria and venereal diseases. *Euphorbia schizacantha* Pax occurs in Ethiopia, Somalia and northern Kenya, and in Somalia the crushed plant is applied to the anus to treat haemorrhoids. In Ethiopia a root infusion is drunk to treat cough. *Euphorbia schizacantha* is sought after by plant collectors because of its drooping branches and because the fusion of the 2 main spines is not complete, thus having a forked tip. *Euphorbia venenifica* Tremaux ex Kotschy occurs in Chad, Sudan, Ethiopia and Uganda. The latex is very caustic and toxic, and in southern Sudan it is part of an arrow poison. In southern Chad and southern Sudan the latex is also used as fish poison.

Ecology *Euphorbia unispina* occurs on rocky hills and slopes in savanna. It is locally common.

Management *Euphorbia unispina* is easily propagated by stem cuttings; these should be at least 20 cm long, preferably cut at the base of a branch where the cut surface will be woody. After cutting they should be allowed to lie in a shaded place for at least 2 weeks for a callus to form on the cut end. *Euphorbia unispina* can also be grown from seed. *Euphorbia unispina* latex is usually harvested from wild plants or from those planted near villages. Harvesting of the leaves is seasonal because the plants are leafless in the dry season.

Genetic resources and breeding *Euphorbia unispina* is locally common and probably not threatened by genetic erosion. As a (semi-) succulent *Euphorbia* species, its trade is controlled under CITES appendix 2.

Prospects Although *Euphorbia unispina* has useful biological activities, its use for medicinal purposes is limited by the toxicity of the latex. However, the prospects of some of its compounds are good; for example, resiniferatoxin is going through phase 2 clinical trials and DPP can be used in the therapy of persistent HIV-1 infection. The taxonomy and distribution areas of *Euphorbia unispina*, *Euphorbia poissonii* and *Euphorbia venenifica* need to be reviewed as these species resemble each other closely.

Major references Asres et al., 2005; Burkill, 1994; Eggli, 2002; Keay, 1958a; Neuwinger, 1996.

Other references Adjanohoun et al., 1989; Evans & Kinghorn, 1977; Evans & Schmidt, 1977; Gemedo-Dalle, Maass & Isselstein, 2005; Kiringe, 2006; Neuwinger, 1996; Newton, 1992; Rauh, Loffler & Uhlarz, 1969; Samuelsson et al., 1992; Stäuble, 1986.

Authors L.E. Newton

EXCOECARIA GRAHAMII Stapf

Protologue Bull. Misc. Inform. Kew 1906: 81 (1906).

Family Euphorbiaceae

Synonyms *Sapium grahamii* (Stapf) Prain (1913).

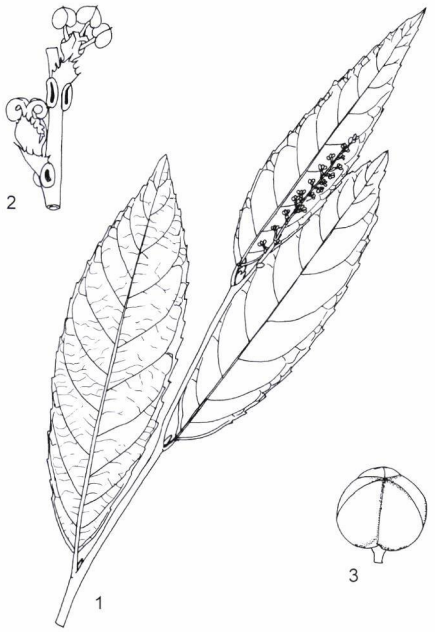
Origin and geographic distribution *Excoecaria grahamii* occurs from Guinea east to Nigeria.

Uses The plant is very toxic. A decoction of the whole plant is used as a bath to treat skin affections and oedema, and is taken internally to treat skin affections, including leprosy and ascites, which require drastic purging. An extract of the pounded leaves is applied to guinea worm sores or a few drops of the latex are applied to the sore to help extract the parasite. In Côte d'Ivoire the smoke of burnt and ground fresh roots together with those of *Gnidia kraussiana* Meisn. is inhaled to treat hallucinations. In Burkina Faso a leaf decoction is taken to induce abortion.

The latex from the root is a powerful caustic; ground up with a little water it is applied on a stick to produce red or black marks on the face, causing swelling and finally a tattoo. It is sometimes used for ritual scarifications, as are the crushed leaves. The root is sometimes an ingredient of arrow poison. It is also used for criminal purposes.

Properties The alcoholic leaf extract, intravenously injected in the heart muscle of rabbits in vivo, has a short stimulatory effect, resembling that of cardiotonic compounds.

Botany Monoecious small, unbranched, glabrous shrub up to 60(–90) cm tall with milky, sticky latex and deep, creeping rhizomes. Leaves alternate, simple; stipules small, soon falling; petiole up to 1.5 cm long; blade elliptical, elliptical-oblong to elliptical-obovate, 4–15 cm × 3–5 cm, base rounded or cuneate, with 2 glands, apex obtuse to acute, margins minutely toothed, pale green beneath. Inflorescence a slender, terminal spike up to 5 cm long, mostly with many male flowers and 1–2 female flowers at base. Flowers unisexual, regular, sessile, petals absent, disk absent; male flowers with 3



Excoecaria grahamii – 1, flowering twig; 2, part of inflorescence; 3, fruit.
Source: Flore analytique du Bénin

elliptical sepals, reddish, stamens 3; female flowers with 3 rounded to ovate sepals, obtuse, toothed to entire, ovary superior, smooth, 3-celled, styles 3, almost free. Fruit a 3-lobed capsule 2–2.5 cm in diameter, hard, pale brown to pinkish, dehiscing explosively, 3-seeded. Seeds almost globose, c. 5 mm long, brown to yellow.

Excoecaria occurs in the Old World tropics and Pacific islands and comprises 35 species; about 6 species occur in continental Africa and about 5 in Madagascar. Formerly, many *Excoecaria* species were included in *Sapium*, which is now considered to be native only to the New World. *Excoecaria guineensis* (Benth.) Müll.Arg occurs in West and Central Africa. In Nigeria a decoction of its root bark or stem bark is taken in small doses as a purgative in case of constipation and also to treat kidney diseases. A decoction of the stem bark is also used as an emetic. In DR Congo the leaf sap is applied to sores. The sap is acrid and poisonous.

Ecology *Excoecaria grahamii* occurs in savanna and at forest edges, usually on moist soil. It flowers and fruits from June to March.

Genetic resources and breeding *Excoecaria grahamii* is relatively common in its fairly large distribution area and therefore not likely to be threatened by genetic erosion.

Prospects *Excoecaria grahamii* is very poisonous, and will therefore remain of limited use in local medicine. It would be interesting to evaluate its pharmacological properties as other *Excoecaria* spp. yield compounds with interesting anti-HIV activities.

Major references Belemtougri, Samate & Millogo-Rasolodimby, 1995; Burkill, 1994; Neuwinger, 2000; Neuwinger, 1998.

Other references Adjanohoun et al., 1989; Brown, Hutchinson & Prain, 1909–1913; Léonard, 1962; Stäuble, 1986.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors G.H. Schmelzer

EXCOECARIA MADAGASCARIENSIS (Baill.) Müll.Arg.

Protologue A.DC., Prodr. 15(2.2): 1219 (1866).

Family Euphorbiaceae

Synonyms *Excoecaria sylvestris* S.Moore (1911).

Vernacular names Milky mangrove, red ears (En).

Origin and geographic distribution *Excoecaria madagascariensis* occurs from Somalia south to Tanzania, and also in Zimbabwe, northern South Africa, Swaziland and Madagascar.

Uses In Kenya the Giriama and Teita people use the plant sap in the preparation of hunting arrow poison, often in combination with the latex of *Acokanthera schimperi* (A.DC.) Schweinf. and the tuber of *Dioscorea quartiniana* A.Rich. The sap causes painful blisters when it touches the skin. The plants are very toxic to cattle and camels.

The wood is used as firewood and for charcoal production and also to make tool handles.

Properties No chemical or pharmacological analyses have been carried out for *Excoecaria madagascariensis*, but several highly toxic alkaloids (excoecarins) and phorbol esters have been reported in other *Excoecaria* species.

Botany Monoecious glabrous shrub or small tree up to 4(–7) m tall; bark rough or smooth, with colourless or milky latex. Leaves opposite, simple and entire; stipules triangular-ovate, c. 2.5 mm long, soon falling; petiole up to 1 cm long, channeled above; blade elliptical, elliptical-oblong to elliptical-oblanceolate, 4–17 cm ×

2–6 cm, base cuneate, apex obtuse to emarginate, glossy and dark green above, reddish brown when young. Inflorescence an axillary spike in the upper leaf axils, 2–3 cm long, with only male flowers or with some female flowers at base. Flowers unisexual, regular, sessile, petals absent, disk absent; male flowers with 3 lanceolate sepals c. 0.5 mm long, acute, toothed, pale yellow-green or whitish, stamens 3, c. 1 mm long; female flowers with 3 rounded to ovate sepals c. 0.5 mm long, obtuse, toothed, ovary superior, 3-lobed, smooth, 3-celled, styles 3, fused at base, recurved. Fruit a 3-lobed capsule c. 1 cm in diameter, smooth, green, turning red or yellowish, 3-seeded. Seeds globose, c. 4 mm in diameter, smooth, greyish brown, mottled.

Excoecaria occurs in the Old World tropics and Pacific islands and comprises 35 species; about 6 species occur in continental Africa and about 5 in Madagascar. Formerly, many *Excoecaria* species were included in *Sapium*, which is now considered to be native only to the New World. *Excoecaria bussei* (Pax) Pax occurs in southern Africa. A root decoction is taken as an emetic. The plant sap is considered poisonous, and cattle do not browse the plant. Sometimes the seeds are chewed; they are tasteless at first but later produce a peppery, burning sensation, which lasts a long time. Most people consider them poisonous. The latex of *Excoecaria benthamiana* Hemsl. ('bois charlot', 'bois jasmin rouge'), a rare endemic of the Seychelles, is a powerful vesicant and is applied externally to warts.

Ecology *Excoecaria madagascariensis* occurs in thickets and evergreen forest, often on sandy soils along rivers, from sea-level up to 1850 m altitude.

Management *Excoecaria madagascariensis* can be propagated through wildlings and cuttings. It is moderately fast growing and can be pruned and pollarded.

Genetic resources and breeding *Excoecaria madagascariensis* is locally common in East Africa and Madagascar, but in Swaziland there are indications that it is at risk of genetic erosion because of forest clearing and invasion of alien plants, such as *Chromolaena odorata* (L.) R.King & H.Rob. and *Melia azedarach* L.

Prospects The latex of *Excoecaria madagascariensis* is very poisonous, but nothing is known about its chemical properties. As other *Excoecaria* species yield chemical compounds with interesting pharmacological activities, more research is warranted. *Excoecaria madagascariensis* is also considered a useful indicator of underground water and could be applied for soil erosion control in riparian areas.

Major references Beentje, 1994; Léonard, 1959; Neuwinger, 1998; Radcliffe-Smith, 1987.

Other references Burrows et al., 2003; Coates Palgrave, 1983; Dumetz, 1999; Gurib-Fakim & Brendler, 2004.

Authors O.O. Bethwell

FLUEGGEA VIROSA (Roxb. ex Willd.) Voigt

Protologue Hort. suburb. Calcutt.: 152 (1845).

Family Euphorbiaceae (APG: Phyllanthaceae)

Chromosome number $2n = 26$

Synonyms *Flueggea microcarpa* Blume (1825), *Securinega microcarpa* (Blume) Müll.Arg. (1866), *Securinega virosa* (Roxb. ex Willd.) Baill. (1866).

Vernacular names White-berry bush, snowberry tree, Chinese waterberry, simpleleaf bushweed, common bushweed (En). Balan des savanes (Fr). Mkwamba, mkwamba maji, mteja (Sw).

Origin and geographic distribution *Flueggea virosa* occurs naturally throughout tropical Africa from Mauritania east to Somalia and south to South Africa, and also in Madagascar and Réunion. It is also distributed from Egypt, the Arabian Peninsula, through tropical Asia to Japan, Australia and Polynesia.

Uses *Flueggea virosa* is an important medicinal plant in tropical Africa, used for the treatment of a wide variety of ailments, alone or in combination with other plants. All parts



Flueggea virosa – wild

of the plant are used, but the root is considered the most active part. A root decoction or root powder taken in water or as a bath is used to treat liver, bile, kidney, urinary and venereal diseases, and also to treat testicular inflammation, frigidity, sterility, heavy menstruation, rheumatism and arthritis. Root preparations are also widely taken as a tonic, as an aphrodisiac or to treat impotence. Sometimes leaves or leafy twigs are used for this purpose. A root infusion or decoction is commonly taken to treat upper respiratory tract infections, ranging from cough to tuberculosis, and to treat abdominal complaints, including stomach-ache, dysentery, intestinal worms and schistosomiasis. The root or fruit is chewed to treat snakebites and the bite is dabbed with a decoction of them. Root pulp acts as an analgesic and is rubbed on the head to treat headache and on the back to treat backache and hernia. A root decoction or infusion is applied externally to wounds, boils and ulcers and different skin ailments, including itching rash and candidosis. Pulped fruits are also rubbed on the skin to treat itch. Leaves and leafy twigs in decoction or infusion are commonly taken to treat malaria, fever, jaundice, measles, oedema, vertigo, sickle cell anaemia, convulsions, vomiting, stomach-ache, intestinal worms, constipation, dysentery and difficult delivery. Leaf sap is used topically against conjunctivitis and earache, and as nose drops to treat headache, including migraine. It is rubbed on the joints and limbs to treat feverish stiffness and pain. In Niger the aerial parts in decoction are taken as a tonic. In the Central African Republic a decoction of the leaves is used in baths to invigorate the body. In Burundi and Tanzania a leaf decoction is taken to treat lactation disorders and is also given to nursing mothers whose baby is sickly at birth or to women with risk of still-born babies. In Uganda leaf powder is taken for abortion. A decoction of leafy twigs or fresh leaf sap is used as nose drops to cure epilepsy and insanity.

In Tanzania a root decoction is taken to treat epilepsy, convulsions and rectal and uterine prolapse. A root bark infusion is taken to treat HIV-related diseases. In Zimbabwe root powder in porridge is applied to depressed fontanelles, while the Ndebele people commonly eat it before intercourse as a contraceptive. In Madagascar a root decoction is taken to treat toothache. In Mauritania a decoction of the stem bark is mixed with other plant parts and is used to treat intestinal worms in livestock. In Ghana, Nigeria and Sudan a bark extract is used to control vermin (water fleas, rats, and mice) and as a fish poison, but its toxicity seems to be low. In the Central African Republic a decoction made from the root and stem bark is used as poison for ritual judgment. In East Africa a root infusion is taken to treat diseases caused by witchcraft.

Flueggea virosa has many other uses. The leaves yield a black dye used to dye palm fibres black. In Madagascar the dye is considered of low quality as it gives an irregular colour. A red dye made from the fruit is used as ink. Bark is used for tanning in India. The bushy nature, attractive foliage and white waxy fruits make *Flueggea virosa* an interesting ornamental. The leaves and fruits are readily browsed by livestock, and are also given as fodder. The fruits are edible when mature. They are juicy and sweet with a slightly bitter taste. They are mainly eaten by children, but are also made into an alcoholic drink. The fruits are also fed to domestic fowl. The wood is commonly used to make beds, fish traps, wicker traps, chair legs, roof structures for granaries and huts, kitchen utensils and storage pots. In Ethiopia the stems are woven into shelves and in Zanzibar they are split for basketry. Twigs are cut to make toothbrushes. *Flueggea virosa* is widely used for firewood and charcoal production, and in northern Nigeria, Mali and Ghana it is commonly grown as a hedge. In Ghana a gum is obtained from the stems, which has been used for sealing envelopes. The Maasai people of Kenya use the wood ash to clean milk containers. The Gamba people of Kenya apply pounded leaves as an insect repellent. In Madagascar branches are put on roofs for this purpose.

Production and international trade Despite the popularity of *Flueggea virosa* in a wide variety of medicinal and other uses, no information on its trade is available. As it is common, it is probably mainly traded locally. *Flueggea virosa* is traded as an ornamental.

Properties All plant parts of *Flueggea virosa* contain indolizidine alkaloids, mainly isomers and derivatives of the highly toxic securinine, which is known from the arrow poison plant *Securidaca longipedunculata* Fresen. The main alkaloids related to securinine are virosecurinine (0.5% in the leaves), viroallosecurinine, norsecurinine, dihydronorsecurinine (virosine); other alkaloids include hordenine and N-methyltetrahydro-β-carboline. Securinine has never been detected in *Flueggea vi-*

rosa. Other compounds isolated from the leaves are the isocoumarine bergenin, gallic acid and ellagic acid, and the flavonoids quercetin and rutin. The stem bark contains the triterpenes friedelin and friedelinol. The twigs contain about 8% tannins. The root bark contains 0.4–0.6% alkaloids, the entire root 0.04%. The root bark of a plant collected in Taiwan contained 1.6% norsecurinine and 0.06% dihydronorsecurinine.

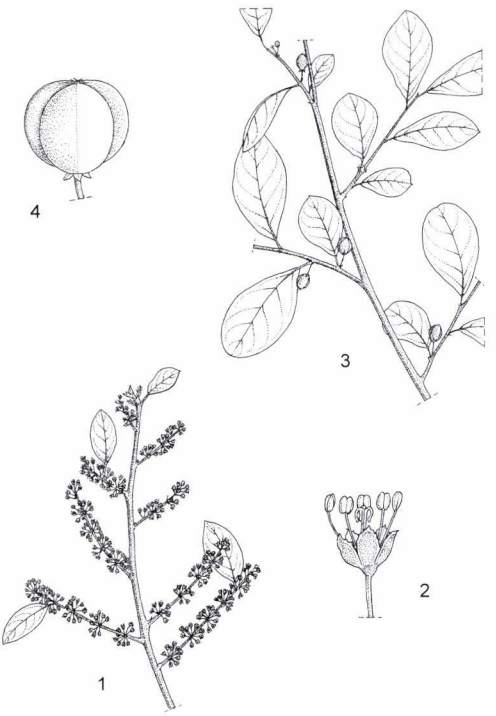
Petroleum spirit, chloroform and ethanol extracts of the root bark were tested for antimicrobial activity against a range of organisms in vitro. The chloroform and the petroleum spirit extracts resulted in a 4-fold and 2-fold potentiation, respectively, of the activity of the antibiotic norfloxacin against methicillin-resistant *Staphylococcus aureus*. Ethanol and chloroform extracts showed significant antimicrobial activities, and moderate antioxidant and free-radical scavenging activities. A methanol extract of the dried fruit pulp and the ethanolic root extract showed significant antifungal activities against *Trichytum mentagrophytes* and *Candida albicans*. Methanol and water extracts of the leaves showed strong antimalarial activity, significantly inhibiting the growth of *Plasmodium falciparum* in vitro in a dose-dependent manner.

Bergenin from *Flueggea virosa* showed an inhibitory effect on the growth of the bloodstream form of *Trypanosoma brucei* with an IC_{50} value of 1 μM. It also showed significant antiarrhythmic activity in rats and has good potential for treating cardiac arrhythmias. Bergenin also showed a significant lipid-lowering and atherogenic index decrease in hyperlipidaemic rats. Bergenin is also extracted from other plant species; in Asia especially it is used for many pharmacological purposes, several of which are in line with traditional uses of *Flueggea virosa* in Africa. Furthermore, oral administration of bergenin showed significant protection against pylorus-ligated and aspirin-induced gastric ulcers in rats and cold restraint stress-induced gastric ulcers in rats and guinea pigs. The alkaloid virosecurinine is mildly toxic to mice with an LD_{50} of 73 mg/kg body weight. Death results from violent tonic convulsions and paralysis similar to those observed with strychnine poisoning. Alcoholic leaf extracts showed significant cytotoxicity in different tumour cell lines in vitro. Virosecurinine was primarily responsible for the cytotoxicity; viroallosecurinine was only cytotoxic to one of the cell lines.

A root bark extract and a total alkaloid preparation caused a transient fall in arterial blood pressure in dogs. Extracts of roots and root bark had a slightly depressive action on the isolated intestine of rabbits, which rapidly normalized. The extracts showed weak haemolytic activity. An aqueous root extract showed a slight activity in the oral glucose tolerance test in rabbits, but did not lower blood glucose below fasting levels in either the fed or fasted state.

About 92% of the fresh fruit is pulp; the composition of the fruit pulp per 100 g is approximately: water 84 g, soluble carbohydrate 12 g, protein 0.5 g and fat 0.3 g. The wood has a fine texture, reddish yellow, and is very strong, elastic and durable.

Description Dioecious, deciduous, much-branched shrub or small tree up to 4(–6) m tall; bark grey-brown, smooth, fissured or rough; branches erect or arching, lower branches often with thorny end. Leaves distichously alternate, simple and entire; stipules lanceolate, 1.5–2



Flueggea virosa – 1, part of male flowering branch; 2, male flower; 3, part of fruiting branch; 4, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

mm long, acute, fringed, deciduous; petiole 3–6 mm long, grooved above, narrowly winged; blade almost orbicular to obovate or elliptical, (1–)2–4(–6) cm × (0.5–)1–2(–3) cm, base cuneate to rounded, apex obtuse, rounded or notched, thinly papery, pinnately veined with 5–9 pairs of lateral veins. Inflorescence an axillary fascicle, many-flowered in male plants, few-flowered in female plants. Flowers unisexual, regular, 5-merous, sweet-scented; pedicel up to 9 mm long; sepals slightly unequal, obovate to lanceolate, fringed, pale greenish yellow; petals absent; male flowers with free stamens, exserted, filaments 2–3 mm long, disk glands fleshy, yellow, rudimentary ovary with 3 styles, up to 2 mm long, fused at base; female flowers with annular disk, shallowly 5-lobed, ovary superior, ovoid, 3-celled, styles 3, fused, stigmas 2-fid, spread horizontally. Fruit a somewhat fleshy slightly 3-lobed, globose capsule, 3–5 mm in diameter, tardily dehiscent, smooth, glabrous, white, up to 6-seeded. Seeds ovoid, 2–3 mm long, shiny, yellowish brown.

Other botanical information *Flueggea* comprises 15 species and occurs in the tropics and subtropics of both hemispheres, extending into warm temperate zones. Only *Flueggea virosa* occurs in tropical Africa. *Flueggea* was included in *Securinega*, but important differences exist between the two genera in seed morphology, pollen sculpture and wood anatomy. *Securinega* now comprises 5 species and is restricted to Madagascar and the Mascarene islands.

Growth and development *Flueggea virosa* usually flowers at the end of the dry season and during the rainy season. In Kenya fruits are available in June and July, while in Tanzania they are mature between April and June. Seeds are dispersed by birds.

Ecology *Flueggea virosa* is common in a wide variety of habitats, in forest edges, bushland, grassland, woodland and thickets. In drier areas it occurs mainly along water courses, and in swampy habitats, sometimes on termite mounds and rocky slopes; it is also common in disturbed localities and fallow land, from sea-level up to 2300 m altitude.

Management *Flueggea virosa* is collected from the wild and is only cultivated as an ornamental. It is commonly spared when clearing land or at weeding operations. It is a fast growing hardy shrub suitable for planting under various conditions.

Harvesting All plant parts harvested are either used fresh or dried and stored for future use.

Genetic resources *Flueggea virosa* is widely distributed in diverse ecological habitats and therefore not threatened by genetic erosion. International Livestock Research Institute, Kenya holds a single accession. It is listed as an invasive species in Florida, United States.

Prospects *Flueggea virosa* is a very important medicinal plant in local medicine. Much research has been done on the chemistry and pharmacological activities of the different compounds and preparations. Different plant parts show significant activity against a variety of bacteria and fungi including human pathogens. More research is needed to fully evaluate its other uses, e.g. for female infertility, as snake venom antidote, analgesic, for increased sexual desire, against diarrhoea, abdominal pains and venereal diseases. The bushy nature, attractive foliage and white waxy fruits of *Flueggea virosa* make it an interesting ornamental.

Major references Berhaut, 1975a; Burkill, 1994; Clarkson et al., 2004; Dickson et al., 2006; Hutchings et al., 1996; Neuwinger, 1996; Neuwinger, 2000; Radcliffe-Smith, 1996a; Ruffo, Birnie & Tengnäs, 2002; Webster, 1984.

Other references Adjanohoun et al., 1989; Adjanohoun et al., 1993; Arbonnier, 2002; Bouquet & Debray, 1974; Coates Palgrave, 1983; Freiburghaus et al., 1996b; Goel et al., 1997; Gurib-Fakim & Brendler, 2004; Hedberg et al., 1983a; Kokwaro, 1993; Kraft et al., 2003; Maundu & Tengnäs, 2005; Moshi et al., 2000; Niang, 1987; Nyasse et al., 2004; Polygenis-Bigendako, 1990; Pu et al., 2002; Samuelsson et al., 1992; Tabuti, Lye & Dhillion, 2003; Tatematsu et al., 1991.

Sources of illustration Boulos, 2000a.

Authors J.R.S. Tabuti

FUMARIA MURALIS Sond. ex W.D.J.Koch

Protologue Syn. fl. germ. helv., ed. 2, 3: 1017 (1845).

Family Fumariaceae

Chromosome number $2n = 48$

Vernacular names Common ramping-fumitory, wall fumitory (En). Fumeterre, fumeterre des murs (Fr). Fumária das paredes, salta-sebes (Po).

Origin and geographic distribution *Fumaria muralis* is indigenous in western Europe and northern Africa, and has been introduced in some localities of tropical Africa: Réunion,

Mauritius and southern Africa. In Réunion and Mauritius it is naturalized. It has also been introduced in the Americas and Australia.

Uses In Réunion and Mauritius a decoction of the plant added to a bath is used to treat eczema, acne, ringworm, scurvy, itch and wounds. It is also used as an eye bath to treat conjunctivitis. It is used internally as a tonic and stimulant, being credited with blood purifying, bile secretion regulating, liver stimulating, laxative, purgative, antidiabetic and hypocholesterolaemic properties. A syrup made from the whole plants of *Fumaria muralis* is administered to children suffering from gastroenteritis. *Fumaria* spp. have been used for similar purposes in Europe, with *Fumaria officinalis* L. as the most important species. Phytopharmaceuticals based on *Fumaria* are traditionally used to enhance renal and digestive elimination functions and as a choleretic.

Properties Several isoquinoline alkaloids have been isolated from *Fumaria muralis*. One of them, fumarophycine, has antioxidant activity. The isoquinoline alkaloid sanguinarine has been isolated from the related *Fumaria officinalis*. This compound is toxic, but also possesses strong antimicrobial, anti-inflammatory and antioxidant properties. It has been suggested that it could serve as a drug for the management of hyperproliferative skin disorders, including skin cancer. Another alkaloid in *Fumaria officinalis* is protopine, which is a spasmolytic, anticholinergic, anti-arrhythmic and antibacterial.

Botany Straggling annual herb with flexuous stems up to 50(–80) cm long, glabrous and slightly glaucous. Leaves alternate, bipinnately compound, petiolate; stipules absent; leaflets with ovate to oblong-lanceolate lobes. Inflorescence a stalked, bracteate raceme, seemingly opposite the leaves, up to 15(–20)-flowered. Flowers bisexual, zygomorphic; pedicel short; sepals 2, lateral, 2.5–5 mm × 1.5–3 mm, toothed; corolla 9–12 mm long, consisting of a spurred upper petal, 2 inner ones and a lower one, pink, blackish red at tips; stamens 6, in 2 bundles of 3; ovary superior, 1-celled. Fruit a small globose nut c. 2 mm in diameter, smooth, 1-seeded.

Fumaria comprises about 60 species, most of them native to Europe. Only a single species is indigenous in tropical Africa: *Fumaria abyssinica* Hammar, which occurs from eastern DR Congo east to Eritrea, Djibouti and Somalia, and south to Tanzania. There are no uses known for this species. Apart from *Fumaria muralis*, *Fumaria officinalis* L. has been introduced locally in Africa, e.g. in South Africa. The two species are difficult to distinguish, *Fumaria officinalis* having narrower leaflet lobes, slightly smaller flowers and slightly rough fruits; they have been much confused. The small size of the flowers as reported for the plants in the Indian Ocean islands raises doubts about the identification as *Fumaria muralis*.

Ecology *Fumaria muralis* occurs in fields, gardens and waste places.

Management *Fumaria muralis* may behave as a weed, e.g. in sugar cane and vegetables in Réunion and Mauritius, and in wheat and barley in South Africa. The plants are collected from the wild for medicinal purposes when the need arises.

Genetic resources and breeding *Fumaria muralis* spreads as a weed in several regions of the world; it is certainly not threatened by genetic erosion.

Prospects Although internal applications of *Fumaria* spp. have a long tradition, they are not supported by valid clinical trials. Caution is needed because of the toxicity. External usage against skin complaints seems more promising, but more pharmacological studies are needed to confirm activity and safety. *Fumaria* spp. are not obvious candidates for promotion as medicinal plants in tropical Africa because most of them are not indigenous and occur only very locally.

Major references Exell, 1960; Gurib-Fakim, Guého & Bissoondoyal, 1997; Lavergne & Véra, 1989; Sousek et al., 1999.

Other references Adhami et al., 2003; Bruneton, 1995; Marais, 1980b; van Wyk, van Heerden & van Oudtshoorn, 2002.

Authors R.H.M.J. Lemmens

GLORIOSA SUPERBA L.

Protologue Sp. pl. 1: 305 (1753)

Family Colchicaceae

Chromosome number $2n$ = 14, 22, 33, 44, 66, 77, 84, 88, 90

Synonyms *Gloriosa simplex* L. (1767), *Gloriosa virescens* Lindl. (1825), *Gloriosa abyssinica* A.Rich. (1850), *Gloriosa carsonii* Baker. (1895), *Gloriosa minor* Rendle (1896), *Gloriosa baudii* (N.Terracc.) Chiov. (1916).

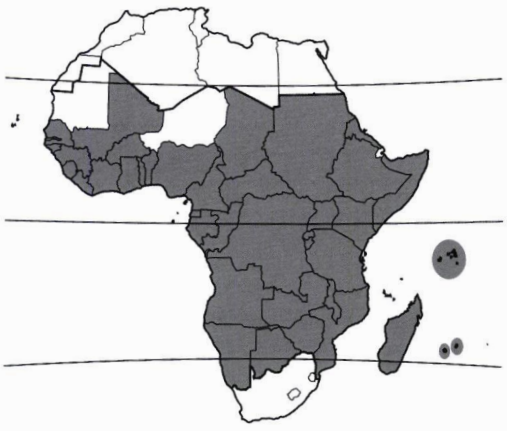
Vernacular names Glory lily, flame lily, climbing lily, creeping lily (En). Lis de Malabar, lis grimpant, lis glorieux (Fr). Garras de

tigre, aranha de emposse (Po). Mkalamu, kimanja nouchawi (Sw).

Origin and geographic distribution *Gloriosa superba* occurs naturally in Africa, in India, and southeastern Asia, and is nowadays distributed widely throughout the tropics, and worldwide as a pot plant. In Africa, its distribution is from Senegal east to Ethiopia and Somalia, and south to South Africa.

Uses In tropical Africa the different parts of *Gloriosa superba* have a wide variety of uses, especially in traditional medicine. In Côte d'Ivoire a leaf decoction applied as a liniment eases cough and general pain, and leaf juice is instilled into the nose in case of fainting. In Côte d'Ivoire and Burkina Faso leaves are administered in enema as a decongestant. In Congo crushed leaves are applied to the chest to treat asthma. In Burundi a leaf decoction is recommended for treating dropsy of the scrotum, while the leaf pulp serves against rheumatism. The Ulanga people of Tanzania burn the herb and apply ash on wounds to promote healing. They also drink the plant juice as an antimalarial.

At low doses, the tuber has numerous medicinal applications. It is used traditionally for the treatment of bruises, colic, chronic ulcers, haemorrhoids and cancer, and is also employed as a tonic and purgative. It is put into poultices to relieve neuralgia, and used in topical applications to treat arthritic conditions, swellings of the joints, sprains and dislocations. The tuber is claimed to have antidotal properties to snakebites. In Sudan tuber sap is an ingredient of a drink that induces sleep. The Marakwet people of Kenya take a tuber decoction against abdominal disorders and to induce abortion.



Gloriosa superba – wild

Macerated tuber is also taken against smallpox, leprosy, eczema, itch, and ringworm. In DR Congo the rasped and washed tuber is used externally to treat venereal diseases and stomach-ache.

The anthelmintic properties of the tuber, fruits and leaves are widely known and they are used to treat infections of guinea-worms, schistosomes (causing bilharzia), roundworm, tapeworm, liver fluke and filaria. A rectal injection of the juice from mashed leaves is applied to cure female sterility among Pygmy groups. A paste made from the tuber is applied externally to facilitate parturition. The Ulanga people of Tanzania use tuber juice for ear drops to treat earache, while the Shona people of Zimbabwe drop tuber juice on painful teeth. In Zambia the tuber is part of a preparation for impotence, and is used as an abortifacient. Soup made from leaf or tuber sap is given to women suffering from sterility, delayed puberty, delayed childbirth and menstrual problems. Leaf juice, unripe fruits mixed with butter, and tuber macerate are frequently used to kill head lice.

In northern Nigeria the tuber is added to arrow poison based on *Strophanthus* sp. In coastal Kenya and Tanzania, powdered tuber is commonly used as a suicidal agent and to commit homicide, because of its high toxicity. The species is also widely believed to have magical properties.

Several cultivars of *Gloriosa superba* are cultivated in the tropics and under greenhouse conditions in temperate regions, the commonest being 'Rothschildiana'. It is grown both as a cut flower and as a pot plant.

Production and international trade *Gloriosa superba* is exported by India and Sri Lanka to pharmaceutical industries, and more recently also by a few African companies based in Nigeria, Cameroon and Zimbabwe. Quantities involved are not known.

Properties The medicinal importance of *Gloriosa superba* is due to the presence of alkaloids in all parts of the plant, mainly colchicine (superbine), an amino alkaloid derived from the amino acids phenylalanine and tyrosine. The presence of colchicine-type alkaloids with a tropolone ring is characteristic for most genera in *Colchicaceae*. The seeds are the best source of colchicine, as their content is 2–5 times higher than in the tubers. A report from Rwanda claims that the highest colchicine content is found in young leaves.

Several colchicine-related alkaloids have been

isolated from tubers and seeds. They are mostly demethyl substitutes and include cornigerine, which is a potent antimitotic, and colchicoside used as a muscle relaxant. A plant can contain up to 0.9% colchicine and 0.8% colchicoside.

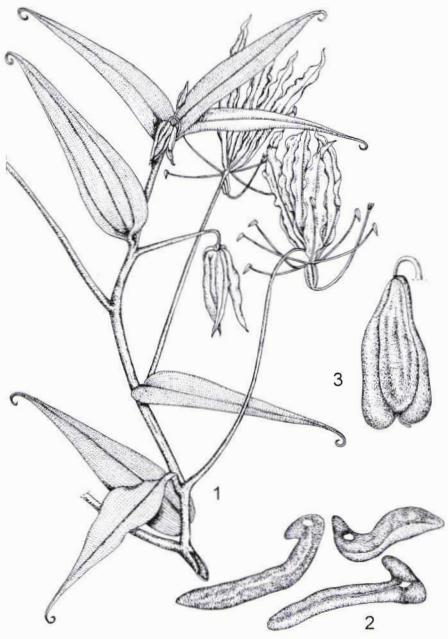
In medicine, colchicine is used in the treatment of gout. In spite of its serious side-effects it is still commonly used for acute gout. It reduces the inflammatory reaction to urate crystals deposited in the joints. Its efficacy might be due to decreased leukocyte mobility. The substance is not an analgesic, and has no effect on blood concentration, nor on renal excretion of uric acid. Diarrhoea, nausea, vomiting and abdominal pains are the first signs of poisoning and occur at doses equal to or lower than those needed to treat gout. The diarrhoea may become severe and haemorrhagic. A burning sensation in the throat, stomach and skin may also be an early sign of intoxication. Nibbling on the tubers causes numbness of the lips and tongue and loss of body hair. Severe reactions include extensive vascular damage and acute renal toxicity with oliguria and haematuria. The patients may develop convulsions, delirium, muscle weakness, neuropathy and ascending paralysis of the central nervous system. In patients who have taken an overdose of *Gloriosa superba* tubers, death occurs as a result of respiratory depression and cardiovascular collapse within a few days.

Colchicine is a powerful antimitotic agent that blocks or suppresses cell division by inhibiting mitosis, the division of a cell's nucleus. It is used in plant breeding to induce polyploidy, as it allows chromosome division but inhibits formation of a mitotic spindle figure, which guides the separation of the two sets of haploid chromosomes. As a result no sister cells are formed. Once the treatment has stopped, however, the normal spindle figure forms again. Colchicine also inhibits the division of animal cells, but it is too toxic to be used to arrest tumour growth. A biosynthetic precursor of colchicine, demecolcine, has a wider margin of safety and is used to treat myelogenic leukaemia and malignant lymphoma. Extracts of the shoots and of the tubers of *Gloriosa superba* show strong nematicidal activity, which can be largely attributed to colchicine. The chemical constituents of the tuber are known to be very poisonous to fish. Severe damage is done by colchicine-containing plants to livestock in different parts of Africa.

In vitro production of colchicine is feasible, although the levels are in general 10–25 times lower than those found in plants grown in vivo.

Adulterations and substitutes The corms of *Colchicum autumnale* L. and *Iphigenia* spp. (also *Colchicaceae*) are traditional sources of colchicine. An increase in demand for colchicine stimulated the search for an alternative source, leading to *Gloriosa superba*. Chemical synthesis of colchicine is possible but complicated. Synthesis is expected to remain an important target of the chemical industry. In-vitro production of colchicine is also possible but gives low yields.

Description Climbing, sometimes erect herb up to 4 m long; stem annual, glabrous and sparsely branched; tuber perennial, horizontal, abruptly bent in a V or L shape, roots fibrous. Leaves in whorls of 3–4, opposite or alternate, simple, sessile; blade ovate to lanceolate, 6–15(–20) cm × 1.5–4 cm, base obtuse, apex of upper leaves with or without 1–2 cm long tendril, parallel-veined. Flowers axillary, solitary, bisexual, regular, 6-merous, 4.5–7 cm in diameter, showy, pendulous; pedicel 4–20 cm long; perianth segments free, lanceolate or oblanceolate, 5–7(–9) cm × 1(–2) cm, often with undulate margins, strongly reflexed when ma-



Gloriosa superba – 1, flowering stem; 2, tubers; 3, fruit.
Source: PROSEA

ture, persistent, usually yellow and red, less often yellow, red or white; stamens with filaments 2–5 cm long, spreading, anthers 7–10 mm long, opening by longitudinal slits; ovary superior, 3-celled, carpels coherent only by their inner margins, style filiform, 2–4(–5.5) cm long, bent at a right angle basally. Fruit a loculicidal, oblong capsule 4–6 cm × 1–2 cm, containing up to 20(–40) seeds. Seeds ovoid, 4–5 mm in diameter, surrounded by a fleshy, red sarcotesta.

Other botanical information The taxonomy of *Gloriosa* is confused, and up to 27 species have been recognized. *Gloriosa superba* is considered here a single highly variable species. In Zimbabwe morphologically uniform populations occur which have variable polyploidy levels, but the cytological differentiation does not reflect any precise geographical trend. The widely cultivated cultivar 'Rothschildiana' is hexaploid.

Growth and development *Gloriosa superba* is a typical geophyte whose aerial stems die down in the dry season and the tuber is dormant during this period, only sprouting with the rains. Two or more tubers develop during each growing season, while the previous season's tuber starts to shrivel. The tuber contains mainly starch, which increases gradually until the tuber is full grown. Colchicine content in tubers increases simultaneously. Plants propagated from seeds take 3–4 years to bloom. Plants produced from tubers develop (1–)3–6 stems, which start flowering after 5–8 weeks and continue flowering for about another 7 weeks, after which the stems die. Development from visible flower bud to bloom takes about 2 weeks and anthesis occurs 1 day later with the stigma being receptive for 4 days; anther dehiscence is one day after anthesis. The same branch flowers at 3-day intervals. Terminal flowers do not usually set fruit, but if they do, only a few seeds are produced. Pollination is probably by butterflies and sunbirds. Fruits are mature 6–10 weeks after pollination. The red sarcotesta suggests seed dispersal by animals. The dimensions and branching pattern of the plants are strongly correlated with tuber weight.

Ecology *Gloriosa superba* prefers a climate with a pronounced rainy season, avoiding perhumid tropical areas. It is most common in forest-savanna boundaries. It is locally common in thickets, hedges, open forest, grassland and bushland, where it can be seen scrambling through shrubs, and is also found in abandoned cultivated areas. It occurs from sea-level up to 2500 m altitude. *Gloriosa superba* grows best in well-drained, acid to neutral soil rich in organic matter.

Propagation and planting *Gloriosa superba* is propagated mainly during the rainy season, by bulblets, division of the tubers or from seed. V- or L-shaped tubers should be divided every third year. The tuber is delicate, and should be teased apart gently just before new growth begins, when the buds are easiest to spot. Each tuber part must contain several axillary buds that ensure the formation of adventitious stems and roots. Vegetative propagation by tubers is common practice but slow as the maximum number of daughter tubers produced per plant per year is two. Separating 2-lobed tubers produces a higher percentage of flowering plants than leaving the tubers undivided (97% versus 63%). Sprouting of the tubers is irregular and reaches about 60% in 30 days. Tuber dormancy can be overcome by soaking in continuously aerated water. Small tubers have been found to have a higher success rate than bigger ones. Tubers of 50–60 g are planted horizontally and 30–45 cm apart in well-tilled soil at a depth of 6–8 cm in furrows 45–60 cm apart. A closer spacing gives a higher percentage of cross-pollination resulting in improved fruit set. The best planting medium is a 1:1:2 mixture of soil, sand and compost.

Growing *Gloriosa superba* from seed requires more time. The seeds have to be soaked overnight in warm water, and then planted in a well-drained medium. Germination is erratic and may take from 3 weeks to 3 months. Seedlings grow rapidly and mostly produce tubers by their second year; flowering starts in the fourth year. Chemical scarification (e.g. with 1% hypochlorite) or removal of the sarcotesta reduces seed dormancy from 6–9 months to about 4 months, and accelerates germination to 11–15 days. Germination rates as high as 97% have been reached for seeds incubated at 20–25°C for a period of 31 days. Higher temperatures have adverse effects.

As seed germination is poor and vegetative propagation is slow, methods of rapid micropropagation have been developed, using explants preferably from tubers and an auxin-enriched growth medium. Explants from meristematic parts of the tuber yield the highest number of plantlets. A growth medium containing thiamine hydrochloride and NaCl yielded large numbers of mature microtubers in 3–4 months. Periodic darkness accelerates

this process.

Management *Gloriosa superba* prefers light to medium shade. In general, the plants are grown organically. Before sowing, 15–20 t of farmyard manure is applied. It is also possible to apply a dose of 40 kg N, 50 kg P_2O_5 and 75 kg K_2O per ha at planting with a top dressing of 80 kg N per ha, 8 weeks after planting. The top dressing should coincide with staking of the growing stems. Irrigation is needed for dry spells during the initial stages of growth. Irrigation applied after flowering may cause the tubers to rot. Poor fruit set is a problem in plantings in southern India. This may be attributed to inadequate pollination, which can be overcome by artificial pollination. Although considerable information is available on the cultivation of *Gloriosa superba* under greenhouse conditions, the techniques used are not applicable to field conditions in tropical regions.

Different pollination methods were studied including natural pollination, controlled selfing and cross-pollination. Although flower colour and shape seem to favour cross-pollination, self-pollination provides better results. Controlled selfing between flowers on the same plant (idiogamy) gives significantly higher seed yield (9.2 g/plant), compared to naturally pollinated ones (4.3 g/plant).

Diseases and pests Leaf blight (*Curvularia lunata*) and tuber rot (*Sclerotium* spp.) are important fungal diseases of *Gloriosa superba* under per-humid conditions. Caterpillars of the moths *Polytela gloriosa* and *Chrysodeixis chalcites* attack foliage and flower buds. Under greenhouse conditions, lice and thrips can be a problem.

Harvesting Mature fruits of *Gloriosa superba* are hand picked, and the tubers are dug out manually.

Yield In South Africa the seed production of 'wild-type' plants is positively correlated with height of the plant, and is on average 258 seeds per plant for plants 60–65 cm tall compared with about 30 seeds per plant for plants 30–40 cm tall. In Tamil Nadu, India, small-scale plantings, raised from tubers, yield on average 250–300 kg seed/ha from the second year onwards.

Handling after harvest Seeds and tubers are traded in various forms: fresh, dry, powdered, or in oil. In South-East Asia, after harvesting, mature fruits of *Gloriosa superba* are left in the shade to dry for 7–10 days. The fruits are then split open and the seeds removed, dried for a week in the shade and subsequently sun dried for another week.

Genetic resources *Gloriosa superba* has a wide natural distribution, and many selections are cultivated. Local depletion of the resource does occur, in India particularly, where the species has become endangered due to overcollection of the tubers. Although in its natural habitat, seed set and germination is poor. *Gloriosa superba* is not threatened and the diversity still offers opportunities for further selection either for chemical constituents or as an ornamental. Investment analysis shows that *Gloriosa superba* cultivation is profitable under both irrigated and rainfed conditions. There are no known germplasm collections of *Gloriosa superba*.

Breeding There are several cultivars of *Gloriosa superba* for ornamental purposes, with 'Rothschildiana' being the most frequently encountered; 'Lutea' is a yellow flowered form, while 'Citrina' is yellow with dark red markings. There is also a dwarf cultivar called 'Nana'.

Prospects *Gloriosa superba* is widely used as a medicinal plant in Africa, despite the fact that the whole plant is very poisonous. It is therefore recommended that protocols for safe use of the different plant parts be developed. *Gloriosa superba* is commonly grown as a garden ornamental in the tropics and also shows interesting potential as a source of colchicine. Thus, in Africa there might be good opportunities for planting the crop commercially for ornamental purposes, or for the production of colchicine.

Major references Bunyapraphatsara & van Valkenburg, 1999; Burkill, 1995; Duke, 1992; Finnie & Van Staden, 1994; Iwu, 1993; Le Roux & Robbertse, 1994; Le Roux & Robbertse, 1997; Neuwinger, 1996; Raina & Gupta, 1999; Sivakumar & Krishnamurthy, 2000.

Other references Chumsri et al., 2000; Cortnummé, Wehrenfennig & Horn, 1997; Engprasert, 1995; Farooqi et al., 1993; Fernando & Widyaratna, 1997; Field, 1972; Khumwanich, 1999; Maroyi, 1999; Ntahomvukiye et al., 1984; Pandey & Haseeb, 1988; Saravanan & Buvaneswaran, 2003; Sivakumar & Krishnamurthy, 2002; Tarar & Vishwakarma, 1995; van Wyk, van Heerden & van Oudtshoorn, 2002; Watt & Breyer-Brandwijk, 1962.

Sources of illustration Bunyapraphatsara & van Valkenburg, 1999.

Authors E. Dounias

Based on PROSEA 12(1): Medicinal and poisonous plants 1.

GRIFFONIA SIMPLICIFOLIA (Vahl ex DC.) Baill.

Protologue Adansonia 6(2): 197 (1866).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Synonyms *Bandeiraea simplicifolia* (Vahl ex DC.) Benth. (1865).

Origin and geographic distribution *Griffonia simplicifolia* is distributed from Liberia to Gabon.

Uses In Côte d'Ivoire and Nigeria the pulped bark is applied to syphilitic sores. A leaf decoction is used as an emetic, cough medicine and aphrodisiac. A decoction of stems and leaves is taken as a purgative to treat constipation and is used externally as an antiseptic wash to treat suppurating wounds. Leaf sap is used as eye drops to cure inflamed eyes and is drunk or applied as an enema to cure kidney problems. Stems and stem bark are made into a paste that is applied to decaying teeth, and a paste made from the leaves is applied to burns. Ground twig bark, mixed with lemon juice and *Capsicum* pepper, is applied to scarifications to treat intercostal pain. Chewing the stems is claimed to produce an aphrodisiac effect. The leaves are put in chicken pens to kill lice. In Nigeria an extract from the powdered roots has been used to treat sickle cell anaemia.

The wood is hard and tough and in Ghana stems are used to make walking sticks. The leaves are used in the production of palm wine, and give the wine a bitter taste. Sap that exudes from cut stems can be drunk to quench thirst. In Ghana the roots are chewed and dried to produce a white powder that is used by women to powder their face. A black dye is obtained from the leaves. The pods are made into toy whistles and spoons. The leaves are highly valued as animal feed and are said to stimulate reproduction. Free-ranging cattle browse heavily on the shrubs. The stems are used to make baskets and chicken cages, and also beaten into fibres serving as chewing sponges, a popular means of tooth cleaning in Ghana. The stems and roots are used as chewsticks.



Griffonia simplicifolia – wild

Production and international trade The seed of *Griffonia simplicifolia* is an industrial source of 5-hydroxytryptophan (5-HTP), a serotonin precursor. Trade statistics are not available. In the early 1990s the annual export from Ghana to Germany amounted to 80 t. In view of the increased demand for 5-HTP in the Western world, the trade must have expanded since then. In 1999 the wholesale price of seed was US$ 8–9 per kg.

Properties The leaves of *Griffonia simplicifolia* contain a volatile oil and coumarins. The ripe seeds contain 6–14% 5-HTP. In the leaves 5-HTP is accompanied by 5-hydroxytryptamine (= serotonin), each at a concentration of 0.1–0.2%. In humans, 5-HTP increases the synthesis of serotonin in the central nervous system and has been shown to be effective in treating a wide variety of conditions, including depression, fibromyalgia, obesity, chronic headaches and insomnia. 5-HTP is poisonous to insects, i.e. bruchids (*Callosobruchus maculatus*). The cyanoglucoside lithospermoside (= griffonin) has been isolated from the roots; it is the active ingredient against sickle-cell anaemia.

In the seeds a number of lectins are found. One of them is of the acetylglucosamine-group which is commonly found in *Poaceae* and *Solanaceae* but is rare in *Leguminosae*. Some lectins have insecticidal properties. Isolectin B4 isolated from *Griffonia simplicifolia* is used as a marker of small primary sensory neurons in neurological research.

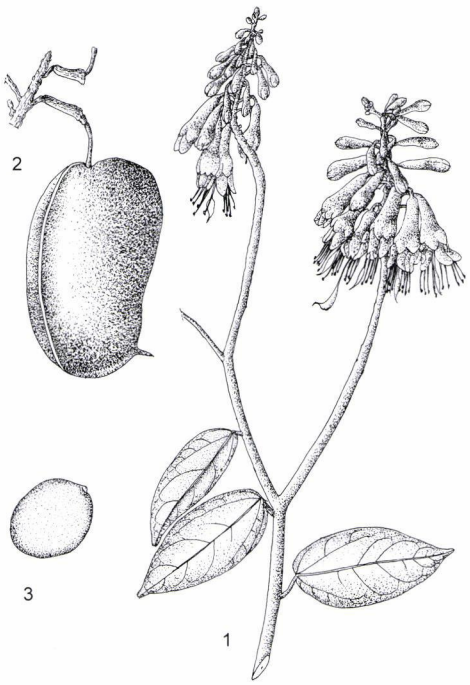
As a fodder *Griffonia simplicifolia* is appreciated for its vigour, high palatability, high crude protein content (about 16%), high P content (about 0.12%) and high Ca content (about 2.2%).

Adulterations and substitutes Lithospermoside (= griffonin) has been isolated from several plants, e.g. from the African *Lophira alata* Banks ex C.F.Gaertn. and *Tylosema fas-*

soglense (Schweinf.) Torre & Hillc.

Description Shrub or large liana with glabrous, brown-black branches. Leaves alternate, simple, glabrous; stipules triangular, 1 mm long, soon falling; petiole up to 1.5 cm long; blade ovate, 6–12 cm × 3–6 cm, base rounded to cordate, apex rounded to short-acuminate, 3(–5)-veined from the base, reticulate veins prominent on both sides. Inflorescence an axillary, pyramidal raceme 5–20 cm long; bracts and bracteoles triangular, very small, persistent. Flowers bisexual, almost regular, 5-merous; pedicel 3–4 mm long; receptacle urn-shaped, 1–1.5 cm long, pale green; calyx tube 12–15 mm long, orange, lobes triangular, up to 2 mm long; petals almost equal, elliptical, 10–12 mm long, fleshy, greenish, sparsely short-hairy on the margin; stamens 10, filaments filiform, up to 2 cm long; ovary superior, c. 4 mm long, stiped, style 1–2 mm long, persistent, stigma small. Fruit an oblique-cylindrical pod c. 8 cm × 4 cm, stipe 1–1.5 cm long, inflated, leathery, 1–4-seeded. Seeds orbicular, c. 18 mm × 5 mm × 6 mm, glabrous. Seedling with epigeal germination.

Other botanical information *Griffonia* occurs in tropical Africa. It belongs to the tribe *Cercideae* and comprises 4 species. *Griffonia physocarpa* Baill., *Griffonia tessmannii* (De Wild.) Compère and *Griffonia speciosa* (Benth.) Taub. occur from Nigeria east to DR Congo and south to Angola. They are less common than *Griffonia simplicifolia*. The main use of *Griffonia physocarpa* is as a dye plant. In DR Congo *Griffonia tessmannii*, *Griffonia physocarpa* and *Griffonia speciosa* have similar medicinal uses. A decoction of the aerial parts is drunk to treat gonorrhoea and stomach problems. Feverish children are bathed in the same decoction to bring down the temperature. Young leaves are chopped and eaten as an aphrodisiac and pulped they serve to massage body parts with oedema. The seeds of *Griffonia physocarpa* and *Griffonia speciosa* contain high concentrations of 5-HTP.



Griffonia simplicifolia – 1, flowering branch; 2, fruit; 3, seed.
Redrawn and adapted by Iskak Syamsudin

Growth and development In West Africa *Griffonia simplicifolia* flowers from July till November. Pods ripen from August onwards.

Ecology *Griffonia simplicifolia* occurs in grass savanna, in coastal plains on termite mounds, in scrub thickets, secondary and disturbed forest, and along the margins of primary forest.

Propagation and planting Propagation by seed gave poor results and different seed treatments did not improve germination, although fungicide treatment of the seed appeared beneficial for establishment. Use of stem cuttings has not been successful. In productivity trials wildlings were successfully used as planting material; this is impractical at a larger scale.

Management There are no indications that *Griffonia simplicifolia* is currently being cultivated.

Diseases and pests *Griffonia simplicifolia* is a host for several lepidopteran defoliators of the important timber tree *Mansonia altissima* (A.Chev.) A.Chev.

Harvesting For local medicinal use *Griffonia simplicifolia* is harvested in small quantities. Although harvesting seeds from the wild is usually fairly sustainable, there are worrying reports of lianas being cut down on a large scale to be able to collect the seeds. Harvesting for fodder is best done at intervals of 12 weeks, as total herbage yields are then considerably higher than when harvested at 6 week intervals.

Yield In Ghana herbage yield of *Griffonia simplicifolia* was comparable to that of *Leucaena leucocephala* (Lam.) de Wit, but both

were outyielded by *Gliricidia sepium* (Jacq.) Kunth ex Walp. There are no data available on seed yield.

Handling after harvest The seeds of *Griffonia simplicifolia* are extracted in factories in the United States, Germany and probably elsewhere. The extract is either a grey-white powder or pale brown crystals containing 95–98% 5-HTP and is sold wholesale at about US$ 800 per kg (prices in 2000). It is finally sold mixed with vitamins and packed in capsules or mixed with green tea or yerba mate.

Genetic resources Even though *Griffonia simplicifolia* is reportedly common, the high commercial value of the seeds forms a serious threat. Destructive harvesting combined with high grazing pressure could contribute to reduction of populations.

Breeding The insecticidal lectins of *Griffonia* are of interest for plant breeders who want to build in insect resistance in other crops.

Prospects *Griffonia simplicifolia* will remain in high demand as a natural alternative for the antidepressant Prozac. Measures for sustainable harvesting need to be enforced or developed. Research to domesticate this species is urgently needed, solving the problems with germination being a first step.

Major references Aubréville, 1968; Bell, Fellows & Qureshi, 1976; Birdsall, 1998; Bouquet, 1969; Burkill, 1995; Cunningham & Schippmann, 2000; Hawthorne & Jongkind, 2006; Mangenot, 1957.

Other references Adjanohoun & Aké Assi, 1979; Ayensu, 1978; Barnes, 1998; Das et al., 2004; Hegnauer & Hegnauer, 1994; Irvine, 1961; Iwu, 1993; Kerharo & Bouquet, 1950; de Koning, 1983; Tra Bi, Kouamé & Traoré, 2005; Waiton, 1986; Wilczek et al., 1952; Wobil, 2005; Zhu-Salzman et al., 2003.

Sources of illustration Mangenot, 1957.

Authors C.H. Bosch

GROSSERA MACRANTHA Pax

Protologue Engl., Pflanzenr. IV, 147(7): 426 (1914).

Family Euphorbiaceae

Origin and geographic distribution *Grossera macrantha* occurs in Cameroon, the Central African Republic, Congo and DR Congo.

Uses In Congo powdered bark is applied to sores, after these have been washed with a decoction of the bark.

Botany Dioecious shrub or small tree up to 6(–20) m tall; bole up to 35 cm in diameter; twigs short-hairy, later glabrescent. Leaves alternate, simple; stipules small, soon falling; petiole 1.5–10 cm long; blade elliptical, 6–33 cm × 2.5–13 cm, base cuneate with 2 sessile glands, apex acute to rounded, margins finely toothed, short-hairy, later almost glabrous, glandular-punctate beneath. Inflorescence a terminal or sometimes axillary panicle at the end of a branch, (5–)10–25 cm long, densely short-hairy. Flowers unisexual, white; male flowers with pedicel up to 6 mm long, calyx splitting into 2–3 lobes 3–4 mm long, short-hairy outside, petals 5, orbicular, 2–4 mm in diameter, stamens 16–25, free, up to 4 mm long, disk glands 5; female flowers with pedicel up to 6 mm long, enlarging to c. 12 mm in fruit, sepals 5, ovate to almost round, c. 2 mm long, hairy outside, petals 5, orbicular, 2–3 mm in diameter, enlarging up to 5 mm, hairy outside, disk cup-shaped, margin densely hairy, ovary superior, rounded, densely hairy, 3-celled, styles 3, 2-fid at apex, hairy. Fruit a 3-lobed capsule 8–10 mm × 14–15 mm, hairy, 3-seeded. Seeds ovoid, 6–8 mm × 5–7 mm, pale brown mottled with dark brown.

Grossera comprises 8 species, 7 occurring in the forest zone of continental Africa and 1 in dry deciduous forest in Madagascar.

Ecology *Grossera macrantha* occurs in the understorey of dense rainforest and periodically inundated rainforest, also as a pioneer species in forest gaps, from sea-level up to 450 m altitude.

Genetic resources and breeding *Grossera macrantha* is locally common as a pioneer species, and therefore probably not threatened by genetic erosion.

Prospects *Grossera macrantha* will probably remain of minor importance as a medicinal plant.

Major references Burkill, 1994; Léonard, 1962.

Other references Govaerts, Frodin & Radcliffe-Smith, 2000.

Authors G.H. Schmelzer

HARRISONIA ABYSSINICA Oliv.

Protologue Fl. trop. Afr. 1: 311 (1868).

Family Simaroubaceae

Chromosome number $2n = 16$

Synonyms *Harrisonia occidentalis* Engl. (1895).

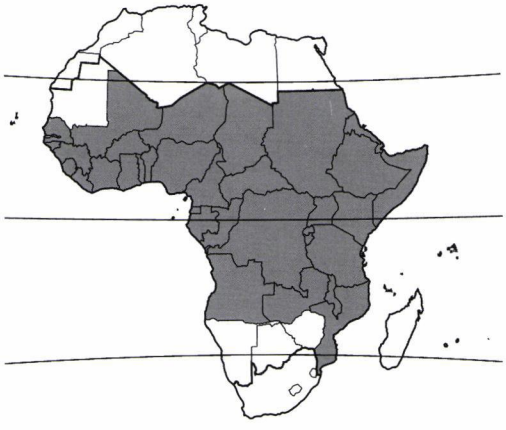
Vernacular names Baingou (Fr). Msam-

burini, mkidori, mpapuradoko, mkusu, mkoromando, msoma (Sw).

Origin and geographic distribution *Harrisonia abyssinica* is widespread in tropical Africa.

Uses Throughout tropical Africa the root powder or a root decoction or infusion is taken to treat venereal diseases, fever and malaria, diarrhoea, urinary problems and intestinal worms. Less often a leaf and twig decoction is used for these purposes. In Ghana pounded and boiled root is taken to treat cough and whooping cough. In Ethiopia the Shinasha (Boro) people use a decoction of roots to treat dysmenorrhoea. In Kenya a root decoction is drunk as a remedy for dizziness, insomnia, nausea, vomiting, bubonic plague, swollen testicles and tuberculosis. It is also taken to induce abortion. The Nyamwezi people swallow the smoke from burning root bark to treat hookworm infections. The roots and bark are crushed and soaked in water and drunk to purify and strengthen the body. In Kenya and Tanzania a root decoction is drunk in the treatment of cancer. The root is also used as a rubefacient. In Uganda a root infusion is drunk to treat snakebites, hernia and is used as nose drops to treat insanity. The root powder is applied to incisions to treat migraine.

Throughout tropical Africa crushed leaves, a leaf decoction or infusion are used as a wash to disinfect wounds and abscesses. A root decoction is used for this purpose by the Shinasha people of Ethiopia. In Togo a leaf decoction is drunk to treat diabetes. In Kenya a decoction of leaves and twigs is drunk to treat haemorrhoids. The Nyamwezi people apply the pulped leaves to snakebites. Leaf sap is drunk to treat general body pain. In Tanzania a hot leaf decoction is prepared as an inhalation to treat headache. In Uganda a root decoction is used in the treatment of livestock against east coast fever and lumpy skin disease.



Harrisonia abyssinica – wild

The fruits are edible. The wood is easy to work, durable and resistant to fungi, termites and wood borers and used for making stools, bows, in house construction and as firewood. In Ghana the stems with the bark removed are used to make state umbrellas and as the supports of chiefs' palanquins. The leaves are an important fodder throughout tropical Africa. In Kenya pruned shrubs are used as a living fence for cattle kraals. In Uganda *Harrisonia abyssinica* is planted to protect the garden and house against bad spirits.

Production and international trade A root decoction of *Harrisonia abyssinica* is sold in many traditional markets in Kenya, in bottles of 300–500 ml.

Properties From the root bark and stem bark of *Harrisonia abyssinica* many pharmacologically active compounds have been isolated, mainly limonoids, which are highly oxygenated terpenoids, several other terpenoids, steroids and chromone derivatives. The most important limonoids isolated are atalantolide, obacunone, harrisonin, 12β-acetoxyharrisonin and deoxyobacunone. Terpenoids isolated are the triterpenoids 5-dehydrooriciopsin, 11β,12β-diacetoxyharrisonin and 3-friedelanone, and the cycloterpene cycloabyssinone (stem bark), the spirotetranortriterpenoid pedonin (root bark), and the quassinoid perforaquassin A. Sterols and ketosteroids isolated are β-sitosterol, stigmasterol and derivatives, campesterol, β-sitostenone, stigmastenone and campestenone. Fractionation of the n-hexane extract of the leaves afforded several unusual prenylated polyketides: oumarone, bissaone and aissatone.

The methanolic root extract showed significant antiplasmodial activity against chloroquine-sensitive and chloroquine-resistant strains of *Plasmodium falciparum*. The methanolic and water extracts from the stem bark showed moderate antiplasmodial activity in vitro, and low toxicity in the brine shrimp toxicity test.

Crude and methanolic root extracts showed significant in-vitro antibacterial activity against different strains of *Helicobacter pylori*, but the effect on a large number of strains of other bacteria was very small. Methanolic root and stem bark extracts showed significant control of *Giardia lamblia* (a parasite causing gastroenteritis) in vitro. Methanolic root extracts

showed significant cytotoxic activity against several human cell lines. A methanolic leaf extract showed no cytotoxicity, but significant antibacterial activity against *Staphylococcus aureus*, *Bacillus subtilis*, *Escherichia coli* and *Mycobacterium phlei*, as well as moderate antiviral activity against Herpes simplex. The antibacterial activities are mainly due to the limonoids. Ethanolic leaf extracts did not show significant antibacterial, antitrypanosomal or antiplasmodial activities.

Root bark and twig extract showed significant antibacterial activity against *Staphylococcus aureus* in vitro and moderate activity against *Neisseria gonorrhoeae*, the bacteria responsible for the disease gonorrhoea. A methanol extract of dried root bark showed significant antifungal activity against *Trichophyton mentagrophyte* and *Candida albicans*.

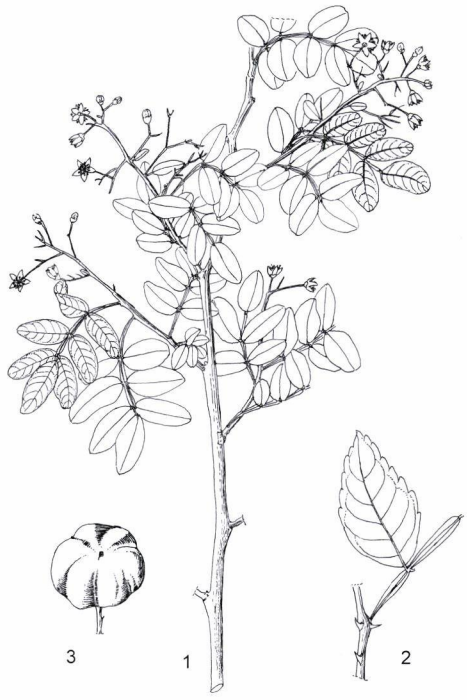
Atalantolide has shown significant immunosuppressant activities, and has been patented for this purpose in the United States. Obacunone was found to inhibit azoxymethane-induced colon carcinogenesis in rats.

Crude root extracts showed strong insect antifeedant activities. Pedonin showed antifeedant activity against larvae of the African sugarcane borer *Eldana saccharina* and the bean pod borer *Maruca vitrata*. Obacunone and harrisonin showed antifeedant activity against larvae of the African armyworm *Spodoptera exempta*, *Maruca vitrata* and *Eldana saccharina*.

Deoxyobacunone, obacunone, harrisonin, 12β-acetoxyharrisonin and pedonin exhibited significant stimulatory activity (up to 98%) on the germination of conditioned *Striga hermonthica* seeds.

The leaves of *Harrisonia abyssinica* are rich in protein, but their utilization as a fodder is hampered by the high tannin content.

Description Evergreen, much-branched shrub or small tree, sometimes climbing, up to 6(–13) m tall; bole and larger branches with up to 2 cm long thorns on conical corky outgrowths; bark pale brown to grey; branches long and flexible. Leaves alternate, imparipinnately compound with 2–7 pairs of leaflets, up to 25 cm long, glabrous or hairy; stipules absent; petiole up to 3 cm long, with 2 recurved spines at base, petiole and rachis with 1–3 mm wide wings; petiolules 0–2 mm long; leaflets elliptical or broadly obovate to almost circular, 0.5–9 cm × 0.5–4 cm, base asymmetrical, cuneate to rounded, apex rounded to acuminate, margins variably toothed or entire. Inflorescence an axillary or terminal, erect panicle 2–14 cm long, glabrous to hairy. Flowers bisexual, regular, 4–5(–6)-merous; pedicel variable in length; sepals almost free, triangular to ovate, c. 1 mm long, glabrous or hairy; petals ovate to lanceolate, 2–5.5 mm × 1–2 mm, glabrous or hairy; stamens 8–10, up to 4 mm long; ovary superior, 4–5(–6)-lobed, c. 2 mm long, styles united, up to 1 mm long, stigma 4–5(–6)-lobed, head-shaped. Fruit a 4–8-lobed, depressed globose berry 4–9 mm in diameter, red to black when ripe, glabrous, fleshy, 4–8-seeded. Seeds ovoid, 3.5–5 mm × 2.5–3 mm, smooth.



Harrisonia abyssinica – 1, flowering branch; 2, detail of twig and leaf; 3, fruit.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Harrisonia* comprises 3 species, 2 of which occur in tropical Asia. Molecular analyses have shown that *Harrisonia* seems to be more closely related to the *Rutaceae* than to the *Simaroubaceae*.

Harrisonia abyssinica is variable, especially size, shape and hairiness of the leaves, especially in East Africa.

Growth and development In Ghana *Harrisonia abyssinica* flowers from February–March and fruits in October. It is a strong

grower and the roots spread widely.

Ecology *Harrisonia abyssinica* occurs in dry evergreen forest, forest edges, wooded grassland, riverine forest and coastal areas, from sea-level up to 1700 m altitude. It may form dense thickets on eroded soils. Annual rainfall in its area of distribution ranges between 150 mm and 2000 mm.

Propagation and planting *Harrisonia abyssinica* can be propagated by seed, stem cuttings and through micropropagation. Stem cuttings root easily when treated with the rooting hormone indole-3-butyric acid.

Management In western Kenya *Harrisonia abyssinica* trees are used as shade trees around homesteads and pruned trees and shrubs are used as living fences for cattle kraals. However, no information is available about its cultivation and management for medicinal purposes. In southern Sudan the Moru people consider *Harrisonia abyssinica* a weed and burn it, because it shades out the sorghum sown under it.

Harvesting Leaves, roots, bark and fruits are collected from the wild and used immediately or dried and stored for use throughout the year.

Handling after harvest A decoction of the leaves, roots and bark of *Harrisonia abyssinica* can be used immediately or put in bottles to be used within a week. If refrigerated the decoction can be stored for up to 1 year. For long term storage (3–6 months) the leaves, roots and bark are sun dried and stored in airtight containers.

Genetic resources *Harrisonia abyssinica* is widely used for medicinal purposes, and is probably locally overharvested, which calls for conservation and research on propagation and domestication. No systematic germplasm collection or preservation programmes exist in tropical Africa. However, there are small collections in botanical gardens and research institutions in Kenya, Uganda, Tanzania, Ethiopia and Nigeria.

Prospects *Harrisonia abyssinica* has considerable value as a medicinal plant because it can be used to treat a wide range of diseases and ailments including malaria, sexually transmitted diseases, diarrhoea, intestinal worms and wounds and abscesses. Extraction and identification of the active ingredients in the bark, roots and leaves may provide useful drugs. International trade in *Harrisonia abyssinica* has been hindered by lack of appropriate post-harvest, processing and preservation technologies and lack of appropriate documentation and scientific experimentation to verify herbalists' claims.

Major references Balde et al., 1995; Burkill, 2000; Chase, Morton & Kallunki, 1999; Johns, Kokwaro & Kimanani, 1990; Kirira et al., 2006; Kokwaro, 1993; Masinde, 1996; Rugutt, Rugutt & Berner, 2001; Stannard, 2000; Watt & Breyer-Brandwijk, 1962.

Other references Anani et al., 2000; Balde et al., 2000; Beentje, 1994; El Tahir, Satti & Khalid, 1999; Fabry, Okemo & Ansorg, 1996; Fernando & Quinn, 1995; Hassanali et al., 1986; Hudson et al., 2000; Johns et al., 1995; Kamuhabwa, Nshimo & de Witte, 2000; Keita et al., 1995; Neuwinger, 2000; Okemo & Mwatha, 2002; Rajab et al., 1997; Rubanza et al., 2005; Runyoro et al., 2006b; Sawhney et al., 1979; Sharland, 2006; Tabuti, Dhillion & Lye, 2003; Timberlake, 1987.

Sources of illustration Wild & Phipps, 1963.

Authors V.E. Emongor

HELIOTROPIUM AEGYPTIACUM Lehm.

Protologue Sem. hort. bot. hamburg.: 20 (1824).

Family Boraginaceae

Origin and geographic distribution *Heliotropium aegyptiacum* is found in Sudan, Ethiopia, Eritrea, Djibouti, Somalia and northern Kenya and also in Egypt and the Arabian peninsula.

Uses The pulp of fresh roots of *Heliotropium aegyptiacum* is applied to snakebites and scorpion stings in Somalia. The ash of burned roots is applied to wounds or alternatively, a mixture of leaf pulp and myrrh (resin of *Commiphora myrrha* (Nees) Engl.) is used. In Ethiopia the leaves are applied to the skin as a treatment for dandruff.

Properties No details have been published on the composition of *Heliotropium aegyptiacum*. In view of the uses that are similar to those of some better studied species of *Heliotropium*, it is probable that pyrrolizidine alkaloids are responsible for the pharmacological actions and for cases of poisoning in livestock in East Africa.

Botany Annual or short-lived perennial, erect herb, up to 75 cm tall, branched from the base. Leaves alternate, simple; stipules absent; petiole up to 5 cm; blade broadly ovate to elliptical, 1–10 cm × 0.5–7 cm; base shortly

cuneate; apex obtuse, mucronate; margin entire or undulate-crenate. Inflorescence a terminal, spike-like cyme. Flowers bisexual, regular, 5-merous, sessile; calyx 3–4 mm long, lobed almost to base, enlarging in fruit; corolla white, 4–6 mm long, tube constricted at throat, lobes ovate. Fruit splitting into 4 nutlets.

Ecology *Heliotropium aegyptiacum* is found in *Commiphora-Acacia* open scrub vegetation with succulents and in *Acacia-Hyphaene* associations at 350–700 m altitude. In Egypt it is found on the banks of the Nile and in moist stony ground. In Eritrea it was found to be a preferred host of gregarizing adults and hoppers of the desert locust.

Genetic resources and breeding In view of its fairly wide distribution and weedy nature, there seem to be no threats of genetic erosion for *Heliotropium aegyptiacum*.

Prospects As the use of *Heliotropium aegyptiacum* in traditional medicine seems restricted, it is likely to remain of limited importance only.

Major references Giday et al., 2003; Neuwinger, 2000.

Other references Boulos, 2000a; Diane, Förther & Hilger, 2002; Singh et al., 1994; Verdcourt, 1991; Woldewahid, 2003.

Authors C.H. Bosch

HELIOTROPIUM INDICUM L.

Protologue Sp. pl. 1: 130 (1753).

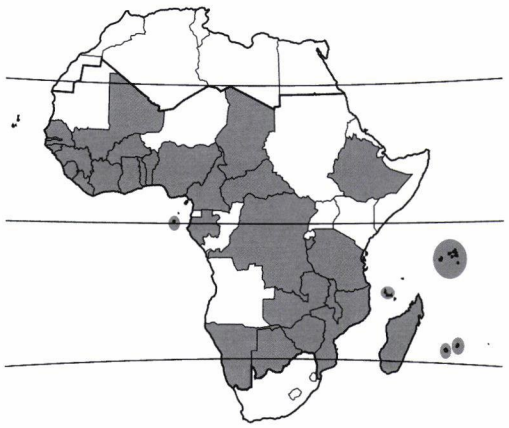
Family Boraginaceae

Chromosome number $2n = 22, 24$

Vernacular names Indian heliotrope, turnsole (En). Herbe papillon, monte au ciel, herbe à verrues (Fr). Heliotrópio-indiano, borragem brava, fedegoso (Po).

Origin and geographic distribution *Heliotropium indicum* has a pantropical distribution, but is probably native of tropical America. It is widespread and common throughout Africa.

Uses *Heliotropium indicum* has been used widely for centuries on warts and to treat inflammations and tumours. Throughout tropical Africa it is used as an analgesic (rheumatism), diuretic and for numerous skin problems (e.g. yaws, urticaria, scabies, ulcers, eczema, impetigo). There is ample variation in plant parts used, and in methods of preparation and administration. In Nigeria, an infusion of the plant is used as an eye-lotion and to clean ulcers. In Gabon the powdered leaves are used to



Heliotropium indicum – wild

treat infected gums. The Ngoni of Tanzania drink an extract made from the roots to treat yaws. In Madagascar a plant infusion is used as a strong diuretic. In the Seychelles the leaves are applied as an analgesic to treat stomach-ache in adult patients after operations. In Mauritius a leaf infusion is taken against kidney infections and as a diuretic. A poultice made from the leaves is applied to rheumatic limbs, to wounds and insect bites. A flower decoction is an emmenagogue in small doses and an abortifacient in large doses. Prostate infections are treated with a decoction made from a mixture with other plants.
In Gambia the whole plant is buried and after the fleshy tissue has rotted away the remaining fibre is used to make false hair for women.

Properties Pyrrolizidine alkaloids are a common constituent of various genera belonging to the *Boraginaceae* and *Asteraceae* and the papilionoid genus *Crotalaria*. They exhibit pronounced toxic effects on liver and lungs, but cytotoxic effects and other mutagenic and carcinogenic activities have also been reported.
From *Heliotropium indicum* the pyrrolizidine alkaloids indicine, indicine-N-oxide, acetylindicine, indicinine, heleurine, heliotrine, supinine, supinidine and lindelofidine have been isolated, all of them with hepatoxic activity. Furthermore the alkaloids trachelanthamidine and retronecine and the pyrrolizidine precursor amines (in leaves and inflorescence) putrescine, spermidine and spermine were isolated. The seeds contain 12% oil and 1.8% nitrogen. The nitrogen-containing lipid fraction contained C_{16} and C_{18} acids esterified with 1-cyano-2-hydroxymethylprop-1-en-3-ol.

Heliotropium indicum grown under greenhouse conditions showed the highest content of alkaloids at the beginning of the flowering period. The young leaves, seedlings and inflorescences showed high alkaloid levels and with ageing, the level of alkaloids decreased 20 fold in the leaves. The highest alkaloid content was found in the roots and inflorescence and these also had the highest relative amounts of N-oxide, ranging from 60–90% of the total alkaloid content. No significant age-dependent differences in N-oxides were found.

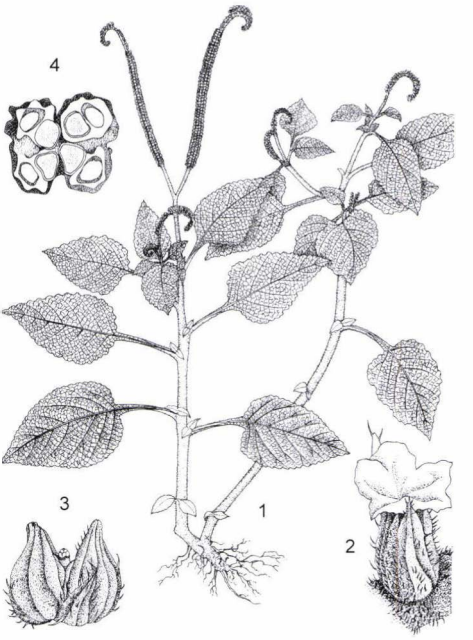
Extracts of *Heliotropium indicum* have been shown to have strong antibacterial and antitumour activities, but no antifungal activity. Furthermore, they showed wound healing activity in rats. The active principle was found to be indicine-N-oxide which has been synthesized in an efficient way. Indicine N-oxide has reached Phase I clinical trials in advanced cancer patients.

Aqueous leaf extracts of *Heliotropium indicum* had an allelopathic effect on rice seedlings; phenolic compounds may be held responsible for this.

Ingestion of *Heliotropium* is dangerous. Fatal accidental poisoning in humans by drinking herbal tea, consuming grain contaminated with *Heliotropium* seeds, and as a result of medicinal use has been recorded. Additionally, pyrrolizidine alkaloids are excreted in milk, and the use by lactating mothers is a toxicity hazard to babies. The plants are considered toxic to livestock with several records of fatal poisoning.

Adulterations and substitutes Many other species of *Heliotropium* contain pyrrolizidine alkaloids and are often used as substitutes for *Heliotropium indicum*.

Description Annual or perennial, erect herb, up to 1.5 m tall, woody at the base, usually much branched. Leaves alternate or opposite, simple; stipules absent; petiole 1–7 cm long; blade ovate to elliptical, (1.5–)3–16 cm × (0.5–)1.5–10 cm; base truncate but narrowly decurrent; apex acute or acuminate; margin irregularly undulate, bristly hairy. Inflorescence a scorpioid, simple, many-flowered cyme, 2.5–45 cm long. Flowers, bisexual, regular, 5-merous; calyx with almost free, unequal lobes, bristly, white hairy; corolla salver-shaped, tube 3–4.5 mm long, lobes rounded, c. 1 mm long, pale-violet, blue or white; stamens included in corolla tube, with very short filaments; ovary superior, 4-celled. Fruit 2–3 mm long, splitting into 4 nutlets. Seedling with epigeal germination; cotyledons leafy, rounded.



Heliotropium indicum – 1, plant habit; 2, flower; 3, fruit; 4, fruit in cross-section.
Source: PROSEA

Other botanical information *Heliotropium* comprises about 250 species and is distributed in tropical, subtropical and warm temperate zones of all continents. The classification suffers from the absence of a recent taxonomic revision covering Old World and the New World species. *Heliotropium* is of special interest in eastern and northern East Africa as it is associated with the initial swarming areas of migratory locusts (*Locusta migratoria*). Likewise butterflies are often associated with *Heliotropium* as they require certain pyrrolizidine alkaloids as precursor for their pheromones.

Heliotropium amplexicaule Vahl is native to South America, but is now found throughout the tropics. In pastures it can cause fatal poisoning in cattle. In Mauritius, where it is locally a weed in sugarcane, a decoction of the plant is drunk to cure cough and fever. *Heliotropium curassavicum* L. is another native of the New World which has been introduced in the Old World tropics. It is less widespread in tropical Africa than *Heliotropium indicum* and no medicinal uses have been reported from Africa. In the Americas, however, uses similar to those of *Heliotropium indicum* are recorded.

In Madagascar, *Heliotropium curassavicum* is burnt in the fields, as it provides good ash. Its English names, 'alkali heath', 'salt heliotrope' and 'seaside heliotrope', and its French name, 'verveine bord-de-mer', refer to its preferred habitat: saline lake- and seashores.

Growth and development *Heliotropium indicum* may flower throughout the year. The flowering season is very long and new flowers develop apically within the cyme while mature nutlets are already present at the base of the inflorescence.

Ecology *Heliotropium indicum* is found in sunny localities, on waste land, in periodically desiccating pools and ditches and anthropogenic habitats, generally below 800 m altitude. It is widely considered a weed of fields and pastures.

Management For medicinal uses *Heliotropium indicum* is exclusively collected from the wild.

Handling after harvest The plants are generally collected when fully grown and can be used either dry or fresh.

Genetic resources *Heliotropium indicum* is widespread both in the Old World and New World, and there is no risk of genetic erosion.

Prospects *Heliotropium* alkaloids have been considered as potential agents in chemotherapy and clinical trials have been executed. However, the applications in cancer therapy are limited by the toxic effects, in particular the hepatotoxic effect, of the pyrrolizidine alkaloids. External application to promote wound healing and to fight infections seems less hazardous, but more research is needed.

Major references Adjanohoun et al., 1983a; Burkill, 1985; Catalfamo, Martin Jr & Birecka, 1982; Iwu, 1993; Jelager, Gurib-Fakim & Adsersen, 1998; Kugelman et al., 1976; Misawa, Hayashi & Takayama, 1983; Rajangam, 1997; Verdcourt, 1991; Wongsatit Chuakul, Noppamas Soonthornchareonnon & Promjit Saralamp, 1999a.

Other references Ahmad, Ansari & Osman, 1978; Bernardo & Oliver, 2000; Birecka et al., 1984; Carballo et al., 1992; Davicino, Pestchanker & Giordano, 1988; Decary, 1946; Fernandez, Ceniza & Amihan, 1994; Gurib-Fakim et al., 1993; Gurib-Fakim, Guého & Bissoondoyal, 1995; Hartmann, 1999; Kokwaro, 1993; Le Gall et al., 2003; Martins & Brummitt, 1990; Ogawa, Niwa & Yamada, 1993; Ohnuma et al., 1982; Raponda-Walker & Sillans, 1961; Reddy, Rao &, 2002; Srinivas, Rao & Rao, 2000; van Weeren et al., 1999.

Sources of illustration Wongsatit Chuakul, Noppamas Soonthornchareonnon & Promjit Saralamp, 1999a.

Authors A. Gurib-Fakim

Based on PROSEA 12(1): Medicinal and poisonous plants 1.

HELIOTROPIUM OVALIFOLIUM Forssk.

Protologue Fl. Aegypt.-Arab.: 38 (1775).

Family Boraginaceae

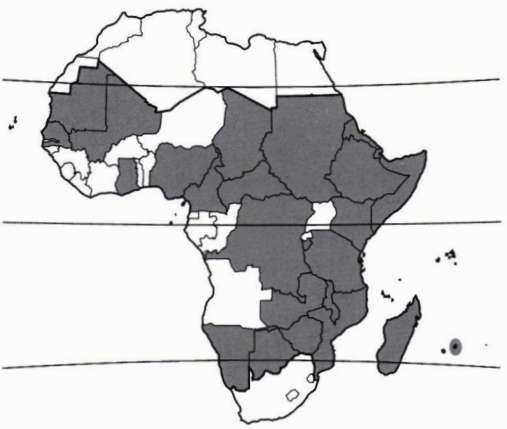
Chromosome number: $2n = 22$

Vernacular names Grey leaf heliotrope (En).

Origin and geographic distribution *Heliotropium ovalifolium* is widespread in tropical and subtropical Africa including Madagascar. Its range extends to tropical Asia and Australia.

Uses *Heliotropium ovalifolium* is used against syphilis in at least 3 different African countries and is reported to have analgesic properties. In Tanzania the dried plant is mixed with butter and the mixture is smeared thickly over painful places during fever. In both Ethiopia and Tanzania it is applied to scorpion stings. In Senegal and Kenya the plant is grazed by all livestock and in Australia by camels. In Zambia however, it is not grazed by cattle. In Kenya, the leaves are chewed as a substitute for tobacco.

Properties Pyrrolizidine alkaloids are a common constituent of the *Boraginaceae* and *Asteraceae* and the Papilionoid genus *Crotalaria*. These alkaloids exhibit pronounced toxic effects on the liver and lungs, whereas cytotoxic, mutagenic and carcinogenic activities



Heliotropium ovalifolium – wild

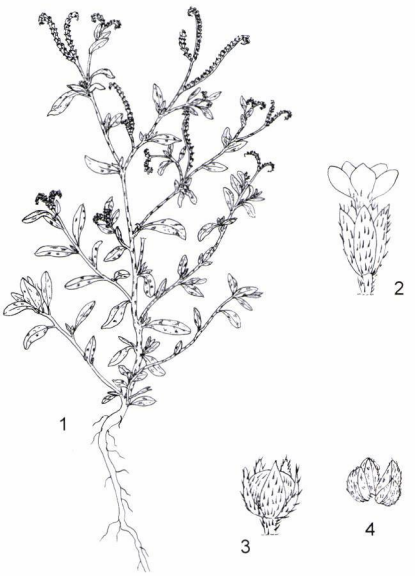
have also been reported. The alkaloids retronecine, helifoline and heliotropamide have been isolated. Helifoline has been reported to show in vivo and in vitro ganglion-blocking activity. Retronecine (the amino-ethanol moiety of many pyrrolizidine alkaloids but without the ester-part) and helifoline (a 1,2-saturated retronecine analogue) are expected not to be hepatotoxic. Supinine (a pyrrolizidine alkaloid), and heliophenanthrone (a phenanthrone derivative), as well as the benzoquinones heliotropinone A and B have been isolated from the aerial parts of the plant. Both quinones have exhibited antifungal and antibacterial properties. The alkaloid heliotropamide did not show any antifungal or antibacterial activity nor did it show any radical-scavenging activity.

Cases of poisoning of sheep and goat in Sudan have been reported, and a fatal liver disease of horses in Australia has been attributed to *Heliotropium ovalifolium* as well. In southern Africa *Heliotropium ovalifolium* is suspected to be the cause of the 'floppy trunk syndrome', a lethal affliction in elephants. In Nigeria, the plant is considered to be poisonous, causing diarrhoea and vomiting.

Adulterations and substitutes Many other species of *Heliotropium* contain pyrrolizidine alkaloids and are often used for similar purposes as *Heliotropium ovalifolium*.

Description Perennial herb, up to 90 cm tall, sometimes with woody base, much branched; young branches silvery pubescent. Leaves alternate, simple; stipules absent; petiole up to 1.5(–2) cm long; blade elliptical or obovate, up to 5.5 cm × 2.5 cm; base cuneate; apex retuse, mucronate or acute. Inflorescence a spike-like cyme, silky hairy, without bracts, with flowers arranged in two ranks, up to 4 cm long. Flowers bisexual, regular, 5-merous; calyx with almost free lobes, densely covered with antrorse hairs; corolla funnel-shaped, up to 3 mm long, pubescent outside, lobes ovate-triangular, up to 2 mm long; stamens included in corolla tube, with very short filaments; ovary superior, 4-celled. Fruit splitting into 4 nutlets, densely white hairy.

Other botanical information *Heliotropium* comprises about 250 species and is distributed in tropical, subtropical and warm temperate zones of all continents. The classification suffers from the absence of a recent taxonomic revision covering Old World and New World species. The genus *Heliotropium* is of special interest in eastern and northern East Africa as it is associated with the initial swarming areas



Heliotropium ovalifolium – 1, plant habit; 2, flower; 3, fruit; 4, nutlets.
Redrawn and adapted by Iskak Syamsudin

of migratory locusts (*Locusta migratoria*). Likewise butterflies are often associated with *Heliotropium* as they require certain pyrrolizidine alkaloids as precursor for their pheromones.

Heliotropium ovalifolium, *Heliotropium ciliatum* Kaplan and *Heliotropium strigosum* Willd. belong to the subgenus *Orthostachys*. *Heliotropium ciliatum* is found in Angola, Namibia, Botswana, Zimbabwe, Mozambique and South Africa. Its leaves are boiled and the water is drunk to cure fever and stomach-ache by Kalahari bushmen. In Namibia a decoction of roots and leaves is drunk or applied as an enema to treat pain in the legs. Oedema as a result of cardiac problems is treated by bathing with a decoction of the whole plant or as a steam bath. *Heliotropium strigosum* is widespread in tropical Africa and Asia as well as in Australia. It is used in Tanzania and DR Congo to treat abscesses of the breast by applying a mixture of the whole plant with butter. In Sudan the plant is thought to be effective in treating scorpion stings. In India it is used to treat snakebites, insect and scorpion stings, as a painkiller for pain in the limbs, to treat sore eyes and for healing boils, wounds and ulcers. It is eaten by camels in Sudan but not by livestock in Senegal. *Heliotropium strigosum* is a variable spe-

cies. The inflorescence lacking bracts distinguishes it from most of the other *Heliotropium* species in tropical Africa. *Heliotropium supinum* L. belongs to the subgenus *Piptoclaina*, which is closely related to subgenus *Orthostachys*. It is widely distributed in tropical Africa, South Africa, northern Africa, southern Europe and south-west Asia. In Namibia the pulped plant is mixed with water and applied to tumours. The pyrrolizidine alkaloids heliotrine and lasiocarpine have been isolated, and extracts have been tested as a control agent for *Sclerotinia sclerotiorum*, a chickpea disease, with limited success.

Growth and development *Heliotropium ovalifolium* may flower throughout the year. The flowering season is long and new flowers develop apically within the cyme while mature nutlets are already present at its base. *Heliotropium ovalifolium* can behave as a pioneer species and stays green well into the dry season.

Ecology *Heliotropium ovalifolium* occurs in diverse habitats, though drier places are preferred in general.

Handling after harvest *Heliotropium* plants are generally collected when fully grown and can be used either fresh or dry.

Genetic resources *Heliotropium ovalifolium* is very widespread; and there is no risk of genetic erosion.

Prospects *Heliotropium* alkaloids have been considered as a potential agent in chemotherapy and clinical trials have been executed. They have not been taken into pharmaceutical use as they have serious toxic (including hepatotoxic) effects attributed to the pyrrolizidine alkaloids. External application to promote wound healing and to fight infections seems less hazardous, but more research is needed. The role of *Heliotropium ovalifolium* in the breeding success of pest insects deserves attention.

Major references Burkill, 1985; Creeper et al., 1999; Guntern, 2003; Jansen, 1981; Neuwinger, 2000; Verdcourt, 1991; Wongsatit Chuakul, Noppamas Soonthornchareonnon & Promjit Saralamp, 1999a.

Other references Boppré & Fischer, 1999; Dorges, Heucke & Dance, 2003; Getahun, 1976; Guilet et al., 2003; Guntern et al., 2001; Guntern et al., 2003; Martins & Brummitt, 1990.

Sources of illustration Andrews, 1956.

Authors A. Gurib-Fakim

Based on PROSEA 12(1): Medicinal and poisonous plants 1.

HELIOTROPIUM RAMOSISSIMUM (Lehm.) DC.

Protologue Prodr. 9: 536 (1845).

Family Boraginaceae

Chromosome number $n = 16$

Synonyms *Heliotropium undulatum* Vahl (1790), *Heliotropium bacciferum* auct. non Forssk.

Vernacular names Wavy heliotrope (En).

Origin and geographic distribution *Heliotropium ramosissimum* is found in West Africa, Sudan and Egypt, extending to the Arabian peninsula and to Afghanistan. It has been introduced in parts of the United States, and is considered a weed there.

Uses In Niger dried and powdered plant parts of *Heliotropium ramosissimum* are added to water and drunk to combat fatigue. Leaf sap is applied to burns in Mauritania. In northern Nigeria it is applied topically to treat headache and used internally to treat gonorrhoea and to increase lactation. The plant is eaten by goats but not by other livestock in Senegal; it is said to provide a good fodder for camels and other livestock in Mauritania. In the western Sahara a macerate of the plant is used as ink.

Properties No data on the properties of *Heliotropium ramosissimum* appear to have been published but pharmacological properties are likely due to the presence of pyrrolizidine alkaloids as in other species of the genus, e.g. *Heliotropium indicum* L. and *Heliotropium ovalifolium* Forssk. In Australia sale, supply and use of *Heliotropium ramosissimum* is prohibited by the Ministry of Health because of the serious danger to health.

Botany Perennial, ascending or procumbent herb up to 50 cm tall; stem much branched from woody base, pubescent, white-bristly. Leaves alternate, simple; stipules absent; petiole up to 1 cm long; blade linear-lanceolate, 0.5–2.5 cm × 0.2–1.6 cm, base cuneate, apex acute or obtuse; margin revolute. Inflorescence a terminal, forked, spike-like cyme with flowers in 2 rows. Flowers bisexual, regular, 5-merous, sessile; calyx lobes narrowly elliptical, up to 3 mm long, persistent in fruit; corolla funnel-shaped, up to 4.5 mm long, lobes up to 1 mm long, almost suborbicular, white. Fruit globose, splitting into 4 nutlets, each up to 2.5 mm in diameter, hairy.

Heliotropium ramosissimum and *Heliotropium bacciferum* Forssk. (synonym: *Heliotropium crispum* Desf.) have often been confused. Probably *Heliotropium bacciferum* is found in Africa only in Cape Verde, North Africa, Sudan

and Madagascar. Its distribution further covers the Arab peninsula to Pakistan and Afghanistan and there the ranges of the 2 species overlap. The main distinction between the species is that in *Heliotropium bacciferum* the flowers are in a single row, flowers and fruits are glabrous while in *Heliotropium ramosissimum* flowers are in 2 rows and fruits are hairy. *Heliotropium bacciferum* is medicinally used in Cape Verde as a cardiotonic and further medicinal uses are reported from throughout North Africa, the Arabian peninsula and from Pakistan. It is used as a repellent for storage insects in Egypt and Pakistan. In Cape Verde, Algeria and the Arabian peninsula it is reportedly grazed by livestock. The pyrrolizidine alkaloids heleurine, heliotrine, supinine and europine have been isolated from *Heliotropium bacciferum*. In Ethiopia *Heliotropium pterocarpum* (DC. & A.DC.) Hochst. & Steud. ex Bunge is used to treat fevers. It is closely related to both *Heliotropium ramosissimum* and *Heliotropium bacciferum*, but differs in having a fruit with 2 winged nutlets. *Heliotropium pterocarpum* is found in Sudan, Eritrea, Ethiopia, Egypt and the Arabian peninsula, where it grows in sandy desert plains and at the edges of littoral salt marshes and is eaten by camels. Nursery sites of locusts are often found in vegetation dominated by *Heliotropium pterocarpum*.

Ecology *Heliotropium ramosissimum* is found in sandy wadis, on calcareous ridges, and is sometimes abundant in poor pastures.

Genetic resources and breeding *Heliotropium ramosissimum* is generally common wherever it occurs and there is no threat of genetic erosion.

Prospects The distinction between *Heliotropium ramosissimum* and *Heliotropium bacciferum*, especially important in West Africa, is obviously not always made correctly. Both species however, deserve pharmacological/toxicological research because they are used internally in traditional medicine despite the presumed presence of toxic pyrrolizidine alkaloids.

Major references Adam, Echard & Lescot, 1972; Burkill, 1985; Riedl, 1967.

Other references Boulos, 1983; Boulos, 2000a; Elhag-Eltayeb, 2000; Farrag-Nawal et al., 1996; Giday et al., 2003; Martins, 1995.

Authors C.H. Bosch

HELIOTROPIUM STEUDNERI Vatke

Protologue Öst. Bot. Zeitschr. 25: 167 (1875).

Family Boraginaceae

Origin and geographic distribution *Heliotropium steudneri* is native of East and southern Africa, from Ethiopia south to Namibia and South Africa.

Uses In Tanzania the leaf juice is applied to cuts to stop bleeding and to prevent infection. In Namibia plants are dipped in boiling water and then squeezed over bruises. The Maasai people in Kenya and Tanzania apply drops of leaf juice to the eyes of their cattle to cure conjunctivitis.

Properties The pyrrolizidine alkaloid lycopsamine has been isolated from the leaves of *Heliotropium steudneri*. As its uses are similar to those of some better studied species of the genus such as *Heliotropium indicum* L. and *Heliotropium ovalifolium* Forssk., pyrrolizidine alkaloids are probably responsible for the alleged medicinal properties. Several butterfly species depend on plants to provide them with lycopsamine as a precursor of the pheromone danaidone. The flowers have a bad smell which is believed to help pollination by flies.

Botany Perennial, erect or spreading herb or subshrub up to 1 m tall, with woody rootstock; stem branched, densely and persistently hairy. Leaves alternate, simple; stipules absent; petiole absent or short, up to 1 cm long; blade narrowly elliptical to elliptical-lanceolate or oblong, 1–9(–13) cm × 0.5–2.5(–3.2) cm; base cuneate, apex acute, margin crenulate, frequently bullate above with venation impressed. Inflorescence a terminal cyme, mostly simple, sometimes 2–3-branched, short and scorpioid at first, extending up to 37 cm long. Flowers bisexual, regular, 5-merous, sessile; calyx 2.5–5.5 mm long, lobed almost to base, densely pubescent; corolla white or creamy-yellow, 4–6 mm long, tube glabrous and narrow at base, funnel-shaped and pubescent above, lobes oblong to obovate-oblong, up to 3 mm × 2 mm. Fruit depressed ovoid, splitting into 2 nutlets.

Ecology *Heliotropium steudneri* is found in open localities, grassland and dry bushland on dry, poor, often sandy soil at 100–1350 m altitude.

Genetic resources and breeding *Heliotropium steudneri* is fairly widespread and common and therefore not in danger of genetic erosion.

Prospects The external uses of *Heliotro-*

pium steudneri in traditional medicine deserve attention by researchers.

Major references Baerts & Lehmann, 2002c; Martins & Brummitt, 1990; Meinwald, 2000; Neuwinger, 2000; Verdcourt, 1991.

Other references Burkill, 1985; Imamura, 2001.

Authors C.H. Bosch

HELIOTROPIUM ZEYLANICUM (Burm.f.) Lam.

Protologue Encycl. 3: 94 (1789).

Family Boraginaceae

Chromosome number $2n = 28$

Synonyms *Heliotropium subulatum* (A.DC.) Vatke (1882).

Origin and geographic distribution *Heliotropium zeylanicum* is widespread throughout mainland tropical Africa. It is also found in Comoros, South Africa, the Arabian peninsula, Pakistan and India.

Uses In Nigeria the plant is applied to scorpion stings and to sore breasts. In Kenya and Tanzania the leaves and roots are pounded and boiled, and the decoction is drunk to treat postpartum ailments and to promote menstruation. Leaves and stems are used as a poultice in DR Congo and Tanzania to treat yaws. A poultice of the leaves, sometimes mixed with butter, is used in Tanzania to treat boils. In Kenya a root infusion which has stood overnight is taken as a stomachic and laxative. Traditional medicinal use in India includes treating boils, sores, ulcers, throat infections, insect stings and snakebites. In Somalia the plant is said to be grazed by all livestock. In Tanzania the plant is considered useful as fodder and as an ornamental. In Nigeria it is eaten as a stimulant and a bitter tonic, probably because it colours the lips and saliva red as do kola nuts. In Tanzania young leaves are cooked and eaten as a vegetable.

Properties The aerial parts of *Heliotropium zeylanicum* contain the pyrrolizidine alkaloids subulacine-N-oxide, 7-angeloyl heliotrine, retronecine and heliotrine. The crude ethanol and hexane extracts have significant in-vitro activity against coxsackie, poliomyelitis and measles viruses and 7-angeloyl heliotrine and heliotrine have shown in-vitro activity against poliomyelitis and vesicular stomatitis viruses. Antitumour activity of several extracts and isolated alkaloids has been confirmed in in-vitro tests on several cancer cell lines including Sarcoma 180, human carcinoma of the nasopharynx and lymphocytic leukaemia. Extracts as well as isolated alkaloids have shown antimicrobial activity in tests with the bacteria *Escherichia coli*, *Streptococcus pneumoniae*, *Bacillus subtilis*, *Bacillus anthracis* and *Staphylococcus aureus*, and the fungi *Aspergillus fumigatus*, *Aspergillus niger*, *Rhizoctonia phaseoli* and *Pennicilium chrysogenum*.

Botany Perennial, erect or procumbent herb up to 60(–90) cm tall, usually with thick rootstock; stem branched, woody at base. Leaves alternate, simple, more or less sessile; stipules absent; blade linear to elliptical or sometimes lanceolate, 1–9(–12) cm × 0.2–1(–2.5) cm, base narrowly attenuate, apex acute. Inflorescence a spike-like, one-sided, single or paired cyme up to 30 cm long. Flowers bisexual, regular, 5-merous, sessile; calyx lobes narrowly elliptical, up to 2 mm × 1 mm, enlarging in fruit; corolla with cylindrical tube, white, up to 4.5 mm long, lobes up to 3 mm long, spreading, long acuminate with tip bent back inwards. Fruit almost globose, up to 2.5 mm in diameter, splitting into 4 nutlets.

Ecology *Heliotropium zeylanicum* is found in dry woodland, savanna, open localities, on sandy riverbanks and on edges of lakes and rivers up to 2000 m at altitude. It is an important weed in Egypt and Ethiopia and probably elsewhere.

Genetic resources and breeding *Heliotropium zeylanicum* is widespread and common throughout its area of distribution. Its weedy nature further assures that it is not threatened.

Prospects *Heliotropium zeylanicum* has promising medicinal properties which merit further research. It should be realized that use as an internal medicine can be dangerous with possible liver damage and poisoning as a result. Use as a vegetable has to be discouraged for the same reason.

Major references Burkill, 1985; Neuwinger, 2000; Ruffo, Birnie & Tengnäs, 2002; Taton, 1971; Verdcourt, 1991.

Other references Kokwaro, 1993; Martins & Brummitt, 1990; Singh, Sahu & Singh, 2002; Singh et al., 2002.

Authors C.H. Bosch

HILLERIA LATIFOLIA (Lam.) H.Walter

Protologue Engl.,Pflanzenr. IV, 83: 81 (1909).

Family Phytolaccaceae

Chromosome number $2n = 36$

Origin and geographic distribution *Hilleria latifolia* possibly originates from South America, but others believe it originates from the Old World. It occurs in tropical Africa from Guinea east to Ethiopia, and south to Angola, Mozambique and northern South Africa. It also occurs in Madagascar and in Sri Lanka.

Uses In Côte d'Ivoire a leaf decoction is taken or administered by enema to treat ascites and food poisoning, as it causes violent purging. The leaf sap is considered haemostatic. Pulped leaves are applied topically to painful areas and to treat persistent headache. A leaf decoction is taken to treat coughing of blood. In Ghana the boiled plant is eaten to treat guinea worm. The vapour from the leaf decoction is inhaled to cure jaundice. The leaves, together with those of *Piper guineense* Schumach. & Thonn., are applied to the body to cure swellings and leprosy. Ground to a paste together with *Alternanthera pungens* Kunth or Capsicum pepper (*Capsicum annuum* L.), they are topically applied to treat rheumatism. The crushed plant is applied to breast cancer. The flowers are ground to a paste and taken with orange juice to treat asthma. In Nigeria the leaves are eaten in soup to treat gonorrhoea. In Congo the leaves are used to treat gynaecological disorders in which purging is considered necessary. In Congo and DR Congo the crushed plant or crushed simmered leaves are applied as a poultice or in lotions to treat skin infections, scabies and smallpox. The sap is also used as ear drops to treat ear infections. The pounded leaves mixed with stem sap of *Costus afer* Ker Gawl. are taken to treat colic and gonorrhoea. In Nigeria the leaves are a component of 'nature cure bitters' a popular polyherbal formulation used for a variety of ethnomedicinal purposes.

In Ghana the presence of the plant is used as an indication of soil suitable for cocoa cultivation.

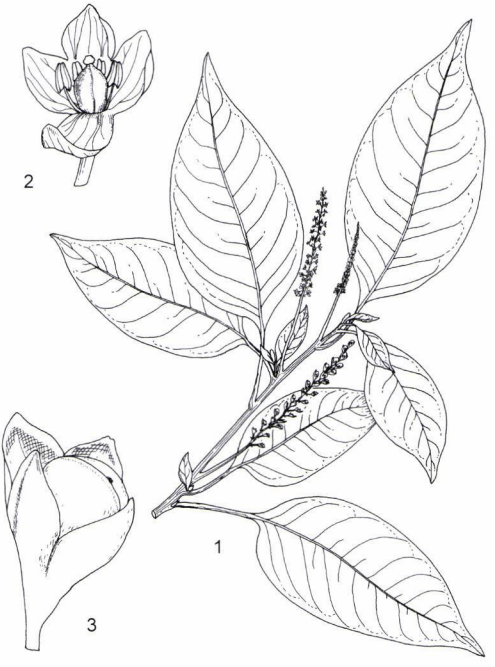
In Narok District of Kenya the Maasai people use the blackened stems for drawing eyebrows.

There is controversial information concerning the toxicity of the plant. In Côte d'Ivoire the plant is considered a violent poison, but in Nigeria and Cameroon the leaves are eaten as a vegetable or in soup. In Ghana the dried fruits are eaten as a relish. In Côte d'Ivoire cattle and sheep refuse to browse the plant, whereas in Ghana the leaves are browsed by sheep and goats, but the flowers and fruits are considered fatally poisonous.

Properties There is little information on phytochemistry and pharmacological activities of *Hilleria latifolia* available. The presence of a flavonoid, probably also alkaloids, and some glycosides have been reported. A crude extract of the stem bark caused significant mortality in vitro of adults and microfilariae of *Onchocerca volvulus*, which causes river blindness.

The leaves contain per 100 g edible portion: water 84.3 g, energy 184 kJ (44 kcal), fat 0.8 g, carbohydrate 7.8 g, Ca 349 mg, Fe 4.1 mg, ascorbic acid 22 mg (Leung, Busson & Jardin, 1968).

Botany Shrubby herb up to 2 m tall, with some weak bristly hairs on young branches. Leaves alternate, simple and entire; stipules absent; petiole (1–)2–5(–7) cm long; blade ovate or elliptical to broadly lanceolate, 8–16(–20) cm × 3.5–7.5(–9) cm, base rounded to cuneate and often unequal, apex long-acuminate. Inflorescence an axillary, sometimes terminal, raceme 4–10 cm long, up to 30 cm in fruit, many-



Hilleria latifolia – 1, flowering branch; 2, flower; 3, fruit.
Source: Flore analytique du Bénin

flowered; axis hairy; bracts 1–2 mm long, caudate, caducous. Flowers bisexual, zygomorphic, 4-merous; pedicel 1–2 mm long, c. 5 mm in fruit; sepals oblong-elliptical, 1.5–2 mm long, c. 4 mm in fruit, 1 sepal free, 3 united to the middle, green to white, turning yellow to red; petals absent; stamens free, a little shorter than sepals; ovary superior, slightly laterally compressed, 1-celled, stigma almost sessile, head-shaped. Fruit a lens-shaped utricle, 2–3 mm in diameter, pericarp very thin, reticulately wrinkled, adhering to seed, yellow to dark red or purple. Seed lens-shaped, black.

Hilleria comprises 3 South American species and belongs to the tribe *Rivineae*. *Hilleria latifolia* is often considered to have been introduced from South America, but its occurrence in little disturbed forest in East Africa and Madagascar may indicate that it is native in these regions.

Ecology *Hilleria latifolia* occurs in rainforest, riverine and groundwater forest, also along forest margins and roads and in plantations, at 500–1600 m altitude. It has been a weed of cultivated fields since the early days of oil palm cultivation in West Africa.

Genetic resources and breeding *Hilleria latifolia* is relatively common in its wide area of distribution, also in secondary vegetation, and therefore not endangered by genetic erosion.

Prospects *Hilleria latifolia* has many interesting medicinal uses, but almost no information is available on chemical compounds or pharmacological activities. It would therefore be useful to verify these uses through scientific tests.

Major references Burkill, 1997; Neuwinger, 2000; Nowicke, 1968; Titanji et al., 1987.

Other references Aniagu et al., 2005; Leung, Busson & Jardin, 1968; Mensah, 1991; Polhill, 1971; Sowunmi, 1985; Stannard, 1988b.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors G.H. Schmelzer

HILSENBERGIA PETIOLARIS (Lam.) J.S.Mill.

Protologue Adansonia, Sér. 3, 25: 184 (2003).

Family Boraginaceae

Synonyms *Ehretia petiolaris* Lam. (1785), *Bourreria petiolaris* (Lam.) Thulin (1987).

Vernacular names Bois de pipe, herbe cipaye (Fr). Mbunduki, mtundutundu, mpandayongoo (Sw).

Origin and geographic distribution *Hilsenbergia petiolaris* is native to Kenya, Tanzania, Mozambique, the Mascarenes and Madagascar.

Uses In Mauritius the leaves of *Hilsenbergia petiolaris* are used to treat skin infections and childhood eczema ('tambave'). In Tanzania the wood is used for firewood, building poles, tool handles and other small objects.

Properties The stems and leaves of *Hilsenbergia petiolaris* are reported to contain alkaloids, triterpenes, saponins and traces of flavonoids, but no results of analyses of the chemistry or pharmacology of the species, or of any other *Hilsenbergia* species, have been published.

Botany Shrub or tree up to 7.5(–12) m tall, occasionally scandent; stems often hollow; bark smooth, grey-brown or grey, rough, fissured longitudinally. Leaves alternate, simple; stipules absent; petiole slender, up to 5 cm long; blade oblong-elliptical to obovate-elliptic, 1–14 cm × 0.5–7.5 cm, base cuneate to rounded, apex rounded to acute, glabrous. Inflorescence a lax, pendulous, corymbose cyme, up to 15 cm long, many-flowered, axes pubescent. Flowers bisexual, regular, 5-merous, fragrant; pedicel up to 2 mm long; calyx 3.5 mm long, lobes valvate, narrowly triangular, up to 2 mm × 2 mm, glabrous to pubescent outside, pubescent inside; corolla campanulate, waxy white, tube 3–5 mm long, lobes broadly triangular or ovate, reflexed, 0.5–1.5 mm long, apex rounded; stamens inserted on corolla tube; ovary superior, 4-celled, style 2.5 mm long, with bifid stigma. Fruit a globose drupe c. 6 mm in diameter, orange-yellow to red, with 4 ridged and winged pyrenes.

Hilsenbergia species have formerly been placed in the genera *Ehretia* and *Bourreria*. *Bourreria* now comprises only a number of Neotropical species. *Ehretia* is pantropical and differs from *Hilsenbergia* in having smooth to slightly ridged pyrenes and imbricate calyx lobes.

Hilsenbergia comprises 18 species, 13 of which are endemic to Madagascar. *Hilsenbergia nemoralis* (Gürke) J.S.Miller (synonyms: *Ehretia nemoralis* Gürke, *Ehretia litoralis* Gürke) closely resembles *Hilsenbergia petiolaris* but the underside of the leaves is pubescent to woolly in the former and glabrous in the latter. *Hilsenbergia nemoralis* is restricted to Kenya, Tanzania and Mozambique and is found in the same coastal habitat as *Hilsenbergia petiolaris*, but also further inland and at higher altitudes. The Swahili names

'mbunduki' and 'mtundutundu' are used for both species and relate to the hollow stems. The roots of *Hilsenbergia nemoralis* are used in a decoction in Tanzania to cure stomach-ache. *Hilsenbergia lyciacea* (Thulin) J.S.Mill. (synonym: *Bourreria lyciacea* Thulin) occurs in Ethiopia, Somalia, Kenya and Madagascar and can be distinguished by its distinctly branched style and flowers that are solitary or 2 together. In Madagascar it is used to treat diarrhoea and haemorrhaging.

Ecology *Hilsenbergia petiolaris* is found in dry coastal forest, littoral scrub vegetation and on coral cliffs, just above the high-tide mark and sand dunes, mainly up to 30 m altitude.

Genetic resources and breeding *Hilsenbergia petiolaris* is fairly restricted in habitat requirements but there are no threats of genetic erosion.

Prospects It seems likely that *Hilsenbergia petiolaris* will remain of limited use only.

Major references Lovett, Ruffo & Gereau, 2003; Miller, 2003; Thulin, 1987.

Other references Beentje, 1994; Gurib-Fakim & Brendler, 2004; Neuwinger, 2000; Verdcourt, 1991.

Authors C.H. Bosch

HOLARRHENA FLORIBUNDA (G.Don) T.Durand & Schinz

Protologue Etudes fl. Congo: 190 (1896).

Family Apocynaceae

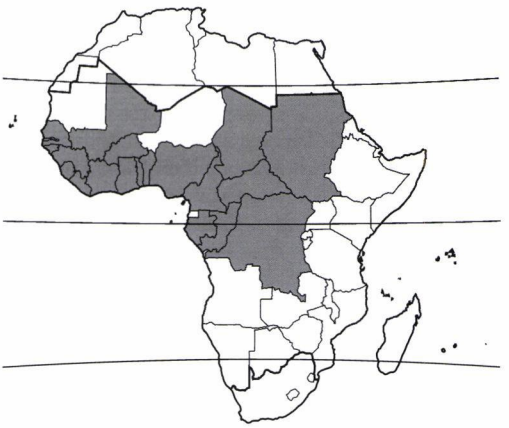
Chromosome number $2n = 20$

Synonyms *Holarrhena africana* A.DC. (1844), *Holarrhena wulfsbergii* Stapf (1902).

Vernacular names False rubber tree, conessi bark, kurchi bark (En). Holarrhène, holarrhène du Sénégal (Fr).

Origin and geographic distribution *Holarrhena floribunda* occurs from Senegal east to Sudan, and south to DR Congo and Cabinda (Angola).

Uses The bark is widely applied in West Africa, in decoction or macerated in palm wine, to treat dysentery and diarrhoea. In Senegal, the roots are used for the same purposes, and are further used to treat stomach complaints, including constipation and colic, to prevent spontaneous abortion, to treat sterility and as a diuretic to treat venereal diseases. An infusion of the leaves is taken to treat diabetes and amenorrhoea. In Sierra Leone the leaves, mixed with kola nut are eaten to treat gonorrhoea. In Guinea Bissau the fruit is used to prepare a remedy for dropsy. The latex is applied to snakebites. The stem bark and leaves are also widely used to treat fever, especially malaria. They are boiled and added to a bath, or taken orally. In Côte d'Ivoire a decoction of the bark is used as an enema or in baths to treat skin affections. The leaf sap is sprinkled on wounds as a haemostatic. The leaves, mashed with those of *Myrianthus arboreus* P.Beauv. and fruits of *Capsicum* pepper in water, are applied as an enema against kidney pain. The latex has been used as arrow poison or fish poison. Like other lactiferous plants, it is considered galactagogue for cattle.



Holarrhena floribunda – wild

The wood is used for carvings, combs, axe handles and small utensils. In Ghana it is considered to be the best white wood available for these purposes. It is usable for packing cases and house construction. The stems are used for the construction of granaries in Benin, as they are easy to work and resistant to the beetle *Prostephanus truncatus*, a pest of stored grain. The wood is suitable for shaving into woodwool for packing fruit. Young stems are flexible and can be bent to make handles of walking sticks. The bark yields copious white sticky resinous latex, which is of little use, but can serve as glue. In Guinea Bissau the hair from the seeds is used for filling pillows. In Côte d'Ivoire the trees are retained in cacao plantations to provide shade and fuel wood. In Ghana and DR Congo charcoal is produced from the wood. Edible caterpillars feed on the leaves. *Holarrhena floribunda* is an attractive tree with white fragrant flowers, and is widely used for ritual purposes.

Properties *Holarrhena floribunda* yields a

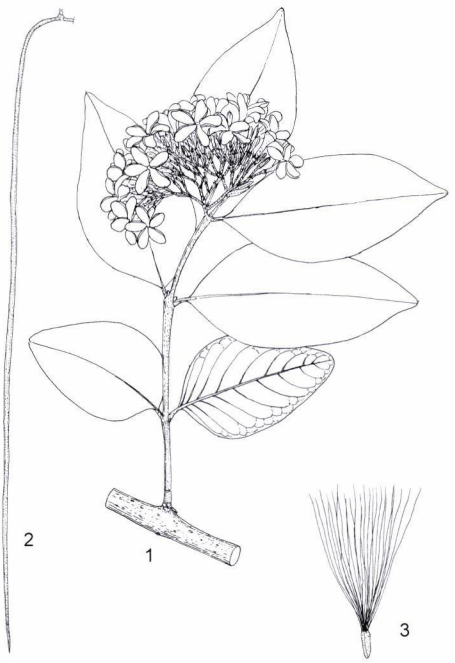
large number of alkaloids. The highest concentration is found in the root bark (2–4%), followed by the stem bark (1–2.5%) and the leaves and flowers (less than 1%). Most of the main alkaloids of the stem bark and root bark are steroid alkaloids derived from conanine or the closely related conamine, which also occur in other *Holarrhena* species. The main alkaloid of the stem bark and root bark is conessine, and minor compounds are norconessine (kurchine), conessimine, kurchamine, conimine, conamine and holarrhenine. The leaves contain mainly steroid alkaloids derived from pregnane, such as holarrhimine, holaphyllamine, holamine and holaphylline, as well as the alkaloid triacanthine (an adenine derivative). The seeds contain conessine, norconessine, conamine and conarrhimine.

Conessine has sedative, central nervous system depressant, cardiac depressant, antipyretic and analgesic activities. It also has significant antiamoebic activity, but it needs to be used with caution because it can produce neurological problems such as vertigo, tremors, insomnia, agitation or anxiety. Conessine also shows antibacterial and antifungal activities against a range of human pathogens in vitro. The steroid alkaloids present in the stem bark and root bark have hypotensive activity and are simultaneously local anaesthetic and spasmolytic, but they are also cardiotoxic. Triacanthine also has hypotensive activity, but is also cardiotonic, antispasmodic and a respiratory analeptic. In addition, triacanthine stimulates the development of mature red blood cells and acts on experimental anaemia in rabbits. Many of the pregnane derivatives can be used as a starting material for the partial synthesis of pharmaceutical steroids, such as adrenocortical hormones (corticosteroids) and sex hormones (e.g. oestrogens, progestrogens and androgens). Holamine, holaphyllamine and holaphylline show significant anti-inflammatory properties. They cause sodium retention and act as a diuretic in rats. Aqueous extracts of the root bark, stem bark or leaves have relatively low toxicity. A stem bark extract showed significant activity in vitro against several human tumour cell lines. Different extracts of the stem bark have shown significant inhibitory activity against drug-resistant strains of *Plasmodium falciparum* in vitro. Lupeol long-chain fatty acid esters were isolated as some of the active compounds. Conessine was found to possess a wide range of disruptive activities against 4 insect species, and showed potential as a larval growth inhibitor, sterilant and antifeedant in laboratory tests.

Callus cultures from *Holarrhena floribunda* tissue produce alkaloids including conessine. Callus derived from root tissue was richer in alkaloids than that derived from stem tissue. Colchicine had a marked positive effect on conessine production.

The wood is soft and white with no distinction between sapwood and heartwood. It works well, is easy to nail, but is perishable and not resistant to termites.

Description Shrub or small to medium-sized tree up to 25 m tall, with abundant white latex in all parts; bole up to 30 cm in diameter; bark in young trees nearly smooth, later corky, pale grey to dark brown. Leaves opposite, simple and entire; stipules obscure; petiole up to 1 cm long, shortly hairy, glandular at base; blade ovate to elliptical, 2–14(–20) cm × 2.5–8(–11) cm, base cuneate to rounded, apex acuminate to acute, shortly hairy to glabrous, pinnately veined with 5–14 pairs of lateral veins. Inflorescence a seemingly axillary cyme, dense and many-flowered; peduncle 0.5–1.5 cm long; bracts linear, 1–2 mm long, shortly hairy. Flowers bisexual, regular, 5-merous, fragrant;



Holarrhena floribunda – 1, flowering branch; 2, part of fruit, one follicle removed; 3, seed. Redrawn and adapted by Iskak Syamsudin

pedicel 0.5–1 mm long; sepals elliptical, 1–4.5 mm long, free or fused at base, shortly hairy; corolla tube cylindrical, 6.5–9 mm × 0.5–1.5 mm, shortly hairy outside and inside from the throat to the insertion of the stamens, lobes elliptical, 7–11.5 mm × 2–3.5 mm, spreading to recurved, shortly hairy to glabrous, white; stamens inserted 2–3 mm from the corolla base, included; ovary superior, ovoid, consisting of 2 carpels connate at extreme base, style cylindrical, c. 2 mm long, pistil head ovoid, stigma 2-lobed. Fruit composed of 2 long and slender follicles 30–60 cm × 5–7 mm, pendulous, dehiscent, pale grey to dark brown, many-seeded. Seeds narrowly oblong, 11–16 mm long, grooved, glabrous, with a dense tuft of 4–6 cm long hairs at apex. Seedling with epigeal germination; cotyledons 2.5–3 mm long.

Other botanical information *Holarrhena* comprises 4 species, 2 of which occur in tropical Africa (one of these also in Asia) and 2 of which are restricted to tropical Asia. *Holarrhena floribunda* and *Holarrhena pubescens* Wall. ex G.Don differ in flower size and fruit size, the flowers of *Holarrhena floribunda* being smaller and its fruits larger. The distribution areas of the two species only overlap in eastern DR Congo. *Holarrhena congolensis* Stapf from western DR Congo and Cabinda (Angola) is considered a hybrid between *Holarrhena pubescens*, introduced from Mozambique, and *Holarrhena floribunda*.

Anatomy Wood-anatomical description (IAWA hardwood codes):
Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; (7: vessels in diagonal and/or radial pattern); (10: vessels in radial multiples of 4 or more common); 13: simple perforation plates; 22: intervessel pits alternate; (23: shape of alternate pits polygonal); 24: intervessel pits minute (≤ 4 µm); 25: intervessel pits small (4–7 µm); 29: vestured pits; 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 41: mean tangential diameter of vessel lumina 50–100 µm; 48: 20–40 vessels per square millimetre. Tracheids and fibres: (61: fibres with simple to minutely bordered pits); 62: fibres with distinctly bordered pits; 66: non-septate fibres present; 69: fibres thin- to thick-walled. Axial parenchyma: 76: axial parenchyma diffuse; 77: axial parenchyma diffuse-in-aggregates; 92: four (3–4) cells per parenchyma strand; 93: eight (5–8) cells per parenchyma strand. Rays: 97: ray width 1–3 cells; (106: body ray cells procumbent with one row of upright and/or square marginal cells); 107: body ray cells procumbent with mostly 2–4 rows of upright and/or square marginal cells; 108: body ray cells procumbent with over 4 rows of upright and/or square marginal cells; 115: 4–12 rays per mm. Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells.
(M. Thiam, P. Détienne & E.A. Wheeler)

Growth and development *Holarrhena floribunda* may become a tree under humid conditions, but remains a bushy shrub in savanna on lateritic soils. It sheds its leaves at the end of the dry season and new leaves appear at the beginning of the rainy season. The flowers appear shortly after the leaves; the flowering period is short. Fruits mature a few months after flowering, but do not dehisce until 3–4 months later. *Holarrhena floribunda* coppices well and can survive bush fires by producing suckers from burned-down stumps.

Ecology *Holarrhena floribunda* occurs in deciduous forest, open localities in dense forest, woodland and savanna, on clay, sand, lateritic soils or rocky outcrops, from sea-level up to 1000 m altitude.

Propagation and planting *Holarrhena floribunda* is easily propagated by seed, suckers or small-diameter cuttings. Fresh seed has a high germination rate, but loses its viability after having been stored for a year.

Management Former cultivation attempts of *Holarrhena floribunda* in Burkina Faso involved transplantation of plantlets taken from natural populations, but 50% failure occurred because the roots had difficulty piercing the locally present lateritic hardpan. Good results have been obtained with nursery-grown plants planted out at a spacing of 3 m × 3 m in a soil without laterite, preferably with mulching. Shade should be avoided.

Diseases and pests In Nigeria larvae of the Saturniid butterflies *Imbrasia epimethea* and *Bunaea alcinoe* seriously defoliate *Holarrhena floribunda*. They are both eaten in DR Congo.

Harvesting Populations of *Holarrhena floribunda* in Burkina Faso are extensively harvested for their stem bark. The root bark is difficult to harvest in the hard lateritic soils; therefore harvesting stem bark is preferred, despite its lower conessine content. The stem bark is harvested by coppicing or peeling. Stems of less than 0.5 cm diameter have a low alkaloid content and should be discarded. In case of peeling, bark pieces are vertically

stripped from trunks, taking care not to ring the tree and damage the vascular system.

Yield Bushy shrubs on hard, poor soils contain the highest levels of conessine. The conessine content of the stem bark and leaves increases as a function of the stem diameter. The yield of a 5-year-old plantation was estimated at 975 kg/ha of stem bark and 7.8 kg/ha of conessine. The maximum content is attained at 8–12 years.

Handling after harvest The bark of *Holarrhena floribunda* is dried for later use or trade. Debarked wood can serve as firewood.

Genetic resources In the relatively dry West African countries, the bark of *Holarrhena floribunda* is overharvested and the species has become endangered. In the forest zone, it is still widespread and common, and not at risk of genetic erosion.

Prospects The steroid alkaloids of *Holarrhena* spp. might be usable as starting material for the partial synthesis of steroids of pharmaceutical interest, and thus deserve further attention. There is an urgent need to domesticate *Holarrhena floribunda* or at least develop sustainable harvesting methods of the bark in the Sahel zone to protect the species from local extinction.

Major references Abreu et al., 1999; Burkill, 1985; de Kruif, 1981; Fotie et al., 2006; Lévy et al., 1990; Neuwinger, 2000; Oliver-Bever, 1986; Tamboura et al., 2005; World Agroforestry Centre, undated.

Other references Adjanohoun & Aké Assi, 1979; Akpalu, 1998; Arbonnier, 2002; Bisset, 1981; Bouillard, 1987; Chukwurah, 1997; Fortin, Lô & Maynart, 1990; Guissou, Millogo-Koné & Kaboré, 1992; Herzog, 1994; Inside-Wood, undated; Kossou, 1992; Latham, 2004; Sourabie, Kabore & Guissou, 1994; Tamboura et al., 2004; Wongsatit Chuakul, Noppamas Soonthornchareonnon & Promjit Saralamp, 1999b.

Sources of illustration de Kruif, 1981.

Authors G.H. Schmelzer

HOLARRHENA PUBESCENS Wall. ex G.Don

Protologue Gen. hist. 4: 78 (1837).

Family Apocynaceae

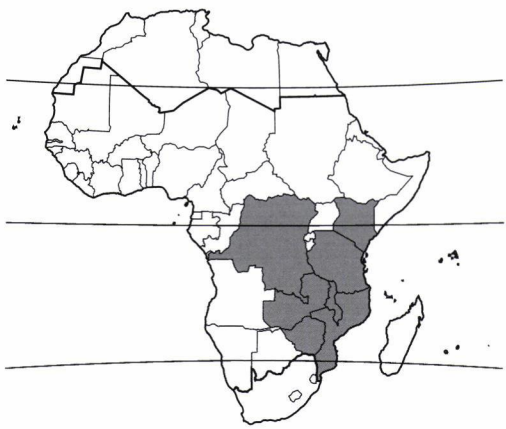
Chromosome number $2n = 22$

Synonyms *Holarrhena antidysenterica* (L.) Wall. ex A.DC. (1844) p.p., *Holarrhena febrifuga* Klotzsch (1862).

Vernacular names Conessi, fever pod, holarrhena, kurchi bark, tellichery bark (En). Ecorce de conessie (Fr). Quina, erva do Malabar (Po). Mti mweupe, mkwale (Sw).

Origin and geographic distribution *Holarrhena pubescens* is indigenous in the eastern part of tropical Africa and in tropical Asia (from India to Vietnam). In Africa, it occurs from eastern DR Congo and Kenya south to northern South Africa. It is planted in botanical gardens in Africa, India and the Indian Ocean Islands.

Uses The stem bark and root bark of *Holarrhena pubescens* are used throughout its distribution area in the treatment of amoebic dysentery. The stem bark is listed in the Pharmacopoeia of India. Although slow in action compared with emetine, it is less toxic and can be administered orally. The bark has astringent, anthelminthic, stomachic, febrifugal and tonic properties. In Kenya the pounded leaves in water are taken to cure stomach-ache. An infusion of the roots is furthermore taken to stimulate milk production. In southern Africa an infusion of the powdered root is taken to treat constipation, asthma, abdominal pains and infertility. It is also taken as an abortifacient and aphrodisiac. The root boiled in milk is applied against snakebites and is used in the treatment of venereal diseases. A hot decoction of the stem bark is used as a gargle to treat toothache. Juice from the fruit is taken to treat cough. In India the bark and leaves are externally applied to cure scabies, boils, ulcers and haemorrhoids. A powder prepared from the roots and leaves is administered to stop haemorrhages after childbirth and nose bleeding. The oil from the seeds is considered to possess similar properties as the bark.



Holarrhena pubescens – wild

The wood is popular for turning and carving. It is used to make small articles such as combs, picture frames, carved boxes, toys, spoons, knives, walking sticks and beads, and sometimes for furniture and ploughs. It has been used to make paper. *Holarrhena pubescens* may prove useful for the reforestation of deforested land in comparatively dry regions, also because it is not readily browsed even by goats. A dye similar to henna is extracted from the leaves, while the wood ash is used as a mordant. The floss from the seeds is used for stuffing pillows. *Holarrhena pubescens* is also cultivated in India as an ornamental for its attractive flowers.

Production and international trade Although *Holarrhena pubescens* has been known as a medicinal plant since historic times, data on its production and international trade are scarce. It is mainly grown or collected for domestic or local use, and the root bark is sold in local markets for medicinal purposes, e.g. in Zimbabwe and South Africa. There is some trade through internet, mainly from India.

Properties The stem bark, root bark and seeds of *Holarrhena pubescens* yield more than 40 alkaloids. The highest concentration is found in the stem bark and root bark, up to 4.3%, but only 0.4% has been reported for flowering plants. The leaves contain 1–1.5% and the seeds 0.6–1.8%. According to the Pharmacopoeia of India, the bark should contain about 2% alkaloids. Most of the alkaloids of the stem bark and root bark are steroid alkaloids derived from conanine or the closely related conamine, which also occur in other *Holarrhena* species. The main alkaloid of the stem bark and root bark is conessine; other compounds are norconessine (kurchine), conessimine, kurchamine, kurchessine, kurcholessine, conimine, conamine and holarrhenine. The leaves contain mainly steroid alkaloids derived from pregnane, such as holarrhimine, holaphyllamine, holamine and holaphylline, as well as the alkaloid triacanthine (an adenine derivative). Various amino-glycosteroids are also present in the leaves. These substances contain an amino-sugar and in some of them, e.g. holarosine and holacurtine, the steroidal part of the molecule is a cardenolide. The seeds contain conessine, norconessine, conamine and conarrhimine.

Conessine has sedative, central nervous system depressant, cardiac depressant, antipyretic and analgesic activities. It also has significant antiamoebic activity, but it needs to be used with caution because it can produce neurological problems such as vertigo, tremors, insomnia, agitation or anxiety. Conessine also shows antibacterial and antifungal activities against a range of human pathogens in vitro. Several other steroidal alkaloids also show antibacterial and antifungal activities. The steroid alkaloids present in the stem bark and root bark have hypotensive activity and are simultaneously local anaesthetic and spasmolytic, but they are also cardiotoxic. Triacanthine also has hypotensive activity, but is also cardiotonic, antispasmodic and a respiratory analeptic. In addition, triacanthine stimulates the development of mature red blood cells and acts on experimental anaemia in rabbits. Many of the pregnane derivatives can be used as a starting material for the partial synthesis of pharmaceutical steroids, such as adrenocortical hormones (corticosteroids) and sex hormones (e.g. oestrogens, progestrogens and androgens). Holamine, holaphyllamine and holaphylline show significant anti-inflammatory properties. Aqueous extracts of the root bark, stem bark or leaves have relatively low toxicity. The alcoholic extract of the fruit showed anticancer activity against human epidermoid carcinoma of the nasopharynx in tissue culture. The aqueous extract of the fruits exhibited hypoglycaemic effects in rats.

Different extracts of *Holarrhena pubescens* seed or bark showed significant antibacterial and antifungal activities against a wide range of human pathogens, including several antibiotic-resistant strains. The bark extract also shows antiplasmodial activity. A stem bark decoction showed anti-ulcerogenic effects in different models of gastroduodenal ulcers in rats. It also showed antimicrobial activity against enterohaemorrhagic *Escherichia coli* strains. Conessine was found to possess a wide range of disruptive activities against 4 insect species, and showed potential as a larval growth inhibitor, sterilant and antifeedant in laboratory tests.

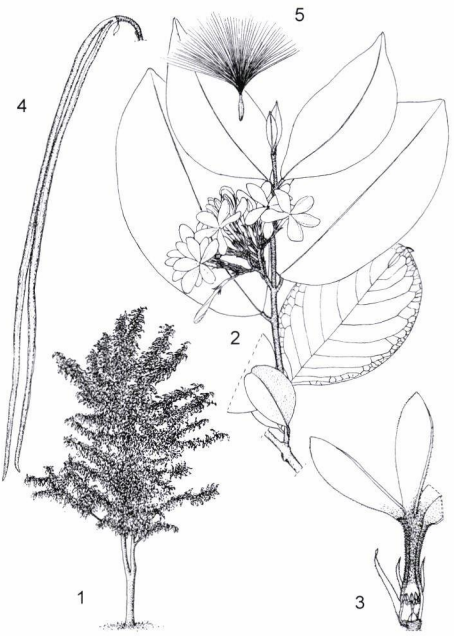
Callus cultures of *Holarrhena pubescens* yielded a maximum of 300 mg alkaloids per 100 g dry cells in 40 days; a suspension culture reached 130 mg per 100 g dry cells in 8 days. The alkaloid production can be boosted by adding cholesterol as a precursor. About 90% of the total alkaloids produced in the cell cultures were conessine. In later experiments, also aminopregnane and other conanine type alkaloids were obtained.

The wood of *Holarrhena pubescens* is moder-

ately soft and white, with straight grain and fine and even texture; there is no distinction between sapwood and heartwood. The wood turns yellowish or pinkish with age. The timber seasons well and develops few end splits and surface cracks with little tendency to warping, but is liable to damage by insects. Air drying as log reduces surface cracking, whereas kiln drying improves the colour of the timber and reduces liability to insect attack. The wood is easy to saw and machine and fairly durable under cover.

Adulterations and substitutes In India the seeds or bark of *Holarrhena pubescens* are sometimes adulterated with those of *Wrightia tinctoria* R.Br., which do not have the same medicinal properties, although both show antibacterial activity. The seeds of *Holarrhena pubescens* are intensely bitter, while those of *Wrightia tinctoria* are tasteless. The stem bark of *Funtumia africana* (Benth.) Stapf also contains steroid alkaloids of the conanine-type, with similar pharmacological activities as extracts of the stem bark of *Holarrhena pubescens*.

Description Shrub or small tree up to 9(–18) m tall, with abundant white latex in all parts; bole up to 25 cm in diameter; bark in young trees nearly smooth, later corky, longitudinally fissured, pale to dark grey; branchlets shortly hairy. Leaves opposite, simple and entire; stipules obscure; petiole up to 1 cm long, shortly hairy, glandular at base; blade almost circular to ovate or elliptical, 1.5–20 cm × 1.5–11 cm, base cuneate to rounded, apex acuminate to acute, shortly hairy to glabrous, pinnately veined with 5–25 pairs of lateral veins. Inflorescence a seemingly axillary cyme, rather lax, many-flowered; peduncle 1–1.5 cm long, shortly hairy; bracts linear, 1–2 mm long, shortly hairy. Flowers bisexual, regular, 5-merous, fragrant; pedicel 0.5–1 mm long; sepals elliptical to linear, 2–12 mm long, free or fused at base, shortly hairy; corolla tube cylindrical, 9–19 mm × 0.5–2 mm, shortly hairy outside and inside from the throat to the insertion of the stamens, lobes elliptical, 10–24(–30) mm × 3–8 mm, spreading to recurved, shortly hairy to glabrous, white; stamens inserted 1.5–2.5 mm from the corolla base, included; ovary superior, ovoid, consisting of 2 carpels connate at extreme base, style cylindrical, c. 1 mm long, pistil head ovoid, stigma 2-lobed. Fruit composed of 2 long and slender follicles 20–38 cm × 2–9 mm, pendulous, dehiscent, pale grey to dark brown, many-seeded. Seeds narrowly oblong, 9–16 mm long, grooved, glabrous, with a dense tuft of 2.5–4.5 cm long hairs at apex. Seedling with epigeal germination; cotyledons 2–3 mm long.



Holarrhena pubescens – 1, tree habit; 2, flowering twig; 3, opened flower; 4, fruit; 5, seed. Source: PROSEA

Other botanical information *Holarrhena* comprises 4 species, 2 of which occur in tropical Africa (one of these also in Asia) and 2 of which are restricted to tropical Asia. *Holarrhena pubescens* and *Holarrhena floribunda* (G.Don) T.Durand & Schinz differ in flower size and fruit size, the flowers of *Holarrhena pubescens* being larger and its fruits smaller. The distribution areas of the two species only overlap in eastern DR Congo. *Holarrhena congolensis* Stapf from western DR Congo and Cabinda (Angola) is considered a hybrid between *Holarrhena pubescens*, introduced from Mozambique, and *Holarrhena floribunda*.

Growth and development *Holarrhena pubescens* sheds its leaves at the end of the dry season and new leaves appear at the beginning of the rainy season. The flowers appear shortly after the leaves; the flowering period is short. Fruits mature a few months after flowering, but do not dehisce until 3–4 months later. *Holarrhena pubescens* coppices well and can survive bush fires by producing sucker shoots

from burned-down stumps. Juvenile plants are more susceptible to damage by fire than older ones. Though sensitive to frost, the plant recovers easily from damage. It can stand slight shade but develops best in full light and it is drought-hardy. Natural reproduction is abundant owing to regular and copious seeding from an early age, comparative immunity of the plant to damage by animals and its power of recovery from injury. Seeds, that are dispersed by wind germinate during the early rains, and seedlings attain 10–15 cm by the end of the first year. In subsequent years, growth is more rapid, the mean annual diameter increment being 7–8 mm. In India, early height increment of *Holarrhena pubescens* is low, only 10–15 cm/year under natural conditions.

Ecology *Holarrhena pubescens* occurs in dry evergreen to dry deciduous forest, scrub woodland, savanna, or in rocky localities, often near watercourses, up to 1500 m altitude. It is a pioneer species that quickly invades open spaces.

Propagation and planting *Holarrhena pubescens* can be propagated by seed, either by direct sowing or by raising seedlings in a nursery. Fresh seeds have a high percentage of germination, but in seeds more than one year old the viability is low. There are 32,000–35,000 seeds/kg. The seed usually germinates in 2–3 weeks. In India the species is successfully intercropped with field crops.
Tissue culture of *Holarrhena pubescens* through nodal and shoot-segment explants has been successful.

Management As far as is known, *Holarrhena pubescens* is not cultivated on a large scale. In India it is used in reclaiming wasteland. Weeding, periodic thinning and loosening of soil are beneficial. Established plants are fast growing and require little or no management. For ornamental purposes shrubs are pruned to improve their appearance. To maintain vigorous growth, pruning should start as early as 12 months after planting and should be repeated at least once a year. The degree of pruning depends on the management objectives: severe pruning favours stem diameter growth and bark production; denser stands are needed for rapid leaf production.

Harvesting Stem bark, root bark, leaves and seeds are collected for medicinal purposes from the wild. The root bark and stem bark are also harvested from cultivated trees. The stem bark is mainly collected from 8–12 year-old trees. The alkaloid content varies with the age of the tree and the season.

Handling after harvest The bark needs to be freed from attached wood, and is cut into small pieces of 1–6 cm long and 1–7 mm thick. The dried stem bark and root bark should be stored in dry, well-closed containers.

Genetic resources *Holarrhena pubescens* is widely distributed in tropical Africa and continental Asia and is found in open anthropogenic habitats. Therefore the risk of genetic erosion seems limited.

Prospects *Holarrhena pubescens* is an important medicinal plant in the tropics. Its steroid alkaloids may be useful for synthesis of pharmaceutical products. Conessine is a possibly valuable alternative for well-known drugs like emetine in the treatment of amoebic dysentery. Outside India there is no commercial production, and this deserves more attention, given the easy propagation and management of *Holarrhena pubescens*. Development of sustainable collection methods is recommended and the possibilities for using leaves or seed instead of stem and root bark deserve investigation.

Major references de Kruif, 1981; Jolly & Mechery, 1996; Kaul & Atal, 1983; Kumar, Sharma & Agrawal, 2005; Neuwinger, 2000; Raha & Roy, 2001; Williamson, 1955; Wongsatit Chuakul, Noppamas Soonthornchareonnon & Promjit Saralamp, 1999b.

Other references Aqil et al., 2005; Begum et al., 1994; Bhutani et al., 1990; Bisset, 1981; Chakraborty & Brantner, 1999; Coates Palgrave, 1983; Endress et al., 1990; Gelfand et al., 1985; Jayaswal, 1977; Kavitha, Shilpa & Devaraj, 2003; Khan, 1987; Kokwaro, 1993; Omino & Kokwaro, 1993; Omino, 1996; Panda et al., 1991; Panda, Mishra & Bisaria, 1992; Raha & Roy, 2003; Raman, Sultana & Anwar, 2004; Rani & Khullar, 2004; Simonsen et al., 2001.

Sources of illustration Wongsatit Chuakul, Noppamas Soonthornchareonnon & Promjit Saralamp, 1999b.

Authors A. Maroyi

HUNTERIA CONGOLANA Pichon

Protologue Bot. Soc. Brot. sér. 2, 27: 101 (1953).

Family Apocynaceae

Origin and geographic distribution *Hunteria congolana* occurs in DR Congo and Kenya.

Uses In DR Congo and Kenya a decoction or

infusion of the bark of *Hunteria congolana* is taken as an anthelmintic and to treat fever, stomach-ache and diarrhoea. The seeds are taken for the same purposes. A root decoction, mixed with parts of other plant species, is used in DR Congo to make arrow poison.

Properties Some 23 indole alkaloids have been isolated from *Hunteria congolana*. Eburnamonine (synonyms: vinburnine, vincamone) from the roots and akuammicine and pseudoakuammigine from the seeds have an effect on the vasomotor and respiratory centres of the brain. In tests with rodents and cats oral application gave an increased tonus, increased blood pressure and in some cases strong muscular contractions and even death. Low doses may result in an increase of arterial blood pressure. These activities are comparable to those of strychnine. Pseudoakuammigine is an indirect, reversible and competitive parasympathomimetic.

Botany Shrub or small to medium-sized tree up to 20 m tall, with milky to yellow latex in all parts; bole sinuous or straight, up to 30 cm in diameter, fluted. Leaves opposite, simple and entire; stipules absent; petiole 1–2 cm long; blade elliptical to oblong, up to 18.5 cm × 6 cm, acute to obtuse at base, acuminate at apex, glabrous, pinnately veined. Inflorescence a terminal or axillary cyme 3–3.5 cm long, 7–18(–45)-flowered; peduncle up to 1.5 cm long. Flowers bisexual, regular, 5-merous; pedicel 2–5 mm long; sepals almost free, erect, ovate, 1–1.5 mm long; corolla white or yellow, creamy pink in bud, tube cylindrical, c. 5 mm long, lobes narrowly ovate to oblong, 4–8 mm long; stamens inserted in the upper part of the corolla tube just above a belt of hairs; ovary superior, composed of 2 separate carpels, gradually narrowing into the style. Fruit consisting of 2 separate ellipsoid to globose indehiscent mericarps, somewhat flattened, 2–2.5 cm long, yellow to bright orange, smooth, dull, 1–3-seeded. Seeds ovoid to ellipsoid, 7–15 mm long; cotyledons thin, leafy.

Hunteria comprises 12 species, which all occur in Africa. *Hunteria congolana*, *Hunteria umbellata* (K.Schum.) Hall.f. and *Picralima nitida* (Stapf) T.Durand & H.Durand are confused in the literature. *Hunteria congolana* flowers and fruits throughout the year.

Ecology *Hunteria congolana* occurs in the understorey of primary forest, rarely in secondary forest and gallery forests, at 500–1700 m altitude.

Genetic resources and breeding In DR Congo *Hunteria congolana* is fairly widespread and it does not appear to be threatened. In Kenya it has been collected only twice on Mount Kulal. The status of the Kenyan population is uncertain but deserves in situ and ex situ conservation.

Prospects *Hunteria congolana*, other *Hunteria* spp. and also the closely related *Picralima nitida* deserve more attention from researchers because of the interesting pharmacological activities. Careful distinction of the different species is necessary, as the number and type of alkaloids within each species only partly overlaps with others.

Major references Burkill, 1985; Burkill, 2000; Neuwinger, 1998; Omino, 1996.

Other references Neuwinger, 2000; Omino, 2002; Terashima & Ichikawa, 2003.

Authors M.J. Boone

HUNTERIA UMBELLATA (K.Schum.) Hallier f.

Protologue Jahrb. Hamburg. Wiss. Anst. Beih. 17(3): 190 (1900).

Family Apocynaceae

Chromosome number $2n = 22$

Synonyms *Picralima elliotii* (Stapf) Stapf (1908), *Hunteria eburnea* Pichon (1953), *Hunteria elliotii* (Stapf) Pichon (1953), *Hunteria mayumbensis* Pichon (1953).

Vernacular names Demouain (Fr).

Origin and geographic distribution *Hunteria umbellata* occurs throughout West and Central Africa, east to central DR Congo, and south to Cabinda (Angola).

Uses In Sierra Leone the bark of *Hunteria umbellata* is made into a bitter tonic and used as a stomachic and as a lotion to treat fever. A fresh root-bark extract is applied in Côte d'Ivoire to sores caused by leprosy. This medication is highly toxic and fatalities have been recorded. Fruits are toxic and are used for criminal purposes. The fruit is rich in latex that is an ingredient of arrow poison in Côte d'Ivoire. In Ghana and Nigeria the root and stem bark are used as an anthelmintic, especially against guinea worm, filaria worms and schistosomiases (causing bilharzia). Aqueous and alcoholic extracts of the seeds are used as a cure for piles, yaws, diabetes and stomach ulcers in Nigeria. The bark and the root are used as a bitter tonic in Nigeria, and powdered root and root decoctions are used to prevent miscarriage and to treat menorrhagia. In Cameroon a bark or fruit decoction is taken to treat

stomach-ache, liver problems and hernia. The plant is also used in the treatment of geriatric problems. *Hunteria umbellata* extracts are used in Germany for phytotherapeutic purposes, to reduce the heart rate, as an aphrodisiac, to decrease blood pressure and reduce blood lipid content.

The creamy to yellowish brown, hard wood is locally used for carving, making combs, spoons, tool handles, police batons, carpenter planes, weaving shuttles and other small articles. In Nigeria forked stems are used as house posts and are considered very durable and immune to termites. In Côte d'Ivoire the wood is used as firewood.

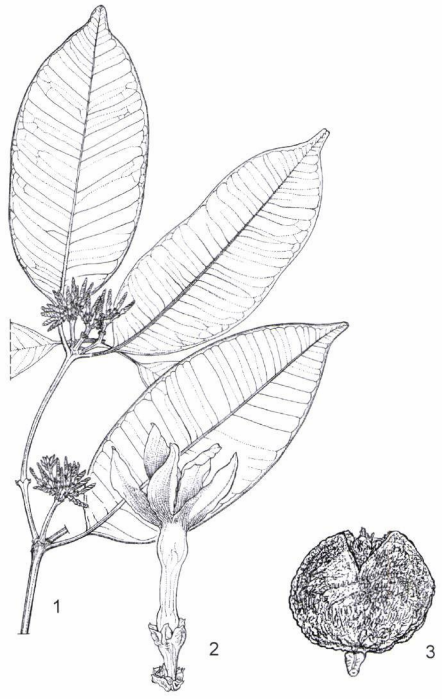
Production and international trade In Ghana the bark of *Hunteria umbellata* is harvested and is exported for medicinal use, but quantities are unknown. The major destination seems to be Germany.

Properties Some 20 indole alkaloids have been isolated from *Hunteria umbellata*, most occurring in the stem bark and root bark. Alkaloids that have shown pharmacological activity are eburnamine, eburnamonine (synonyms: vinburnine, vincamone), hunteriamine, hunterine, vincamine and corymine. Eburnamonine, eburnamine and hunterine show cardio-vascular properties, some symphathomimetic properties and a strong and lasting hypotensive action. Eburnamonine has the same pharmacological effect as strychnine and is useful as a cerebrovascular agent. This alkaloid is abundantly present in the seeds and is a stimulant of the central nervous system, and seems to have a positive effect on the general blood circulation. Vincamine exhibits significant activity as an anti-hypertensive and sedative agent. Research supports the traditional use of seed extracts in Nigeria for treatment of diabetes, as it increases the activity of glucokinase and lowers blood glucose levels in alloxan diabetic rabbits. Hunteriamine showed hypotension of short duration in dogs and cats.

Aqueous and methanolic extracts of the leaves, seeds and stem bark have shown significant anthelmintic activity against earthworms. The methanolic extract of the stem bark has the highest activity. Tests with leaf extracts have shown molluscicidal action on the freshwater snail *Bulinus globulus*.

The wood is very hard, fine grained, creamy, brown to yellow or orange.

Botany Shrub or small tree up to 15(–22) m tall, with colourless or milky latex in all parts; bole sinuous or straight, up to 40 cm in diameter, fluted; outer bark 1 mm thick, rough or smooth, grey to dirty brown; crown dense. Leaves opposite, simple and entire; stipules absent; petiole 1–2.5 cm long; blade elliptical to oblong, up to 22.5 cm × 11 cm, cuneate to obtuse at base, obtuse to acuminate at apex, glabrous, leathery, pinnately veined. Inflorescence a terminal, rarely axillary, dense to lax cyme, 10–20(–80)-flowered; peduncle up to 1.5 cm long. Flowers bisexual, regular, 5-merous, fragrant; pedicel 3–7 mm long; sepals almost free, broadly ovate to triangular, 0.5–2 mm long, erect and stuck to the corolla tube with thick resinous substance; corolla white, creamy or pale yellow, with cylindrical tube 4–8 mm long, lobes 6–12 mm long, twisted in bud, with a belt of hairs inside the tube just below the insertion of the stamens; stamens inserted in the upper part of the corolla tube; ovary superior, composed of 2 separate carpels, abruptly narrowing into the style, terminating in a stigmatic ellipsoid basal part and a 2-lobed apex. Fruit consisting of 2 separate globose mericarps 3–6 cm long, yellow, smooth, 8–25-seeded. Seeds oblong to ellipsoid, 1–1.5 cm long, flattened at



Hunteria umbellata – 1, flowering twig; 2, flower; 3, part of fruit.
Source: Flore analytique du Bénin

one side.

Hunteria comprises 12 species, which all occur in Africa. In Ghana the bark of *Hunteria ghanensis* J.B.Hall & Leeuwenb., which occurs in Côte d'Ivoire and Ghana, is mixed with some other species and taken as a stomachic and to treat difficulties with urination. It is confined in the south of Ghana to extremely dry forest, where the expansion of agriculture has caused severe decline of the habitat. Therefore, it qualifies as 'endangered' on the IUCN Red List. *Hunteria ballayi* Hua occurs in Central Africa (Cameroon, Central African Republic, Gabon and Congo). Women swallow the seed together with the sweet mesocarp as a fertility drug. *Hunteria simii* (Stapf) H.Huber is distributed in West Africa (Guinea, Sierra Leone, Liberia and Côte d'Ivoire). The hard, yellow wood is used to make small objects in Côte d'Ivoire. No records have been found on medicinal use. *Hunteria umbellata*, *Hunteria congolana* Pichon and *Picralima nitida* (Stapf) T.Durand. & H.Durand have been confused in the literature. *Hunteria umbellata* flowers and fruits all year round.

Ecology *Hunteria umbellata* occurs in rain forest and gallery forest, also in secondary forest,up to 600 m altitude.

Genetic resources and breeding *Hunteria umbellata* is considered a threatened species in Ghana and Nigeria.

Prospects Many alkaloids have been isolated from *Hunteria umbellata*, but little is known about the pharmacological activities of most of them. Some alkaloids show promising cerebrovascular and cardiovascular activities, which merit further research. As the habitat of *Hunteria umbellata* is disappearing fast, it is necessary to investigate possibilities for protecting it.

Major references Burkill, 1985; Dalziel, 1937; Neuwinger, 2000; Oliver-Bever, 1986; Omino, 1996.

Other references Adegoke & Alo, 1986; Bouquet & Debray, 1974; Burkill, 2000; Endress et al., 1996; Herzog, 1994; Oluwemimo & Usifoh, 2001; Raman & Mallam, 1994; Renner, 1963; Vercauteren et al., 1980.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors M.J. Boone

HUNTERIA ZEYLANICA (Retz.) Gardner ex Thwaites

Protologue Enum. pl. zeyl. 3: 191 (1860).

Family Apocynaceae

Chromosome number $2n = 22$

Synonyms *Hunteria corymbosa* Roxb. (1824).

Vernacular names Mziwaziwa (Sw).

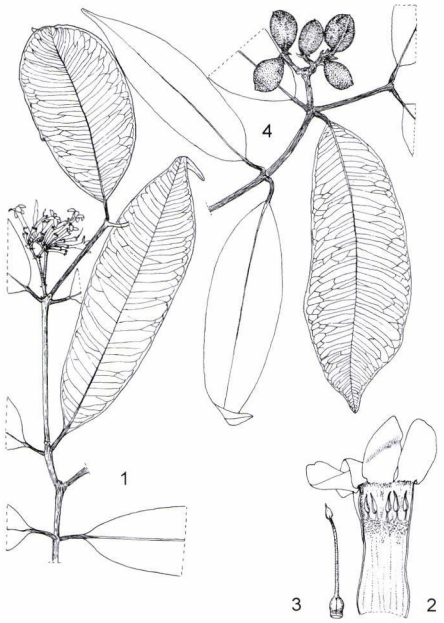
Origin and geographic distribution *Hunteria zeylanica* is widely distributed in eastern Africa, from southern Somalia to Mozambique, and in tropical Asia.

Uses In Kenya a leaf decoction of *Hunteria zeylanica* is drunk to cure stomach-ache. Pounded leaves mixed with water are given as a galactagogue to cows.

The hard, whitish to yellowish wood is used for handles of knives, swords or axes, combs, boxes, sheaths and bows, and as firewood. The latex is used as a substitute for rubber. The tree is used as an ornamental because of its dark green shiny leaves and sweet-scented white flowers.

Properties Over 20 indole alkaloids have been isolated from *Hunteria zeylanica*. The alkaloid corymine was extracted from the leaves. This compound aggravated convulsions induced by either picrotoxin or strychnine. In tests with mice, a crude methanol extract of the leaves produced biphasic effects on the central nervous system, depression and stimulation, whereas corymine only had a stimulatory effect. A stem bark extract showed anti-inflammatory activity in mice, and an inhibitory effect on 5-lipoxygenase activity in vitro, but neither (–)-eburnamine nor pleiomutinine, major constituents of the alkaloid extract, were responsible for these activities. This extract also exhibited antinociceptive and antipyretic effects in mice and rats; the former effect may be mediated by the anti-inflammatory action. The results of tests with mice suggest that a stem bark extract has peripheral analgesic and mild antipyretic effects, with strictosidinic acid as the major active constituent.

Botany Evergreen shrub or small to fairly large tree up to 15 m tall, with colourless or milky latex in all parts; bole sinuous or straight, up to 30 cm in diameter, fluted; bark smooth or slightly fissured, grey, inner bark bright orange. Leaves opposite, simple and entire; stipules absent; petiole 1–1.5 cm long; blade elliptical to oblong or obovate, up to 21 cm × 7 cm, cuneate to rounded at base, rounded to acuminate at apex, leathery, gla-



Hunteria zeylanica – 1, flowering branch; 2, opened corolla; 3, pistil; 4, fruiting branch. Source: PROSEA

brous, pinnately veined. Inflorescence a terminal, compound, dichasial cyme, many-flowered; peduncle 1–4 cm long. Flowers bisexual, regular, 5-merous, fragrant; pedicel 4–10 mm long; sepals free, 1–2.5 mm long, with colleters inside, ovate to triangular or elliptical, obtuse to shortly acuminate at apex; corolla white to pale yellow, with almost cylindrical tube 6–10 mm long, pubescent inside below the stamens, lobes twisted in bud; stamens inserted in upper part of corolla tube, filaments short; ovary superior, composed of 2 separate carpels united at the extreme base by a disk-like thickening, style up to 7 mm long, terminating in a stigmatic globose basal part and a stigmoid apex. Fruit composed of 2 separate, obovoid to globose mericarps up to 3 cm long, stiped at base, yellow or orange, smooth, usually 2-seeded. Seeds oblong to ellipsoid, 1–1.5 cm long, smooth, orange; cotyledons thin, leafy.

Hunteria zeylanica flowers in January–February in Mozambique, in September–January in Kenya and all year round in Tanzania.

Hunteria comprises 12 species, which all occur in Africa. Only *Hunteria zeylanica* extends to tropical Asia. *Hunteria* is related to *Pleiocarpa* and *Picralima*.

Ecology *Hunteria zeylanica* occurs in dry coastal forest, mixed evergreen forest, gallery forest and wooded bushland. Along the coast it grows on sandy soil or coral rock, but it is also found on sandy gravelly soils along rivers inland, up to 350 m altitude. The trees can withstand waterlogging and salinity.

Genetic resources and breeding *Hunteria zeylanica* is locally common but restricted in its range in Africa and may therefore be threatened. There are no known accessions in genebanks.

Prospects The results of pharmacological research, mainly from Thailand, show several interesting activities of *Hunteria zeylanica* extracts: anti-inflammatory, analgesic and antipyretic activities. These warrant more investigation towards the possible development of *Hunteria zeylanica* as a medicinal plant of importance.

Major references Leeuwenberg et al., 1985; Omino, 1996; Omino, 2002; Sriana Azis, 2003.

Other references Endress et al., 1996; Kokwaro, 1993; Leewanich et al., 1996; Leewanich et al., 1997; Neuwinger, 1998; Omino & Kokwaro, 1993; Reanmongkol et al., 1995a; Reanmongkol et al., 1995b; Reanmongkol et al., 2000.

Sources of illustration Sriana Azis, 2003.

Authors M.J. Boone

Based on PROSEA 12(3): Medicinal and poisonous plants 3.

HYMENOCARDIA ACIDA Tul.

Protologue Ann. Sci. Nat., Bot. sér. 3, 15: 256 (1851).

Family Euphorbiaceae (APG: Phyllanthaceae)

Chromosome number $n = 13$

Vernacular names Heart-fruit (En). Cœurs-volants (Fr). Uapau (Po).

Origin and geographic distribution *Hymenocardia acida* occurs throughout tropical Africa, from Senegal east to Ethiopia and south to South Africa.

Uses The acidic leaves, stem bark and roots are commonly used as medicines. A leaf infusion is taken to treat chest complaints and smallpox, a leaf and root infusion is taken to treat oedema caused by malnutrition and an extract of the leafy twigs is rubbed in to strengthen sickly children. A leaf macerate or leaf decoction is taken to treat stomach-ache,



Hymenocardia acida – wild

trypanosomiasis and coughs. A leaf decoction or leaf sap is used as eye drops to treat eye infections; together with honey they are taken to treat gall bladder problems and fever, and also as a bath to treat fever and haemorrhoids. Leaf sap is also used as ear drops to treat otitis. Leaf powder is taken as snuff to treat headache; the vapour of the boiling leaves is inhaled to treat headache. Leaf powder is topically applied in friction to treat rheumatic pains, toothache and fever; it is also sprinkled on sores after washing. Leaf powder in food is taken to treat asthma. A leaf decoction is taken as an emetic and to treat snakebites. A decoction of the leafy twigs is used for bathing to treat tetanus, convulsions and exhaustion.

The bitter stem bark is slightly astringent and causes copious salivation when chewed. In West Africa it is chewed together with kola (*Cola* spp.) to treat dysentery. A bark decoction is widely taken to treat pulmonary affections, including tuberculosis; it is also used as a steam bath, alone or with the fruits, to treat breathing difficulties and colds. The powdered bark, together with parts of other plants, is used as a macerate to treat fractures. The powdered bark with copper dust is sprinkled on syphilitic sores. Powdered bark in water or pulped bark is taken internally to treat abdominal pains, diarrhoea, dysentery, menstrual pains, female infertility, painful swellings, cough and epileptic fits. The powdered bark in water or a bark decoction is applied as a poultice to treat colic, abscesses and tumours, eye infections, migraine and also skin afflictions such as itch, prickly heat, parasites and leprosy.

A root decoction or a leaf infusion is drunk against threatened abortion, as an aphrodisiac and to treat severe stomach-ache. A root decoction or root bark in porridge is taken as a febrifuge, to treat malaria, arterial hypertension and amoebic dysentery. It is also drunk or used as a mouth wash to treat toothache and infected gums. Root sap and fruit juice are used as ear drops to treat earache and also to treat toothache. Root ash is also applied to treat toothache. Root powder is applied to skin diseases. In southern Africa steam inhalations from the root powder are considered cleansing for the stomach. Powdered root in porridge is given to breast-feeding women to diminish the milk flow. Powdered fresh roots are also taken to treat anaemia, including sickle cell anaemia. Pulped roots and leaves are applied to haemorrhoids and rectal prolapse. A fresh root decoction is also taken to treat haemorrhoids. A root or stem bark decoction is taken as an antidote for plant poisoning.

In Central Africa a brownish red dye obtained from the bark is used to colour raffia work and cloth; the bark contains much tannin and is used for tanning leather. The young leaves and twigs are commonly browsed by cattle and in DR Congo they are eaten by edible caterpillars. Bees commonly visit the flowers for nectar and pollen. The young fruits are eaten by children, although they are rather sour. In West and Central Africa, the wood is considered brittle, and not much used as a timber. In East and southern Africa the wood is known for its hardness and resistance to termites; it is used to make house posts, poles, pestles and tool handles. The wood is commonly used as fuel and for charcoal production; it burns slowly with a hot flame and little smoke. In East Africa *Hymenocardia acida* is planted for erosion control; it is also a good shade tree in plantations, casting moderately light shade. Young leafy shoots of *Hymenocardia acida* are sometimes eaten as a condiment. The twigs are used as toothbrush. The stem bark is made into rope.

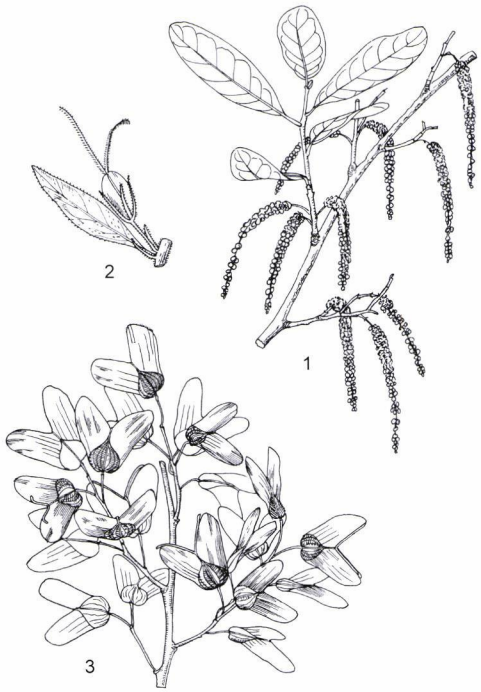
Properties Preliminary studies of the chemistry of *Hymenocardia acida* showed the presence of saponins. From the root bark the cyclopeptide alkaloid hymenocardine was isolated. All plant parts contain tannin, the stem bark being richest (up to 12%). The bark contains amphiphile lupane-type triterpenoids, which are associated with its antimalarial and anti-inflammatory activities.

A dichloromethane extract of the leafy twigs

showed significant antitrypanosomal activity; different root and leaf extracts only showed moderate activity. Methylene chloride and methanolic stem bark and root extracts showed moderate activity against *Plasmodium falciparum* in vitro. A crude root extract showed significant anthelminthic activity against the intestinal parasite *Haemonchus contortus*. In an in-vitro test of plants from DR Congo, water extracts, and to a lesser extent ethanol extracts, of the leaves showed significant effect against sickle cell formation. An ethanolic root extract showed marked antibacterial activity against *Klebsiella pneumoniae*, *Staphylococcus aureus*, *Streptococcus mutans* and *Salmonella enterica* in vitro, as well as spasmolytic and anti-inflammatory activities in vivo in mice and rats. An aqueous stem bark extract showed significant anti-ulcer activity against induced gastric lesions in rats. A methanolic leaf extract showed very high radical scavenging activity, comparable to tocopherol. Methanol extracts from the root bark exhibited moderate cytotoxic activity against 60 human cell lines of the National Cancer Institute of the United States.

The wood is pale brown or pink, darkening to orange, hard, with fine texture and conspicuous annual rings.

Description Dioecious, deciduous shrub or small tree up to 6(–10) m tall, often straggling; bole up to 30 cm in diameter, often stunted or contorted; bark smooth, pale brown or grey, flaking off, showing a powdery reddish to orange inner bark; upper branches spreading, lower branches drooping; young shoots short-hairy. Leaves alternate, simple and entire; stipules 1–3 mm long, linear, soon falling; petiole 0.5–1.5 cm long, short-hairy; blade elliptical-ovate to oblong-oblanceolate, 2.5–9.5 cm × 1.5–5 cm, base rounded, apex rounded to obtuse, short-hairy to almost glabrous above, densely soft-hairy below or almost glabrous except main veins, sparingly to evenly yellowish gland-dotted. Male inflorescence a dense axillary spike up to 7 cm long, solitary or fascicled; female inflorescence a terminal few-flowered raceme up to 3 cm long, usually several together, or flowers solitary. Flowers unisexual, petals absent, disk absent; male flowers sessile, calyx 1.5–2 mm in diameter, shallowly 5-lobed, lobes obtuse, ciliate, pinkish, stamens 4–6, c. 1.2 mm long, free; female flowers with pedicel c. 1 mm long, extending up to 2 cm in fruit, sepals 5–9, linear, 1.5–4 mm long, sometimes fused at base, soon falling, pinkish, ovary



Hymenocardia acida – 1, flowering branch; 2, female flower; 3, infructescence.
Source: Flore analytique du Bénin

superior, obovoid, 2-winged in upper half, gland-dotted, glabrous to densely short-hairy, glaucous to red, 2-celled, styles 2(–3), 2–20 mm long, free. Fruit a V-shaped, flattened capsule, 2–3.5 cm × 2.5–4 cm, with 2 apical divergent rounded to rhomboid membranous striate wings, rounded to cordate at base, glabrous to hairy, gland-dotted or not, yellow-green at first, turning pink then reddish brown, 2-seeded, on a stipe up to 2 mm long. Seeds compressed circular, c. 10 mm × 5 mm, smooth, shiny, dark purplish brown, streaked with black.

Other botanical information *Hymenocardia* comprises 6 species, 5 of which occur in continental Africa and 1 in South-East Asia. *Hymenocardia* shows similarities in wood anatomy and pollen morphology to *Ulmaceae* which, coupled to the winged fruits, caused some botanists to place it in a family of its own, *Hymenocardiaceae*. Closer examination has shown that most similarities are superficial and possibly the result of convergence. Two varieties are distinguished in *Hymenocardia acida*: var. *acida*, which is distributed through-

out tropical Africa, and var. *mollis* (Pax) Radcl.-Sm., with short-hairy fruits, which occurs from DR Congo south to Mozambique. *Hymenocardia heudelotii* Müll.Arg. is also medicinally used in West Africa. In Sierra Leone the leaf sap is used as eye drops to treat ophthalmia.

Growth and development *Hymenocardia acida* starts flowering mainly during the second half of the dry season, when new leaves also develop. In Benin it flowers from January to October and fruits from February to October; in Zambia it flowers in September–November and seeds mature in June–September.

Ecology *Hymenocardia acida* occurs in savanna and deciduous woodland, also on lakeshore sand dunes. It occurs mainly on sandy, loamy or clayey soils, from sea-level up to 1750 m altitude.

Propagation and planting *Hymenocardia acida* is propagated by seed and by wildlings. The fruits are dewinged and soaked in cold water for 48 hours before sowing. Direct seeding is possible.

Management *Hymenocardia acida* can be coppiced.

Diseases and pests *Hymenocardia acida* is a host for the fungus *Coniella diplodiella*, which causes white rot of grapes (*Vitis vinifera* L.).

Harvesting The stem bark and roots of *Hymenocardia acida* can be harvested whenever the need arises. The leaves can be harvested during the rainy season, as the species is deciduous.

Genetic resources *Hymenocardia acida* is widely distributed throughout tropical Africa, and is locally common. It is therefore not threatened by genetic erosion.

Prospects *Hymenocardia acida* is an important medicinal plant throughout tropical Africa, and the effectiveness of many traditional uses has been confirmed by preliminary pharmacological research. However, not much is known about the active compounds, and therefore more research is warranted.

Major references Arbonnier, 2004; Berhaut, 1975a; Burkill, 1994; Hoët et al., 2004b; Koné et al., 2005; Levin & Simpson, 1994; Mpiana et al., 2007; Neuwinger, 2000; Radcliffe-Smith, 1996a; Sofidiya et al., 2006.

Other references Adjanohoun et al. (Editors), 1988; Atindehou et al., 2004; Chilufya & Tengnäs, 1996; Coates Palgrave, 1983; Freiburghaus et al., 1996a; Latham, 2004; Markström, 1977; Muanza et al., 1995; Muanza et al., 1994; Nacoulma-Ouédraogo & Millogo-Rasolodimby, 2002; Nkounkou-Loumpangou et al., 2005; Sackeyfio, 1988; Sharma & Singh, 2002; Stäuble, 1986; Ukwe, 2004; Vonthron-Sénécheau et al., 2003; World Agroforestry Centre, undated.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors G.H. Schmelzer

HYOSCYAMUS MUTICUS L.

Protologue Mant. pl. 1: 45 (1767).

Family Solanaceae

Chromosome number $2n = 28, 56$

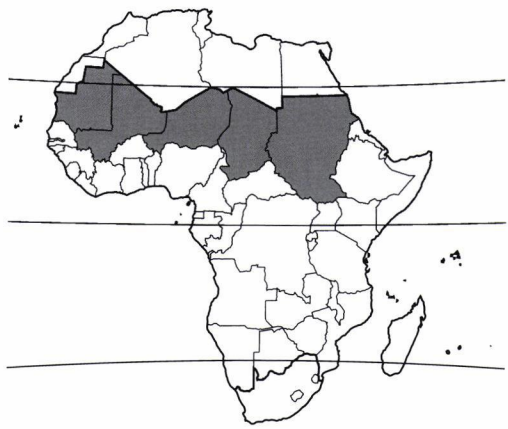
Synonyms *Hyoscyamus falezlez* Coss. (1864).

Vernacular names Egyptian henbane, Egyptian hemp (En). Jusquiame d'Egypt (Fr). Meimendro negro (Po).

Origin and geographic distribution In tropical Africa *Hyoscyamus muticus* is restricted to the fringes of the Sahara from Mauritania to Sudan. It also occurs in the Mediterranean countries.

Uses Fresh leaves are applied as a poultice to relieve pain. Dried leaves are smoked in cigarettes to treat asthma but also for their intoxicating effect. The plant is reputed to be poisonous. Fatalities on record involve eating dates poisoned with the plant and eating locusts that had eaten the plant. The Tuareg people use the plant as a fish poison. In northern Nigeria it is sometimes cultivated for medicinal use.

Records of value for grazing vary and range from resulting in fat animals on the one hand



Hyoscyamus muticus – wild

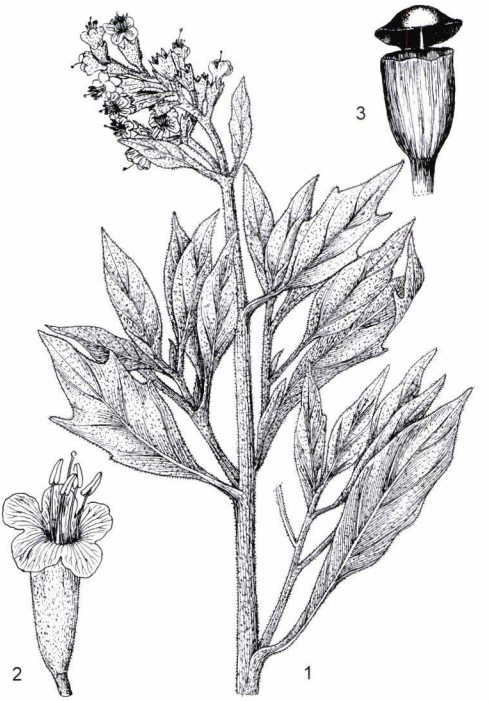
to demented sheep on the other. The variation in alkaloid content by growth stage and among populations may be reasons for variations in its toxicity and its value as fodder.

Production and international trade About 500–600 t of *Hyoscyamus muticus* stems and leaves, most of it collected in the wild, are exported annually from Egypt to Germany.

Properties The leaves of *Hyoscyamus muticus* have a high alkaloid content, with up to 5.2% of dry matter in individual plants. In smaller amounts, alkaloids are also present in roots and stems and the marketed product is a mixture of stems and leaves. The major alkaloid is hyoscyamine, but scopolamine (= hyoscine), tigloidine and tropine are also present. Scopolamine content is of interest to the pharmaceutical industry. In general the level of scopolamine is low in leaves, as low as 0.02%, but in the 'Cairo' strain, the scopolamine content of the leaves can exceed 4%. Atropine (a racemic mixture of d- and l-hyoscyamine) and scopolamine are used in ophthalmology as an analgesic, and scopolamine is used to cure or prevent motion sickness. These tropane alkaloids are classified as anticholinergics as they bind to acetylcholine receptors. In-vitro production of hyoscyamine and scopolamine is feasible but is not economical.
The seed oil contains considerable quantities of sterols (about 11.6 g/kg) and tocopherols (about 2.9 g/kg) and is thought to be of medicinal interest.

Adulterations and substitutes Species of other genera of *Solanaceae* such as *Duboisia*, *Datura* and *Atropa* are also used for their tropane alkaloids. Other species of *Hyoscyamus* also have medicinal uses and contain the same alkaloids but in lower concentrations.

Description Perennial herb or shrub up to 1.5 m tall, glabrous or hairy; stems thick, succulent. Leaves arranged spirally, simple, with stellate and simple hairs; stipules absent; petiole 1.5–5.5(–13) cm long; blade elliptical to ovate, 4–12 cm × 1–9 cm, base cuneate, apex acute, margin coarsely toothed, upper leaves smaller and often entire. Inflorescence a dense terminal cyme, elongating up to 30 cm long or more. Flowers bisexual, 5-merous; calyx regular, funnel-shaped, 5-toothed, teeth c. 5 mm long, in fruit c. 2 cm long; corolla zygomorphic, broadly funnel-shaped, 5-lobed, lobes c. 2 cm long, white to pink with dark violet veins or spots; stamens exserted, anthers c. 4 mm long; ovary superior, 2-celled, style very long, thin. Fruit an obovoid capsule c. 6 mm in diameter, dehiscing by an equatorial circular slit, many-seeded. Seeds kidney- or wedge-shaped, c. 1 mm × 1.5 mm.



Hyoscyamus muticus – 1, flowering branch; 2, flower with calyx removed; 3, fruit.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Hyoscyamus* comprises about 20 species and is found in Europe, northern Africa and south-western and central Asia. *Hyoscyamus muticus* has been introduced in India and Pakistan, tested as a crop and even subjected to breeding, but commercial cultivation apparently has not been successful. Most literature from Pakistan and India on *Hyoscyamus muticus* probably relates to other species. *Hyoscyamus insanus* Stocks occurs in Iran, Afghanistan, Pakistan and India and is used medicinally, sometimes even being cultivated for medicinal purposes. *Hyoscyamus niger* L. is commonly cultivated in India.

Ecology *Hyoscyamus muticus* occurs in desert areas in rocky localities, wadis and plains.

Propagation and planting Direct sowing is recommended. Germination has been reported as erratic and troublesome, but treatment of the seeds with concentrated sulphuric acid for 75 seconds, fluctuating temperatures

between day and night and the use of kinetin (60 mg/l) all promote germination. Spacing for optimal leaf production and alkaloid yield is about 45 cm between rows and 15 cm in the rows.

Management The critical period of competition with weeds is 30–75 days after sowing, when weeds can reduce yield by as much as 60%. In field trials in Egypt the response of *Hyoscyamus muticus* to compost and chicken manure, either alone or in combination with different rates of NPK, was investigated. All treatments increased plant height, number of branches, and fresh and dry weights of leaves, stems and roots per plant and per ha. Highest yield of alkaloids (about 88 kg/ha) was obtained with high levels of manure and NPK. The combined effect of organic manure and NPK resulted in the highest content of hyoscyamine (65% of total alkaloids). Irrigation can increase plant yield but reduces alkaloid content.

Diseases and pests A large number of pests and diseases have been reported for *Hyoscyamus muticus*, but the extent of damage caused is unknown. Some of the more important problems are root-knot nematode (*Meloidogyne incognita*), *Alternaria* leaf spot, cucumber mosaic virus (CMV), bacterial blight (*Pseudomonas cichorii*) and aphids (*Myzus persicae*). In Sudan the plants were attacked by caterpillars (*Heliothis* sp.).

Harvesting *Hyoscyamus muticus* should be harvested about 3 weeks after the beginning of flowering when the first fruits are ripe. After that time the alkaloid yield will drop, although the plant yield will still increase. In Sudan the summer crop is harvested after about 145 days, the winter crop after 190 days.

Yield In Egypt and Sudan *Hyoscyamus muticus* yields about 2 t/ha of dry plant material and 20–30 kg/ha of alkaloids.

Handling after harvest Fresh leafy stems are dried in the sun for 2–3 days and then dried in the shade till they are crisp and dry.

Genetic resources Harvesting from the wild, as currently is the practice in most of the area where it is native, can deplete populations of *Hyoscyamus muticus*. This is an incentive for cultivation, but a serious danger of genetic erosion is not foreseen. There are a few accessions in germplasm collections in the United States, Germany, Switzerland and the Netherlands.

Breeding In India breeding and selection work resulted in selection of a vigorously growing, autotetraploid, highly fertile mutant. It produced 4.5 t/ha of dry matter (about 23 kg alkaloids/ha), but this selection was never released. Scopolamine content was found to be inherited straightforwardly and with breeding the content could be increased by a factor 20 in 4 generations.

Prospects *Hyoscyamus muticus* can become an important commercial crop in dry areas of tropical Africa. It could secure the supply of hyoscyamine and scopolamine for local pharmacological industries as well as for export markets. Selection, breeding and research into optimal management of the crop would offer prospects for increased productivity. Recent analysis of the seed oil makes it a potentially interesting source for essential fatty acids and lipid-soluble bioactives.

Major references Batanouny, 1999; Boulos, 2000b; Bruneton, 1999; El Sheikh et al., 1982; Lavania, 1986.

Other references Burkill, 2000; El-Bahr & Ghanem, 1997; Misra, Sharma & Lal, 1992; Naguib & Aziz, 2003; Oksman-Caldentey et al., 1987; Oksman-Caldentey et al., 1989; Ramadan, Zayed & El Shamy, 2007; Siddiqi, 1978; SEPASAL, 2007a.

Sources of illustration Siddiqi, 1978.

Authors N.S. Alvarez Cruz

JATEORHIZA MACRANTHA (Hook.f.) Exell & Mendonça

Protologue Journ. Bot. 73, Suppl. Polypet.: 10 (1935).

Family Menispermaceae

Synonyms *Jateorhiza strigosa* Miers (1849).

Origin and geographic distribution *Jateorhiza macrantha* occurs from south-western Nigeria and Bioko (Equatorial Guinea) east to eastern DR Congo and south to Cabinda (Angola).

Uses The Edo people of south-eastern Nigeria apply leaf sap, mixed with other medicines, to stop bleeding during pregnancy. In western Cameroon the bark, together with that of *Kigelia africana* (Lam.) Benth., is used against snakebites, whereas hairs from the stem are applied as a dressing on ulcers. In DR Congo leaf sap is dropped into the ears, nose or eyes against headache. The succulent roots are eaten in times of famine. The Efe people of DR Congo tie the leaves to the cut end of the raffia palm to increase the flow of sap for palm wine. They also eat the sweet fruit, and girls tie the twining stem around the limbs when dancing.

Properties The roots contain the diterpenes columbin, chasmanthin and palmarin, and the alkaloids columbamine, jatrorrhizine and palmatine.

Botany Dioecious, strongly hairy liana with tuberous roots. Leaves alternate; stipules absent; petiole 12–20 cm long, robust, appressed hairy; blade broadly rounded in outline, palmately 3–5-lobed, 20–25 cm × 20–26 cm, base rounded or cordate, lobes triangular, acuminate at apex, thin, appressed hairy on both surfaces, palmately veined with 5–7 main veins. Male inflorescence an axillary panicle, several together, up to 25 cm long, branches 3–4 cm long, bearing clusters of 3–7 flowers; female inflorescence an axillary raceme up to 25 cm long. Flowers unisexual; sepals 6, 3 outer ones oblong to elliptical, c. 4 mm × 2 mm, 3 inner ones obovate, c. 2.5 mm wide, greenish or whitish; petals 6, c. 2.5 mm long, somewhat concave, abruptly bent inwards at apex, margins incurved; male flowers sessile, with 6 free stamens c. 2.5 mm long, filaments joined to the top; female flowers with pedicel 3–5 mm long, with 6 tongue-shaped staminodes 1.5–2 mm long, ovary superior, consisting of 3 free ovoid carpels 2.5–3 mm long, styles short, recurved, stigma broad. Fruit composed of up to 3 ovoid drupelets 2–3 cm × c. 2 cm, yellowish ochre to orange-red, covered with stiff long brown hairs, pulp slimy, creamy-white, stone kidney-shaped, hard, 1-seeded. Seed 1.5–2 cm long, with fleshy, ruminate endosperm.

During flowering *Jateorhiza macrantha* loses its leaves.

Jateorhiza comprises 2 species, both in tropical Africa. It was formerly considered a section of *Chasmanthera*.

Ecology *Jateorhiza macrantha* occurs in dense and humid evergreen or semi-evergreen forest at low to medium altitudes.

Management *Jateorhiza macrantha* is collected from the wild, but in Cameroon it is also retained as a medicinal plant on cocoa farms.

Genetic resources and breeding *Jateorhiza macrantha* is fairly widely distributed and there are no signs that it is in danger of genetic erosion where forest remains.

Prospects Too little is known about the pharmacological properties of *Jateorhiza macrantha* to assess its potential, but its medicinal uses warrant initial screening.

Major references Burkill, 1997; Raponda-Walker & Sillans, 1961; Terashima & Ichikawa, 2003.

Other references Bouquet, 1969; Laird, Leke Awung & Lysinge, 2007; Neuwinger, 2000; Oliver-Bever, 1983a; Sandberg, Perera-Ivarsson & El-Seedi, 2005; Troupin, 1962.

Authors L.P.A. Oyen

JATEORHIZA PALMATA (Lam.) Miers

Protologue Hook., Niger Fl.: 214 (1849).

Family Menispermaceae

Synonyms *Jateorhiza columba* (Roxb.) Oliv. (1868).

Vernacular names Columba, calumba, colombo (En). Colombo (Fr). Calumba, columba, colombo do África (Po). Mkaumwa (Sw).

Origin and geographic distribution *Jateorhiza palmata* occurs naturally in Kenya, Tanzania, Malawi, Zimbabwe, Mozambique and South Africa (Kwazulu-Natal). It is cultivated in Mozambique, and cultivated and locally naturalized in many tropical countries, including Ghana, Madagascar, Mauritius, Réunion and also in India and Brazil.

Uses The root is the source of the formerly popular medicine 'radix calumbae' that was imported into Europe from Mozambique and Tanzania. It was used against dyspepsia and diarrhoea, and especially suitable for people with a weak stomach. In Tanzania the root is eaten against snakebites and as a vermifuge. The Zigua people of Tanzania use it to treat hernia and ruptures. Root scrapings are applied onto scarifications made in abscesses to mature them. Throughout south-eastern Africa the roots are considered tonic and are taken against dysentery and diarrhoea, whereas in India they are taken as a bitter tonic with antipyretic and anthelmintic properties, against gastric irritability and vomiting during pregnancy. In Europe *Jateorhiza palmata* is still used in laxative herbal mixtures.

In Italy and the United States the root has been added to herbal bitters.

Production and international trade The dried root is traded internationally, but the current extent of the trade is unknown. It is sold through the internet on a small scale.

Properties The succulent roots contain the diterpenoid furanolactones columbin, palmarin and chasmanthin and several related glycosides including palmatosides A–G, and the protoberberine alkaloids palmatine, jatrorrhizine, bisjatrorrhizine and columbamine. They also contain traces of the sapogenins diosgenin and kryptogenin. The roots contain about 1% of a greenish essential oil with a fragrance remi-

niscent of hay; older roots contain very little of it. The essential oil consists mainly of thymol. The roots are rich in starch.

In a test with rats, columbin suppressed the induction of adenocarcinomas in the colon by administration of the carcinogen azoxymethane. Columbin shortened the sleeping time induced by a urethane and α-chloralose mixture, but prolonged the sleeping time induced by hexobarbital. This may be explained by an effect of columbin on drug metabolizing enzymes in the liver. A methanol extract obtained from the rhizome inhibited the growth in vitro of a range of fungi tested. In the European Union the use of the essential oil (calumba extract) is permitted in animal feeds (CoE 247).

Botany Dioecious liana from tuberous roots; branchlets densely appressed hairy. Leaves alternate; stipules absent; petiole 18–25 cm long; blade broadly rounded in outline, palmately 5-lobed, 15–35 cm × 16–40 cm, base deeply cordate, lobes ovate and acuminate at apex, membranous, appressed hairy on both surfaces, palmately veined with 5 main veins. Male inflorescence a branched axillary panicle up to 40 cm long, branches 2–10 cm long, bearing clusters of 3–7 flowers; female inflorescence an axillary raceme up to 10 cm long. Flowers unisexual, sessile; sepals 6, 3 outer ones oblong to elliptical, 3 inner ones obovate, c. 3 mm × 1.5 mm; petals 6, c. 2 mm long, somewhat concave, mostly abruptly bent inwards at apex, margins incurved; male flowers with 6 free stamens 1–2 mm long, slightly fused to the petals; female flowers with 6 tongue-shaped staminodes, ovary superior, consisting of 3 free, ovoid carpels, styles short, recurved, stigma broad. Fruit composed of up to 3 ovoid drupelets 2–2.5 cm × 1.5–2 cm, appressed stiff hairy, stone ovoid, flattened, one side smooth, other side with silky hairs, 1-seeded. Seed with fleshy, ruminate endosperm.

In Mozambique the stems growing from the roots may be annual.

Jateorhiza comprises 2 species, both in tropical Africa. It was formerly considered a section of *Chasmanthera*.

Ecology *Jateorhiza palmata* occurs in rainforest and fringing forest, up to 1500 m altitude.

Management The tubers are dug up during dry weather. The tubers are rejected and the succulent roots are cleaned and cut transversely or obliquely into slices, which are dried in the shade. After drying they are about 0.5–1.5 cm thick. After washing and brushing, the slices are graded and marketed as 'radix calumbae'. Compact, uniform and bright yellow coloured pieces are preferred. The drug has a short-mealy fracture, slight musty odour and a very bitter taste. It is sometimes adulterated with pieces of sliced rhizome and in India with pieces of the stem of *Coscinium fenestratum* Colebr.

Genetic resources and breeding As *Jateorhiza palmata* has a wide distribution and is cultivated as a home-garden plant, it is not in danger of genetic erosion.

Prospects 'Radix calumbae' has lost much of its former importance in medicine at least in the Western World. *Jateorhiza palmata* is likely to retain some importance in herbal bitters, but there are no indications that it will become an important source of extracts or chemical compounds for the pharmaceutical industry.

Major references CSIR, 1959; Cunningham, 1993; Troupin, 1956; Troupin & Conçalves, 1973; Watt & Breyer-Brandwijk, 1962.

Other references Burkill, 1997; Carvalhas, 1972; d'Oliveira Feijão, 1960; Horn & Steffen, 1968; Itokawa et al., 1987; Kohno et al., 2002; Neuwinger, 2000; Sturm & Stuppner, 1998; Wada et al., 1995.

Authors L.P.A. Oyen

JATROPHA CHEVALIERI Beille

Protologue Bull. Soc. Bot. France 55, Mém. 8: 83 (1908).

Family Euphorbiaceae

Origin and geographic distribution *Jatropha chevalieri* occurs in Mauritania, Senegal, Mali and Niger.

Uses In Senegal the leaves and latex are considered haemostatic, and are applied directly on wounds to stop bleeding. The latex is also locally applied to mumps. The root extract is taken for treating complications of syphilis and leprosy. In Niger the oil from the grilled seeds is applied to boils and abscesses. Powdered seed mixed with lizard fat, is massaged onto the skin to treat spleen pain. The leaves are used to apply henna to the skin.

Properties The latex of *Jatropha chevalieri* contains the cyclic oligopeptides chevalierin A, B, and C. Chevalierin A showed weak activity against *Plasmodium falciparum*. *Jatropha chevalieri* is toxic to herbivores.

Botany Deciduous, somewhat succulent, monoecious shrub up to 1 m tall; branches lon-

gitudinally striate, glabrous. Leaves alternate; stipules divided into filiform segments; petiole 3–7 cm long, glabrous; blade broadly ovate in outline, 5-lobed to the middle, 6–12 cm long, base deeply cordate, lobes ovate, sharply sinuately 5–8-toothed, papery, glabrous. Inflorescence a terminal corymb, with a solitary female flower terminating each major axis and male flowers in lateral cymules; peduncle up to 3 cm long, glabrous; bracts lanceolate, apex acuminate, with gland-tipped teeth. Flowers unisexual, regular, 5-merous; pedicel short; sepals fused at base, 2–3 mm long; petals slightly longer than the sepals, apex rounded, greenish yellow; disk fleshy; male flowers with 8 stamens, filaments partially fused; female flowers with superior ovary, 3–celled, styles 3, fused at base, stigma 2-lobed. Fruit a somewhat fleshy to dry capsule, broadly ellipsoid, up to 1.5 cm long, shallowly 3-lobed, dehiscent into 2-valved cocci, usually 3-seeded. Seeds oblong-ellipsoid, up to 1 cm long, smooth, caruncle large, 5–6-partite.

Jatropha comprises about 170 species, mainly in warm temperate regions and seasonally dry tropics. Africa counts 70 native species and Madagascar has 1 endemic. Another West African species with medicinal uses is *Jatropha kamerunica* Pax & K.Hoffm. from Senegal, Mali and Cameroon. In Senegal the seeds are taken as a strong purgative.

Ecology *Jatropha chevalieri* occurs mainly on sandy soils, e.g. sand dunes. In the dry zone of Mauritania it occurs in wadis, in the Sahel zone in savanna and shrub vegetation.

Genetic resources and breeding *Jatropha chevalieri* is not very common, but is probably not in danger of genetic erosion.

Prospects *Jatropha chevalieri* has not been subjected to extensive chemical or pharmacological research, despite its interesting local uses. The latex contains cyclic peptides, compounds which show a large spectrum of biological activity and are sought after as promising lead compounds for drug discovery.

Major references Baraguey et al., 1998; Berhaut, 1975a; Brown, Hutchinson & Prain, 1909–1913; Burkill, 1994.

Other references Adam, Echard & Lescot, 1972; Keay, 1958a; Kerharo, 1971; Taleb, 2000.

Authors G.H. Schmelzer

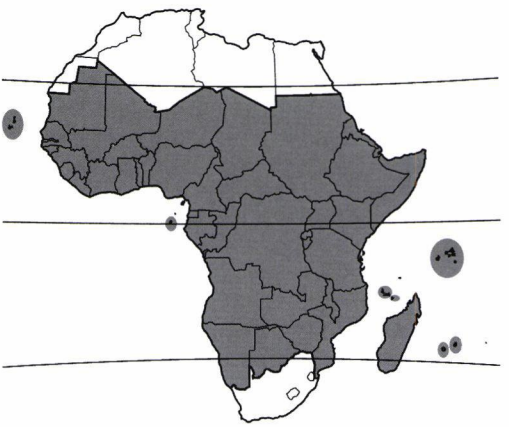
JATROPHA CURCAS L.

Protologue Sp. pl. 2: 1006 (1753).
Family Euphorbiaceae
Chromosome number $2n = 22, 33, 44$
Synonyms *Jatropha afrocurcas* Pax (1909).

Vernacular names Jatropha, physic nut, purging nut, Barbados nut (En). Pourghère, purghère, grand pignon d'Inde, fève d'enfer, gros ricin, médicinier purgatif (Fr). Purgueira, pinhao, rícino major, grão de maluco, galamaluco (Po). Mbono (Sw).

Origin and geographic distribution *Jatropha curcas* probably originated in Mexico or neighbouring parts of Central America, which are the only areas where it has often been collected from undisturbed vegetations. Portuguese seafarers took it to Cape Verde, where it became an export crop, at one time representing 60% of the total value of agricultural exports. It was distributed all over the world long ago and is now naturalized throughout the tropics and subtropics.

Uses Throughout tropical Africa, different parts of *Jatropha curcas* are used for a range of medicinal purposes. It is a source of oil that is traditionally used for soap production and as a source of energy; it is also an important hedge plant. The oil-rich seeds and seed oil (called 'oleum ricini majoris' or for good reason 'oleum infernale' or 'hell oil') are used as purgative and to expel internal parasites, although their application often leads to strong irritation of the gastro-intestinal tract or even poisoning. The leaves and bark have the same purgative effect. The oil is also applied internally and externally as an abortifacient, and externally as a rubefacient to treat rheumatic conditions



Jatropha curcas – planted and naturalized

and a variety of skin infections, although its use on the skin may also cause an irritative rash. The oil is used as an ingredient of hair conditioners. The latex has a widespread reputation for healing wounds, as a haemostatic and for curing skin problems; it is applied externally to treat infected wounds, ulcers, ringworm, eczema, dermatomycosis, scabies and sarcoptic mange in sheep and goats. Upon drying, the initially viscous latex forms an airtight film, resembling that produced by collodion. The latex has a styptic effect and is used against pains and stings of bees and wasps. Dried and pulverized root bark is made into poultices and is taken internally to expel worms and to treat jaundice. Leaves are also applied on wounds and in decoction they are used against malaria in Mali and Madagascar, while in Benin and Réunion a decoction is taken against hypertension. The leaf sap is used externally to treat haemorrhoids in Benin and Madagascar. In Guinea Bissau a hot water extract of the leaves is taken orally to accelerate secretion of milk in women after childbirth. Fresh stems are used as chew sticks to strengthen the gums, and to cure bleeding, spongy gums or gum boils. A decoction of the roots is a cure for diarrhoea and gonorrhoea. In Madagascar a decoction of the leaves and roots is taken to treat malaria. *Jatropha curcas* is also used in the preparation of arrow poison and in the Philippines the bark is used to prepare a fish poison. The seeds are often a source of accidental poisoning, both in animals and humans.

The seed oil is not edible as it contains toxic compounds. Traditionally, it is used for the manufacture of candles and soap, as lamp oil and as fuel for cooking. It is a poor lubricant as it dries quickly. Throughout the tropics and warm subtropics *Jatropha curcas* is increasingly planted for bio-fuel purposes. The oil is either used directly in adapted engines powering local grain mills, oil presses, water pumps and small generators, or first refined by transesterification with methanol or ethanol to produce regular fuel suitable for high-performance diesel engines.

The seed cake left after oil extraction is too toxic to be used as animal feed, but constitutes a valuable organic fertilizer rich in nitrogen. Some accessions of *Jatropha curcas* found e.g. in Mexico are almost free of toxins and the seed cake from such selections would provide a nutritious feedstock on account of the high protein content. Their seeds are sometimes boiled or roasted and eaten as a snack, and young leaves as a vegetable.

Leaf sap yields a black dye or ink that is said to be indelible; the bark yields a dark blue dye, which, however, is not fast. Ash from the roots and branches is used as cooking salt, and as lye in dyeing. *Jatropha curcas* is widely cultivated in the tropics as a living fence, for erosion control, demarcation of boundaries and for protection of homesteads, gardens and fields against browsing animals. In Madagascar and elsewhere in Africa it serves as a support for vanilla, black pepper and yams. The wood is very poor as fuelwood. Hybrids of *Jatropha curcas* and other *Jatropha* species are grown as ornamentals.

Production and international trade Official statistics on areas planted and production are still lacking. In recent years, *Jatropha curcas* has become the focus of large planting programmes in several tropical countries on account of its potential as a bio-fuel crop with low agro-ecological demands. Most of these are still in the pilot stage of development, together probably not exceeding 100,000 ha. India alone may have more than 10 million ha of small-scale and large plantations by 2030, mostly on reclaimed wastelands. Countries in tropical Africa with major development projects for jatropha bio-fuel production include Mali, Burkina Faso, Ghana, Tanzania, Malawi, Zambia and Madagascar. The total length of jatropha hedges in tropical Africa is estimated at 75,000 km, yielding potentially 60,000 t of seeds per year.

Prices of jatropha seeds vary between countries. Where seeds were used for manufacturing soap (Mali, Tanzania) the price per kg was close to US$ 0.10. Once the demand for seeds for bio-fuel increases, the prices of seeds will rise. In India a price of US$ 0.40 per l of jatropha-based fuel is expected to be realistic (cost price plus modest profit margin). To this price tax has to be added and the value of carbon-credit-certificates deducted. Prices for gasoil in landlocked countries of West Africa were US$ 0.80–0.97 in 2007. It is estimated that large-scale plantations and oil extraction mills could produce jatropha bio-fuel in West Africa at a price 5–12% cheaper than current gasoil prices. In remote areas, small-scale production and use of bio-fuel from *Jatropha curcas* is obviously more promising than the modest margins predict.

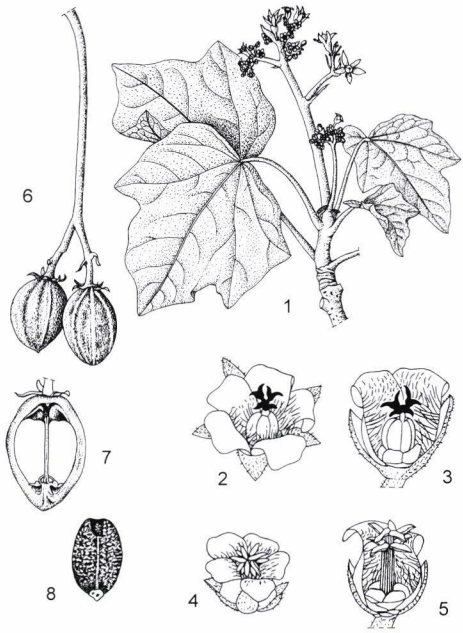
Properties Decorticated seeds (kernels) contain per 100 g: water 3–6 g, energy 3100–

3300 kJ (740–790 kcal), protein 23–29 g, fat 53–70 g, neutral detergent fibre 4 g, acid detergent fibre 0.1–0.2 g, ash 3.8 g. Fat content of whole seeds is 32–45%, since the seed coat constitutes 35–40% of total seed weight. The fatty acid composition of the oil is: palmitic acid 3.5–15.6%, palmitoleic acid 0.7–0.9%, stearic acid 6.7–7.5%, oleic acid 34.3–46.3%, linoleic acid 30.8–43.1%, linolenic acid 0.2% and traces of myristic, pentadecanoic, margaric, margaroleic, arachidic, gadoleic, behenic, lignoceric and nurvonic acids. Depending on the origin, either the oleic or linoleic acid content is higher. The bio-fuel produced after trans-esterification of the oil has characteristics similar to petrodiesel. The energy balance (the total energy inputs into the crop : the energy output) of jatropha bio-fuel is estimated at 1 : 4–5, which is considerably better than for rapeseed (Canola) oil. Protein content of the seed cake after oil extraction is about 60% with a composition in essential amino acids similar to soya bean protein, but higher in sulphur-containing amino acids.

The toxic compounds in the seed and seed-oil are esters of the diterpenoid 12-deoxy-16-hydroxy-phorbol; in toxic cultivars up to 2.7 mg/g has been found, in non-toxic ones 0.1 mg/g. As they are thermo-stable, the oil and seed cake cannot be detoxified by heating. Quantitative toxicity assessment studies have been effected in many animal models. The irritant properties of the seed oil have been evaluated in the mouse irritation test. Another study showed that the oil does not have mutagenic properties, so that there is no danger for workers handling the cake; however, after initiation with 7,12-dimethylbenz(a)anthracene, the oil induced skin tumours. The seeds also contain a toxic protein fraction: 'curcin'. Purified proteins from this fraction have been shown to inhibit protein synthesis in vitro in a way similar to that of ricin from castor (*Ricinus communis* L.). However, curcin lacks the protein-moiety that allows ricin to pass cell membranes, making curcin a much less dangerous toxin. Curcin has a significant antitumour effect in several tumour cell lines and its mechanisms are related to the N-glycosidase activity. The anti-metastatic potential of curcusone B, a diterpene isolated from the aerial parts, was investigated against 4 human cancer cell lines. Treatment with non-cytotoxic doses of curcusone B effectively suppresses the metastatic processes. Extracts from the seeds showed pregnancy-terminating effects in rodents, but it is unclear whether this is due to a specific action or a result of general toxicity.

The latex from *Jatropha curcas* has shown proteolytic activity that may be responsible for some of its therapeutic effects, e.g. healing wounds and haemostatic (coagulating effect). The diluted latex however shows anticoagulant activities. Analysis of the latex resulted in the isolation of the protease 'curcain'. The wound-healing properties of curcain were investigated in a mouse model. Application of curcain in a hydrophilic ointment (0.5–1%) showed better wound-healing properties than observed for nitrofurazone, a common drug for wound healing. The latex also contains the cyclic octapeptide 'curcacycline A' and the cyclic nonapeptide 'curcacycline B'. Curcacycline A showed a moderate dose–dependent inhibition of human T cell proliferation, while no direct cytotoxic effects were observed. In a clinical trial common warts treated with the latex disappeared completely after 16–20 days. Curcacycline B enhances the rotamase activity of human cyclophilin B. The leaves of *Jatropha curcas* have a potent cardiovascular action, somewhat similar to that of β-blockers. A methanol extract of the leaves showed moderate protection of human cell-lines in vitro against HIV, while a water extract from the branches strongly inhibited the HIV-induced cytopathic effects with low cytotoxicity. The methanol extract of the roots showed significant activity against castor oil- and magnesium sulfate-induced diarrhoea in mice through inhibition of prostaglandin biosynthesis and reduction of osmotic pressure. The latex shows significant antibacterial action against a variety of gram-positive bacteria. Ground seeds showed molluscicidal activity against different species that are host for human diseases. The seed oil has pesticidal properties comparable to that of neem (*Azadirachta indica* A.Juss.) against insects such as the cotton bollworm (*Helicoverpa armigera*) and the cowpea weevil (*Callosobruchus maculatus*). It is also effective against termites. The latex is strongly inhibitory to several fungal diseases of crops, e.g. *Phytophthora palmivora* and *Fusarium solani* and also to watermelon mosaic virus. Steroids (stigmasterol, β–sitosterol, β–sitosterol–β–D–glucoside) and flavonoids have been found to be present too.

Description Deciduous, somewhat succulent, monoecious shrub or small tree up to 5(–8) m tall; stem arising from a thick, perennial rootstock, with watery to whitish latex; bark smooth, grey or reddish, shiny, peeling off in



Jatropha curcas – 1, flowering branch; 2, female flower; 3, opened female flower; 4, male flower; 5, opened male flower; 6, fruits; 7, fruit in longitudinal section; 8, seed.
Source: PROSEA

papery scales. Leaves alternate, simple; stipules minute, soon falling; petiole (3–)10–15(–20) cm long, glabrous; blade broadly ovate in outline, usually shallowly 5-lobed, 7–14(–18) cm × 5.5–14(–18) cm, base shallowly to deeply cordate, apex acute, margins usually entire, glabrous, 5–7-veined from the base. Inflorescence a terminal or axillary umbel-like cyme, often paired, with a solitary female flower terminating each major axis and many male flowers on lateral branches; peduncle up to 5(–7) cm long, hairy; bracts elliptical-lanceolate, c. 1 cm long, acuminate. Flowers unisexual, regular, 5-merous, greenish yellow; male flower with ovate calyx lobes c. 2 mm long, petals fused in lower half, lobes oblong to ovate, c. 3 mm long, disk composed of 5 free glands, stamens 8, in 2 distinct whorls, the 5 outer fused at base, the 3 inner with filaments completely fused; female flower with ovate-lanceolate calyx lobes 4–5 mm long, hairy, petals c. 6 mm long, free, disk composed of 5 free glands, ovary superior, ovoid-ellipsoid, 3-celled, styles 3, fused at base, stigmas 2-lobed, staminodes 10. Fruit a broadly ellipsoid capsule 2.5–3 cm × c. 2 cm, smooth-skinned, initially fleshy and green, turning yellow and eventually dry and black, late dehiscent, 3-seeded. Seeds ellipsoid, 1–2 cm long, mottled black and coarsely pitted. Seedling with epigeal germination, forming a taproot and 4 peripheral roots; hypocotyl elongated; cotyledons broadly oblong and emergent; first 2 leaves alternate.

Other botanical information *Jatropha* belongs to the tribe *Jatropheae* of the subfamily *Crotonoideae*. The genus comprises about 170 species, most of them in warm temperate and subtropical regions and seasonally dry tropics. Africa counts about 70 native species, Madagascar 1 endemic. *Jatropha curcas* belongs to subgenus *Curcas*. Several *Jatropha* species are widely grown in the tropics as medicinal or ornamental plants; they sometimes escape from cultivation.
The seeds of *Jatropha mahafalensis* Jum. & H.Perrier, endemic to Madagascar, contain an oil called 'huile de Betrata' with similar properties as *Jatropha curcas* and with similar traditional uses. The oil is also used for lighting and applied as hair oil against lice. A root decoction is taken as an invigorating drink. The latex contains a cyclic heptapeptide, named mahafacyclin A.

Growth and development Growth in *Jatropha curcas* is intermittent and sympodial; it follows the architectural model of Leeuwenberg. Dormancy is induced by fluctuations in rainfall, temperature and light. Not all plants respond simultaneously; in a hedge plants without leaves may be found besides ones full of green leaves. Flowers of *Jatropha curcas* produce nectar and are scented. The nectaries are hidden in the corolla and only accessible to insects with a long proboscis or tongue. The sweet, heavy perfume at night and greenish yellow colour of the flowers suggest that they are pollinated by moths. In inflorescences, the female flowers open one or two days before the male ones or at the same time as the earliest male flowers. Male flowers last only one day. Seed never sets in indoor cultivation unless the flowers are pollinated by hand. Plants raised from seed are more resistant to drought than those raised from cuttings, because they develop a taproot. Fruit development from flowering to seed maturity takes 80–100 days. Plants from cuttings produce seeds earlier than plants grown from seed. Full production is achieved in the 4th or 5th year. Mycorrhizae have been observed on the roots; they promote growth, especially where phosphate is limiting. The poten-

tial lifespan of *Jatropha curcas* is 30–50 years.

Ecology *Jatropha curcas* occurs in semi-arid tropical and warm subtropical climates with mean daily temperatures of 20–30°C and annual rainfall of 300–600 mm. It does not withstand frost, but is resistant to periods of drought of up to 7 months. It will grow on degraded, sandy or gravelly and even saline soils with low nutrient content, but cannot survive in waterlogged terrain. However, economically sustainable oil production requires well-drained soils of reasonable physical and chemical quality, and at least 750 mm annual rainfall, or supplementary irrigation.

Propagation and planting Propagation is done by seeds or cuttings. The 1000-seed weight is 400–730 g. Seed storage behaviour is orthodox. The average germinating capacity after 7 years storage at 16°C is about 50%. Seeds are sown at the beginning of the rainy season. Soaking overnight improves germination. Under good conditions seeds germinate in about 10 days. Seeds can also be sown in seedbeds or containers and 4–6 months later transplanted into the field. Nursery-grown seedlings have a higher survival rate than direct-seeded ones. Hedges around homesteads or fields are mostly grown from cuttings. Branch cuttings of 30 cm length planted directly in the field a few weeks before the beginning of the rainy season will root and regrow easily, as a wax coat protects the cuttings from drying out. However, raising plants in a nursery from rooted cuttings with only 2–3 nodes, prior to field planting, has the advantage of a much larger multiplication rate for valuable selections intended for high-yielding plantations. Clonal propagation by tissue culture, starting from hypocotyl-, petiole- or leaf-explants, is technically possible but rather expensive for mass-propagation.
In plantations established for oil production, spacings applied are 2–3 m between and 2–2.5 m within rows, giving plant densities of 1350–2500 plants/ha.

Management Cultural practices in new plantations include regular weeding, pruning and fertilization. Recently planted seedlings have to be protected against ruminants, because they have not yet developed the repellent toxins in leaves and shoots. Pruning starts 3–4 months after field planting to induce a frame with up to 25 branches for increased flowering and fruit set; maintenance pruning of mature shrubs aims at inducing growth of new laterals and restricting height to facilitate harvesting. When grown as a protective hedge, regular pruning is needed to reduce shade on neighbouring crops. Nutrient requirements for maximum oil production are not yet well-defined for *Jatropha curcas*, but it appears to respond particularly well to organic fertilizers, including the composted fruit walls and seed cake. Leaf litter and prunings from the plantation will also contribute to improving the organic matter content of the soil. Addition of N, P and K fertilizers to the planting hole will boost early establishment and rapid growth of new plantations. Where climatic and soil conditions are favourable and the plants are spaced more widely, intercropping with vegetables or pulses is possible. Fertilization of the intercrop will then also benefit the jatropha crop.

Diseases and pests *Jatropha curcas* is rarely attacked by diseases or pests. Powdery mildew may damage leaves and flowers, while *Alternaria* may cause leaf fall. Caterpillars of *Spodoptera litura* feed on the leaves, while several species of beetles feed on the leaves of young plants. These pests may also affect intercrops grown together with *Jatropha curcas*. It is an alternative host for cassava viruses, so it should not be planted as a fence around cassava fields.

Harvesting Harvesting and separation of seeds from the fruits is done manually. The best pickers can harvest about 30 kg fruit per hour, which is approximately 18 kg of seeds. Since the fruits stay on the branches for quite some time, they have to be picked or knocked down with a stick.

Yield Annual seed production of mature plants, raised from seedlings, may vary from 300 g to 3(–6) kg, depending on the growing conditions and inherent production capacity. Available data from pilot plantations show the following seed yields per ha: 0.5 t within 1 year after field planting, 1.2–1.5 t in year 2 and further increasing to 2.5–3.0 t from year 5 onwards when the plantation is in full production. Yields of 5 t of seeds/ha, which is equivalent to 1.6–2.0 t of oil plus 3.0–3.4 t of seed cake, have been claimed for jatropha plantations under optimum agro-ecological conditions (e.g. India and Nicaragua).
Old and dense hedges in and around villages or towns may produce 2 kg of seeds per m and per year (height 5–6 m, good soil, 800 mm annual rainfall), pruned hedges around gardens and fields usually not more than 0.8 kg.

Handling after harvest Seeds for planting should be carefully dried in the shade until 6–9% moisture content and stored cool in airtight

containers. Traditional oil extraction involves boiling of roasted and ground seeds until the floating oil can be skimmed off the surface. More efficient methods are based on oil extrusion by hand-operated or mechanized screw presses. The extraction efficiency of this cold method of oil extraction is increased considerably by prior crushing of the seeds in a hammer mill. The remaining seed cake requires composting before use as organic fertilizer. The oil may be refined in a continuous transesterification reactor to produce bio-fuel of diesel-oil quality and glycerol as a valuable by-product. The bio-fuel represents about 92% in weight of the initial oil.

Genetic resources Several types of *Jatropha curcas* are known. A non-toxic type is grown in Mexico (no phorbol esters in the seeds). In Nicaragua a type exists with larger leaves with rounded lobes, and larger but fewer fruits and seeds. Male sterile types exist, which produce more fruits than normal types. A provenance trial in the late 1980s showed that different selections from Africa showed significant differences in vegetative development, but not in morphological characters. Wageningen University (Netherlands) has started a programme to collect and evaluate germplasm of *Jatropha curcas*, maintain it in field gene banks and initiate breeding work.
The Banco Nacional de Germoplasma Vegetal, Departamento de Fitotecnia, Universidad Autónoma de Chapingo, Chapingo, Mexico and the Departamento de Biología, Universidad Nacional Autónoma de Nicaragua, León, Nicaragua both hold about 100 accessions of *Jatropha curcas*, but collection, characterization and maintenance of germplasm covering the full variation of the species is still very much needed.

Breeding Most plant material used so far is derived from simple selection within semi-wild populations or landraces. Between-plant variation for vigour and seed yield is tremendous and great genetic improvement in seed yields and other important characteristics may, therefore, be expected from systematic breeding. Breeding programmes have been initiated recently in several countries, e.g. at Wageningen University (Netherlands), but information on progress is not yet available. Obviously, oil yield per ha will dominate breeding objectives for *Jatropha curcas* cultivars for bio-fuel production. Cultivars with compact growth would facilitate harvesting.

Prospects The multiple traditional uses of *Jatropha curcas*, as medicinal, nonfood-vegetable oil and auxiliary plant, have been well exploited in the tropics and subtropics for hundreds of years. Its considerable potential as an oil crop for bio-fuel purposes at relatively low costs and modest demands on the local agro-ecosystem has received much attention in recent years. Prospects are that within the next decade or so, *Jatropha curcas* will become a major source of renewable energy in the drier rural areas of (sub)tropical Asia, Africa and America. Much agronomic and breeding work needs still to be done to maximize the oil production potential per ha and thus improve the economic sustainability of jatropha oil production. Rapid multiplication techniques and facilities have to be developed to make improved planting material available in adequate amounts. This is especially urgent as planting of unimproved material not only leads to low returns on investments, but may also lead to a loss of interest in this crop. More research should also be initiated on medicinal properties of different plant parts, e.g. wound healing, antimalarial and anti-HIV effects. Investigation of the agronomic and medicinal potential of other *Jatropha* species would be valuable as well.

Major references Burkill, 1994; Francis, Edinger & Becker, 2005; Gübitz, Mittelbach & Trabi, 1999; Heller, 1996; Henning, 2001b; Makkar, Aderibigbe & Becker, 1998; Mujumdar & Misar, 2004; Openshaw, 2000; Osoniyi & Onajobi, 2003; Susiarti, Munawaroh & Horsten, 1999.

Other references Anonymous, 1997–1998; Baraguey et al., 2000; Fangrui & Milford, 1999; Grimm, 1999; Haas & Mittelbach, 2000; Heim, Garrigue & Husson, 1919; Henning, 2001a; Lin et al., 2003; Maheu & Husson, 1920; Makkar & Becker, 1999; Makkar, Becker & Schmook, 1998; Muangman, Thippornwong & Tohtong, 2005; Mujumdar et al., 2001; Neuwinger, 2000; Rajore, Sardana & Batra, 2002; Rouillard & Guého, 1983; Satish Lele, 2007; SEPASAL, 1999; Shah, Sharma & Gupta, 2004; Songjang & Wimolwattanasarn, 2004; Sujatha & Prabakaran, 2003; Venturini del Greco & Rademakers, 2006; World Agroforestry Centre, undated.

Sources of illustration Susiarti, Munawaroh & Horsten, 1999.

Authors R.K. Henning

JATROPHA DICHTAR J.F.Macbr.

Protologue Candollea 5: 381 (1934).
Family Euphorbiaceae
Origin and geographic distribution *Jatropha dichtar* occurs in eastern Ethiopia, Somalia and northern Kenya.

Uses In northern Somalia and in Kenya the sap of the aerial parts is used as eye drops to treat eye infections. A root decoction is taken to treat abdominal pain. The peeled root is crushed and soaked in cold water, and the bitter infusion is taken as an emetic and laxative. The root can also be chewed and swallowed for these purposes.

Properties Neither chemical analysis nor phytopharmacological screening has been done on *Jatropha dichtar*.

Botany Much-branched monoecious shrub up to 3 m tall, with stiffly erect branches arising from near ground-level; bark dark purplish brown, peeling; short shoots densely shortly hairy; sap watery, turning reddish and drying black. Leaves alternate, 2–3 at the apex of short shoots; stipules forming strong, straight spines (0.5–)1–5 cm long, sharply pointed, purplish brown or black; petiole 0.5–2 cm long; blade broadly ovate to almost round in outline, shallowly 3–5-lobed, 1.5–5.5 cm × 1.5–6 cm, base narrowly cordate, lobes rounded, apex obtuse, almost entire or indistinctly toothed, densely shortly hairy, greyish yellow-green. Inflorescence a dense axillary cyme up to 6.5 cm long, with a solitary female flower terminating each major axis and male flowers in lateral cymules; peduncle short, densely shortly hairy; bracts ovate-lanceolate to linear-lanceolate, 3–9 mm long, densely shortly hairy. Flowers unisexual, regular, 5-merous, cream-coloured; pedicel short; calyx lobes linear-lanceolate, densely hairy outside; petals oblanceolate, 14–19 mm × 5–7 mm, rounded, clawed, reflexed; disk glands 5, free; male flowers with calyx lobes 4–5(–8) mm long, petals fused at base, disk glands cylindrical, stamens 10 with filaments fused except at apex; female flowers with calyx lobes 1–1.5 cm long, petals free, disk glands ovoid, ovary superior, almost globose, 3-celled, styles 3, c. 1 cm long, fused at base, stigma 2-lobed. Fruit a 3-lobed ovoid capsule 1.5–2.5 cm × 2–3 cm, each lobe with a thick apical ridge, densely shortly hairy, green, tinged orange-pink at apex, dehiscent into 2-valved cocci, usually 3-seeded. Seeds ovoid, c. 1.5 cm × 1 cm, dark brown mottled, somewhat shiny, caruncle covering the apex, fringed.

Jatropha comprises about 170 species, mainly in warm temperate regions and seasonally dry tropics. Africa counts 70 native species and Madagascar has 1 endemic. Several other *Jatropha* species occur in the same region as *Jatropha dichtar* and have medicinal uses. In Kenya the latex from *Jatropha ellenbeckii* Pax is applied to wounds to improve healing. In Somalia and Ethiopia pieces of root of *Jatropha rivae* Pax are eaten as a strong purgative. In Kenya an infusion of the roots of *Jatropha parvifolia* Chiov. is taken as an emetic and to treat fever. The plant is burnt inside the home as the bad smell keeps flies and mosquitoes away. Its twigs are used as a layer under the sleeping mat. In Somalia the fresh roots of *Jatropha nogalensis* Chiov. are chewed to treat snakebites, and the juice is also externally applied to the wound. The roots of *Jatropha spicata* Pax, from East and southern Africa are cooked in Somalia with chicken and the soup is eaten to treat gonorrhoea. The ground root mixed with water is taken as a strong purgative. In Kenya, the Boran people take a leaf or stem infusion as a laxative. The ethanol extract of the roots showed antibacterial activity in vitro.

Ecology *Jatropha dichtar* occurs among lava rocks, and is locally common in open bushland on red sandy soils, at 200–900 m altitude.

Genetic resources and breeding *Jatropha dichtar* is relatively common in its distribution area and not threatened by genetic erosion.

Prospects Unless pharmacological and chemical analyses prove otherwise, *Jatropha dichtar* will remain of local importance only.

Major references Heine & Heine, 1988b; Kokwaro, 1993; Neuwinger, 2000; Radcliffe-Smith, 1987.

Other references Beentje, 1994; Elmi et al., 1986; Gilbert, 1995; Guillaumet, 1972; Jäger, 2003; Samuelsson et al., 1992.

Authors G.H. Schmelzer

JATROPHA GLAUCA Vahl

Protologue Symb. bot. 1: 78 (1790).
Family Euphorbiaceae
Chromosome number $2n = 22$
Synonyms *Jatropha lobata* (Forrsk.) Müll.Arg. (1866).
Origin and geographic distribution *Jatropha glauca* occurs in Sudan, Eritrea, Ethiopia, Djibouti and Somalia, and extends to Yemen and Saudi Arabia.

Uses In Ethiopia the whole plant including the root is mashed in water and the liquid is taken to treat constipation and used as ear drops to treat earache. The sap is taken as an astringent.

Properties Methanol and chloroform extracts of fresh or dry leaves showed significant molluscicidal activity against the snail vector of schistosomiasis, *Biomphalaria pfeifferi*. The chloroform extract of the dry leaves showed the highest activity (LD_{50} 10–100 ppm). Cold water extracts of the dry leaves also showed molluscicidal activity.

Botany Small monoecious shrub up to 1 m tall with smooth, pale branches; stems and leaves glabrous to shortly hairy. Leaves alternate; stipules with 4–6 linear, gland-tipped lobes 1(–20) mm long; petiole 1–7 cm long; blade rounded in outline, deeply 3–5-lobed, base cuneate to truncate, middle lobe oblanceolate, 3.5–8 cm × 1.5–4 cm, the lateral lobes smaller, margins coarsely and irregularly toothed. Inflorescence a dense leaf-opposed cyme 2–11 cm long, with a solitary female flower terminating each major axis and male flowers in lateral cymules; peduncle up to 6.5 cm long. Flowers unisexual, regular, 5-merous, pale red; pedicel short; male flowers with c. 1.5 mm long calyx lobes, petals fused at base, obovate, c. 4 mm long, stamens 8; female flowers with 3–5 mm long calyx lobes, with stalked glands at margins, petals fused at base, oblong, c. 4 mm long, soon falling, ovary superior, almost globose, 3-celled, styles 3, 1.5 mm long, fused at base, 1.5 mm long, stigma 2-lobed. Fruit an almost globose capsule, c. 1 cm in diameter, glabrous, dehiscent into 2-valved cocci, usually 3-seeded. Seeds oblong, 8 mm × 4.5 mm, pale grey, caruncle deeply fringed.

Jatropha comprises about 170 species, mainly in warm temperate regions and seasonally dry tropics. Africa counts 70 native species and Madagascar has 1 endemic. Several other *Jatropha* species occur in the same region as *Jatropha glauca* and have medicinal uses. In Sudan the root and stem extract of *Jatropha aethiopica* Müll.Arg. is taken to treat epilepsy and rabies. In Ethiopia the sap of the petiole of *Jatropha pelargoniifolia* Courbai is applied to ulcers. In Sudan an infusion of the roots and stem of *Jatropha aceroides* (Pax & K.Hoffm.) Hutch. is taken as a molluscicide. The methanol and chloroform extract of the root, stem and seeds showed significant antibacterial activity against *Bacillus subtilis* and *Staphylococcus aureus*, and the stem and root extract also against *Pseudomonas aeruginosa*. The plant is poisonous to livestock.

Ecology *Jatropha glauca* occurs in open bush land, extending to semi-desert conditions, on lava and limestone, from sea-level up to 1000 m altitude.

Genetic resources and breeding *Jatropha glauca* is relatively common in its distribution area and is not browsed by livestock. It is therefore not likely to be threatened by genetic erosion.

Prospects *Jatropha glauca* shows interesting molluscicidal activities, and it would be worthwhile investigating the species chemically and pharmacologically in order to evaluate its possibilities.

Major references Al Zanbagi, Banaja & Barrett, 2000; Gilbert, 1995; Jansen, 1981; le Floc'h et al., 1985.

Other references Barri et al., 1983; Elegami et al., 2001; Gilbert, Holmes & Thulin, 1993; Hemming & Radcliffe-Smith, 1987; Neuwinger, 2000.

Authors G.H. Schmelzer

JATROPHA GOSSYPIIFOLIA L.

Protologue Sp. pl. 2: 1006 (1753).

Family Euphorbiaceae

Chromosome number $2n = 22$

Vernacular names Cotton-leaved physic nut, bellyache bush, wild cassada, red fig-nut flower (En). Pourghère rouge, médecinier sauvage, médecinier rouge (Fr). Chagas velhas, pinhao roxo, pião vermelho (Po).

Origin and geographic distribution *Jatropha gossypiifolia* is native to tropical America



Jatropha gossypiifolia – planted and naturalized

from Mexico to Paraguay and the Caribbean region. It has been introduced as an ornamental and medicinal plant elsewhere in tropical America and in many parts of the Old World tropics, and regularly escapes from cultivation. *Jatropha gossypiifolia* occurs throughout tropical Africa, except the dry regions in southern Africa, but including South Africa.

Uses Throughout tropical Africa, different parts of *Jatropha gossypiifolia* are used for a range of medicinal purposes, in a similar way as *Jatropha curcas* L. The oil-rich seeds and seed oil are used as a drastic purgative and emetic and to expel internal parasites. The leaves and bark have the same purgative effect. The oil is applied internally as abortifacient, and externally as rubefacient to treat rheumatic conditions and a variety of skin infections, although its use on the skin may also cause an irritative rash. In Senegal the seed oil is also applied against leprosy and rabies. The sap has a widespread reputation for healing wounds, as a haemostatic and for curing skin problems; it is applied externally to treat infected wounds, ulcers, cuts, abrasions, ringworm, eczema, dermatomycosis, scabies and venereal diseases. The sap has a styptic effect and is used against pains and bee and wasp stings. Dried and pulverized root bark is made into poultices and is taken internally to expel worms and to treat oedema.

In Senegal a decoction of the leaves is taken to treat colic, stomach-ache and fever, including malaria. In Ghana the leaves are used as a purgative, and the leaf sap is applied to the tongue of babies to treat thrush and to inflamed tongues of adults. The pith of old stems is inserted into the nostril to cause sneezing to cure headache. In the Caribbean the plant sap is traditionally used in the treatment of cancer. In the West Indies an infusion of the stem is taken to treat hypertension.

In West Africa *Jatropha gossypiifolia* is planted around villages as a hedge plant for its striking dark red young foliage and also to protect the houses against fire. It is also planted near houses to keep snakes away. It is locally planted for field boundary marking. It is sometimes grown as a container plant. The seed oil is used as lamp oil and fuel.

Production and international trade Although *Jatropha gossypiifolia* is widely planted as an ornamental and hedge plant, and has become locally naturalized, there are no data available on trade in Africa or elsewhere.

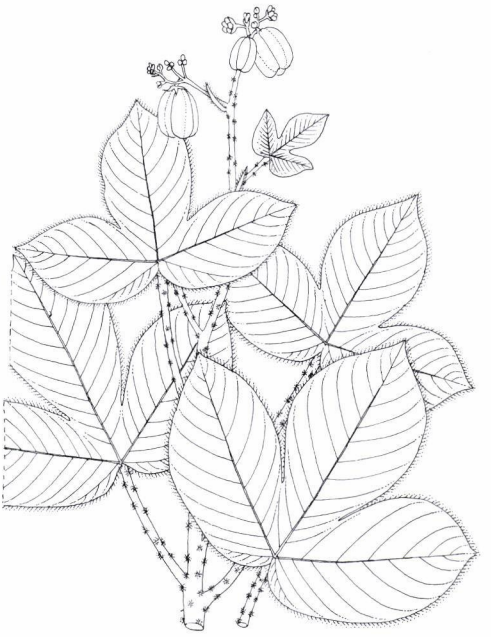
Properties The seed contains per 100 g: protein 13 g, crude oil 36 g, carbohydrate 30 g and fibre 9 g. The fatty acid composition of the oil is: unsaturated fatty acids 74% of which palmitic acid up to 31% and oleic acid and linoleic acid 68–84%, and further traces of caprylic acid, myristic acid, stearic acid, arachidic acid, behenic acid, lignoceric acid, palmitoleic acid and vernolic acid. The energy value of the seed oil is 42,000 kJ/kg.

An alcoholic root extract of *Jatropha gossypiifolia* showed significant inhibitory activity in different human cancer cell lines. This finding led to the isolation of the macrocyclic diterpenes jatrophone and related jatrophanes. Evaluation of this activity in the P-388 lymphocytic leukaemia test in vitro and in vivo and in Eagle's carcinoma of the nasopharynx in vitro revealed that most of these components were very active. In addition, it was found that jatrophone had direct inhibitory effects on contractions of cardiac and smooth muscle preparations, which were typically non-competitive in nature. The action of jatrophone may involve more than one mechanism; this might be related to alterations in the Ca^{2+} handling by cells. Later, the diterpenoids jatropholones A and B were isolated from the roots. They have shown only little biological activity. An ethanol extract from the stems caused a significant and dose-dependent reduction of the systolic blood pressure when given orally to rats. An aqueous extract of the stems increased the amplitude between the systolic tone and the diastolic tone of the arterial pressure in guinea pig. In rabbit, the extract markedly reduced the level of arterial pressure. A leaf extract showed significant activity as an anticoagulant for haematological analyses. The anticoagulant effect of the extract was found to be comparable to that of dipotassium ethylenediamine tetraacetic acid. The leaf extract must be purified to remove interfering substances to make it suitable for biochemical analyses. On the contrary, the sap from the stem showed significant coagulant activity in vitro.

A methanolic seed extract was found to be active against the snail *Bulinus globosus*, but was considered of little value, because of the large quantity required for lethal concentrations and the rapid inactivation under field conditions. The stem sap, however, was strongly active against the snail *Lymnaea acuminata* in its aquatic environment. The toxicity of the sap is partly due to inhibitory effects on acetylcholinesterase, and on acid and alkaline phosphatases in the snail. The cyclic

peptides cyclogossine A, B and C were isolated from the stem sap. Methanol and n-butanol extracts of unripe seeds showed significant molluscicidal activity against the snails *Lymnaea luteola* and *Indoplanorbis exustus*, the n-butanol extract being more toxic to the egg and adult stages of both snails. Furthermore, jatrophone and jatropholone A and B from the roots were tested against the snail *Biomphalaria glabrata*. Only jatrophone showed significant molluscicidal activity. Crude hot water extracts from the aerial parts were examined for antimalarial properties against *Plasmodium falciparum* in vitro, and were found to be capable of 100% growth inhibition. Hexane extracts of the fresh fruits showed significant activity against fungi and some bacteria. Stem sap was found to inhibit the growth of *Helminthosporium oryzae* and *Alternaria brassicicola*. The ethanolic stem extract showed significant larvicidal activity against larvae of the tick *Boophilus microplus*.

In addition to the compounds mentioned above, phytochemical investigations revealed the presence of lignans (e.g. gadain, jatrodien, gossypifan, gossypidien and prasanthaline) in the light petroleum extract of stem, root and seeds, the alkaloid jatrophine in the sap, and flavonoids (apigenin, vitexin and isovitexin) and triterpenes in the ethanolic leaf extract.



Jatropha gossypiifolia – flowering and fruiting branch.
Redrawn and adapted by Iskak Syamsudin

Description Much-branched, deciduous, somewhat succulent, monoecious shrub up to 3 m tall; rhizome thick, with orange-pink to brownish sap; bark smooth, green, peeling off in thin grey layers; stem and young leaves dark purple, glabrous. Leaves alternate; stipules c. 5 mm long, divided into many segments, gland-tipped; petiole 8–12 cm long, with simple to 3-fid glandular hairs; blade broadly ovate in outline, 6–10 cm × 8–14 cm, shallowly to deeply 3(–5)-lobed, base shallowly cordate, lobes obovate to oblanceolate, middle lobe longest, apex acute, margins glandular and minutely toothed, otherwise glabrous. Inflorescence a sparingly flowered leaf-opposed cyme, with a solitary female flower terminating each major axis and male flowers in lateral cymules; peduncle up to 6 cm long, shortly hairy; bracts linear-lanceolate, c. 1.5 cm long, acuminate, margin with glandular hairs. Flowers unisexual, regular, 5-merous, dark red; male flowers with elliptical-lanceolate calyx lobes c. 3 mm long, glandular at margins, petals fused in lower half, lobes obovate, c. 4 mm long, disk composed of 5 free glands, stamens 8, in 2 distinct whorls, the 5 outer fused to halfway, the inner 3 almost completely fused; female flowers with calyx lobes and petals twice as large as in male flowers, disk shallowly 5-lobed, ovary superior, globose to shallowly 3-lobed, 6-ribbed, 3-celled, styles 3, c. 2 mm long, fused at base, stigma 2-lobed. Fruit a somewhat fleshy to dry, globose to 3-lobed capsule, c. 1 cm in diameter, sparingly hairy to glabrous, green becoming brownish, dehiscent into 2-valved cocci, usually 3-seeded. Seeds ellipsoid, c. 7.5 mm × 4.5 mm, glabrous, pale grey-brown, caruncle with many lobes, dark brown. Seedling with epigeal germination.

Other botanical information *Jatropha* comprises about 170 species, mainly in warm temperate regions and seasonally dry tropics. Africa counts 70 native species and Madagascar has 1 endemic. In East Africa and Asia all *Jatropha gossypiifolia* plants are referred to as var. *elegans* (Pohl) Müll.Arg., which differs from var. *gossypiifolia* in having minutely toothed and glandular-hairy leaf margins. Several other *Jatropha* species known for their ornamental value are locally used as a purgative, e.g. *Jatropha multifida* L. and *Jatropha podagrica* Hook.

Growth and development *Jatropha gos-*

sypiifolia starts flowering and fruiting at the start of the rainy season, and can continue throughout the year if soil moisture remains high. Flowering can start in plants 4–6 weeks old, but generally starts 2 years after sowing. High densities of *Jatropha gossypiifolia* plants reduce flowering and fruiting. The plant can produce seed by selfing or cross-pollination, and many insects, including bees, visit the flowers to collect the nectar.

Ecology Where *Jatropha gossypiifolia* is naturalized, it occurs in regions with a pronounced dry season, along roads, on waste places, in grassland and shrub vegetation, generally at low altitudes in coastal areas. Annual rainfall requirements are 400–1200 mm. It grows on well-drained sand, sandy loams and stony soils.

Propagation and planting *Jatropha gossypiifolia* can be propagated by seed and rhizome or stem cuttings. Stem cuttings are most vigorous and root best using IBA, although rooting also occurs without this hormone. The fruits float, facilitating long-distance dispersal of seeds along watercourses and onto floodplains.

Management *Jatropha gossypiifolia* can become weedy, as it is an opportunistic invader of disturbed sites, e.g. in sugar cane fields in Mauritius. In northern Australia it has become a noxious weed, especially of rangeland in seasonally inundated flood plains, where competition with other plant species is limited. It can be controlled effectively by herbicides, mechanical means and by burning. In Central America biological control is effected through Jatropha mosaic virus (transferred by white fly) and recently in northern Australia through the seed-sucking bug *Agonosoma trilineatum*. In a heavily infested soil, up to 3.8 million seeds/ha are present at 1–5 cm soil depth, and weeding has to be continued for several years.

Diseases and pests *Jatropha gossypiifolia* is generally not attacked by diseases or pests in tropical Africa.

Yield The seed yield is 500 kg per ha annually, with seed shell to kernel ratio of 35:65.

Genetic resources As *Jatropha gossypiifolia* is widely planted as an ornamental and medicinal plant, and locally commonly naturalized, it is not endangered by genetic erosion.

Prospects *Jatropha gossypiifolia* is an interesting medicinal plant with many medicinal uses. Especially its anticancer and molluscicidal activities have been investigated, with promising results, but more research is warranted to confirm the activities of the individual compounds. In addition, the antiplasmodial activity, blood pressure lowering activity and coagulant or anticoagulant properties of different plant parts need to be studied in more detail.

Major references Abbiw, 1990; Abreu et al., 2003; Betancur-Galvis et al., 2003; Csurhes, 1999; Oduola, Avwioro & Ayanniyi, 2005; Radcliffe-Smith, 1996a; Sukumaran, Parashar & Rao, 1995; Traoré et al., 1999.

Other references Arbonnier, 2002; Bebawi & Campbell, 2002; Berhaut, 1975a; Burkill, 1994; Gbeassor et al., 1989; Kumar & Swarnkar, 2003; Kupchan et al., 1976; Mshana et al., 2000; Neuwinger, 2000; Ogbobe & Akano, 1993; Pandey, Maity & Samaddar, 1996; Radcliffe-Smith, 1987; Raina & Gaikwad, 1987; Seigler, 1994; Singh & Agarwal, 1988; Stäuble, 1986.

Sources of illustration Berhaut, 1975a.

Authors V. Kawanga

JATROPHA ZEYHERI Sond.

Protologue Linnaea 23: 117 (1850).

Family Euphorbiaceae

Origin and geographic distribution *Jatropha zeyheri* occurs in Botswana, Zimbabwe, northern South Africa and Swaziland.

Uses The Xhosa people apply the powdered rhizome externally to wounds, boils and burns to heal them fast. Young shoots are rubbed in for this purpose, or plant sap is applied. A rhizome infusion is taken to treat uterine pain, irregular periods, leg and feet pain, and is given as an emetic to treat food poisoning. A rhizome decoction is taken to treat headache and cough, and also as a blood purifier and purgative. Overdoses are dangerous as the plants are poisonous.

Properties A stem infusion of *Jatropha zeyheri* did not show antibacterial activity in vitro, although an ethyl-acetate extract did show some antibacterial activity against *Bacillus subtilis* and *Staphylococcus aureus*, but only in very large doses. The daphnane diterpenoid jaherin, isolated from the plant, has shown some antimicrobial activity.

Botany Perennial, somewhat succulent, monoecious, densely hairy herb up to 30 cm tall, sometimes creeping; rhizome thick; stems simple or sparingly branched; sap watery, greenish. Leaves alternate; stipules c. 2 mm long, divided into filiform segments, gland-

tipped; petiole 1–5 mm long; blade broadly ovate in outline, deeply 3–5-lobed, 5–12 cm long, base cuneate to truncate, lobes narrowly elliptical-oblanceolate, apex acute, lateral lobes progressively shorter, almost entire. Inflorescence a terminal corymb up to 10 cm long, with a solitary female flower terminating each major axis and male flowers in lateral cymules; peduncle up to 2.5 cm long; bracts linear-lanceolate, 0.5–1 cm long, apex acuminate, gland-tipped. Flowers unisexual, regular, 5-merous, cream-coloured; pedicel c. 2 mm long; male flowers with c. 0.5 mm long calyx tube, lobes lanceolate, 2–3 mm long, glandular hairy, petals oblanceolate, c. 4.5 mm long, disk glands 5, free, stamens 8, partially fused; female flowers with c. 2 mm long calyx tube, lobes triangular-lanceolate, 4–7 mm long, petals oblong-lanceolate, 7–8 mm long, disk glands 5, free, ovary superior, 3-celled, styles 3, c. 3 mm long, fused at base, stigma 2-lobed. Fruit an almost cylindrical, smooth capsule, 11–13 mm × 9–12 mm, densely shortly hairy, dehiscent into 2-valved cocci, usually 3-seeded. Seed compressed-ellipsoid, up to 9 mm long, smooth, mottled brown, caruncle 2 × 4 mm, 2-lobed, lobes fringed, golden brown.

Jatropha comprises about 170 species, mainly in warm temperate regions and seasonally dry tropics. Africa counts 70 native species and Madagascar has 1 endemic. Several other *Jatropha* species occurring in the same region as *Jatropha zeyheri* also have medicinal uses. A rhizome decoction of *Jatropha erythropoda* Pax & K.Hoffm. is drunk by Kalahari bushmen to treat blood in the urine and stomach-ache, and the plant is rubbed on the skin to treat wounds and venereal diseases. The dried rhizome powder of *Jatropha hirsuta* Hochst. from Mozambique and South Africa is applied to fresh wounds to heal them. A rhizome extract is used as an enema to cure fever.

Ecology *Jatropha zeyheri* occurs in wooded grassland with scattered shrubs, in mopane woodland on sand, also in disturbed areas, at 900–1250 m altitude.

Genetic resources and breeding As *Jatropha zeyheri* is fairly widespread and occurs in disturbed areas, there are no indications that it is in danger of genetic erosion.

Prospects *Jatropha zeyheri* has similar wound-healing and emetic properties as many other *Jatropha* species, but virtually nothing is known about the chemical compounds, and only very little about the pharmacology. More research is warranted to investigate whether it contains promising lead compounds.

Major references Arnold et al., 2002; Carter & Leach, 2001; Neuwinger, 2000.

Other references Beentje, 1994; Dekker et al., 1987; Elmi et al., 1986; Imamura, 2001; van Wyk, van Oudtshoorn & Gericke, 1997.

Authors G.H. Schmelzer

KIRKIA TENUIFOLIA Engl.

Protologue Bot. Jahrb. Syst. 32: 123 (1902).

Family Simaroubaceae (APG: Kirkiaceae)

Origin and geographic distribution *Kirkia tenuifolia* is distributed in Ethiopia, Somalia and Kenya.

Uses In Somalia a bark decoction of *Kirkia tenuifolia* is drunk to cure cholera. In Kenya the bark is chewed against thirst.

Properties No studies on the properties of *Kirkia tenuifolia* have been published. Quassinoids and indole alkaloids, characteristic of the *Simaroubaceae*, are probably responsible for the medicinal properties. An aqueous stem bark extract showed significant inhibition of cholera toxin-induced intestinal hypersecretion in mice.

Botany Semi-deciduous, monoecious shrub or small tree up to 8 m tall; bark grey, fissured with age; crown bushy, spreading; branches almost at right angles to main stem. Leaves alternate, clustered at ends of branches, up to 9 cm long, imparipinnately compound with (2–) 3(–4) pairs of leaflets; stipules absent; petiole and rachis hairy; petiolules short or absent but on terminal leaflet 5–10 mm long; leaflets alternate, opposite at top of leaf, narrowly elliptical to orbicular, 1–2.5 cm × 1–2 cm, base rounded to cuneate, apex rounded to notched, margin usually entire, glabrous or hairy. Inflorescence an axillary thyrse up to 6.5 cm long, hairy or glabrous. Flowers unisexual, regular, 4-merous; sepals almost free, deltoid, c. 1.5 mm × 1.5 mm, short-hairy outside; petals free, lanceolate, 3–5 mm × 0.5–1 mm, glabrous or short-hairy outside, greenish yellow to cream; stamens free, in female flowers reduced; ovary superior, 4-celled, reduced in male flowers. Fruit an ellipsoid to shortly cylindrical berry 10–12 mm × 6–8 mm, 4-angled, woody, short-hairy to glabrous, separating into 1-seeded mericarps, each attached by a strip of tissue to top of central column. Seeds almost as large as mericarp, rounded at one end and pointed at the other, 3-angled.

Kirkia comprises 5 species, distributed in tropi-

cal Africa from Ethiopia and Somalia to northern South Africa.

Ecology *Kirkia tenuifolia* occurs in *Acacia-Commiphora* bushland at 100–1000 m altitude. It is usually found on red sandy to stony soil and on limestone. In Somalia it is not a common species and is not associated with specific soil requirements.

Management *Kirkia tenuifolia* is easily propagated using seed or stem parts.

Genetic resources and breeding Although *Kirkia tenuifolia* is not widely distributed and not common, it is unlikely to be threatened by genetic erosion.

Prospects *Kirkia tenuifolia* will probably remain of local importance as a medicinal plant, unless pharmacological research shows interesting opportunities for drug development. Monitoring the populations is useful to detect threats.

Major references Beentje, 1994; Samuelsson et al., 1993; Stannard, 1981; Thulin, 1999.

Other references Claeson & Samuelsson, 1989; Gemedo-Dalle, Maass & Isselstein, 2005; Stannard, 2000; Wieland & Werger, 1985.

Authors C.H. Bosch

KNIPHOFIA FOLIOSA Hochst.

Protologue Flora 27: 30 (1844).

Family Asphodelaceae

Vernacular names Torch lily, red hot poker (En).

Origin and geographic distribution *Kniphofia foliosa* is endemic to Ethiopia.

Uses The rhizomes of *Kniphofia foliosa* are used in Ethiopia for the treatment of abdominal cramps. The plant is also used to eradicate endoparasites in cattle. The rhizome is said to be edible. *Kniphofia foliosa* is sometimes planted as an ornamental in Europe.

Properties Knipholone was isolated from the roots of *Kniphofia foliosa*. It was the first phenylanthraquinone to be isolated and has since also been found in *Bulbinella*, *Bulbine* and *Senna*. Phenylanthraquinones have antiplasmodial activity with little cytotoxicity. The antiplasmodial activity is slightly less than that of chloroquine, and chloroquine resistant *Plasmodium* strains are resistant to the *Kniphofia* compounds as well. The roots of *Kniphofia foliosa* further contain the anthraquinone chrysophanol as well as putrescine-derived amides.

Botany Robust perennial herb up to 175 cm tall, forming clumps, without stem, rarely with stem up to 40 cm long, with thick erect rhizome. Leaves in basal rosette, simple, spreading, without stipules and petiole, linear to lanceolate, up to 100 cm × 4(–7) cm, keeled, apex long-acuminate, margin finely toothed. Inflorescence a terminal raceme 15–40 cm long, very densely flowered; peduncle erect, 30–150 cm long; bracts ovate to ovate-lanceolate, 4–12 mm long, finely toothed. Flowers bisexual, regular, 3-merous; pedicel 3–4 mm long; perianth funnel-shaped, 18–27 mm long, slightly constricted at base, widening at mouth, perianth lobes up to 6 mm × 3 mm, yellow, orange or red; stamens 6, 8–15 mm long, exserted; ovary superior, 3-celled, style slender, 8–15 mm long, stigma minute. Fruit an ovoid capsule c. 8 mm long, dehiscing loculicidally, brown to black, few-seeded. Seeds slightly flattened, 3-angled, grey-black.

Kniphofia comprises about 65 species of which about 45 in southern Africa. In Ethiopia 7 species occur, including 5 endemics. Isoenzyme analysis showed that the Ethiopian endemic species share a fairly recent common ancestor, but have differentiated in floral and inflorescence characteristics through rapid evolution.

Kniphofia linearifolia Baker is distributed from Malawi, Zimbabwe and Mozambique into South Africa. In Zimbabwe the powdered root is mixed with food to treat infertility in women. *Kniphofia linearifolia* is widely planted as an ornamental and cut flower in southern Africa.

Ecology *Kniphofia foliosa* grows along roadsides, in overgrazed grassland with scattered trees, on hillsides with rocky outcrops and on mountains at 2500–4000 m altitude.

Management *Kniphofia foliosa* is only harvested from the wild.

Genetic resources and breeding *Kniphofia foliosa* is fairly widespread in Ethiopia and there are no indications of over-utilization.

Prospects *Kniphofia foliosa* will remain of local importance as a medicinal plant. It remains of interest to pharmacologists for its antiplasmodial activity and has potential as an ornamental.

Major references Dagne & Steglich, 1984; Demissew Sebsebe & Nordal, 1997; Wirtu et al., 1999.

Other references Abegaz, 2002; Bringmann et al., 1999; Gelfand et al., 1985; Teklehaymanot et al., 2004; Wube et al., 2005.

Authors C.H. Bosch

KOLOBOPETALUM AURICULATUM Engl.

Protologue Bot. Jahrb. Syst. 26: 410 (1899).
Family Menispermaceae
Origin and geographic distribution *Kolobopetalum auriculatum* occurs in the coastal areas along the Gulf of Guinea, from Côte d'Ivoire to DR Congo and Cabinda (Angola).

Uses An infusion of the leaves and seeds is taken against sleeplessness, and an infusion of the leaves and twigs is used as a mouthwash against oral infections including aphthae.

Properties The plant contains O-methylflavinanthine, which has a morphine-like structure and a narcotic-analgesic action of about 20% of the strength of morphine. From the leaves and stem the aporphine alkaloids N-methylcorydine and magnoflorine have been isolated.

Botany Dioecious slender liana; stems with numerous aerial roots. Leaves alternate, simple; stipules absent; petiole 2–9 cm long, bent at the base and sometimes twisted; blade elliptical to ovate, 5–15 cm × 3.5–9 cm, base cordate, sometimes slightly peltate, apex long-acuminate, margins slightly toothed, thinly leathery, glabrous and shiny above, pinnately veined with 3–4 pairs of lateral veins. Inflorescence an axillary panicle 40–60 cm long, branches up to 20 cm long; bracts lanceolate, c. 1 mm long; female inflorescence raceme-like. Flowers unisexual, small; pedicel 2–3.5 mm long; sepals 6, in 2 whorls, 3 outer ones broadly ovate, c. 0.5 mm long, yellowish white, 3 inner ones ovate-oblong, c. 2 mm × 1 mm, yellow to pale pink, membranous; petals 6, 1–1.5 mm long, bent inwards at base; male flowers with (3–)6 stamens, filaments slender or swollen or partly fused, anthers globular; female flowers with 3 small, linear staminodes, ovary superior, composed of 3 free carpels, styles short, stigma 3-lobed. Fruit composed of 1–3 ellipsoid drupes 1–1.5 cm × 0.5–1 cm, apex covered with the remainder of the style, glabrous, stone hard and brittle, densely spiny outside, 1-seeded. Seed kidney-shaped, 3–8 mm × 2 mm.
Kolobopetalum comprises 4 species, all from the forest area of Africa. *Kolobopetalum chevalieri* (Hutch. & Dalziel) Troupin, from West and Central Africa, is also used medicinally. In Congo the plant sap is applied to scarifications on the arms of a dying patient as a last effort of revival. In DR Congo a leaf infusion is taken to treat psychosis and to treat intercostal pain. Leaf sap is applied as eye drops to treat eye infections in dogs. The supple stems are used as rope.

Ecology *Kolobopetalum auriculatum* occurs in rainforest and forest regrowth, up to 400 m altitude.

Genetic resources and breeding As *Kolobopetalum auriculatum* also occurs in secondary vegetation and the area of distribution is large, there are no signs of genetic erosion.

Prospects Too little is known about the chemical and pharmacological properties to assess the potential of *Kolobopetalum auriculatum*.

Major references Burkill, 1997; Oliver-Bever, 1983b; Troupin, 1951.

Other references Baerts & Lehmann, 2006e; Dwuma-Badu et al., 1980a; Osei, 1977.

Authors L.P.A. Oyen

LEPIDIUM AFRICANUM (Burm.f) DC.

Protologue Syst. nat. 2: 552 (1821).
Family Brassicaceae (Cruciferae)
Chromosome number $2n = 16$
Vernacular names African pepperwort, pepperweed, Cape peppercress (En).

Origin and geographic distribution *Lepidium africanum* occurs from eastern DR Congo, Sudan and Ethiopia south to Namibia and South Africa, and in the Indian Ocean islands. It has been introduced in Europe, the United States, Australia and New Zealand.

Uses In Namibia the leaves are used in traditional medicine to treat cough, bronchitis and sore throat. Dried unripe seed is added to food for the treatment of stomach ulcers. The leaves are eaten as a vegetable. In South Africa, *Lepidium africanum* is grazed by sheep during the dry season.

Botany Annual or short-lived perennial herb up to 75(–100) cm tall; stems erect or straggling, usually much branching, finely hairy. Leaves alternate, simple, first leaves in a short-lived rosette; stipules absent; petiole short; blade lanceolate to oblanceolate, up to 6 cm long, cuneate at base, acute at apex, irregularly toothed, sparsely hairy or glabrous. Inflorescence a terminal raceme up to 15 cm long, many-flowered. Flowers bisexual, regular, 4-merous, minute, greenish; pedicel 2.5–4 mm long; sepals ovate, 0.5–1 mm long; petals absent or narrowly spatulate or linear and up to 0.5 mm long; stamens 2; ovary superior, broadly elliptical, flat, 2-celled, with projecting style. Fruit an elliptical to ovate, flattened silique 2–3.5 mm × 1.5–2.5 mm, slightly

notched, with style not projecting outside the sinus, 2-seeded. Seeds 1–1.5 mm long, bright red-brown.

Lepidium comprises about 200 species and is distributed worldwide. In tropical Africa about 10 species are found. Two subspecies are distinguished within *Lepidium africanum*: subsp. *africanum* and subsp. *divaricatum* (Aiton) Jonsell (synonym: *Lepidium divaricatum* Aiton); the latter is confined to Namibia and South Africa and differs from subsp. *africanum* mainly in its stems branching from the base (in subsp. *africanum* only in upper half of stem) and its slightly larger fruits and seeds.

Ecology *Lepidium africanum* occurs on roadsides, open grassland and as a weed in fields, at (100–)1100–2600 m altitude.

Genetic resources and breeding *Lepidium africanum* occurs widespread and often in disturbed habitats, and is thus not threatened by genetic erosion.

Prospects Research on the phytochemistry and pharmacological properties of *Lepidium africanum* is desirable to confirm its medicinal activity. This may lay the foundation for an increasing use in folk medicine, comparable to garden cress (*Lepidium sativum* L.), which is not only a well-known vegetable but also much used as a medicinal plant with proven pharmacological activities.

Major references Jonsell, 1975; Neuwinger, 2000; von Koenen, 2001.

Other references du Toit, 1998; Jonsell, 1982a; Jonsell, 1982b; Jonsell, 2000; Marais, 1970.

Authors R.H.M.J. Lemmens

LEPIDIUM DIDYMUM L.

Protologue Mant. pl.: 92 (1767).

Family Brassicaceae (Cruciferae)

Chromosome number $2n = 32$

Synonyms *Coronopus didymus* (L.) Sm. (1800).

Vernacular names Lesser swine-cress (En). Corne de cerf didyme, cressonnette (Fr).

Origin and geographic distribution *Lepidium didymum* originates from South America, but has become an almost cosmopolitan weed. It occurs scattered in East and southern Africa, where it has been recorded from Ethiopia, Kenya, Tanzania, Namibia, Zimbabwe and South Africa, and from the Indian Ocean islands. *Lepidium didymum* is still expanding its distribution area.

Uses In Mauritius *Lepidium didymum* is credited with stimulant, tonic and antiscorbutic properties. A decoction of the whole plant is drunk to treat headache, and a leaf poultice is applied externally for the same purpose. The decoction is used internally to treat fever. In India the plant is valued in traditional medicine as a treatment for allergies and wounds. In Argentina *Lepidium didymum* is used as an expectorant, antiscorbutic, digestive and febrifuge, and to treat cancer, gangrene and haemorrhoids. The plant is eaten as a vegetable in South America.

Production and international trade In local markets in South America (e.g. Argentina) dried aerial parts of *Lepidium didymum* are traded as a drug.

Properties Phytochemical screening of *Lepidium didymum* showed the presence of flavonoids, saponins and tannins. The bioactive flavonoid chrysoeriol and its glycoside chrysoeriol-6-O-acetyl-4'-β-D-glucoside have been isolated. These compounds have free radical-scavenging and antioxidant properties. The sterol β-sitosterol has been isolated from the petroleum ether extract; it has hypocholesterolaemic activity. The seeds contain erucic acid and glucosinolate.

Tests with rats and mice in India showed wound-healing, anti-inflammatory, anti-allergic, antipyretic, hypoglycaemic and hepatoprotective activities of *Lepidium didymum* extracts.

Cows may produce off-flavoured milk when they have been fed with grass mixed with *Lepidium didymum*. It has been suggested that this is caused by the inhibitory actions of benzyl isothiocyanate present in the plant on microbial and/or enzymatic activities in the rumen of the cows.

Botany Small annual or short-lived perennial herb, with an offensive smell; stems creeping or ascending, up to 40 cm long, usually strongly branched, finely hairy. Leaves alternate; stipules absent; first leaves in a rosette, bipinnate, later ones pinnately cleft, 1.5–3 cm × 0.5–1 cm, with lanceolate to elliptical, entire to deeply incised lobes, glabrous. Inflorescence a leaf-opposed raceme up to 5 cm long. Flowers bisexual, regular, 4-merous, minute, greenish; pedicel 2–3 mm long; sepals elliptical, 0.5–1 mm long; petals shorter than sepals, very narrow, often reduced to small scales; stamens usually 2; ovary superior, flat, notched, 2-celled, with sessile stigma. Fruit a heart-shaped, flattened silique 1.5 mm × 2–2.5 mm,

notched, wrinkled, divided into 2 ellipsoid 1-seeded halves. Seeds 1–1.5 mm long, finely reticulate, orange to reddish brown. Seedling with epigeal germination; hypocotyl 5–16 mm long, epicotyl absent; cotyledons lanceolate, leafy.

Lepidium comprises about 200 species and is distributed worldwide. In tropical Africa about 10 species are found. In most of the literature, *Lepidium didymum* is included in *Coronopus*, a genus of about 10 species which belongs to *Lepidium* according to recent morphological as well as molecular studies.

After germination, *Lepidium didymum* plants develop rapidly. They often complete their life cycle within a few months.

Ecology *Lepidium didymum* occurs on roadsides, open grassland, forest clearings and as a weed in fields, in East Africa at 1350–2800 m altitude, in Madagascar at 1000–2000 m, but elsewhere in tropical Africa occasionally also at lower altitudes. It prefers bare, not too dry soils.

Management In some regions *Lepidium didymum* is considered a serious weed, e.g. in wheat, potato, pea, carrot and onion in India and in onion in Brazil, but in Africa it does not seem to be causing problems yet. It is a host of several pathogens that attack crops, e.g. cucumber mosaic virus, the fungi *Sclerotinia minor* and *Xanthomonas campestris* and fungi causing powdery mildew, the nematodes *Meloidogyne javanica* and *Rotylenchulus reniformis*, and cotton bollworm (*Helicoverpa armigera*).

Genetic resources and breeding Being an extremely widespread weed, *Lepidium didymum* is not threatened by genetic erosion.

Prospects Interesting pharmacological properties have been demonstrated for *Lepidium didymum*, but it is still poorly known and little used in tropical Africa. In view of the common use of the plant in traditional medicine in South America and India and its increasing spread as a weed in Africa, more research attention seems justified.

Major references Gurib-Fakim, Guého & Bissoondoyal, 1995; Lujan & Barboza, 1999; Mantena et al., 2005; Prabhakar, Srinivasan & Rao Padma, 2002.

Other references Al-Shehbaz & Mummenhoff, 2002; De Ruiz et al., 1994; Freyre et al., 2000; Jonsell, 1982b; Jonsell, 2000; Mishra et al., 2003; Shimoda et al., 2000.

Authors R.H.M.J. Lemmens

LIMACIOPSIS LOANGENSIS Engl.

Protologue Bot. Jahrb. Syst. 26: 414 (1899).

Family Menispermaceae

Origin and geographic distribution *Limaciopsis loangensis* occurs from Cameroon and the Central African Republic south to Gabon, Congo and DR Congo.

Uses A decoction of the tuber is given to children against convulsions. In Gabon a tuber decoction is taken with a little salt against gonorrhoea. A decoction of the leaves or twigs is drunk to treat stomach-ache.

Properties About 20 alkaloids have been isolated from various parts of *Limaciopsis loangensis*; tests for flavonoids, saponines, tannins and quinones have been negative. Per 100 g dry matter the roots contain about 1.5 g alkaloids, the stems 0.3 g, the leaves 0.02 g, whereas the fruits contain no alkaloids. The alkaloids belong to the groups characteristic of *Menispermaceae*: bisbenzylisoquinolines, aporphines and protoberberines. Isotetrandrine accounts for about 90% of the alkaloids, and minor alkaloids are cycleanine, nor-2-isotetrandrine, N-oxy-isotetrandrine, liriodenine, 8-oxy-palmatine, thalrugoside, thalrugosamine and berbamine. Isotetrandrine is active against catarrh, and its role in the mitochondrial respiratory chain is being investigated.

Botany Dioecious twining liana; tuber 50–60 cm in diameter; stem up to 8 cm in diameter, hairy when young. Leaves arranged spirally, simple and entire; stipules absent; petiole 3–5 cm long, swollen and bent at apex, reddish brown hairy; blade elliptical to ovate-elliptical, 10–19 cm × 3–10 cm, base rounded or slightly cuneate, apex rounded with very short mucro, glabrous, leathery, palmately and pinnately veined with lateral veins in 3–5 pairs, prominent on both sides. Male inflorescence a panicle, single or grouped, 2–12 cm long, hairy, bearing many small flower heads, bracts linear, c. 1 mm long; female inflorescence a raceme. Flowers unisexual; pedicel 3–5 mm long, hairy; bracteoles 2–3, 2–4 mm long; sepals 9–10, 3 outer ones linear-oblong to oblong, 2–2.5 mm × 1–1.5 mm, inner ones larger; petals 6, c. 1 mm long, somewhat fleshy, hairy; male flowers with stamens 6(–9) in 2(–3) whorls, free, filaments 1–1.5 mm long; female flowers with superior ovary of 3–4 free carpels, silky hairy, brownish black. Fruit composed of up to 3 drupelets c. 2 cm × 2.5 cm × 1.5 cm, smooth, orange, shiny; stone spirally twisted, bony.

Seeds linear, 1.5–2.5 cm × c. 0.5 cm.
Limaciopsis comprises a single species.

Ecology *Limaciopsis loangensis* occurs in the undergrowth of rainforest, including secondary forest, and in fringing forest and forest relics in the savanna.

Genetic resources and breeding *Limaciopsis loangensis* seems fairly common in primary and secondary forest and in forest remnants. There are no signs that it is in danger of genetic erosion.

Prospects From the isolated alkaloids in *Limaciopsis loangensis*, isotetrandrine occurs in large amounts and further research seems warranted to assess its potential.

Major references Adjanohoun et al. (Editors), 1988; Cave et al., 1979; Fang, Zhang, & Ku, 2005; Neuwinger, 2000; Troupin, 1962.

Other references Troupin, 1951.

Authors L.P.A. Oyen

LOESENERA KALANTHA Harms

Protologue Engl. & Prantl, Nat. Pflanzenfam. II–IV Nachtr. 1: 197 (1897).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae).

Origin and geographic distribution *Loesenera kalantha* is only known from Liberia and Côte d'Ivoire.

Uses In Côte d'Ivoire a leaf decoction is commonly taken to treat syphilis and sometimes also to treat leprosy. It is also used to treat rheumatic arthritis. The wood is used in local house building. Formerly *Loesenera kalantha* played an important role in witchcraft.

Production and international trade Leaves of *Loesenera kalantha* have been imported from Liberia into Côte d'Ivoire for medicinal purposes. No details are available on quantities traded.

Properties Nothing appears to have been published on the pharmacology of *Loesenera kalantha* to date. The pinkish brown heartwood is not clearly demarcated from the whitish sapwood. The wood is moderately heavy and moderately hard. It is tough and strong, but not durable. It is easy to work and finishes smoothly.

Botany Medium-sized to fairly large tree up to 30 m tall; bole up to 70 cm in diameter, straight and cylindrical, base with short, thick root swellings; bark smooth, grey, finely flaky. Leaves alternate, paripinnate with 3–4 pairs of opposite leaflets, the end pair the largest; petiolule twisted with gland at the top on lower side; leaflets oblong to lanceolate, 6–8 cm long, base asymmetrical, apex acute to acuminate, rusty hairy below. Inflorescence a terminal, unbranched raceme up to 18 cm long. Flowers bisexual, zygomorphic; sepals 4, imbricate in bud, reddish brown; 3 petals well developed, clawed, cherry-red, 2 petals small, pinkish; stamens 10, free; ovary superior, stipitate. Fruit a broadly oblong, flattened pod c. 17 cm × 7 cm, oblique at base, apex acuminate, dehiscent, woody, pendulous, pale brown hairy, 1–2-seeded. Seeds 3–5 cm long.
Loesenera comprises 4 species, restricted to rain forest from Liberia to Gabon. *Loesenera walkeri* (A.Chev.) J.Léonard is endemic to Gabon. Its wood is used locally in construction, but is not of interest for large-scale exploitation. The bark is used to construct bathtubs in which patients with backache or kidney problems can take a bath in capsicum pepper solution.
In experiments in Côte d'Ivoire, seedlings of *Loesenera kalantha* reached a height of 4–5 m and a diameter of 20–30 cm in 15 years.

Ecology *Loesenera kalantha* occurs in swamp forest, along creeks and in depressions that are inundated during the rainy season. In eastern Liberia it forms gregarious stands.

Genetic resources and breeding The natural range of *Loesenera kalantha* extends over only 315 km and it is on the IUCN Red List as vulnerable in both Liberia and Côte d'Ivoire. In Côte d'Ivoire *Loesenera kalantha* is rare. In the past it was protected by superstition and because of the role it played in witchcraft. Erosion of traditional values could bring about more intensive exploitation and eventually cause extinction of the species.

Prospects In-situ and ex-situ conservation of *Loesenera kalantha* are very urgently required. In view of the local medicinal uses, it is surprising that no pharmacological research has been undertaken. Pharmacological investigations, especially of the leaves, could yield rewarding results.

Major references Burkill, 1995; Holmgren et al., 2004; Keay, Hoyle & Duvigneaud, 1958; Kerharo & Bouquet, 1950.

Other references Aké Assi, 2001; Aubréville, 1968; Cooper & Record, 1931; Normand & Paquis, 1976; Raponda-Walker & Sillans, 1961; Voorhoeve, 1965.

Authors C.H. Bosch

LYCIUM SHAWII Roem. & Schult.

Protologue Syst. veg. 4: 693 (1819).
Family Solanaceae
Chromosome number $2n = 24$
Origin and geographic distribution *Lycium shawii* is distributed from Sudan and Ethiopia south through Kenya and Tanzania to Malawi, Zambia, Botswana and Zimbabwe. It also occurs in South Africa, the Mediterranean region, the Middle East and western India.

Uses In Tanzania the roots of *Lycium shawii* are boiled and the decoction is used to treat sores in the mouth; in Somalia, Kenya and Tanzania it is used to treat coughs. The decoction is applied externally to relieve backache and to wash polio patients, and administered internally to cure tick fever in livestock. An infusion of leaves and roots is drunk to induce vomiting in case of tapeworm infection. Leaves are used to treat constipation and stomachache. In Saudi Arabia and Mediterranean countries similar medicinal uses have been reported. The salty leaves are much liked by livestock. The leaves are eaten as a vegetable after chopping and cooking, either alone or mixed with other green vegetables. The Chamus and Turkana people of Kenya use the branches for fencing.

Properties Aqueous stem and leaf extracts showed low cytotoxicity to melanoma cell lines and low antiplasmodial activity. An extract of the aerial parts exhibited persistent hypoglycaemic effects in alloxan-induced diabetic rats. The extract induced wheat rootlet elongation in a root growth inhibition test, but the reason needs to be elucidated.
The crude protein content of the aerial parts is about 17%.

Botany, Erect to spreading, much-branched shrub, sometimes scandent, up to 2.5(–3) m tall, very spiny with axillary spines 5–10(–15) mm long; stems slightly zigzag, robust, glabrous, branches curving, greyish white. Leaves in fascicles of 2–6, simple and entire; stipules absent; petiole 2–5 mm long; blade obovate to lanceolate, 2–3.5 cm × c. 1 cm, base cuneate, apex acute to rounded, glabrous or with short glandular hairs, glossy. Flowers bisexual, regular, 5-merous; pedicel 6–15 mm long, pendulous; calyx tubular, 3–5 mm long, lobes triangular, c. 5 mm long, erect; corolla narrowly tubular, 12–16 mm long, lobes ovate-oblong, 3–4 mm long, creamy white to pale mauve with purple venation; stamens unequal, inserted above the middle of the corolla tube, filaments 3–9 mm long, 3 included, 2 slightly exserted; nectary red; ovary superior, globose, 1.5–2 mm long, style 10–12 mm long, stigma obtuse, 2-lobed. Fruit a globose or slightly obovoid berry 3–5 mm in diameter, red, many-seeded. Seeds ovate in outline, 2 mm × 1.5 mm, flattened, brown.
Lycium comprises about 90 species and is found mainly in warm temperate areas, the largest number of species occurring in the New World and about 35 in mainland Africa. *Lycium shawii* has long been regarded as a form of *Lycium europaeum* L., but in recent flora treatments for tropical Africa, all specimens collected south of Sudan are placed in *Lycium shawii*. The 2 species can mainly be distinguished by the calyx, which is cup-shaped, c. 2 mm long and with unequal teeth in *Lycium europaeum* and tubular, 3–5 mm long and with equal teeth in *Lycium shawii*.
Several other *Lycium* spp. are medicinally used in southern Africa and Madagascar. In Namibia the roots of young shrubs of *Lycium oxycarpum* Dunal are used against backache, diseases of the male genitals, painful and excessive menstruation, diarrhoea in children and as a purgative. In Botswana the smoke of the burnt roots of *Lycium cinereum* Thunb. is used as an analgesic for painful eyes. A decoction of the roots is taken to treat kidney pain. Reports on the properties of the fruit are contradictory, poisonous as well as edible. In Namibia the branches are used to make impenetrable barriers around gardens and kraals. Dried, powdered plant parts have a pleasant smell and are used as a perfume. *Lycium mascarenense* A.M.Venter & A.J.Scott from southern Mozambique, coastal South Africa and Madagascar is medicinally used in Madagascar. The aerial parts are commonly used in a medicine to treat Parkinson's disease. The fruits are considered poisonous; birds that eat them die.

Ecology *Lycium shawii* occurs in dry to relatively moist areas, from hilly country to the edge of floodplains and riverbanks, also in mixed woodland, wooded grassland and cultivated areas, and along roads, on clayey and loamy, even saline soils. In southern Africa it occurs up to 2100 m altitude.

Management For medicinal use and as a vegetable, *Lycium shawii* is exclusively harvested from the wild. When planted as hedges either stem cuttings or seeds can be used. In Kuwait, tissue culture technology was developed of certain genotypes of *Lycium shawii* because of their potential for use in urban

landscaping and in desert revegetation.

Genetic resources and breeding Although widespread, *Lycium shawii* is not common within its area of distribution. In tropical Africa there are no threats reported, but in the Sinai Desert and in Jordan the species is threatened by its unsustainable use. In the wild *Lycium* species hybridize frequently, offering opportunities for breeders.

Prospects The lack of knowledge of the chemistry of *Lycium shawii* makes it difficult to judge its potential. It will probably remain a locally important multi-purpose species.

Major references Abdalla et al., 1995; Goncalves, 2005; Neuwinger, 2000; Ruffo, Birnie & Tengnäs, 2002; Sathiyamoorthy et al., 1999.

Other references Beentje, 1994; Boiteau, Boiteau & Allorge-Boiteau, 1999; Boulos, 2000b; Heine & Heine, 1988a; Heine & Heine, 1988b; Rahman et al., 2004; SEPASAL, 2007b; Shabana et al., 1990; Van Damme & Van den Eynden, 2000; Venter & Scott, 1999.

Authors C.H. Bosch

LYCOPODIELLA CERNUA (L.) Pic.Serm.

Protologue Webbia 23: 166 (1968).

Family Lycopodiaceae

Chromosome number $2n = 312$

Synonyms *Lycopodium cernuum* L. (1753), *Palhinhaea cernua* (L.) Vasc. & Franco (1967).

Vernacular names Stag-horn moss, monkey's paws, nodding club-moss (En). Lycopode ornamental, fougère décorative (Fr). Enxofre vegetal, licopódio brasileiro, palma de São João, pinheirinho do campo (Po).

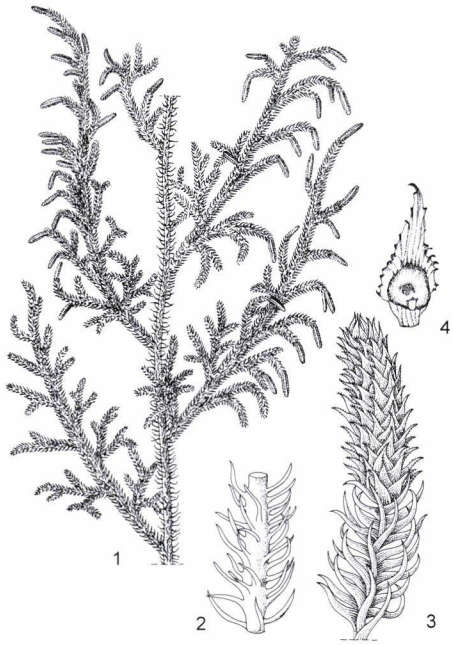
Origin and geographic distribution *Lycopodiella cernua* is found throughout the tropics and subtropics, extending to Japan, the Azores and New Zealand. It occurs throughout continental Africa, Madagascar and the Mascarene Islands, except in the driest regions.

Uses In Rwanda the whole plant is crushed and applied as a dressing to wounds. In DR Congo the plant is used as a flea repellent. In Madagascar a decoction of the plant is used as a tonic and in a mixture with *Tristemma mauritianum* J.F.Gmel. to treat neuralgia and hypertension. The whole plant is used to prepare a tea that is drunk to treat stomach ulcers. In tropical America and Asia it also has several applications in traditional medicine. In South-East Asia a decoction of the whole plant is used externally as a lotion to treat beri-beri, coughs and asthma, and in embrocations to treat skin eruptions and abscesses. In tropical America it is used as a diuretic, and to treat gout, arthritic swellings, skin irritations, gonorrhoea, leucorrhoea and dysentery. A traditional Chinese medicine is prepared from *Lycopodiella cernua* plants by ultrafiltration. It is administered to treat rheumatism, hepatitis and dysentery, and applied externally to bruises, burns and scalds. In Micronesia *Lycopodiella cernua* is used as a cockroach repellent. It is also used to stuff cushions as a kapok substitute. In Gabon the leaves are used to filter palm wine. *Lycopodiella cernua* is widely grown as an ornamental, both indoors and outdoors. It is also used in floral decoration, for making wreaths and baskets.

Properties Phytochemical investigations of *Lycopodiella cernua* showed the presence of alkaloids, such as cernuine and lycocernuine, the flavonoids apigenin and apigenin-7-glucoside, the triterpene serratenediol and, as in many other *Lycopodiaceae*, a high concentration of aluminium (up to 12.5% of ash). Tests with rats showed that injection with a traditional Chinese medicine prepared from *Lycopodiella cernua* is effective against experimental silicosis, not only as a prophylactic but also to treat the disease.

Botany Terrestrial herb with creeping main stem of indefinite length, rooting at long intervals; erect shoots distant, somewhat resembling little pine trees, up to 100 cm tall, basal part simple, distal part with numerous almost opposite, highly compound, spreading branches, ultimate branches nodding to pendulous. Leaves arranged spirally, linear-subulate, 2–3(–5) mm × 0.1–0.3 mm, base broadly decurrent, apex sharply pointed, margin entire, pale yellowish or brownish, thick but soft, changing gradually from patent-reflexed and rather distant on the shoot axis to falcately ascending and closely approximate on the ultimate branches. Cone-like structures producing spores terminal on the branches, sessile, pending, ovoid to ellipsoid, 3–15(–25) mm × 1.5–3(–5) mm; sporophylls ovate to deltoid, c. 2 mm × 1 mm, margins coarsely and irregularly slashed, yellowish or greenish; sporangium globose, opening with very unequal valves, concealed by the sporophyll base. Spores globose, with a 3-pronged scar, slightly wrinkled.

Lycopodiella cernua has been placed in the genus *Palhinhaea* on the basis of phytochemical characteristics. However, it is currently accepted that this genus should be treated as a section of *Lycopodiella*, i.e. sect. *Campylo-*



Lycopodiella cernua – 1, part of a spore-producing plant; 2, part of a branch; 3, apical part of a spore-producing branch; 4, sporophyll with sporangium.
Source: PROSEA

stachys. At least 40 varieties have been described within *Lycopodiella cernua*, most of which are hardly distinguishable. *Lycopodiella cernua* may produce spores throughout the year, but may also spend the dry season as buried stem tips while the rest of the plant dies.

Ecology *Lycopodiella cernua* occurs along forest fringes, in young secondary forest, often in swamp margins, in grassland (including wet grassland), along roadsides and railways, on moist cliff-faces, hillsides and mountain slopes, up to 2400 m altitude. Locally it is abundant, sometimes as a weed. In southern Africa it is not found in areas with less than 600 mm annual rainfall. It is apparently fire resistant.

Management *Lycopodiella cernua* can be propagated by layering of growing tips. Harvesting is done from wild populations when the need arises. Fresh stems and branches are tied up into bundles and brought to the market for sale.

Genetic resources and breeding *Lycopodiella cernua* is probably the world's most abundant and widespread club-moss, and is therefore not in danger of genetic erosion.

Prospects More research on the pharmacological activities of *Lycopodiella cernua* is desirable, considering its applications in traditional medicine in many parts of the world and the fact that other species of *Lycopodiaceae* have medicinal uses. Since this club-moss is in great demand in floriculture, research on its cultivation warrants more attention.

Major references Burkill, 2000; He et al., 1998; Jacobsen, 1983; Ma & Gang, 2004; Schelpe, 1970.

Other references Adjanohoun et al., 1989; Alston, 1959; Hegnauer, 1986; Lawalrée, 1989; Markham, Moore & Given, 1983; Novy, 1997; Perry, 1980; Raponda-Walker & Sillans, 1961; Tardieu-Blot, 1971b; Yamada, 1999.

Sources of illustration Wulijarni-Soetjipto & de Winter, 2003.

Authors R.H.M.J. Lemmens

LYCOPODIUM CLAVATUM L.

Protologue Sp. pl. 2: 1101 (1753).

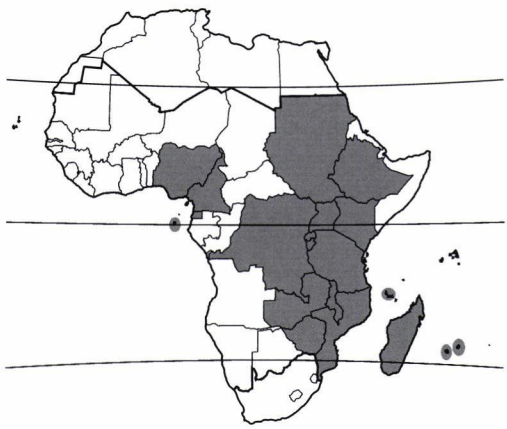
Family Lycopodiaceae

Chromosome number $2n = 68, 102, 136$

Vernacular names Staghorn clubmoss, common clubmoss, ground pine, running pine (En). Lycopode à massue (Fr). Licopódio chifre de veado (Po).

Origin and geographic distribution In continental Africa *Lycopodium clavatum* is found from Nigeria east to Ethiopia and south to South Africa. It is also indigenous in the Indian Ocean Islands. It is found in all continents except Australia and is most common in boreal regions.

Uses In many countries throughout the



Lycopodium clavatum – wild

world *Lycopodium clavatum* is used as a medicinal plant. In southern Nigeria a decoction of young leaves is applied externally to wounds and ulcers. Sun-dried, pulverized leaves are mixed with plantain and milk, and the mixture is given in small doses to children to cure diarrhoea and dysentery. In eastern DR Congo the plant is used to repel insects. In Rwanda an extract of the aerial parts is drunk to cure dysentery and malaria. In Madagascar the whole plant is grilled with sugarcane and banana skins and applied to cracked lips to promote healing. In Lesotho the whole dried plant is pulverized and smoked as a cure for headache. In New Guinea and in the Philippines the whole plant is chewed to induce vomiting after food poisoning or acute stomach pain. North-American Indians apply the aerial parts as a remedy for stiff joints. In traditional European medicine it has been used as a diuretic in oedema, as a strong medicine to cure diarrhoea and dysentery, to suppress spasms and hydrophobia, to treat gout and scurvy, as a tonic and as a wound powder. It was also applied against affections of the urinary tract and inflammations of the bladder or kidneys.

The spores traded as 'lycopodium seed', 'pulverized lycopodium', 'vegetable sulphur' or 'sporae lycopodii', have been used for centuries as a styptic and as a dusting powder in various skin diseases such as eczema and erysipelas and for chafed skin, to prevent pills from sticking together and for metal-casting moulds. The aerial parts are still a popular medicine in phytotherapy, and used to alleviate anxiety, anticipatory fears, apprehension, over-sensitivity and inability to adapt to new surroundings. They are also used to treat constipation, bloating, digestive upset, heartburn, migraine, dryness of mucous membranes, dry wrinkled skin, sallow complexion and a plethora of other inconveniences.

Lycopodium clavatum is one of the ingredients of a remedy to alleviate jet lag. It is used as a feed additive for cows to improve their constitution and as a cure for anaemia with jaundice and for dogs suffering from fleas. The spores are used as a reference in pollen traps used to monitor pollen in the air to establish hay-fever risks. Sporopollenin, the outer cover of the spores has been found to be a suitable solid support for peptide synthesis. It is stable to chloromethylation and to standard deblocking procedures and its constant mesh size, ready commercial availability and constant molecular structure give it important practical advantages over synthetic resins. *Lycopodium clavatum* has been used for sifting milk and other liquids and is used as ornamental e.g. for decorations and garlands. The stems are woven into mats and the whole plant is used as a mordant in dyeing.

Production and international trade Trade statistics on *Lycopodium clavatum* are rare. China, Nepal, eastern Europe and former Soviet Republics are sources in international trade. In the early 1990s Nepal exported 40 t of the crude herb per year. The wholesale market price per kg spores in early 2001 was US$ 110, and US$ 28 per kg cut and sifted plant material. In some areas, such as western Europe, *Lycopodium clavatum* has declined in abundance too much to allow collecting.

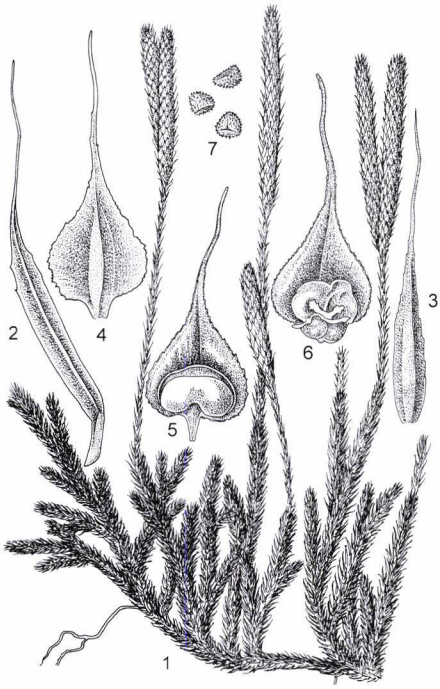
Properties The aerial parts contain dihydrocaffeic acid, which has a blood pressure lowering effect in animals, as well as alkaloids such as lycopodine, chinoline, clavatine, clavatoxine and annotinine, which all cause an increase in blood pressure. Lycopodine also stimulates the peristaltic movements of the intestine; in in-vivo tests with rats, lycopodine causes contraction of the uterus. Furthermore, the aerial parts contain derivatives of cinnamonic acid and flavonoids; the ash contains 3.5–12.5% aluminium. A methanol extract showed strong prolyl-endopeptidase-inhibiting activity and is expected to have activity against loss of memory.

The spores contain about 50% greenish yellow acidic oil, 3% sugar, 1–4% ash and a trace of a volatile alkaloid. The spores are highly inflammable because of the oil, which contains 80–86% decyl-isopropyl acrylic acid, 3–5% glycerine and solid fatty acids (mainly myristic acid). Other analyses showed a neutral oil, 8.2% glycerine, 5.3% protein and no alkaloids. In several pharmacopoeias *Lycopodium clavatum* spores form a pharmacologically indifferent, fine, pale yellow, very mobile, inodorous and tasteless powder. The powder should be free from pollen, starch, sand and other impurities. When ignited with free access to air, the spores should not leave more than 5% ash. The spores are strongly water repellent. *Lycopodium clavatum* spores used as dusting powder can cause asthma and other allergy problems (itchy skin, eye and nose problems) when used over a long period. The powder is safe for consumers who are exposed to small amounts, but hepatotoxic effects have been observed. When the spores enter surgical wounds a lesion may develop months or even years later.

Description Herb with creeping main stem, rooting at long intervals, much branched, usually up to 1.5 m long and 2–4 mm in diameter (excluding the leaves); erect shoots up to 60(–80) cm long, dichotomously branched. Leaves arranged spirally or apparently in rows, linear-lanceolate, 4–7 mm × 0.5–1 mm, apex narrowly acute to attenuate, with translucent hair-point 2–4 mm long, margin indistinctly toothed to entire, midrib distinct. Cone-like structures producing spores terminal on branches, erect, cylindrical, 1–8 cm × 4–6 mm, 1–6 together; sporophylls ovate, 1.5–3.5(–5) mm × c. 1 mm, appressed, imbricate, apex elongated, with a 1.5–4 mm long spreading hair-point, margins irregularly toothed; sporangium globose to kidney-shaped, c. 1 mm × 1.5 mm, bright ochreous. Spores globose, with a 3-radiate scar, reticulate, bright yellow.

Other botanical information *Lycopodium* comprises about 40 species. Formerly many more species were included in *Lycopodium*, but most of these have been separated into the genera *Huperzia* and *Lycopodiella*. *Lycopodium clavatum* is very variable, and there is a nearly continuous series of forms from compact plants with parallel branches and firm, imbricate leaves to amply branched plants with diverging branches and soft, spreading leaves. The former are typical for cold and exposed habitats, the latter for warm and sheltered locations.

Several *Huperzia* species have medicinal uses in Madagascar. *Huperzia phlegmaria* (L.) Rothm. (synonym: *Lycopodium phlegmaria* L.), an epiphytic herb with pendant stems found in forests in large parts of tropical Africa, tropical Asia, Australia and New Zealand, *Huperzia stricta* (Baker) Tardieu (synonym: *Lycopodium strictum* Baker), an endemic terrestrial herb from Madagascar, *Huperzia megastachya* (Baker) Tardieu (synonym: *Lycopodium megastachyum* Baker), an endemic epiphytic herb from Madagascar, and *Huperzia obtusifolia* (Sw.) Rothm. (synonym: *Lycopodium obtusifolium* Sw.), an epiphytic herb from Madagascar and Réunion all share several vernacular names in Madagascar. The dried plant is smoked and the fresh leaves are used in an infusion as a tonic or fortifier. The infusion is also given to dancers, wrestlers, fighting cocks and bulls. Since cannabis (*Cannabis sativa* L.) is an illegal drug in Madagascar, the *Huperzia* species are much sought after as a substitute.



Lycopodium clavatum – 1, habit; 2, leaf from inner side; 3, leaf from outer side; 4, sporophyll from outer side; 5, sporophyll with sporangium; 6, sporophyll with open sporangium; 7, spores. Source: PROSEA

Growth and development The spores of *Lycopodium clavatum* remain dormant for 3–8 years. During this period they settle in the soil at a depth of 3–10 cm and this, combined with a relatively thick spore wall, may retard germination considerably. When spores are exposed to sulfuric acid, germination takes only 2 months. The subterranean prothallus develops slowly and reaches sexual maturity after 6–15 years and may live for 20 years. It is top-shaped, differentiated into various tissues and lives in close symbiosis with a fungus, possibly a species of *Pythium*. Without the fungus, the development of the gametophyte stops at an early, few-celled stage. Once the sporophyte has established, it can spread rapidly by the long creeping stems. If competition with higher growing plants is not strong, it is long-lived and slowly forms large colonies.

Ecology *Lycopodium clavatum* is found in cool, wet climates where it prefers open habitats such as mountain sides, moors and heaths, clearings and road cuttings in cloud forest. In the tropics it grows in highland areas above 1300 m altitude. It is often found as one of the pioneers on bare soil of road embankments and

recently burned patches, frequently accompanied by ferns.

Propagation and planting *Lycopodium clavatum* is usually propagated by division of the main stem. The long juvenile phase of the prothalli make propagation by spores virtually impossible. *Lycopodium clavatum* is difficult to transplant but once established it may grow vigorously. A well-draining potting mix is recommended.

No successful mass production method either by traditional cultivation or by tissue culture has been developed for any *Lycopodium* species.

Diseases and pests The fungus *Leptosphaeria crepini* has been recorded on *Lycopodium clavatum*; it blackens the sporophylls with abundant fruiting bodies.

Harvesting Collectors cut the spore-producing tops from the plants, and the spore powder is obtained by shaking the tops and sifting out the other matter. The annual yield is rather variable, depending on spore production.

Genetic resources *Lycopodium clavatum* is extremely widespread, but in some areas it is threatened with extinction.

Prospects At present *Lycopodium clavatum* is utilized for various purposes. Research is being carried out to elucidate the value of the many pharmacological claims. Specially promising is the application of alkaloids in the treatment of Alzheimer's disease and in increasing efficiency of learning and memorizing. Cultivation would be desirable, both for the quality of the crude herb and spores and for its protection.

Major references Burkill, 2000; Cullinan et al., 1993; de Winter, 2003; Ma & Gang, 2004; May, 1978; Verdcourt, 2005.

Other references Boiteau, Boiteau & Allorge-Boiteau, 1999; Debray, Jacquemin & Razafindrambao, 1971; Lawalrée, 1989; Neuwinger, 2000; Pichi Sermolli, 1983; Rwangabo, 1993; Schelpe, 1970; Tardieu-Blot, 1964; Tardieu-Blot, 1971a; Tardieu-Blot, 1971b; Tezuka et al., 1999; Tulp & Bohlin, 2005; Watt & Breyer-Brandwijk, 1962; Yamada, 1999.

Sources of illustration de Winter, 2003.

Authors C. Zimudzi & C.H. Bosch

Based on PROSEA 15(2): Cryptogams: Ferns and fern allies.

MACARANGA HETEROPHYLLA (Müll.Arg.) Müll.Arg.

Protologue A.DC., Prodr. 15(2.2): 993 (1866).

Family Euphorbiaceae

Origin and geographic distribution *Macaranga heterophylla* occurs from Senegal east to Cameroon.

Uses Various parts of the plant are used as a purgative. In southern Senegal a root decoction is taken to treat amenorrhoea, and also as an abortifacient. In Sierra Leone a decoction of young leaves is taken to treat gonorrhoea. In Côte d'Ivoire a bark decoction is taken and used in a bath to treat cough. The plant is used to treat snakebites.

The ash from the burnt stem and branches is used as vegetable salt.

Botany Dioecious shrub or small tree up to 10 m tall; twigs and stem covered with stout, woody spines; stem sap yellowish orange, gelatinous. Leaves alternate, simple; stipules lanceolate to ovate, 2.5–4 cm long, brown, appressed hairy; petiole 10–20 cm long; blade digitately 3–7-lobed, rarely not lobed, 13–32 cm in diameter, base rounded to shallowly cordate, apex long acuminate, margins toothed, glabrous above, sparingly short-hairy on the veins beneath. Male inflorescence an axillary, many-flowered panicle 15–30 cm long; female inflorescence an axillary, spike-like raceme or narrow, sparsely branched panicle up to 14 cm long. Flowers unisexual, petals absent, disk absent; male flowers almost sessile, calyx lobes 3, tiny, white, tinged pink, reddish hairy outside, stamens 3, free, minute; female flowers with pedicel up to 1 mm long, extending in fruit, calyx tiny, ovary superior, glandular, 2-celled, style 1, small. Fruit a rounded 2-lobed drupe 10–20 mm in diameter, pink to red, covered with small yellow glands, 2-seeded. Seeds almost globose, dull black.

Macaranga comprises about 280 species, of which about 30 are native to tropical continental Africa and about 15 to Madagascar and the Indian Ocean islands. Several other West-African *Macaranga* species are medicinally used in West Africa. In Côte d'Ivoire the crushed leaves of *Macaranga beillei* Prain, together with the crushed aerial parts of *Scleria boivinii* Steud. and vegetable salt, are wrapped in leaves of *Thaumatococcus daniellii* (Bennet) Benth., and the decoction is drunk to treat cough. In Sierra Leone an infusion of ground leaves of *Macaranga heudelotii* Baill.

with lemon juice is drunk to treat gonorrhoea. In Ghana a leaf infusion is taken to treat diarrhoea.

Ecology *Macaranga heterophylla* occurs in secondary forest in wet localities and riverine forest. It is a pioneer species in forest gaps.

Genetic resources and breeding *Macaranga heterophylla* is not threatened by genetic erosion.

Prospects *Macaranga heterophylla* will probably remain of local importance as a medicinal plant, unless research into the chemistry and pharmacology offers new possibilities.

Major references Berhaut, 1975a; Burkill, 1994; Neuwinger, 2000; Stäuble, 1986.

Other references Adjanohoun & Aké Assi, 1979; Keay, 1958a; MacFoy & Sama, 1983.

Authors G.H. Schmelzer

MACARANGA MONANDRA Müll.Arg.

Protologue Journ. Bot. 2: 337 (1864).

Family Euphorbiaceae

Origin and geographic distribution *Macaranga monandra* occurs from southern Nigeria east to Uganda and south to Tanzania and Angola.

Uses In Gabon a decoction of the stem bark is taken as a galactagogue. In Congo the decoction, together with the bark of *Pentaclethra eetveldeana* De Wild. & T.Durand, is taken by women to treat sterility. A bark decoction is drunk to treat dyspnoea. A large amount of bark decoction is drunk in case of threatened abortion. A twig bark decoction is taken to treat intercostal neuralgia.

In DR Congo *Macaranga monandra* is considered a good food plant for different species of edible caterpillars. The wood is considered a good firewood.

Properties Hexane and ethyl acetate fractions of the methanol extract of the stem bark showed growth inhibition of different plant fungi: *Colletotrichum acutatum*, *Colletotrichum fragariae*, *Colletotrichum gloeosporioides*, *Fusarium oxysporum*, *Botrytis cinerea*, *Phomopsis obscurans* and *Phomopsis viticola*. Two active clerodane-type diterpenes were isolated: kolavenic acid and 2-oxo-kolavenic acid. These 2 compounds showed moderate growth inhibition of *Phomopsis viticola* and *Botrytis cinerea*. Isolated from other plants, these compounds also showed cytotoxic and antibacterial activities.

Botany Dioecious, much-branched medium-sized tree up to 25 m tall, with bushy crown, usually with a spiny bole; spines sparse, up to 7.5 cm long, blunt; young shoots, petioles and inflorescences densely hairy. Leaves alternate, simple; stipules linear-lanceolate, 5–7 mm long, soon falling; petiole 4–10 cm long; blade ovate, oblong-ovate to elliptical-oblong, (5–)11–16(–20) cm × (3–)6–10(–12) cm, base rounded, cuneate or truncate to shallowly cordate with 2 basal glands, apex acuminate, margins coarsely toothed, softly hairy above, later glabrescent, densely and minutely yellowish glandular-punctate and shortly hairy on the main veins beneath. Male inflorescence an axillary, many-flowered panicle 3–9 cm long, bracts up to 1 cm long; female inflorescence an axillary, few-flowered raceme (2–)3–5.5 cm long, bracts up to 1 cm long. Flowers unisexual, petals absent, disk absent; male flowers almost sessile, calyx lobes 3, broadly ovate, c. 0.5 mm long, pale greenish brown to brownish white, stamens usually 2, fused at base, minute; female flowers with pedicel up to 1 mm long, extending to 1–2 cm in fruit, calyx cup-shaped, c. 1 mm long, splitting into 3 lobes, ovary superior, 1.5–2 mm long, densely yellowish glandular, 2-celled, stigma sessile, recurved, c. 1 mm long. Fruit a transversely ovoid drupe 6–7 mm × 8–9 mm, densely yellowish glandular, becoming blackish when ripe, sometimes late dehiscent, stigma persistent, 1-seeded. Seed almost globose, 5–6 mm long, rough, dull, brownish to blackish.

Macaranga comprises about 280 species, of which about 30 are native to tropical continental Africa and about 15 to Madagascar and the Indian Ocean islands. Several other *Macaranga* species occurring in Central Africa are medicinally used. In Congo, leaf sap of *Macaranga angolensis* (Müll.Arg.) Müll.Arg. is rubbed on painful spots, sores and wounds, or a vapour bath with the leaf decoction is taken to treat bronchitis. In Gabon a bark infusion is drunk to treat hypermenorrhoea and dysmenorrhoea. In DR Congo a stem bark decoction of *Macaranga saccifera* Pax together with salt is taken to treat headache. The large leaves are used to wrap seeds and tobacco for storage purposes.

Ecology *Macaranga monandra* occurs in secondary forest and is common in riverine, lakeside and swamp-edge forest, from sea-level up to 1500 m altitude. It is a fast-growing, light-demanding pioneer species of forest gaps.

Management *Macaranga monandra* can be grown from seeds and cuttings. It is the main

competitor of *Aucoumea klaineana* Pierre in forest gaps as it grows slightly faster.

Genetic resources and breeding *Macaranga monandra* is relatively widespread and a fast-growing pioneer species of forest gaps. It is therefore not threatened by genetic erosion.

Prospects The stem bark of *Macaranga monandra* has several gynaecological applications. Kolavenic acid and 2-oxo-kolavenic acid, isolated from the stem bark, show antifungal activity against plant fungi. However, nothing is known about the pharmacological activity of *Macaranga monandra* against human pathogens.

Major references Burkill, 1994; Neuwinger, 2000; Radcliffe-Smith, 1987; Salah et al., 2003.

Other references Bourobou Bourobou et al., 1996; Doucet, Otimbo & Boubady, 2004; Latham, 2004; Terashima & Ichikawa, 2003.

Authors G.H. Schmelzer

MACARANGA SPINOSA Müll.Arg.

Protologue Flora 47: 466 (1864).

Family Euphorbiaceae

Vernacular names Mkalanga, mbawa (Sw).

Origin and geographic distribution *Macaranga spinosa* occurs from Liberia east to Uganda and south to Burundi, Tanzania and Angola.

Uses In Côte d'Ivoire the plant is used in the treatment of dysentery and cough. In Congo leaf sap or bark sap is drunk, rubbed in or used in a vapour bath to treat lung complaints (including bronchitis, cough and asthma), headache, feverish stiffness, rheumatism, liver complaints and stomach-ache. A bark decoction is gargled or used as a mouth wash to treat toothache, stomatitis and aphthae. A maceration of the crushed leaves is taken by women to treat amenorrhoea. The root ash is inhaled to treat haemorrhoids.

The wood is used for construction of house posts, stools and spoons, as firewood and to make charcoal. The tree is planted for shade in home gardens. In Cameroon potters sprinkle an extract from the crushed stem bark on pots that come from the fire and are still red hot, to make them waterproof.

Properties In a preliminary analysis, saponins, steroids and terpenes have been isolated from the stem bark. A water extract of the stem bark contains procyanidins, of which the pyrolysis products have waterproofing properties.

Botany Dioecious shrub or small tree up to 10(–20) m tall, with a spiny bole; spines 10–20 cm long, directed downwards, simple or forked, woody; twigs often spiny, young shoots densely softly hairy. Leaves alternate, simple and entire; stipules linear-lanceolate, 5–7 mm long, soon falling; petiole 1–5 cm long, widened at base; blade elliptical, elliptical-oblong to elliptical-oblanceolate, 5–13 cm × 3–6.5 cm, base rounded to shallowly cordate with 2 basal glands, apex acute to acuminate, softly hairy above, later glabrescent, glandular-punctate beneath. Inflorescence an axillary panicle 3–6.5 cm long; bracts triangular, small. Flowers unisexual, petals absent, disk absent; male flowers almost sessile, calyx lobes 3, ovate, up to 0.5 mm long, creamy white, stamens 3, free, minute; female flowers with pedicel up to 1 mm long, extending to c. 5 mm in fruit, calyx cup-shaped, c. 0.5 mm long, splitting into 3 unequal lobes, ovary superior, c. 1 mm long, densely glandular, 2-celled, style 1, stigma recurved, c. 1 mm long. Fruit a transversely ovoid drupe c. 3 mm × 4 mm, densely glandular, sometimes late dehiscent, stigma persistent, c. 3 mm long, 1-seeded. Seed almost globose, c. 2.5 mm long, rough, dull, brownish.

Macaranga comprises about 280 species, of which about 30 are native to tropical continental Africa and about 15 to Madagascar and the Indian Ocean islands. Several *Macaranga* species endemic to Madagascar are also used medicinally. The aromatic stem bark of *Macaranga cuspidata* Boivin ex Baill. is crushed on insect bites. The wood is used to make poles, which are suitable for humid soils as they do not rot. A stem bark infusion of *Macaranga echinocarpa* Baker is taken to treat malaria. The plant is also used to treat certain diseases of pigs. The wood of large-stemmed trees is used to make boats. Fresh leafy twigs of *Macaranga myriolepida* Baker are ground and applied to burns as a dressing. Young branches are made into whistles. Also of this species, the wood of large-stemmed trees is used to make boats. A stem bark infusion of *Macaranga ribesioides* Baker is taken to treat venereal diseases. A leaf decoction of *Macaranga sphaerophylla* Baker is taken to treat rheumatism, sciatica and lumbar pain.

Ecology *Macaranga spinosa* occurs along edges of primary forest and in secondary forest, often on soils with a high groundwater table, from sea-level up to 1200 m altitude. In the forest-savanna transition zone in littoral Congo, it is one of the pioneer species involved

in forest expansion.

Genetic resources and breeding *Macaranga spinosa* has a large area of distribution and also occurs in secondary forest. It is therefore probably not threatened by genetic erosion.

Prospects In Congo *Macaranga spinosa* has many local medicinal uses, but virtually nothing is known concerning its chemistry or pharmacology. More research is therefore needed to evaluate its potential.

Major references Bouquet, 1969; Burkill, 1994; Diallo, Vanhaelen & Gosselain, 1995; Radcliffe-Smith, 1987.

Other references Boiteau, Boiteau & Allorge-Boiteau, 1999; Chifundera, 2001; Favier, de Namur & Dubois, 2004; Lovett et al., 2006; Neuwinger, 2000; Randriambelona, 2002.

Authors G.H. Schmelzer

MAESOBOTRYA FLORIBUNDA Benth.

Protologue Hook.f., Icon. pl. 13: t. 1296 (1879).

Family Euphorbiaceae (APG: Phyllanthaceae)

Origin and geographic distribution *Maesobotrya floribunda* occurs from Cameroon and the Central African Republic south to DR Congo and Zambia.

Uses In DR Congo the leaves are rubbed on the skin to treat prickly heat.
In Gabon the young leaves provide a sour potherb. In DR Congo the wood is used to make house posts and kitchen utensils. Birds will not eat the fruits.

Properties The picrotoxane sesquiterpenoid picrotoximaesin was isolated from a methanol extract of the seeds.

Botany Dioecious shrub or small tree up to 8(–12) m tall, with drooping branches; bark greyish brown, longitudinally grooved; twigs angular, yellowish short-hairy. Leaves alternate, simple; stipules linear-lanceolate, 2.5–4 mm long, short-hairy, soon falling; petiole up to 7 cm long; blade elliptical to oblong-oblanceolate, 4–18 cm × 2.5–7 cm, base cuneate to rounded, apex shortly acuminate, distantly shallowly glandular-toothed in upper part, glabrous or short-hairy. Inflorescence a slender axillary or cauliflorous raceme up to 10 cm long, solitary or up to 4 together. Flowers unisexual, 5-merous, petals absent; male flowers with pedicel 1–1.5 mm long, jointed, calyx lobes triangular, c. 1 mm long, creamy yellow, stamens c. 1.5 mm long, free, disk glands fleshy; female flowers with pedicel 1–2 mm long, calyx lobes ovate, c. 1 mm long, greenish cream, disk c. 1.5 mm in diameter, ovary superior, ovoid-ellipsoid, c. 1.5 mm long, densely short-hairy, 2-celled, styles 2, fused at base, c. 0.5 mm long, persistent, stigma papillose. Fruit an ellipsoid capsule 5–6 mm × 4.5–5 mm, late dehiscent, smooth, sparingly short-hairy, green to reddish or purplish, 1-seeded by abortion. Seed ellipsoid, c. 6 mm × 3.5 mm, purplish grey to bluish. *Maesobotrya* comprises 18 species, which all occur in tropical Africa. Several other *Maesobotrya* species are also used medicinally in the region. In Congo a paste of pounded fruits of the Central African *Maesobotrya cordulata* J.Léonard is applied to treat psoriasis. Pulverized leaves are applied to wounds to heal them and are applied to scarifications to treat oedema. In Congo a bark decoction of *Maesobotrya vermeulenii* (De Wild.) J.Léonard is drunk and taken in baths to treat leprosy.

Ecology *Maesobotrya floribunda* occurs mainly in gallery forest, often in open, seasonally inundated localities, from sea-level up to 1000 m altitude. It mainly grows on sandy loam, enriched with clay or organic material.

Genetic resources and breeding *Maesobotrya floribunda* is fairly common in its area of distribution and is therefore not likely to be threatened by genetic erosion.

Prospects *Maesobotrya floribunda* is not much used medicinally, and will probably remain of local importance only.

Major references Kalanda & Bolamba, 1994; Radcliffe-Smith, 1996a; Tane et al., 1996; Terashima & Ichikawa, 2003; Yamada, 1999.

Other references Bouquet, 1969; Burkill, 1994; Neuwinger, 2000.

Authors G.H. Schmelzer

MALLOTUS OPPOSITIFOLIUS (Geiseler) Müll.Arg.

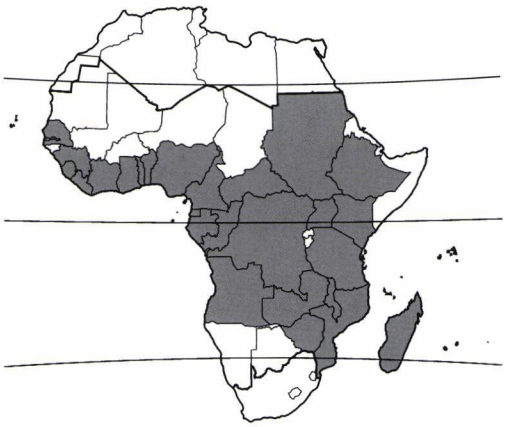
Protologue Linnaea 34: 194 (1865).

Family Euphorbiaceae

Vernacular names Arbre de kisse kisse (Fr). Mchacha, mtundutundu, mgendahamwe (Sw).

Origin and geographic distribution *Mallotus oppositifolius* is widely distributed and occurs from Senegal east to Ethiopia and south to Angola and Mozambique, and also in Madagascar.

Uses In West Africa most plant parts, but



Mallotus oppositifolius – wild

especially the leaves, are commonly used for medicinal purposes. A leaf or stem bark infusion is taken to expel tapeworms and to treat diarrhoea. The crushed or chewed fresh leaves, sometimes mixed with butter, are put on cuts and sores as a haemostatic and antibacterial, and on skin eruptions and rashes for fast healing. They are also applied to burns to calm pain. A steam bath with the leaves is taken to treat headache, epilepsy or mental illness. Leaf sap is used as nose drops or eye drops and the head is massaged with the pulped leaves to treat headache. The crushed leaves or leaf sap are applied to aching teeth and inflamed eyes. The ground leaves in salted water are applied to snakebites and the extract is also drunk for this purpose. Crushed leaves or a leaf infusion are applied to treat urinary infections, venereal diseases, malaria, leprosy, chickenpox and female sterility. A leaf and fruit infusion is taken to treat dysentery and diarrhoea, or the leaves are added to food. A leaf and root decoction is drunk to treat anaemia and general fatigue. A root and leaf paste is applied to treat convulsions, stomach-ache and chest pains. An infusion of the roots together with the seeds of *Aframomum melegueta* K.Schum. is taken as an enema to treat lumbago. In eastern Africa a root decoction is taken as an aphrodisiac. A root decoction and leaf sap are taken to treat pneumonia, vomiting and chest pain. The seeds are considered poisonous.

Mallotus oppositifolius is commonly browsed by cattle. The wood is also used as firewood and to make tool handles or yam stakes. The thinner stems or the bark are sometimes used as binding material. The twigs are commonly used as chew sticks.

Properties Preliminary phytochemical screening revealed the presence of flavonoids, saponins, tannins, cardenolides (cardiac glycosides), anthocyanins and possibly also alkaloids and anthraquinones. The leaves contain a higher concentration of these compounds than the roots.

Different leaf, root and stem bark extracts showed significant antibacterial activity against *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa* and *Bacillus subtilis* in vitro. The aqueous leaf extract showed significant activity against *Shigella dysenteriae* A1-induced diarrhoea in rats. The extract was not toxic. Aqueous and ethanol extracts of dried leaves showed significant antifungal activity in vitro against *Aspergillus flavus*, *Candida albicans*, *Microsporum audouinii*, *Penicillium* sp. and *Trichoderma* sp. A methanolic leaf extract showed moderate antitrypanosomal and anthelminthic activity in vitro, but low antiplasmodial activity. Crude methanolic leaf and root extracts showed significant antioxidant and anti-inflammatory activities in tests with rats.

The digestibility of the leaves of *Mallotus oppositifolius* by West African dwarf sheep was 68%, and the leaves were considered suitable as an alternative and supplementary browse feed.

Description Dioecious shrub or small tree up to 6(–13) m tall; young shoots densely stellate-hairy, older twigs almost glabrous, often purplish-brown. Leaves opposite, simple; petiole long and short in each pair, 2.5–11 cm long when long and 0.5–2 cm long when short, slightly thickened at both ends; stipules tiny, soon falling; blade broadly ovate to oblong-ovate, 3–18(–21) cm × 2–13 cm, unequal in size in each pair, base shallowly cordate to rounded or truncate, with 4 disk-shaped glands, apex acuminate, margins almost entire to more or less deeply toothed or lobed, 3-veined from the base, sparingly stellate-hairy to almost glabrous, sparingly gland-dotted, also with simple hairs beneath. Inflorescence a terminal or axillary raceme; male inflorescence up to 10(–15) cm long, female one up to 10(–18.5) cm long; bracts 0.5–1.5 mm long, triangular, each 1–5-flowered. Flowers unisexual, fragrant, petals absent; male flowers with jointed pedicel 3–7 mm long, sepals 3–4, elliptical, c. 2 mm long, strongly reflexed, pale yellow-green, disk absent, stamens numerous, filaments c. 2 mm long, free, greenish white; female flowers with



Mallotus oppositifolius – 1, flowering branch; 2, part of male inflorescence; 3, part of infructescence.
Source: Flore analytique du Bénin

pedicel 2–3 mm long, extending to 2(–5) cm in fruit, calyx lobes 3–5(–6), ovate to lanceolate, c. 2 mm long, united at the base, recurved, green, ovary superior, shallowly 3-lobed, c. 1 mm in diameter, densely short-hairy and covered with yellow glands, 3-celled, styles 3, c. 1.5 mm long, free, plumose. Fruit a deeply 3-lobed capsule 5–7 mm × 7–9 mm, short-hairy and gland-dotted, 3-seeded. Seeds almost globose, 3.5–4 mm × c. 3 mm, smooth, shiny, greyish olive-brown.

Other botanical information *Mallotus* comprises about 135 species, which all occur in the Old World tropics, mainly in Asia and Oceania. Only few species occur in tropical Africa: 2 in continental Africa and 4 in Madagascar, of which 3 are endemic. The seeds of *Mallotus baillonianus* Müll.Arg. (synonym: *Deuteromallotus acuminatus* (Baill.) Pax. & K.Hoffm.) from Madagascar, cause numbness when chewed. The fruits are eaten to treat malaria. A decoction of the aerial parts was taken as an ordeal poison. The wood is used as firewood and to make poles for enclosures.

Growth and development *Mallotus oppositifolius* is mainly pollinated by different species of bees and butterflies.

Ecology *Mallotus oppositifolius* occurs in dry secondary forest undergrowth, forest edges and associated bushland or thickets, also along rivers, from sea-level up to 1650 m altitude. In Nigeria it is a weed in rice fields.

Propagation and planting *Mallotus oppositifolius* is mainly propagated by seed, although vegetative propagation may be possible as well, in view of its easy growth.

Management *Mallotus oppositifolius* can be coppiced and pollarded. It has a high growth rate compared to other commonly used browse plants. It is deep-rooting and has a root:shoot ratio of 2:1. It has an extensive system of fine roots, indicating its potential for use in agroforestry and land management. In West Africa it is grown in and around cassava fields to reduce the impact of animals that feed on the leaves, as they prefer *Mallotus oppositifolius* leaves. Regular weeding is necessary.

Diseases and pests *Mallotus oppositifolius* is one of the major food plants for the grasshopper *Zonocerus variegatus*, and a host of Lepidopterous species, including *Endoclita malabaricus*.

Handling after harvest The harvested leaves are usually used fresh, whereas the roots are usually dried, pounded and kept in a pot for later use. The stems or the twigs are chewed fresh, or dried for later use.

Genetic resources *Mallotus oppositifolius* is very common in its large distribution area, and not in danger of genetic erosion. Small germplasm collections are maintained in the United Kingdom and South Africa.

Prospects *Mallotus oppositifolius* leaves and stem bark have several interesting local medicinal uses, including analgesic, antibacterial, anthelminthic and haemostatic uses. Although antibacterial and anti-inflammatory activities have been demonstrated in in-vitro tests, more research is needed to evaluate its potential as a medicinal plant.

Major references Adekunle & Ikumapayi, 2006; Atindehou et al., 2002; Burkill, 1994; Chukwujekwu, Van Staden & Smith, 2005; Farombi, 2003; Farombi, Ogundipe & Moody, 2001; Kamgang et al., 2006; Neuwinger, 2000; Okpekon et al., 2004; Okwu & Ekeke, 2003.

Other references Adjah, 1979; Adjanohoun et al., 1989; Aschfalk et al., 2000; Boiteau, Boiteau & Allorge-Boiteau, 1999; Bokdam & Droogers, 1975; Chhabra, Mahunnah & Mshiu, 1990; Govaerts, Frodin & Radcliffe-Smith, 2000; Irvine, 1961; Le Gall et al., 2003; Lovett et al., 2006; McPherson, 1995; Meregini &

Nzegbule, 2000; Novy, 1997; Pax & Hoffmann, 1914; Radcliffe-Smith, 1987; Rasoanaivo, Petitjean & Conan, 1993; Twum-Boateng, 2003.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors D.M. Mosango

MALLOTUS SUBULATUS Müll.Arg.

Protologue Linnaea 34: 192 (1865).

Family Euphorbiaceae

Origin and geographic distribution *Mallotus subulatus* occurs from Sierra Leone east to Cameroon and south to DR Congo.

Uses In Ghana an infusion of the roots together with the seeds of *Aframomum melegueta* K.Schum. is taken as an enema to treat lumbago. In Nigeria the roots, leaves and fruits are ground and taken in water to treat dysentery. Wet leaves are pulped and applied to wounds as a styptic. The ground seeds in water are taken to treat stomach-ache. In Gabon the head is massaged with the pulp or maceration of young leaves to treat headache and nervous break-down. In Congo the bark sap is rubbed onto local scarifications in case of pain in the side and lumbago.

In southern Nigeria the Igbo people apply the powdered seeds to the faces of young men and girls as a mask.

Properties Preliminary tests revealed traces of alkaloids in the roots, and abundant saponins and little tannin in the stem bark and roots.

Botany Dioecious shrub or small tree up to 5 m tall; twigs stellate hairy. Leaves opposite, simple and entire; stipules subulate, 6–8 mm long, persistent; petiole 1–5.5 cm long; blade oblong to ovate, 10–18 cm × 7.5–10 cm, base rounded, apex acute to acuminate, glabrous. Inflorescence an axillary raceme up to 5 cm long. Flowers unisexual, regular, petals absent, disk absent, pedicel short; male flowers in small fascicles, with obovoid calyx, 3–4-lobed, cream, stamens 40–50, free; female flowers solitary on inflorescence axis, with 3 recurved sepals, densely stellate hairy, cream, ovary superior, globose, 3-lobed, 3-celled, rough, stigmas 3, sessile, densely papillose, spreading. Fruit a 3-lobed capsule 12–16 mm in diameter, covered with slightly hooked bristles, 3-seeded. Seeds ovoid, c. 5 mm in diameter, smooth.

Mallotus comprises about 135 species, which all occur in the Old World tropics, mainly in Asia and Oceania. Only few species occur in tropical Africa: 2 in continental Africa and 4 in Madagascar, of which 3 are endemic.

Ecology *Mallotus subulatus* occurs in evergreen lowland forest.

Genetic resources and breeding *Mallotus subulatus* is at least locally common and does not seem under threat of genetic erosion.

Prospects Unless chemical and pharmacological research shows interesting results, *Mallotus subulatus* will remain of local importance only as a medicinal plant.

Major references Brown, Hutchinson & Prain, 1909–1913; Burkill, 1994; Irvine, 1961.

Other references Keay, 1958a; Neuwinger, 2000; Sillans, 1953.

Authors G.H. Schmelzer

MAPROUNEA AFRICANA Müll.Arg.

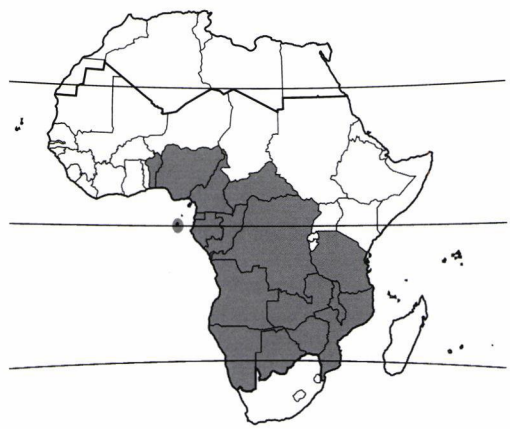
Protologue A.DC., Prodr. 15(2): 1191 (1866).

Family Euphorbiaceae

Vernacular names Magic nut, redskin bush (En). Mburabu (Sw).

Origin and geographic distribution *Maprounea africana* occurs from Benin east to Tanzania and south to Angola, Namibia (Caprivi Strip), Botswana, Zimbabwe and Mozambique.

Uses *Maprounea africana* is widely known for its purgative properties. A macerate of root bark is taken as a purgative in limited doses, large amounts being lethal. A root decoction is drunk to treat schistosomiasis, venereal diseases, leprosy, amoebic dysentery and syphilis. In Gabon preparations of the roots, bark and leaves are used as an emetic and diuretic. In Congo both stem and root barks, laced with



Maprounea africana – wild

honey or sugar-cane juice, are chewed to treat constipation, ascites and generalized oedema, intestinal worms, female sterility and irregular menstrual cycle. They are also used as a vaginal douche to treat uteritis and vaginitis, or the rolled-up leaves may be placed as a vaginal suppository for the same purpose. An ointment made from powdered bark in palm oil is applied externally to leprous sores and smallpox sores and to skin infections. In DR Congo the leaves or root bark are chewed and the bitter pulp is swallowed to treat stomach complaints and colic. A root decoction is applied to the eyes to treat infections and the sap is applied to circumcision wounds. Chewed or chopped leaves are applied to decaying teeth to treat toothache. The leaves are used in a preparation to treat epilepsy. In Tanzania a preparation of the young twigs is taken to relieve constipation. Sap of young leaves is drunk or pulverized leaves mixed with white clay are eaten as a remedy for respiratory diseases in children. In Mozambique a root bark macerate is taken to treat malaria.

In southern Africa the leaves are browsed by goats and the wood is used as firewood. In DR Congo the twigs are used as a toothbrush.

Production and international trade *Maprounea* root bark, stem bark and leaves are collected and traded locally in market places. Reliable production figures are not available because wild plants are mainly harvested for home consumption and sold at local markets.

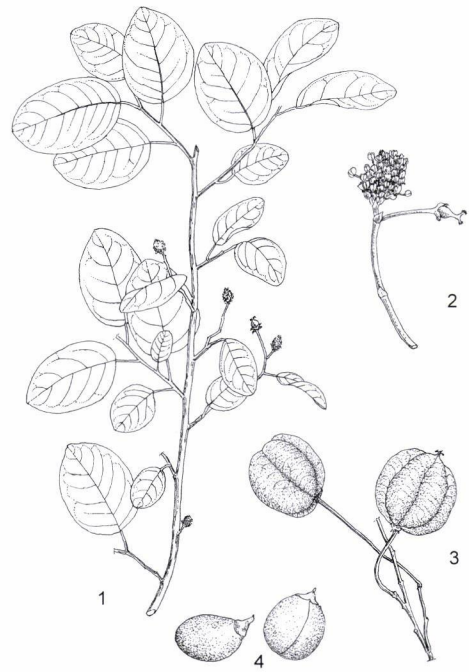
Properties The root bark contains the pentacyclic triterpenes maprounic acid, maprounic acid acetate and several derivatives, of which 1β-hydroxyaleuritolic acid 3-p-hydroxybenzoate showed significant activity against P-388 cancer cells in vitro, whereas several other derivatives exhibited potent inhibitory activity against HIV-1 reverse transcriptase. The compounds were not cytotoxic to cultured mammalian cells.

The ethanolic root bark extract showed potent glucose-lowering properties when given orally to mice. This activity was caused by the daphnane-type diterpenoid maprouneacin.

The acetone extract of the root bark showed high toxicity to mice.

Crude methanolic root bark extracts demonstrated a marked antibacterial activity against *Klebsiella pneumoniae*, *Staphylococcus aureus* and *Streptococcus mutans* and also significant antifungal activity against *Aspergillus niger*, *Candida albicans* and *Microsporum gypseum*. The extracts also showed significant antiamoebic activity in vitro. The ethanolic leaf extract induced hypothermia and prolonged the sleeping time when administered orally to mice. It also significantly delayed the onset of induced clonic convulsions, but had no significant effects on induced generalized convulsions or on limbic status epilepticus. Organic root bark extracts also contained the cyclobutenic diterpene bershacolone, koumbalones A and B with a casbane ring system, and oxygenated tetracyclic triterpenes of the cucurbitacin type.

Description Monoecious, much-branched deciduous shrub or small tree up to 8(–10) m tall, with pendent branches; bark corky, deeply fissured, grey or pale to dark brown; twigs reddish brown. Leaves alternate, simple and entire; stipules ovate, c. 1 mm long; petiole 0.5–3 cm long, red; blade ovate or elliptical-ovate to ovate-lanceolate, 1.5–8 cm × (1–)2–4(–5) cm, base cuneate, rounded or cordate, apex obtuse to rounded, glabrous, pinnately veined with 8–11 pairs of yellow lateral veins. Inflorescence a terminal raceme up to 2 cm long, on short lateral shoots, with male flowers in an apical, globose to ovoid, yellowish or reddish head 3–8 mm in diameter and 1–3 female flowers at



Maprounea africana – 1, flowering branch; 2, inflorescence; 3, infructescence; 4, seeds.
Redrawn and adapted by Iskak Syamsudin

base, green; bracts c. 1 mm long. Flowers unisexual, petals absent; male flowers with pedicel up to 1 mm long, calyx lobes 2–3, c. 1 mm long, acute, stamens (1–)2(–3), fused into a staminal column c. 2 mm long; female flowers with pedicel 3–5 mm long, extending to 2(–3) cm long in fruit, calyx lobes 3–6, c. 1 mm long, ovary superior, ovoid, c. 1 mm in diameter, 3(–5)-celled, smooth, styles 2–3, 1–1.5 mm long, fused at base, reflexed at apex, persistent. Fruit a depressed, slightly 3(–5)-lobed capsule 8–12 mm × 14–16 mm, smooth, dull green, tinged reddish, later bright red or brown red, 3–5-seeded. Seeds ovoid, 7–9 mm × 6–7 mm, usually smooth, greenish black, caruncle 6–7 mm long, the 2 lobes covering up to half the seed, orange or bright red.

Other botanical information *Maprounea* comprises 4 species, 2 of which occur in tropical Africa and 2 in South America. In Central Africa *Maprounea africana* and *Maprounea membranacea* Pax & K.Hoffm. are similarly used as medicinal plants.

Ecology *Maprounea africana* is relatively common in savanna and open, deciduous forest, usually on well-drained or dry sandy soils, and also occurs on lakeshore and coastal dunes, on escarpments, rocky hillsides and in floodplain grassland, from sea-level up to 1600 m altitude.

Propagation and planting *Maprounea africana* regenerates profusely by seed. Seed used in cultivation should be freshly extracted from the fruit as viability declines rapidly when seed is stored. Rains must follow germination to ensure seedling survival. Plantations can be established by direct sowing or by using nursery-raised seedlings. Propagation by stem cuttings is probably feasible as well.

Management *Maprounea africana* is fast growing and requires little or no management once established. It can be coppiced and pollarded.

Harvesting Root bark, stem bark and leaves are only collected from the wild.

Genetic resources Neither germplasm collections nor breeding programmes are known for *Maprounea africana*. Since it is widespread and rather common, it is not liable to genetic erosion.

Prospects *Maprounea africana* is regarded as an important medicinal plant species by the populations using it, and it seems underexploited. Considering the many medicinal purposes for which it is used, there is enormous scope for future research and further phytochemical and pharmacological investigations are warranted, especially on the anti-HIV activities of the pentacyclic triterpenes. However, large-scale cultivation for its root and stem bark is not expected.

Major references Burkill, 1994; Carney et al., 1999; Chilufya & Tengnäs, 1996; Jung et al., 2000; Muanza et al., 1994; Neuwinger, 2000; N'Gouemo, Nguemby & Baldy, 1994; Pengsuparp et al., 1995; Radcliffe-Smith, 1987; Tona et al., 2000.

Other references Adjanohoun et al. (Editors), 1988; Bernart et al., 1993; Beutler et al., 1995; Bouquet, 1969; Chaudhuri et al., 1995; Chhabra, Mahunnah & Mshiu, 1990; Coates Palgrave, 1983; Disengomoka & Delaveau, 1983; Kambu et al., 1989; Kashman et al., 1994; Latham, 2005; Léonard, 1962; Pengsuparp et al., 1994; Sandberg & Cronlund, 1982; Tona et al., 1998; Wani et al., 1983; Watt & Breyer-Brandwijk, 1962.

Sources of illustration Radcliffe-Smith, 1987.

Authors A. Maroyi

MAPROUNEA MEMBRANACEA Pax & K.Hoffm.

Protologue in H.G.A. Engler, Pflanzenr. IV, 147, 5 (Heft 52): 178 (1912).

Family Euphorbiaceae

Origin and geographic distribution *Maprounea membranacea* occurs from Nigeria east to the southern part of the Central African Republic and DR Congo and south to Angola.

Uses In Congo and northern DR Congo pieces of root bark or stem bark, laced with honey or sugar, are used as a violent purgative to treat constipation, ascites and generalised oedema, intestinal worms, female sterility and an irregular menstrual cycle. A cold water maceration of bark scrapings is given to constipated babies. In Gabon the dried powdered leaves are used to cicatrise wounds, especially circumcision wounds. In Congo a bark infusion is used as a vaginal douche to treat vaginitis and problems of the uterus, and rolled-up leaves or leaf pulp may be placed as a vaginal suppository for the same purpose. Externally, an ointment of the powdered bark in palm oil is applied to treat leprosy, smallpox, scabies and other skin infections. In northern DR Congo a leaf decoction is used to wash infected eyes. A root decoction is drunk to treat syphilis. In Gabon the bruised young stems are laid in houses to repel cockroaches.

In Gabon the wood is used to make mortars.

Properties The stem bark contains small amounts of pentacyclic triterpenes and derivatives, which do not seem to have biological activity. The stem bark also contains cucurbitacin A and derivatives, diterpenes, phorbol esters of the daphnane type, of which several exhibited potent inhibitory activity against HIV-1 reverse transcriptase.

Botany Monoecious or sometimes dioecious small to medium-sized tree up to 25 m tall; bole up to 30(–50) cm in diameter; bark longitudinally fissured, pinkish grey. Leaves alternate, simple and entire; stipules ovate, c. 0.5 mm long; petiole 0.5–2 cm long; blade elliptical to ovate, 2.5–10 cm × 1.5–5 cm, base unequal, one side cuneate and other side cordate, apex rounded, glabrous with sparse glandular dots, pinnately veined with 6–10 pairs of lateral veins. Inflorescence a terminal raceme up to 3.5 cm long, on short lateral shoots, with male flowers in an apical, oblong, compact, reddish spike, 4–9 mm × 3–6 mm and 1–5 female flowers at base, green; bracts up to 1.5 mm long. Flowers unisexual, petals absent; male flowers with pedicel 1–1.5 mm long, calyx lobes 2–3, c. 0.5 mm long, red, stamens 2, fused into a staminal column 1–1.5 mm long, white; female flowers with pedicel 0.5–1 cm long, extending to 3 cm long in fruit, calyx lobes 3, c. 1 mm long, ovary superior, ovoid, c. 1.5 mm in diameter, 3(–4)-celled, smooth, styles 3, fused at base, reflexed at apex, persistent. Fruit a globose capsule 5–7 mm in diameter, smooth, green, later red or brown, 3-seeded. Seeds oblong, 4.5–5.5 mm × 3.5–4 mm, usually smooth, black, caruncle 2–3 mm long, the 2 lobes covering up to half the seed, orange or bright red.
Maprounea comprises 4 species, 2 of which occur in tropical Africa and 2 in South America.

Ecology *Maprounea membranacea* occurs in periodically inundated forest, wet forest and secondary forest on dry soil, at low altitudes.

Genetic resources and breeding *Maprounea membranacea* is common in its area of distribution and therefore not threatened by genetic erosion.

Prospects The stem bark and root bark of *Maprounea membranacea* have antibacterial and anthelmintic uses, but no research has been done to identify the compounds responsible for these activities, or their pharmacological properties. The pentacyclic triterpenes isolated show interesting anti-HIV activity, which merits further research.

Major references Beutler et al., 1995; Burkill, 1994; Léonard, 1962; Neuwinger, 2000.

Other references Beutler et al., 1989; Paris & Tessier, 1972; Raponda-Walker & Sillans, 1961; Tessier, 1975; Tessier & Paris, 1978.

Authors G.H. Schmelzer

MAREYA MICRANTHA (Benth.) Müll.Arg.

Protologue A.DC., Prodr. 15(2): 792 (1866).

Family Euphorbiaceae

Synonyms *Mareya spicata* Baill. (1860).

Vernacular names Number one (En).

Origin and geographic distribution *Mareya micrantha* occurs from Guinea east to Cameroon and south to DR Congo.

Uses The leaves and fruits are very bitter and poisonous, causing drastic purging when eaten. A leaf decoction or leaf sap is widely known as a violent purgative and abortifacient. Even when diluted, a decoction of fresh leaves is never given to pregnant women, children or old persons. A leaf decoction is mainly used to treat diseases which require drastic action, such as tapeworm infections, gonorrhoea and leprosy. In Sierra Leone, however, a decoction of dried leaves is given to children as a worm treatment. Burnt leaves mixed with clay are applied to scabies and measles. A leaf decoction or fermented leaves with rum and coconut are taken to treat malaria, cough and general weakness. A leaf infusion is taken as an analgesic to treat headache and stomach-ache; externally a paste of the leaves is applied to fractures, stiffness, sprains, sores and ulcers including guinea-worm sores, lumbago, kidney-pain or rheumatic pains. The powdered roots are applied to snakebites and stings of venomous animals. The pounded bark mixed with white clay is applied to treat river blindness, and a leaf decoction is taken internally for the same purpose.
The name 'number one' is an indication of the dangerous toxicity of the plant. The fruits were formerly used as ordeal poison; an overdose will cause complete exhaustion by purging.
The stems of *Mareya micrantha* are commonly used as yam stakes. In Guinea it is cultivated as a hedge plant.

Properties Preliminary analysis of the leaves showed the presence of anthraquinone glycosides and cucurbitacin-like substances. Aqueous leaf extracts suppressed cardiac contractility of isolated frog and rat hearts in a concentration-dependent way. In another test

an aqueous leaf extract elicited concentration-dependent contractions of the longitudinal muscle of isolated guinea-pig ileum. Leaf extracts caused hypotension in dogs, and a root extract caused paralysis of the respiratory centre in rats. The methanol and hot and cold aqueous extracts of the leaves showed antibacterial activity against *Enterobacter aerogenes*, *Agrobacterium tumefaciens*, *Bacillus subtilis*, *Clostridium sporogenes*, *Escherichia coli* and *Staphylococcus aureus*. Ethanolic leaf extracts showed low antiplasmodial activity against a chloroquine-resistant strain of *Plasmodium falciparum* and no anti-amoebic activity in vitro. The extract showed considerable cytotoxicity to mammalian cells.

The wood is white, soft and perishable.

Botany Monoecious shrub or small tree up to 8(–12) m tall; twigs short-hairy. Leaves alternate, simple; stipules small, triangular, soon falling; petiole 0.5–7.5 cm long; blade ovate, ovate-oblong to oblanceolate, (5–)10–25 cm × 2–9 cm, base cuneate, apex shortly acuminate, slightly toothed in upper part, glabrous or slightly short-hairy. Inflorescence a slender axillary raceme up to 25(–40) cm long with male flowers in clusters in upper part and female flowers solitary or accompanied by several male flowers in lower part. Flowers unisexual, petals absent; male flowers with pedicel 1.5–2.5 mm long, calyx splitting into 3–4 lobes, c. 1.2 mm long, obtuse, green, stamens 10–20(–24), longer than calyx lobes, free; female flowers almost sessile, sepals 3–5, c. 1 mm long, imbricate, greenish, disk flattened, lobed, ovary superior, ovoid, short-hairy, 3-celled, styles 3, fused at base, recurved, papillose. Fruit a 3-lobed capsule 3–4 mm in diameter, slightly depressed above, short-hairy, pale brown to reddish, 3-seeded. Seeds ovoid, c. 2 mm in diameter, smooth, brownish.

Mareya comprises 3–4 species, which mainly occur in West and Central Africa. *Mareya brevipes* Pax, a shrub occurring in Central Africa and Uganda, is also used medicinally. In Gabon the seeds are eaten as a strong purgative. *Mareya congolensis* (J.Léonard) J.Léonard is endemic in DR Congo. The bark is chewed as a purgative.

Ecology *Mareya micrantha* occurs in primary and secondary forest, from sea-level up to 500 m altitude.

Genetic resources and breeding *Mareya micrantha* is a common shrub throughout its distribution area and is therefore not threatened by genetic erosion.

Prospects *Mareya micrantha* has many medicinal uses despite its toxicity, and the pharmacological tests show interesting activities. Not much is known about its chemistry though, and it seems worthwhile to identify the compounds responsible for the activities.

Major references Abo et al., 2000; Brown, Hutchinson & Prain, 1909–1913; Burkill, 1994; MacFoy & Cline, 1990; Neuwinger, 2000.

Other references Awohee, 1987; Guédé-Guina et al., 1995; Keita et al., 1995; Léonard, 1996b; Raponda-Walker & Sillans, 1961; Tessier & Paris, 1978; Tsai et al., 1995; Zirihi et al., 2005.

Authors G.H. Schmelzer

MARGARITARIA ANOMALA (Baill.) Fosberg

Protologue Kew Bull. 33(2): 185 (1978).

Family Euphorbiaceae (APG: Phyllanthaceae)

Chromosome number $2n = 26$

Synonyms *Phyllanthus erythroxyloides* Müll.Arg (1866).

Vernacular names Bois chenille (Fr).

Origin and geographic distribution *Margaritaria anomala* occurs in Comoros, Madagascar, Aldabra (Seychelles) and Mauritius.

Uses In Madagascar a bitter root decoction is considered the best medicine to treat impotence. It is also taken to treat chronic constipation.

The fruits are edible. The wood is hard and used to make tool handles and peddles. The twigs are used to make baskets.

Botany Dioecious, deciduous glabrous shrub or small tree up to 6 m tall; bark scaly or detaching in strips, brown. Leaves alternate to whorled at the end of branches, simple and entire; stipules oblong-lanceolate, 2.5–5 mm long, brown, soon falling; petiole up to 6(–10) mm long; blade elliptical to obovate or spoon-shaped, (2–)3–6(–10) cm × 1.5–4(–6) cm, base cuneate, apex rounded to emarginate, with distant shallow glandular teeth in upper part, glabrous or short-hairy. Male inflorescence an axillary cluster, few-flowered; female flowers solitary or sometimes paired at the end of young branches. Flowers unisexual, petals absent; male flowers with pedicel 3–6 mm long, sepals 4, ovate, rounded, 2 outer ones 1–2 mm long, 2 inner ones 1.5–2.5 mm long, greenish, stamens 4, c. 1.5 mm long, free, disk annular; female flowers with pedicel 5–15(–20) mm long, sepals 4, ovate to oblong, 1.5–2.5 mm long,

yellowish green, disk annular, 1–2 mm in diameter, ovary superior, ovoid, 2(–3)-celled, styles 3, free or fused at base, up to 1.5 mm long, stigma 2-fid, branches drooping. Fruit an almost globose or laterally compressed capsule or drupe 6–8 mm in diameter, indehiscent or irregularly dehiscent, smooth, blue-greenish, up to 4-seeded. Seeds plano-convex to trigonous-lens-shaped, 3.5–5.5 mm long, fleshy, bluish.

Margaritaria consists of 13–14 species, and is pantropical. It was formerly included in *Phyllanthus* and discussion continues as to whether it is distinct or not. Another *Margaritaria* species is also used medicinally in Madagascar. A root decoction of *Margaritaria decaryana* (Leandri) G.L.Webster (synonym: *Phyllanthus decaryanus* Leandri) is drunk as a stimulant and aphrodisiac, and to treat impotence and senility.

Ecology *Margaritaria anomala* occurs in bushland and deciduous forest, from sea-level up to 1000 m altitude.

Genetic resources and breeding *Margaritaria anomala* is probably not common in its distribution area. It is rare and endangered in Mauritius, and a multiplication program has started there.

Prospects *Margaritaria anomala* will probably remain of local importance only, unless pharmacological tests can prove the stimulant activities of the roots.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Webster, 1979.

Other references Neuwinger, 2000; Schatz, 2001.

Authors G.H. Schmelzer

MEINECKIA PAXII Brunel ex Radcl.-Sm.

Protologue Kew Bull. 52: 174 (1997).

Family Euphorbiaceae (APG: Phyllanthaceae)

Synonyms *Zimmermannia capillipes* Pax (1910).

Origin and geographic distribution *Meineckia paxii* is endemic to the Usambara mountains in north-eastern Tanzania.

Uses A root decoction is drunk as an anthelmintic and to treat stomach-ache. The wood is white and rather soft and is used as firewood.

Meineckia paxii is suitable as a shade tree and ornamental.

Botany Monoecious or sometimes dioecious, glabrous, evergreen shrub to much-branched, small tree up to 7.5 m tall; twigs pale grey to grey-green. Leaves alternate, simple and entire; stipules broadly ovate, (3–)5–6 mm long, acuminate, soon falling to fairly persistent; petiole up to 12(–17) mm long, grooved above; blade elliptical to elliptical-oblong, 6–18 cm × 3–7.5 cm, base cuneate to rounded, apex acute to acuminate, pinnately veined with 8–10 pairs of lateral veins. Inflorescence an axillary 2–many-flowered fascicle when male, female flowers solitary. Flowers unisexual, 5-merous, regular; sepals obovate to obovate-oblong, 4–6 mm × 2–5 mm, rounded, pale green with dark green veins, petals absent, disk annular to slightly lobed, 3–5 mm in diameter, yellow; male flowers with slender pedicel 4–8 mm long, stamens 5, free, 2.5–3.5 mm long; female flowers with pedicel 2–4 cm long, extending in fruit to 5.5 cm, ovary superior, rounded, up to 2 mm long, 3-celled, styles 3, fused at base, 1.5–2 mm long, spreading-recurved, apex slightly broadened. Fruit a slightly 3-lobed capsule c. 1 cm × 1.5 cm, smooth, pale green, up to 6-seeded.

Meineckia comprises about 30 species and occurs in tropical America, Africa and Asia.

Ecology *Meineckia paxii* occurs in moist evergreen submontane forest, at (200–)900–1100 m altitude.

Genetic resources and breeding *Meineckia paxii* is uncommon in its small area of distribution and included in the IUCN Red List as vulnerable.

Prospects Nothing is known concerning the chemistry and pharmacology of *Meineckia paxii*, and as the species has a small distribution area, it will remain of local importance only.

Major references Kokwaro, 1993; Lovett et al., 2006b; Radcliffe-Smith, 1987.

Other references Lovett & Clarke, 1998.

Authors G.H. Schmelzer

MICRODESMIS KEAYANA J.Léonard

Protologue Bull. Jard. Bot. Etat 31: 180 (1961).

Family Pandaceae

Vernacular names Sonoufoko (Fr).

Origin and geographic distribution *Microdesmis keayana* occurs from Senegal east to south-western Nigeria.

Uses The stem bark, leaves and roots have numerous medicinal uses throughout the distribution area of *Microdesmis keayana*; they

are similar to the uses of the closely related species *Microdesmis puberula* Hook.f. ex Planch. Leaf sap or crushed and burnt twigs or roots are applied to snakebites or to wounds to stop bleeding and to heal them. Leaf sap, sometimes together with twig sap, is commonly taken orally or applied as an enema to treat diarrhoea.

In Sierra Leone a paste made from pounded leaves together with those of *Desmodium adscendens* (Sw.) DC. is mixed with white clay and applied to scabies. The leaves, cooked with chicken, are given to treat palpitations. In Liberia a leaf infusion is taken to induce menstruation and as an abortifacient. In Côte d'Ivoire crushed leaves together with those of *Mareya micrantha* (Benth.) Müll.Arg. are used as a local massage to treat general body pain, painful kidneys or ribs, or overall fatigue. The Gouro people use the leafy twigs as a major component of a medicinal wash used for the daily care of newborn babies in order to prevent dermatological and intestinal affections and excessive weight loss. Ground leaves, sometimes with *Capsicum* fruits, or a leaf decoction are rubbed on the abdomen or taken orally to treat colic, chest complaints, fatigue, pain in the side, kidney pain and feverish stiffness. A decoction made from the leaves or leafy twigs or ground young leaves is used as a steam bath or wash to treat rheumatism or migraine. The leaf sap is applied as nose drops to treat epilepsy and convulsions. A decoction of the whole plant is taken as an emmenagogue and to treat dysentery. In Côte d'Ivoire and Ghana ground twig bark is rubbed on the body and a macerate of leafy twigs and roots is applied in the form of an enema as an aphrodisiac. A root infusion or decoction of the whole plant taken orally is also considered to be an aphrodisiac. The leaves are an ingredient of poison antidotes. In Ghana a root decoction is drunk to treat venereal diseases. Leaf and bark pulp are applied to sprains and burns. Boiled fruits are applied to tumours. The fruit is chewed to prevent ulcers. Root bark scrapings with leaves of *Piper guineense* Schumach. & Thonn. in water are applied to the breasts to treat mastitis. In Togo mental disorders are treated with a decoction of leaves and roots of *Microdesmis keayana* and *Newbouldia laevis* Seem. ex Bureau orally and by bathing. In Sierra Leone the leaves are one of the ingredients of an embrocation used to heal bone fractures in cattle.

The stems are used to make fishing gear and spring traps because of their strength and resilience, and the wood to make handles and implements. The plant is commonly browsed by goats and cattle. In Ghana and Nigeria the twigs are used as chew sticks. The thin flexible branches are used as ties for fastening roof thatch. In Côte d'Ivoire coastal villages grow *Microdesmis keayana* as a shade tree and for making village palisades. The fruits are sometimes eaten in Sierra Leone.

Properties Three trihydroxycinnamoylspermidines were isolated from a methanolic root extract of *Microdesmis keayana* (collected near Abidjan, Côte d'Ivoire) and were named keayanidines A, B and C. Two other compounds were isolated from a hydromethanolic root extract: xanthoquininamide (6-hydroxyquinoline-4-carboxamide) and keayanine, a spermine derivative.

The aqueous and methanolic root extracts have hypotensive and vasorelaxing properties in tests when using normotensive rabbits in vivo and aorta strips of guinea pigs in vitro, respectively. Both extracts also showed strong antioxidant activity. A dichloromethane extract from the leaves showed significant antiplasmodial activity in vitro against a chloroquine-resistant strain of *Plasmodium falciparum*. Different plant extracts did not show significant antitrypanosomal or anthelmintic activities in vitro.

The wood is brown, hard, flexible, of fine structure and is easily worked, taking a lustrous polish.

Botany Dioecious shrub up to 3(–6) m tall; twigs densely short-hairy. Leaves alternate, distichous, simple; stipules linear, persistent; petiole 4–12 mm long; blade elliptical-oblong to ovate-lanceolate or ovate, 5–12(–18) cm × 2–5(–7) cm, base asymmetrical, cuneate to rounded, apex acute to acuminate, margin finely toothed, shiny above, short-hairy on the midrib above. Inflorescence an axillary fascicle, male fascicle 5–many-flowered, female fascicle 1–3(–5)-flowered; bracts minute. Flowers unisexual, 5-merous, regular; calyx c. 2 mm long, lobes ovate, c. 1.5 mm long, short-hairy, green; petals almost circular to ovate-oblong, c. 3 mm × 2–2.5 mm, spreading, short-hairy in upper half, pink to orange; male flowers with pedicel 3–4 mm long, filaments c. 1 mm long, fleshy, fused to the pistillode, reddish orange, pistillode 2–2.5 mm long, reddish orange; female flower with pedicel 3–4 mm long, enlarging to 5–10 mm in fruit, short-hairy, ovary superior, ellipsoid, c. 1 mm long, (2–)3-celled, densely short-

hairy, styles 2–3, c. 1 mm long, white. Fruit an ovoid drupe 4.5–6 mm × 5–8 mm, smooth when fresh, later wrinkled, hard, shiny, red, (1–)2–3-seeded. Seeds broadly ovate, flattened, curved. Seedling with epigeal germination.

Microdesmis comprises about 11 species, 2 of which occur in Asia and the others in tropical Africa. *Microdesmis keayana* and *Microdesmis puberula* are morphologically nearly similar, their medicinal uses are largely overlapping and they might well belong to the same species. The distribution area of *Microdesmis puberula* links up with that of *Microdesmis keayana*, from Nigeria east to Central Africa and Uganda.

Ecology *Microdesmis keayana* is common in the undergrowth of damp secondary forest, and also occurs on firm soil in primary rainforest. It is tolerant to bush fire.

Genetic resources and breeding *Microdesmis keayana* is a common undergrowth species, and therefore not at risk of genetic erosion.

Prospects Several spermidine derivatives have been isolated from *Microdesmis keayana*; they deserve further pharmacological analysis. As *Microdesmis keayana* and *Microdesmis puberula* resemble each other morphologically and in their medicinal uses, taxonomical studies are warranted.

Major references Burkill, 1997; Cunningham, 1993; Neuwinger, 2000; Vonthron-Sénécheau et al., 2003; Zamblé et al., 2006b.

Other references Abbiw, 1990; Aké Assi, 1980; Atindehou et al., 2002; Atindehou et al., 2004; Hawthorne & Jongkind, 2006; Léonard, 1961; Sofowora, 1982; Tchouto, 2004; Zamblé et al., 2007; Zamblé et al., 2006a.

Authors N.S. Alvarez Cruz

MICRODESMIS PUBERULA Hook.f. ex Planch.

Protologue Hook.f., Icon. pl. 8: t. 758 (1848).

Family Pandaceae

Chromosome number $2n = 30$

Synonyms *Microdesmis zenkeri* Pax (1897).

Origin and geographic distribution *Microdesmis puberula* occurs from eastern Nigeria east to DR Congo and Uganda.

Uses The stem bark, leaves and roots have numerous medicinal uses throughout the distribution area of *Microdesmis puberula*; they are similar to the uses of the closely related species *Microdesmis keayana* J.Léonard. Leaf sap, or crushed and burnt twigs and roots are applied to snakebites or to scarifications. Leaf sap, sometimes together with twig sap, is commonly taken orally or applied as an enema to treat diarrhoea. It is rather mild and thus prescribed for pregnant women and young children. Leaf and stem sap or an infusion of them, sometimes combined with other plants, is commonly taken to treat stomach-ache, intestinal worms and genital problems such as menstrual complaints, sterility, miscarriage, loss of virility and venereal diseases. Leaf and stem sap, or a leaf or stem infusion is also externally applied to treat skin problems such as eczema, scabies, burns, circumcision wounds, abscesses and sores from gonorrhoea.

In Central Africa pregnant women drink a beverage made of macerated leaves, sometimes mixed with salt and onions, to ease delivery. In Nigeria a leaf decoction is taken to treat acute spleen pain. In Cameroon the Baka pygmies use leaf sap as nose drops to treat malaria and cough and as eye drops to treat blurred vision. In the Central African Republic the Lissongo people drink a leaf decoction and rub the breasts with crushed leaves to calm mastitis. Legs from newborn babies are also rubbed with crushed leaves to encourage rapid stand-up and walking. The Monzombo people massage the head with leaves, mixed with leaves of several other plants, to treat fever. Heated leaves are used in massage to relieve backache. Ash from burnt stems mixed with salt and palm oil is massaged into scarifications on the hip in case of limping. The Fang people of Gabon wash the head with macerated leaves to calm severe headache. In Congo leaves are pounded



Microdesmis puberula – wild

in water and the liquid is drunk to prevent fainting. Chopped up young leaves are eaten to treat a sore throat and colds. Leaf sap is used as ear drops to treat ear infections. The leaves are put in vapour baths to treat rheumatism. Crushed leaves and twigs are applied on glandular swellings, and the roots or pounded young leaves mixed with the juice of sugar cane are considered to be aphrodisiac. In DR Congo the Efe and Mbuti pygmies rub burnt and powdered bark and wood into incisions on the side of the body to treat rib pain. The pounded stem is mixed with salt and rubbed on scarifications to treat pneumonia. Ash of burnt roots mixed with palm oil is rubbed into scarifications to treat renal pain and severe headache. In Rwanda and Burundi grated roots are mixed with cornflour and eaten to cure gonorrhoea. The grated root is also applied on wounds and hernia. The boiled fruits are applied to tumours. Pounded fruits mixed with *Capsicum* fruits are eaten by the Baka pygmies to calm cough. Seeds are eaten to provide strength.

Most pygmy groups consume the leaves as a vegetable. The fruits are sometimes eaten, although they are laxative. In Nigeria *Microdesmis puberula* is a common browse species of goats and cattle. In DR Congo the Efe and Mbuti pygmies use the flexible stem as fishing rods. Young shoots are used by the Aka, Baka and Mbuti pygmies for hut building, and also to make snare hooks and harps. Older stems provide hard wooden stakes for yam support, digging sticks and hooks to attach hunting nets in the undergrowth. The wood is widely used to make chairs, spring traps, handles and implements. In south-eastern Nigeria the wood is made into a type of guitar. In DR Congo, Rwanda and Burundi, the older stems are made into arrows and bed frames. The twigs serve as chew sticks.

In many African societies *Microdesmis puberula* has magical uses. The vapour from burned leaves is believed to chase bad spirits from houses. The plant is reputedly deep-rooted and the Baka and Aka pygmies therefore use it as a magical protection against semi-wild yam tubers being robbed in the forest. In DR Congo the plant is used in concoctions to improve one's luck.

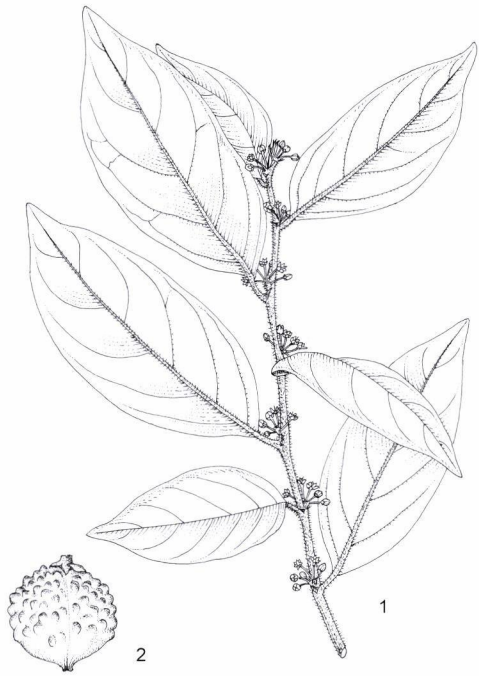
Properties In preliminary tests, traces of alkaloids were detected in stems and roots, but no further chemical or pharmacological analyses have been carried out. As a fodder shrub, *Microdesmis puberula* shows a high content of crude protein, 23–33%, and compares favourably with *Leucaena* and *Gliricidia* (22%). Analysis of the air-dry leaves shows the following results: dry matter 93%, crude protein 25.8%, ash 4.8%, crude fibre 19.9%, ether extract 6.3%, nitrogen-free extract 36.1%, acid-detergent fibre 21.3%, neutral-detergent fibre 46.5%, hemi-cellulose 25.2%, tannin 0.9%, phytin 25.2 mg/g, HCN 1.86 mg/g.

In different feeding experiments with broiler chickens using up to 10% *Microdesmis puberula* leaves in the meal, contradictory results were observed. When the leaves were used in laying hen diets, no significant differences were observed in body weight, egg shell thickness, yolk index and albumin index with up to 15% inclusion of *Microdesmis puberula* leaf meal. The intensity of the egg yolk coloration increased with increasing levels of the leaf meal in the diets. In a feeding experiment with dwarf goats, feeding mixed forages with a maximum of 25% *Microdesmis puberula* leaves led to an increase in the growth rate of goats.

The wood is brown, hard and flexible; it works easily and takes a lustrous polish.

Description Dioecious shrub up to 6 m tall, sometimes small tree up to 15 m tall; stem up to 8 cm in diameter; twigs usually densely short-hairy. Leaves alternate, distichous, simple; stipules linear, up to 4 mm long, persistent; petiole 4–12 mm long; blade elliptical-oblong to ovate-lanceolate or ovate, 5–15(–20) cm × 2–6(–9) cm, base asymmetrical, cuneate to rounded, apex acute to acuminate, margin finely toothed to almost entire, shiny above, short-hairy on the midrib above. Inflorescence an axillary fascicle, male fascicle 5–many-flowered, female fascicle 1–3(–5)-flowered; bracts minute. Flowers unisexual, 5-merous, regular; calyx c. 2 mm long, lobes ovate, c. 1.5 mm long, short-hairy, green; petals almost circular to ovate-oblong, c. 3 mm × 2–2.5 mm, spreading, short-hairy in upper half, pink to orange; male flowers with pedicel 3–9 mm long, filaments c. 1 mm long, fleshy, fused to the pistillode, pistillode 2–2.5 mm long, reddish orange; female flowers with pedicel 3–4 mm long, enlarging to 5–10 mm in fruit, short-hairy, ovary superior, ellipsoid, c. 1 mm long, 2(–3)-celled, sparsely to densely short-hairy, styles 2, c. 1 mm long, white. Fruit an ovoid drupe 10–12 mm × 9–11 mm, smooth when fresh, later wrinkled, hard, shiny, red, (1–)2-seeded. Seeds broadly ovate, flattened, curved. Seedling with epigeal germination.

Other botanical information *Microdesmis*



Microdesmis puberula – 1, branch with male flowers; 2, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

comprises about 11 species, 2 of which occur in Asia and the others in tropical Africa. *Microdesmis puberula* and *Microdesmis keayana* are morphologically nearly similar, their medicinal uses are largely overlapping and they might well belong to the same species. The distribution area of *Microdesmis keayana* links up with that of *Microdesmis puberula*, from Nigeria west to Senegal.

Microdesmis haumaniana J.Léonard occurs from Cameroon south to Angola. In Congo ground fresh leaves, sometimes mixed with the rhizome of ginger, are applied as an enema to treat haemorrhoids. Plant sap is taken to treat gastrointestinal disorders including colic and diarrhoea, ovarian complaints and gonorrhoea. Leaf sap is used as ear drops to treat otitis. A vapour bath with boiled leaf sap is taken to treat rheumatism. The stems are made into bows.

Anatomy Wood-anatomical description (IAWA hardwood codes):

Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; 9: vessels exclusively solitary (90% or more); 12: solitary vessel outline angular; 14: scalariform perforation plates; 17: scalariform perforation plates with 20–40 bars; 18: scalariform perforation plates with ≥ 40 bars; 21: intervessel pits opposite; (24: intervessel pits minute (≤ 4 μm)); 25: intervessel pits small (4–7 μm); 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 41: mean tangential diameter of vessel lumina 50–100 μm; 48: 20–40 vessels per square millimetre. Tracheids and fibres: 60: vascular/vasicentric tracheids present; (61: fibres with simple to minutely bordered pits); (62: fibres with distinctly bordered pits); (63: fibre pits common in both radial and tangential walls); 66: non-septate fibres present; 70: fibres very thick-walled. Axial parenchyma: 76: axial parenchyma diffuse; 77: axial parenchyma diffuse-in-aggregates; 78: axial parenchyma scanty paratracheal; 91: two cells per parenchyma strand; 92: four (3–4) cells per parenchyma strand; 93: eight (5–8) cells per parenchyma strand; 94: over eight cells per parenchyma strand. Rays: 98: larger rays commonly 4- to 10-seriate; 102: ray height > 1 mm; 107: body ray cells procumbent with mostly 2–4 rows of upright and/or square marginal cells; (108: body ray cells procumbent with over 4 rows of upright and/or square marginal cells); 110: sheath cells present; 115: 4–12 rays per mm. Mineral inclusions: 136: prismatic crystals present; 137: prismatic crystals in upright and/or square ray cells; 138: prismatic crystals in procumbent ray cells; 142: prismatic crystals in chambered axial parenchyma cells.
(P. Ng'andwe, H. Beeckman & P.E. Gasson)

Growth and development When *Microdesmis puberula* is cut, it resprouts profusely from the base.

Ecology *Microdesmis puberula* occurs in primary and secondary forest and at forest edges, also in fallow land, from sea-level up to 1100 m altitude.

Propagation and planting *Microdesmis puberula* may germinate massively in fallow land. Seed dispersal is ensured mainly by monkeys.

Diseases and pests Male inflorescences are sometimes galled and become panicle-like; male flowers can be deformed into scabs.

Genetic resources As a common undergrowth species, *Microdesmis puberula* is not at risk of genetic erosion.

Prospects Despite the extensive use of *Microdesmis puberula* as a medicinal plant, virtually nothing is known about its chemical

composition or pharmacology, and research is warranted. Recent experiments to evaluate the effect of supplementing diets of chickens with *Microdesmis puberula* leaves showed contradictory results, possibly due to certain chemical compounds. As *Microdesmis puberula* and *Microdesmis keayana* resemble each other morphologically and in their medicinal uses, taxonomical studies are warranted.

Major references Adjanohoun et al. (Editors), 1988; Betti, 2004; Bouquet & Debray, 1974; Carter & Radcliffe-Smith, 1988; Esonu, Azubuike & Ukwu, 2004; Hawthorne & Jongkind, 2006; Neuwinger, 2000; Robyns, 1958; Umoh et al., 2004; Villiers, 1975.

Other references Abbiw, 1990; Adjanohoun et al., 1989; Adjanohoun et al., 1986; Adjanohoun et al., 1984; Bouquet, 1969; Burkill, 1997; Dounias, 1993; Esonu et al., 2004; Esonu et al., 2002; Esonu et al., 2003; Govaerts, Frodin & Radcliffe-Smith, 2000; InsideWood, undated; Léonard, 1961; Lewis, 1980; Motte, 1980; Okafor & Ham, 1999; Okoli et al., 2001; Terashima & Ichikawa, 2003.

Sources of illustration Carter & Radcliffe-Smith, 1988.

Authors E. Dounias

MICROSTACHYS CHAMAELEA (L.) Müll.Arg.

Protologue Linnaea 32: 95 (1863).

Family Euphorbiaceae

Chromosome number $2n = 34, 68$

Synonyms *Sebastiania chamaelea* (L.) Müll.Arg. (1866).

Vernacular names Creeping sebastiania (En).

Origin and geographic distribution *Microstachys chamaelea* occurs from Ghana east to the Central African Republic. It also occurs in tropical Asia and Australia.

Uses In Benin a decoction of the leafy stems is used as a bath to relieve teething pain in babies. In India such a decoction taken with butter is considered a tonic, and is applied to the head as a treatment for vertigo. The plant sap is astringent and taken to treat syphilis and diarrhoea.

Botany Monoecious, erect to sprawling annual to perennial herb or shrub up to 0.5(–1) m tall with slender stems. Leaves alternate, simple, almost sessile; stipules ovate, small; blade linear-lanceolate, 3–6 cm × c. 8 mm, base cuneate, apex obtuse, margins finely toothed, short-hairy beneath. Inflorescence a small, terminal or leaf-opposed spike, most flowers male with 1–2 female flowers at base; bracts with 2 large glands at base. Flowers unisexual, regular, sessile, sepals 3, ovate, greenish yellow, petals absent, disk absent; male flowers with 3 free, shortly exserted stamens; female flowers with superior ovary, glabrous, 3-celled, styles 3, free. Fruit a 3-lobed capsule c. 6 mm long, with 2 lines of stiff hairs on each lobe, 3-seeded. Seeds ellipsoid-oblong, c. 4 mm long, smooth, blackish or grey.

Microstachys comprises about 15 species and occurs in the tropics and subtropics, mainly in South America; 4 species occur in tropical Africa. *Microstachys* was formerly included in *Sebastiania*, which now comprises about 75 species in the New World tropics. The African specimens of *Microstachys chamaelea* are rather uniform and have larger leaves, fruits and seeds than the Asian and Australian specimens.

Ecology *Microstachys chamaelea* occurs in gallery forest, savanna and fallow land, often on sandy soils, at low altitudes.

Genetic resources and breeding *Microstachys chamaelea* is widespread and occurs in anthropogenic habitats. It is therefore not likely to be threatened by genetic erosion.

Prospects *Microstachys chamaelea* has only few uses and nothing is known about its properties. It will therefore probably remain of local importance only.

Major references Adjanohoun et al., 1989; Brown, Hutchinson & Prain, 1909–1913; Esser, 1998; van Welzen, 2003.

Other references Burkill, 1994.

Authors G.H. Schmelzer

MOSTUEA BATESII Baker

Protologue Oliv., Fl. trop. Afr. 4(1): 506 (1903).

Family Loganiaceae (APG: Gelsemiaceae)

Synonyms *Mostuea stimulans* A.Chev. (1946).

Origin and geographic distribution *Mostuea batesii* occurs from Cameroon and the Central African Republic south to Gabon and DR Congo.

Uses In Gabon the grated root is used to dispel sleep or as an aphrodisiac with similar action to that of *Tabernanthe iboga* Baill. It is consumed alone or mixed with *Tabernanthe iboga*; extended use may lead to cerebral troubles. In the Central African Republic a root

decoction is taken as an anthelminthic by children.

Properties *Mostuea batesii* contains 0.06% indole alkaloids in the leafy stems, 0.15% in the roots and 0.33% in the root bark. The root bark alkaloids are related to sempervirin and gelsemine. Subcutaneously administered root-bark extract had a mean lethal dose of 0.25 g/kg in mice, and death was preceded by a phase of hyperexcitability. In anaesthetized dogs, an intravenous dose of up to 0.10 g/kg produced hypotension followed by hypertension. A short phase of tachyardia and hyperpnoea was succeeded by cardiac and respiratory depression. A higher dose only produced hypotension.

Botany Small shrub up to 1.5 m tall; twigs hairy when young, later glabrescent. Leaves opposite, simple; stipules hairy outside; petiole 0.5–8 mm long, hairy; blade elliptical, oblong-elliptical to oblong-ovate, 0.5–6.5 cm × 0.5–2.5 cm, base obliquely cuneate to rounded, apex acute, obtuse or rounded, often apiculate, margins entire or obscurely wavy-toothed, hairy on both sides. Inflorescence a terminal, sessile cyme on lateral branches, 1–3-flowered. Flowers bisexual, slightly zygomorphic, 5-merous, heterodistylous, almost sessile; sepals fused at base, ovate-lanceolate to ovate-linear, 2.5–6 mm long, apex awl-shaped, hairy outside; corolla white with yellow base, tube funnel-shaped 7–11 mm long, outside hairy in upper part, glabrous in lower part, inside glabrous except near the insertion of the stamens, lobes 1.5–3 mm long; stamens free, included or exserted; ovary superior, ovoid, 0.5–1 mm long, at apex with some hairs, 2-celled, style simple, shorter or longer than the stamens. Fruit a 2-lobed capsule 5.5–8 mm × 11–13 mm, hairy, medium brown, 4-valved, 2–4-seeded. Seeds plano-convex, obliquely ovate-orbicular, 5–7 mm × 4–6 mm, pale brown.
Mostuea comprises 7 species in Africa and Madagascar and 1 in northern South America.

Ecology *Mostuea batesii* occurs in secondary rainforest, from sea-level up to 750 m altitude.

Genetic resources and breeding Although the natural distribution of *Mostuea batesii* is restricted, it seems not to be in danger of genetic erosion.

Prospects The active ingredients of *Mostuea batesii* are unknown. As related species contain interesting indole alkaloids with antitumour activity, more research into the chemical composition and pharmacological activities of the compounds of *Mostuea batesii* seems warranted.

Major references Burkill, 1995; De Smet, 1996; Gassita et al. (Editors), 1982; Leeuwenberg, 1961a; Neuwinger, 2000.

Other references Leeuwenberg, 1980; Neuwinger, 1998; Onochie & Leeuwenberg, 1963; Raponda-Walker, 1953; Raponda-Walker & Sillans, 1961; Sillans, 1953.

Authors A. de Ruijter

MOSTUEA BRUNONIS Didr.

Protologue Vidensk. Meddel. Dansk Naturhist. Foren. Kjobenhavn 1853: 87 (1854).

Family Loganiaceae (APG: Gelsemiaceae)

Chromosome number $2n = 20$

Origin and geographic distribution *Mostuea brunonis* occurs from Ghana east to Kenya and south to Angola and Mozambique. It also occurs in Madagascar.

Uses In the Central African Republic a root decoction or infusion is taken to treat colds, hypermenorrhoea, kidney troubles and as an aphrodisiac. A bath is taken with a root decoction to treat yellow fever. Young leaves are taken in food to treat stomach complaints and a twig decoction is taken to treat distended stomach in children. In Tanzania the root is chewed to treat stomach-ache. A root decoction or grated fresh root is taken as vermifuge. The grated root is also used to treat snakebites and it is applied as dressing to treat wounds. In Madagascar an infusion of twigs and leaves is taken to treat general pain, including intestinal pain and colitis, and dysentery. In DR Congo the root bark is used as ingredient of arrow poison.

Properties *Mostuea brunonis* contains several indole alkaloids. The stems and leaves contain gelsemicine, mostueine and some related compounds. The roots contain sempervirin and the quinoline-based alkaloid camptothecin. Camptothecin and its derivatives are candidate chemotherapy drugs to treat breast and colon cancers, malignant melanoma, small-cell lung cancer and leukaemia. Its use in agricultural fungicides has been patented in China. Whole plant extracts of *Mostuea brunonis* contain 20-O-β-glucopyranosyl camptothecin and some related compounds, as well as the moderately cytotoxic alkaloids deoxypumiloside and strictosamide. 20-O-β-glucopyranosyl camptothecin is more soluble in alcohol and water than camptothecin, and may have value as a drug that could be more readily formulated

than camptothecin.

Botany Much branched shrub, undershrub, or occasionally liana up to 7 m tall; stems erect or overhanging, with spreading branches; twigs near the apex variously hairy or glabrous. Leaves opposite, simple and entire; stipules membranous, triangular; petiole 0.5–8 mm long; blade oblong-ovate, ovate-elliptical or elliptical, 0.5–15(–28) cm × 0.5–8(–13) cm, base cuneate, apex acuminate, variously hairy or glabrous, often with domatia beneath in the angles of some lateral veins. Inflorescence a lax to headlike axillary or terminal cyme, usually on a short lateral branch, 1–many-flowered, variously hairy. Flowers bisexual, slightly zygomorphic, 5-merous, heterodistylous; sepals fused to up to half of their length, ovate, ovate-lanceolate to ovate-linear, 1–5 mm × 0.5–1 mm, apex acute, hairy or glabrous outside; corolla white, lilac or pink, mostly with a yellow or orange base and throat, sometimes entirely yellow, orange or red, or red with yellow, tube funnel-shaped 5–13 mm long, glabrous outside, lobes 1–5 mm long; stamens free, included or slightly exserted; ovary superior, ovoid, 1–1.5 mm × 0.5–1 mm, glabrous or appressed hairy near the apex, 2-celled, style simple, shorter or longer than the stamens. Fruit a 2-lobed capsule 4–7(–13) mm × 8–14 mm, glabrous or hairy, dull, medium to dark brown when dry, 4-valved, 2–4-seeded. Seeds plano-convex, obliquely ovate-orbicular, c. 10 mm × 6 mm × 2.5 mm, pale brown.

Mostuea comprises 7 species in Africa and Madagascar and 1 in northern South America.

Ecology *Mostuea brunonis* occurs in gallery or rainforest, also in secondary forest, from sea-level up to 1100 m altitude.

Genetic resources and breeding *Mostuea brunonis* is widely distributed and hence not threatened by genetic erosion.

Prospects The active ingredients of *Mostuea brunonis* found so far (camptothecin and derivatives) have interesting antitumour activity. More research into the chemical composition of the plant and pharmacological activities of the compounds seems warranted.

Major references Dai et al., 1999; De Smet, 1996; Leeuwenberg, 1961a; Leeuwenberg, 1980; Neuwinger, 2000.

Other references Bouquet, 1972; Burkill, 1995; Haerdi, 1964; Lorence & Nessler, 2004; Neuwinger, 1998; Onanga, 1983; Onochie & Leeuwenberg, 1963; Raponda-Walker & Sillans, 1961; Sillans, 1953; Vergiat, 1970.

Authors A. de Ruijter

MOSTUEA HIRSUTA (T.Anderson ex Benth. & Hook.f) Baill. ex Baker

Protologue Oliv., Fl. trop. Afr. 4(1): 509 (1903).

Family Loganiaceae (APG: Gelsemiaceae)

Chromosome number $2n = 20$

Synonyms *Mostuea gabonica* Baill. (1880).

Origin and geographic distribution *Mostuea hirsuta* occurs from Senegal east to Sudan and south through Central Africa to Angola.

Uses In Senegal *Mostuea hirsuta* is taken as an analgesic. In Cameroon ground young leaves are used as a dressing to treat initial stages of leprosy. In the Central African Republic a root infusion is taken to treat colds. In Gabon and Congo grated roots are used to dispel sleep or as an aphrodisiac with similar action to that of *Tabernanthe iboga* Baill. It is consumed alone or mixed with *Tabernanthe iboga*; extended use may lead to cerebral troubles. In Congo leaf or root sap is taken to treat pain; leaf pulp is massaged on painful areas caused by pulmonary infections, abdominal pains and umbilical hernia in infants. A root infusion is taken to treat rheumatism. In DR Congo leaf sap is applied to treat pain caused by caries.

In the Central African Republic the roots are used as an ingredient of arrow poison. The branches of *Mostuea hirsuta* are used as brooms.

Properties *Mostuea hirsuta* contains indole alkaloids, probably sempervirin and gelsemine or closely related compounds. Extracts of *Mostuea hirsuta* have analgesic properties, lower heart action and stimulate respiration in low dosage; high dosage can cause death by paralysis of respiration.

Botany Shrub or undershrub, sometimes slightly scandent, up to 2 m tall; stems erect or decumbent, branched; twigs hairy when young, later glabrescent, dark brown. Leaves opposite, simple; stipules triangular to ovate-elliptical, outside hairy; petiole 0.5–2.5 mm long, hairy; blade obliquely ovate, ovate-elliptical or elliptical, 1–8 cm × 0.5–4.5 cm, base obliquely rounded, apex acuminate, margins entire or obscurely wavy, hairy on both sides. Inflorescence a congested terminal cyme on a short lateral branch, 3–6-flowered; peduncle (1–)2–4(–7) mm long, at apex with 2 large bracts. Flowers bisexual, slightly zygomorphic, 5-merous, heterodistylous; sepals fused to up to half of their length, ovate-lanceolate to lanceolate, 1–5.5 mm long; corolla white, sometimes

pale yellow or yellow striped at the base, tube funnel-shaped, 7–16 mm long, lobes 3–5 mm × 3–5 mm; stamens free, included or exserted; ovary superior, ovoid, 1–1.5 mm long, glabrous or minutely hairy, usually with stiff erect hairs at the apex, 2-celled, style simple, shorter or longer than the stamens. Fruit a broadly orbicular to broadly obcordate capsule 6–8 mm × 8–12 mm, base obtuse, apex truncate, retuse and mucronate or 2-lobed, glabrous, yellow to dark brown, 4-valved, 2–4-seeded. Seeds planoconvex, obliquely ovate-orbicular, 6–7 mm × 4–5 mm, pale brown.

Mostuea comprises 7 species in Africa and Madagascar and 1 in northern South America.

Ecology *Mostuea hirsuta* occurs in open localities in rainforest or secondary forest, gallery forest or savanna, sometimes in moist localities, from sea-level up to 1000 m altitude. It is resistant to bush fires.

Genetic resources and breeding *Mostuea hirsuta* is widely distributed and hence not threatened by genetic erosion.

Prospects The active ingredients of *Mostuea hirsuta* are largely unknown. As related species contain interesting indole alkaloids with antitumour activity, more research into the chemical composition of the plant and pharmacological activities of the compounds of *Mostuea hirsuta* seems warranted.

Major references De Smet, 1996; Gassita et al. (Editors), 1982; Kerharo & Adam, 1974; Leeuwenberg, 1961a; Neuwinger, 2000.

Other references Leeuwenberg, 1980; Neuwinger, 1998; Ngavoura, 1990; Oliver-Bever, 1982; Onochie & Leeuwenberg, 1963; Raponda-Walker, 1953; Raponda-Walker & Sillans, 1961.

Authors A. de Ruijter

MOTANDRA GUINEENSIS (Thonn.) A.DC.

Protologue Prodr. 8: 423 (1844).

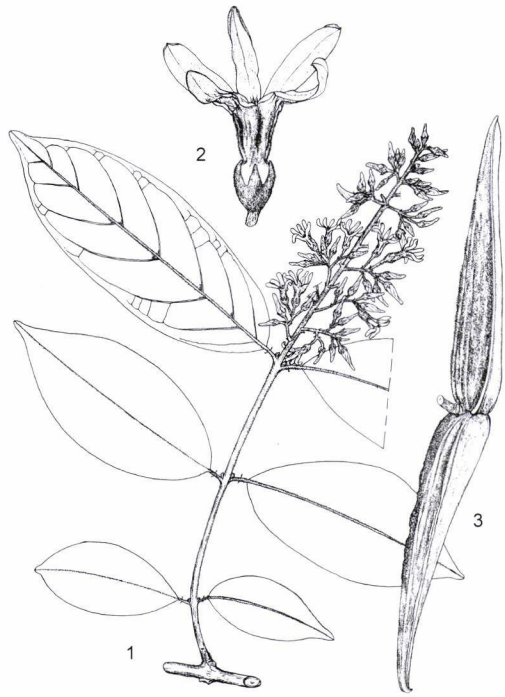
Family Apocynaceae

Origin and geographic distribution *Motandra guineensis* is widespread in Africa, occurring from Sierra Leone and Mali east to Sudan and Uganda, and south to Angola.

Uses In Côte d'Ivoire leaf sap of *Motandra guineensis* is applied to the eyes to treat eye infections, as a mouthwash or massage to the gums to treat toothache or instilled in the nose in case of fainting, headache or to calm insanity. The initial response is irritation of the mucous membranes, followed by sedation. Bark sap is used as an enema to calm stomach-ache in women that have just given birth. In Sierra Leone the hollow stem is cut into short lengths, which are threaded as beads.

Properties An ethanol extract of *Motandra guineensis* leaves was tested in vitro for antibacterial and antifungal activities, but did not show a significant effect.

Botany Climbing shrub or liana up to 40 m long, with white latex; stem up to 10 cm in diameter; bark brown, smooth, later longitudinally fissured; branches pale brown, with small orange-brown lenticels. Leaves opposite, simple and entire; stipules absent; petiole 3.5–10(–13) mm long, glabrescent or rusty brown-hairy, with stalked glands near apex; blade elliptical to oblong-obovate, 3.5–14 cm × 1.5–4.5 cm, base rounded, apex acuminate, with tufts of pale brown hairs in axils of lateral veins. Inflorescence a terminal panicle, 2.5–15.5 cm × 1.5–7(–9) cm, rusty brown hairy, but glabrescent, many-flowered. Flowers bisexual, regular, 5-merous, fragrant; pedicel 1–5 mm long; sepals triangular, 1–2 mm long; corolla white to greenish white, tube obconical, 2.5–4 mm long, urn-shaped at base, inside with tufts of hairs



Motandra guineensis – *1, flowering twig; 2, flower; 3, fruit.*
Source: Flore analytique du Bénin

1–2 mm from the base, lobes narrowly ovate to narrowly obovate, 2.5–7 mm long; stamens inserted at base of the corolla tube, apex of anthers with tuft of hairs; ovary half-inferior, 2-celled, style very short, pistil head with long appendages. Fruit composed of 2 spreading follicles, 4–18 cm × 1–3.5 cm, tapering to the tip, opening by longitudinal slits, dark green with dense rusty brown hairs, longitudinally winged, many-seeded. Seeds c. 18 mm × 9 mm, with tuft of hairs 30–80 mm long at apex; cotyledons broadly ovate, leafy.

Motandra comprises 3 species, which all occur in continental tropical Africa. It is related to *Baissea* and *Oncinotis*. *Motandra guineensis* is the most widely distributed species whereas *Motandra lujaei* De Wild. & T.Durand and *Motandra poecilophylla* Wernham are restricted to the more humid rainforest of western Central Africa. In DR Congo the bark sap of *Motandra lujaei* is taken to treat cough. The long stem is used for making snares and as binding material.

Motandra guineensis flowers towards the end of the dry and the beginning of the rainy season. Fruits mature during the dry season.

Ecology *Motandra guineensis* occurs in open or secondary deciduous forest, gallery forest and in secondary regrowth. It grows on sand, clay and rocky outcrops, from sea-level up to 1200 m altitude.

Genetic resources and breeding *Motandra guineensis* is widespread, also in more or less disturbed habitats, and does not appear to be threatened.

Prospects Because of the varying medicinal uses of the leaf sap, *Motandra guineensis* deserves research attention.

Major references Bouquet & Debray, 1974; Burkill, 1985; de Kruif, 1984; Kerharo & Bouquet, 1950.

Other references Atindehou et al., 2002; Omino, 2002; Terashima & Ichikawa, 2003.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors M.J. Boone

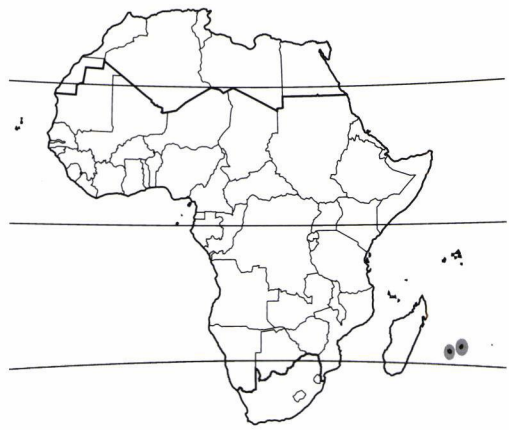
OCHROSIA BORBONICA J.F.Gmel.

Protologue Syst. nat. 2: 439 (1791).

Family Apocynaceae

Vernacular names Bois jaune, quinquina du pays (Fr).

Origin and geographic distribution *Ochrosia borbonica* is endemic to the Mascarene Islands (Réunion and Mauritius).



Ochrosia borbonica – wild

Uses In Réunion a small piece of the bark is boiled and the decoction is sweetened with honey and is drunk to treat loss of appetite, hypotension and constipation, and to reduce fever, e.g. in case of malaria. The bark soaked in wine is taken daily to purify the blood; the bark soaked in rum or water is taken before meals to reduce stomach cramps. In Mauritius the bark boiled with leaves is taken to treat fever. It is also widely taken as a tonic and stomachic and is applied against stomach cramps, as a bath or drink. It is also used against childhood eczema, locally known as 'tambave'.

The wood was formerly used as timber for making household utensils.

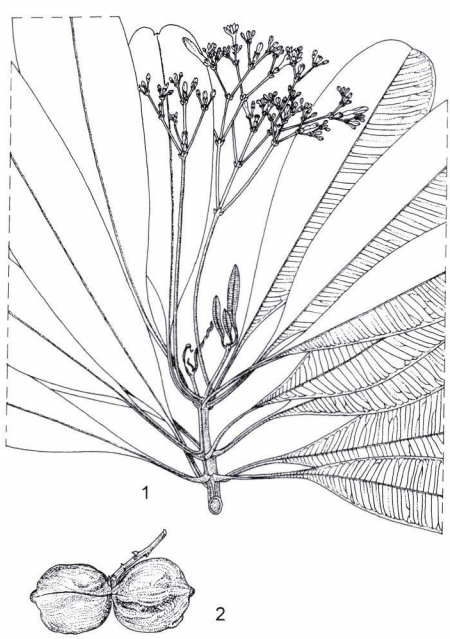
Production and international trade *Ochrosia borbonica* is used at a local scale only, and because it has become rare, it is no longer traded much.

Properties Research on active constituents in *Ochrosia* has focused on anticancer compounds following the isolation of the indole alkaloids ellipticine, elliptinine, 9-methoxy-ellipticine and isoreserpiline from the Asian *Ochrosia elliptica* Labill. Many *Ochrosia* spp. have since been subject to investigation of their alkaloid content, and the production of ellipticine in in-vitro grown callus from *Ochrosia elliptica* has been successful.

The bark of *Ochrosia borbonica* is rich in indole alkaloids and contains mainly ellipticine, 9-methoxy-ellipticine, reserpiline and isoreserpiline. Ellipticine and 9-methoxy-ellipticine show antitumour properties, but also disturb biological membranes, which makes their utili-

zation in medicines impossible.
Semisynthetic derivatives show higher activities against cancer cells and are less toxic. So far, only one ellipticine derivative, celiptium© (N-methyl-9-hydroxy-ellipticine, as acetate salt) has been introduced onto the market for treatment of metastatic breast cancer. This drug also shows significant activity against several leukaemia and melanoma cell lines. Ellipticine derivatives and analogues are also reversible non-competitive inhibitors of cholinesterases and interact with muscarine receptors. The ellipticine derivative hydroxy-methyl-ellipticine shows strong antiviral activities and is being extensively screened in clinical anti-Aids treatments.

Description Small tree up to 15 m tall, glabrous, except for the fringed sepals, with white latex; bole up to 40 cm in diameter; bark dark grey, fissured; branches with ring-shaped leaf scars. Leaves in whorls of 4, simple and entire; petiole 1–3.5 cm long, widened into a stipule at base; blade obovate to elliptical, 3–25 cm × 1.5–5 cm, base decurrent into the petiole, apex rounded, retuse, obtuse or acute, pinnately veined with numerous lateral veins at right angles to the midrib. Inflorescence a terminal cyme, but often seemingly axillary, many-flowered; peduncle 2–12 cm long; bracts scale-like. Flowers bisexual, regular, 5-merous, fragrant, sessile; sepals free, ovate, 2.5–3 mm long, thick, subtended by a sepal-like bracteole; corolla tube 7.5–10 mm long, cylindrical, slightly widened around the stamens, white with pink or red throat, lobes elliptical, 6–13 mm × 3–7 mm, apex rounded, spreading; stamens inserted 5–7 mm from the base of the corolla tube, included, filaments short; ovary superior, consisting of 2 carpels fused at base, style 2.5–4 mm long, split at base, ending in a conical pistil head. Fruit consisting of (1–)2 free ellipsoid drupes, 3.5–4.5 cm × 2–3 cm, apex rounded or apiculate, indehiscent, smooth, with 2 lateral ridges, mesocarp fibrous, each drupe 1–2-seeded. Seeds elliptical, flattened, 1.5–2.5 cm long, winged.



Ochrosia borbonica – 1, flowering branch; 2, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Ochrosia* comprises about 30 species from the Mascarene Islands and Seychelles to South-East Asia, the Pacific and northern Australia. New Caledonia is particularly rich in endemic species. *Ochrosia* belongs to the tribe *Rauvolfieae*, together with the well-known genus *Rauvolfia*.

Growth and development *Ochrosia borbonica* flowers almost throughout the year, with a peak in January and February. Fruits are mainly observed from November to February. The fruits float with their thick fibrous mesocarp and are dispersed by sea currents. Likewise, the seeds float because of cavities in the endocarp. The seeds germinate readily when washed ashore. Natural regeneration of *Ochrosia borbonica* is very slow. It is also often not more than a shrub in the semi-arid vegetation.

Ecology *Ochrosia borbonica* occurs in forest, up to 1250 m altitude.

Propagation and planting *Ochrosia borbonica* can be propagated by seed or by cuttings. In Mauritius attempts are being made at propagating *Ochrosia borbonica* by ripe-wood cuttings, and plantlets are present in nurseries of the Ministry of Agriculture.

Genetic resources In Mauritius and Réunion, *Ochrosia borbonica* has become rare because of habitat loss and destructive harvesting of the bark. It is now confined to remnants of forest and the risk of genetic erosion and extinction is very real for this species. It is classified as endangered on the IUCN Red List. Although *Ochrosia borbonica* is officially protected, pieces of bark collected from the wild can still be found on markets in Réunion.

Prospects The indole alkaloids isolated from *Ochrosia borbonica* possess interesting anti-cancer and anti-viral activities. This potential can only be realized if the future of the species is secured.

Major references Bruneton, 1995; Gurib-Fakim & Brendler, 2004; Gurib-Fakim, Guého & Bissoondoyal, 1995; Lavergne, 2001; Leeuwenberg, 1988a; Leeuwenberg & Rudjiman, 2005; Matte et al., 2002; van Valkenburg & Hendrian, 2001.

Other references Aubert & Picot, 2005; Bisset, 1988b; Chénieux, Ramawat & Rideau, 1988; Lavergne & Véra, 1989; Loupy, 1987; Moinet-Hedin et al., 2000; Rouillard & Guého, 2000; Svoboda, Poore & Montfort, 1968.

Sources of illustration Leeuwenberg, 1988a.

Authors A. Gurib-Fakim

OCHROSIA OPPOSITIFOLIA (Lam.) K.Schum.

Protologue Engl. & Prantl, Nat. Pflanzenfam. 4(2): 156 (1895).

Family Apocynaceae

Chromosome number $2n = 22$

Synonyms *Ochrosia parviflora* (Forst.f.) G.Don (1837).

Vernacular names Bois chauve-souris (Fr).

Origin and geographic distribution *Ochrosia oppositifolia* is widely distributed on the coasts of the islands throughout South-East Asia and the Pacific. In Africa it is restricted to the Seychelles.

Uses In the Seychelles a bitter bark decoction is taken to purify the blood, as an appetizer, purgative and carminative, and in high doses as an abortifacient. A leaf decoction is used to wash the abdomen of women after childbirth. *Ochrosia oppositifolia* has similar uses in South-East Asia. The wood was formerly used for construction.

Properties Research on active constituents in *Ochrosia* has focused on anticancer compounds following the isolation of the indole alkaloids ellipticine, elliptinine, 9-methoxy-ellipticine and isoreserpiline from the Asian *Ochrosia elliptica* Labill. Many *Ochrosia* spp. have since been subject to investigation of their alkaloid content.

The main compounds present in the bark of *Ochrosia oppositifolia* are reserpiline, isoreserpiline and ochropposine. Numerous other indole alkaloids have been recorded in the bark, including epi-rauvanine, bleekerine, ochropposinine, reserpinine and isoreserpinine, but no ellipticine or derivatives. The principal constituent of the leaves is isoreserpiline, with 10-hydroxy-apparicine and 10-methoxy-apparicine as minor compounds.

The wood is yellowish white and hard.

Botany Small to medium-sized tree up to 25 m tall, glabrous except for the corolla tube inside, with white latex; bole up to 50 cm in diameter; bark pale grey, rough; branches with ring-shaped leaf scars. Leaves in whorls of 4, sometimes opposite near the inflorescence, simple and entire; petiole 1–6.5 cm long, not widened into a stipule at base; blade obovate to elliptical, 8–35 cm × 3–15 cm, base decurrent into the petiole, apex rounded, retuse or obtuse, pinnately veined with numerous lateral veins at right angles to the midrib. Inflorescence a terminal cyme, but often seemingly axillary, many-flowered; peduncle 2–14 cm long; lower bracts leafy, broadly ovate, others scale- or sepal-like. Flowers bisexual, regular, 5-merous, almost sessile; sepals connate at base, ovate, 1–2 mm long, thick; corolla creamy to white, tube 4–10 mm long, cylindrical, slightly widened around the stamens, lobes elliptical, 5–9 mm × 2–3 mm, apex rounded, spreading; stamens inserted c. 2 mm below the mouth of the corolla tube, included, sessile; ovary superior, consisting of 2 free carpels, style 1–4.5 mm long, ending in an ovoid pistil head, with a basal ring and a 2-lobed apex. Fruit consisting of 2 free ovoid to ellipsoid drupes 5–8 cm × 3–5.5 cm, apex rounded or apiculate, indehiscent, smooth, mesocarp fibrous, each drupe 1–2-seeded. Seeds elliptical, flattened, 1.5–2.5 cm long, winged.

Ochrosia comprises about 30 species and occurs from the Mascarene Islands and Seychelles to South-East Asia, the Pacific and northern Australia. New Caledonia is particularly rich in endemic species. *Ochrosia* belongs to the tribe *Rauvolfieae*, together with the well-known genus *Rauvolfia*.

The fruits float with their thick fibrous mesocarp and are dispersed by sea currents. *Ochrosia oppositifolia* fruits planted without removal of the pulp germinate poorly and only after about 8 months.

Ecology *Ochrosia oppositifolia* occurs in coastal forest, bush or open localities, only occasionally far inland, often on limestone, up to 100 m altitude.

Genetic resources and breeding The widespread natural distribution of *Ochrosia oppositifolia* and its tolerance of disturbed habitats limit the risk of genetic erosion. In the

Seychelles, it has become rare because of overharvesting of the bark, but it is still relatively abundant on some of the outer islands.

Prospects Several indole alkaloids isolated from *Ochrosia* species show interesting anticancer activity, especially ellipticine and derivatives of it. So far, no ellipticine-based alkaloids have been isolated from *Ochrosia oppositifolia*, and the species is therefore likely to remain of local importance only.

Major references Gurib-Fakim & Brendler, 2004; Leeuwenberg, 1988a; Pheube-Locou et al., 1972; van Valkenburg & Hendrian, 2001.

Other references Adjanohoun et al., 1983a; Friedmann, 1994.

Authors G.H. Schmelzer

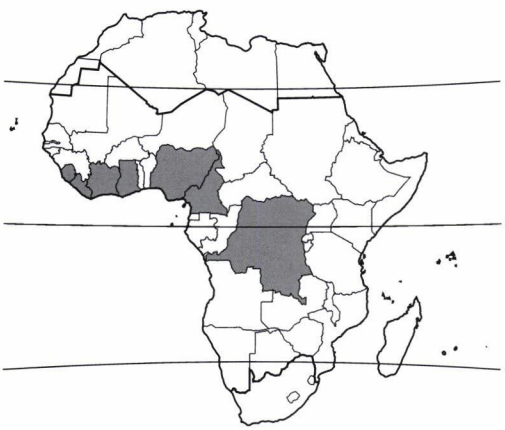
OKOUBAKA AUBREVILLEI Pellegr. & Normand

Protologue Bull. Soc. Bot. France 93: 139 (1946).

Family Santalaceae

Origin and geographic distribution *Okoubaka aubrevillei* occurs from Sierra Leone east to Cameroon and DR Congo.

Uses In West Africa *Okoubaka aubrevillei* bark is widely used as a medicine. Skin problems, including those caused by syphilis and leprosy, are treated by washing with, or bathing in a macerate or infusion of the bark in water. External application of bark preparations is also practised to counteract poisoning. Bark macerate is drunk to cure tachycardia and is taken as a vapour bath or as nose drops to cure oedema. In a compress it is used to disperse haematomas.



Okoubaka aubrevillei – *wild*

In the Western world the bark is used in phytotherapeutic medicine. Its main applications are for stomach upsets caused by poisoning and to boost the system in cases of tiredness, depression and allergies. The bark is used as a fish poison. In southern Nigeria *Okoubaka aubrevillei* is an important tree in religious ceremonies.

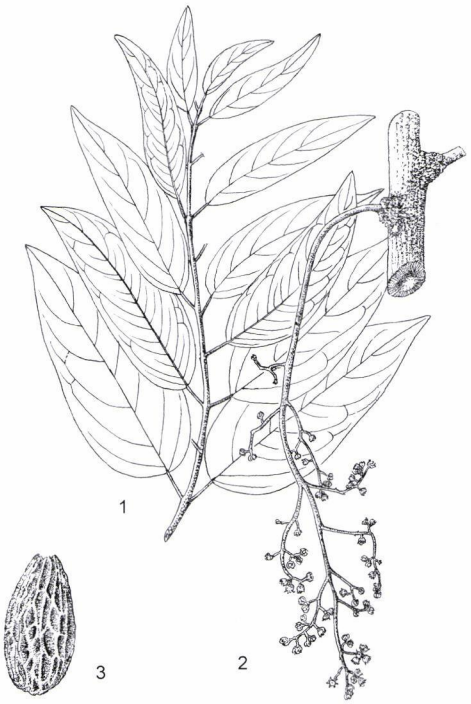
The wood is sometimes used for construction or as firewood.

Production and international trade The bark of *Okoubaka aubrevillei* is traded throughout the coastal countries of West Africa. In local markets it was sold in 2005 for about US$ 20 per kg. In view of the widespread use in the Western world, international trade must be considerable, but statistics are lacking.

Properties From the bark, 6 different catechins have been isolated, including (+)-catechin and (+)-gallocatechin, as well as β-sitosterol and stigmasterol. The bark has antimicrobial and immunostimulating properties that are attributed to phenolic compounds.

Description Monoecious, deciduous, medium-sized tree up to 30 m tall; bole cylindrical, straight, up to 80 cm in diameter; bark surface coarse, greyish brown to reddish brown; branches horizontal, branchlets slightly grooved, densely hairy. Leaves alternate to almost opposite, simple and entire; stipules absent; petiole 3–15 mm long, 2-ribbed; blade ovate to oblong, 7.5–15 cm × 3.5–6 cm, base rounded to slightly cordate, apex acuminate, dark green, with 3–5 pairs of lateral veins, densely hairy when young. Inflorescence a panicle on older branches, up to 20 cm long. Flowers unisexual, 5-merous, regular, sessile, green; male flowers with triangular petals, c. 2.5 mm × 2.5 mm, short-hairy, stamens c. 0.5 mm long, disk cup-shaped, lobed, ovary with abortive ovules, style c. 1 mm long, stigma 4-pointed; female flowers slightly larger than male flowers, stamens sterile, disk cup-shaped, prominently lobed, hairy on upper margin, ovary superior, 4-celled, style c. 1 mm long, stigma 4-lobed. Fruit an ellipsoid drupe up to 9 cm long, glabrous, green turning yellow, 1-seeded. Seed ellipsoid, c. 7 cm × 4.5 cm, longitudinally ridged. Seedling with hypogeal germination.

Other botanical information *Okoubaka* comprises 2 species and is restricted to tropical Africa. It is now generally accepted that it belongs to *Santalaceae*, but it was formerly placed in the families *Octoknemaceae* and *Ola-*



Okoubaka aubrevillei – 1, leafy twig; 2, inflorescence; 3, seed.
Redrawn and adapted by Iskak Syamsudin

caceae. Two varieties are distinguished in *Okoubaka aubrevillei*: var. *aubrevillei* and var. *glabrescentifolia* J.Léonard, the latter known from DR Congo, where it is rare. *Okoubaka michelsonii* J.Léonard & Troupin also occurs in DR Congo and is poorly known. It is distinguished from *Okoubaka aubrevillei* by its glabrous branchlets and disk, shorter inflorescence and smaller fruits. The bark is taken as a febrifuge and tonic.

Growth and development *Okoubaka aubrevillei* is a hemi-parasite. Within 6 months after germination, when nutrient reserves in the seed become depleted, the roots attach themselves to those of nearby plants by means of haustoria. However, one year after germination no differences were found in growth and foliar nutrient concentrations between plants grown with and without hosts. The hosts, however, showed increased mortality or reduced growth. Hence, the apparent benefit which *Okoubaka aubrevillei* gains from the parasitic association is killing potential competitors for water, light and nutrients. The only tree species surviving close to *Okoubaka aubrevillei* are *Myrianthus arboreus* P.Beauv. and *Musanga cecropioides* R.Br. Tree development is in accordance with Mangenot's architectural model: the trunk is formed by superposition of renewal shoots from lateral buds; the new shoot is initially orthotropic but later becomes plagiotropic; the phyllotaxy is spiral in the orthotropic parts, distichous in the plagiotropic parts. This architecture is often found in climbing forest species, but is extremely rare in tree species.

Ecology *Okoubaka aubrevillei* is usually found in forest on rocky hills. It is usually solitary but there are reports from Côte d'Ivoire and Ghana that it is found in pure stands.

Propagation and planting Multiplication of *Okoubaka aubrevillei* is best done by seed. Germination rates of 60–100% have been recorded. Natural regeneration is poor as fruits and seeds are eaten by porcupines.

Management In DR Congo attempts have been made to cultivate *Okoubaka aubrevillei*. After germination, seedlings were transplanted in rows 4 m apart, at a distance of 2 m within the row. Between the rows *Millettia laurentii* De Wild. was planted. After about 10 years 54% of the plants had survived and had reached an average height of 4.2 m and a maximum height of 8.6 m. *Millettia laurentii* did perform well for the first 6 years, but then started dying.

Harvesting In Nigeria special rituals are performed before the bark of *Okoubaka aubrevillei* is removed. A wooden tool is traditionally used for the removal of the bark and under no circumstances is a metal implement used.

Genetic resources *Okoubaka aubrevillei* is considered vulnerable. It is apparently rare throughout its range and the high demand for bark justifies close monitoring of its exploitation. Its poor natural regeneration is a further reason for concern.

Prospects Study of the genetic diversity and the population biology of *Okoubaka aubrevillei* could form the basis for measures to protect natural stands and appropriate management. Assessment of the extent of damage done to the tree by harvesting the bark is needed to be able to specify the need for management strategies and conservation measures.

Major references Burkill, 2000; Cunningham, 1993; Hawthorne & Jongkind, 2006; Keay, 1989; Léonard, 1947; Veenendaal et al., 1996; Villiers, 1973a; Wagner, Kreutzkamp & Jurcic, 1985.

Other references Aubréville, 1959b; Bou-

quet & Debray, 1974; FAO, 1986; Hallé, 1987; Hallé, Oldeman & Tomlinson, 1978; Kerharo & Bouquet, 1950; Léonard & Troupin, 1950; Louis & Léonard, 1948; Maundu, Kariuki & Eyog-Matig, 2004; NACGRAB, 2004; Normand, 1950; Razali Yusuf, 1999b.

Sources of illustration Hallé, 1987; Louis & Léonard, 1948.

Authors D.O. Ladipo, A.A. Adebisi & C.H. Bosch

ONCINOTIS GLABRATA (Baill.) Stapf ex Hiern

Protologue Cat. afr. pl. 1(3): 674 (1898).

Family Apocynaceae

Synonyms *Oncinotis glandulosa* Stapf (1902).

Origin and geographic distribution *Oncinotis glabrata* is widespread in West and Central Africa, from Guinea east to Uganda and western Tanzania, and south from Cameroon to Angola.

Uses In Cameroon and Equatorial Guinea the latex of the grated bark of *Oncinotis glabrata* is sprinkled into yaws sores to cure them. The plant is of distinct decorative value. The stems are used as bowstrings in southern Nigeria.

Properties No chemical data are recorded for *Oncinotis glabrata*. In several other *Oncinotis* species polyamine alkaloids of the spermidine type have been found. Spermidine derivatives show structural similarities to spider and wasp toxins, which are potent inhibitors of glutamate receptors in the central nervous system.

Botany Climbing shrub or liana up to 50 m long, with milky latex; stem up to 12 cm in diameter; bark smooth, later longitudinally fissured, greyish brown, with large pale brown lenticels. Leaves opposite, simple and entire; stipules absent; petiole 5–25 mm long, glabrous, upper side with small triangular glands up to 1 mm long; blade elliptical to ovate, up to 15.5 cm × 7.5 cm, base cuneate, apex acuminate, papery to leathery, glabrous, with small domatia in axils of lateral veins. Inflorescence an axillary or terminal panicle, 4–12.5 cm × 2–5 cm, many-flowered, rusty brown hairy but glabrescent; bracts ovate to triangular. Flowers bisexual, regular, 5-merous; pedicel 2–5 mm long; sepals ovate, 1.5–3.5 mm long; corolla yellow to greenish yellow, tube urn-shaped, 3–5 mm long, lobes triangular, 2–6 mm long, spreading, with a belt of hairs inside the tube just below the insertion of the stamens; stamens inserted at the base of the tube, filaments short; ovary half-inferior, 2-celled, style very short, pistil head at apex with 2 appendages. Fruit composed of 2 spreading, spindle-shaped follicles 10–30 cm long, pendulous, opening by longitudinal slits, longitudinally winged, many-seeded. Seeds 5–25 mm long, smooth, with tuft of hairs 10–75 mm long at apex; cotyledons thin, leafy.

Oncinotis comprises 7 species, 6 occurring in continental Africa and 1 in Madagascar. It is related to *Baissea* and *Motandra*. The West African *Oncinotis nitida* Benth. is used in Côte d'Ivoire to prevent abortion. From the stem bark the spermidine derivative oncinotine has been isolated as the major alkaloid. The bark decoction of the Central and East African *Oncinotis hirta* Oliv. is applied in Gabon to wounds to promote healing. In the Central African Republic root bark, stem bark and seeds of different *Oncinotis* spp. are added to arrow poison and have the reputation of being extremely effective. *Oncinotis gracilis* Stapf is a decorative climber in West and Central Africa, and in Ghana the stems are used for bowstrings.

Ecology *Oncinotis glabrata* occurs in rainforest, swamp forest, secondary deciduous forest and gallery forest. It grows on clay and rocky outcrops, from sea-level up to 2200 m altitude.

Genetic resources and breeding *Oncinotis glabrata* is widespread and it does not appear to be threatened.

Prospects Very little information is available on *Oncinotis* including *Oncinotis glabrata*. More research on the phytochemistry and pharmacological properties is needed before their prospects as medicinal plants can be judged.

Major references Burkill, 1985; Dalziel, 1937; Irvine, 1961; de Kruif, 1985; Neuwinger, 1996.

Other references Abbiw, 1990; Bouquet & Debray, 1974; Popaj, Guggisberg & Hesse, 2000; Raponda-Walker & Sillans, 1961.

Authors M.J. Boone

OSYRIDICARPOS SCHIMPERIANUS (Hochst. ex A.Rich.) A.DC.

Protologue Prodr. 14(2): 635 (1857).

Family Santalaceae

Origin and geographic distribution *Osyri-*

dicarpos schimperianus is distributed from Eritrea south to South Africa.

Uses The Samburu people of northern Kenya drink a root decoction to cure malaria. To reduce excessive swelling of the breasts the roots are soaked in water, which is then drunk. In South Africa leaves and stems are traded by traditional medicine sellers, but the use appears to be undocumented.

Botany Hemiparasitic shrub, scrambling up to 5 m high, straggling; branches ribbed, glabrous to coarse-hairy. Leaves alternate, simple and entire; stipules absent; petiole 1–4 mm long; blade elliptical, 0.5–5 cm × 2.5–15 mm, base cuneate, apex acute, dark green, 3-veined at base. Inflorescence a terminal panicle or raceme 3–30 cm long, 10–30-flowered; bracts leaf-like. Flowers bisexual, 5-merous, regular, sessile; perianth white, pale yellow or greenish, ribbed, tube cylindrical, 3–7 mm long, lobes spreading, ovate, acute; stamens free, with filament up to 1.5 mm long and anthers up to 1 mm long; ovary superior, 5-ribbed, style up to 8 mm long, stigma 2–5-lobed. Fruit a globose drupe up to 6 mm in diameter, crowned with persistent perianth, turning creamy-white, 1-seeded.

Osyridicarpos comprises a single species. Recently, phylogenetic research has confirmed a close relationship between *Osyridicarpos* and *Thesium*.

Ecology *Osyridicarpos schimperianus* occurs mainly in upland dry, evergreen forest and bushland, at 900–2400 m altitude, and less often in more humid forests, along rivers and in deciduous woodland.

Management Harvesting of *Osyridicarpos schimperianus* is exclusively from the wild.

Genetic resources and breeding *Osyridicarpos schimperianus* is fairly widespread; it is not uncommon, not heavily utilized and thus not likely to be threatened by genetic erosion.

Prospects Research on the ethnobotany and properties of *Osyridicarpos schimperianus* is still needed to be able to assess its potential as a medicinal plant.

Major references Bussmann, 2006; Polhill, 2005.

Other references Arnold et al., 2002; Cunningham, 1993; Hutchings et al., 1996; Miller, 1989; Nickrent & Malécot, 2001.

Authors C.H. Bosch

PACHYELASMA TESSMANNII (Harms) Harms

Protologue Bot. Jahrb. Syst. 49: 430 (1913).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae).

Synonyms *Stachyothyrsus tessmannii* Harms (1910).

Origin and geographic distribution *Pachyelasma tessmannii* occurs from southern Nigeria east to the Central African Republic, and south to Gabon and DR Congo.

Uses In Cameroon the fruit of *Pachyelasma tessmannii* is used to cure diarrhoea and as an abortifacient. For the latter either an extract of the ground fruits is administered as an enema or the macerated fruits are added to water and the patient takes a bath in the solution. In Gabon and DR Congo the fruits, seeds and bark are used as fish poison and the species is reported as one of the most effective fish poisons of Central Africa.

The tree is used for timber to a limited extent. The gigantic dimensions of fully-grown trees make felling and transport hazardous and conversion work difficult with the usual equipment. As a result such giant trees have generally been left standing in commercial timber operations. The timber is known in trade as 'mekogho', 'eyek' or 'faux tali'. The wood is suitable for heavy construction, boat building, vehicle bodies, furniture and cabinet work, joinery, sporting goods and implements, interior trim, toys and novelties, and turnery. It is particularly suitable for very thin veneer.

Properties The methanol extract of the root bark of *Pachyelasma tessmannii* exhibits molluscicidal properties. Four triterpene saponins, pachyelasides A–D, have been isolated from the root bark, and each of them showed molluscicidal properties.

The heartwood is reddish brown and usually distinctly demarcated from the whitish pink sapwood, which is up to 10 cm wide. The heartwood is heavy and hard. The grain is often interlocked or wavy, texture coarse. At 12% moisture content the density is 810–900 kg/m^3. The rates of shrinkage are high; quarter-cutting of the logs is recommended. The wood saws well, but strength is required. It is difficult to machine and plane. The use of a filler is required to produce a smooth finish, but a filler is not easily applied. The nailing and screwing properties are good. The wood is durable and only rarely attacked by termites and marine borers, but attack by pinhole borers may occur. The sapwood is moderately resistant to im-

pregnation with preservatives, the heartwood resistant.

The timber of *Pachyelasma tessmannii* can be confused with that of 'tali' (*Erythrophleum ivorense* A.Chev.).

Botany Very large tree up to 60 m tall; bole straight and cylindrical, up to 250 cm in diameter; with buttresses; bark rough, greyish; crown dome-shaped. Leaves alternate, bipinnately compound with 2–5 pairs of opposite or rarely alternate pinnae, up to 35 cm long; stipules lanceolate-linear, soon falling; petiole 2–7 cm long, rachis 5–15 cm long; leaflets alternate, 9–14 per pinna, oblong to oblong-lanceolate, 4–11 cm × 1.5–3.5 cm, base asymmetrical, cuneate to obtuse, apex obtuse, rounded or notched. Inflorescence an axillary or terminal panicle consisting of spike-like racemes up to 18 cm long. Flowers bisexual, regular, 5-merous, malodorous; pedicel 2–3 mm long; sepals c. 2 mm × 2 mm, yellowish green; petals narrowly obovate, up to 6 mm × 3 mm, cherry-red with yellow base; stamens 10, free, c. 4 mm long; ovary superior, long woolly hairy, 1-celled, style cylindrical, c. 3 mm long. Fruit a linear-oblong or oblong-lanceolate, flattened pod, 15–35 cm × 3–4 cm, sutures thickened, indehiscent, thickly woody, pendulous, black, 10–18-seeded. Seeds ovoid, compressed, c. 20 mm × 9 mm × 6 mm.

Pachyelasma comprises a single species and is closely related to *Erythrophleum*.

Ecology *Pachyelasma tessmannii* occurs in primary rainforest.

Genetic resources and breeding *Pachyelasma tessmannii* is widely distributed and not very sought after for timber. Hence no major threats of genetic erosion are envisaged although large-scale habitat destruction could have a negative impact.

Prospects The recent isolation of novel saponins from the root bark of *Pachyelasma tessmannii* will undoubtedly fuel interest in its pharmacology and as the fruits have the widest application in folk medicine, research should also target the fruits.

Major references Bolza & Keating, 1972; Burkill, 1995; Nihei et al., 2005b; Raponda-Walker & Sillans, 1961; Wilks & Issembé, 2000.

Other references Aubréville, 1968; Betti, 2002; Bruneau et al., 2001; Collardet, 1976; de Saint-Aubin, 1963; Keay, Hoyle & Duvigneaud, 1958; Neuwinger, 1996; Neuwinger, 2004; Wilczek et al., 1952.

Authors C.H. Bosch

PAROPSIA BRAZZEANA Baill.

Protologue Bull. Mens. Soc. Linn. Paris 1: 611 (1886).

Family Passifloraceae

Origin and geographic distribution *Paropsia brazzeana* occurs from Cameroon and the Central African Republic south to Angola, the Caprivi strip of Namibia, Botswana and Zimbabwe.

Uses In Congo a bark decoction is used as a vapour bath and leaf sap is drunk to treat rheumatism, whereas leaf pulp is rubbed on the painful area. In DR Congo a root-bark decoction is taken orally to treat amoebic dysentery. In Zimbabwe a root extract is taken orally to treat gonorrhoea and it is also used as a mouthwash to treat toothache. The fruit juice is taken to treat headache and is used as nose drops to cure infections in the nose.

Properties An aqueous root-bark extract of *Paropsia brazzeana* showed significant antibacterial, anti-amoebic and antispasmodic activities. The plant contains flavones, tannins, saponins and hydrocyanic acid.

Botany Many-stemmed shrub up to 4 m tall; stem up to 5 cm in diameter; young branches brownish hairy. Leaves alternate, more or less in 2 rows, simple; stipules soon falling; petiole thick, (3–)5–7 mm long; blade oblong-elliptical to ovate-oblong, (3–)6–10(–13) cm × (1.5–)2.5–6(–7.5) cm, base broadly cuneate to rounded, apex acute to acuminate, margin with acute teeth, leathery, glandular, initially softly brownish hairy on both surfaces, glabrescent above when older. Inflorescence an axillary fascicle, 1–3(–5)-flowered; bracts c. 2 mm long, ovate. Flowers bisexual, regular, 5-merous; pedicel up to 5 mm long, brownish hairy; sepals oblong, 10–12 mm × (3–)4–5 mm, greenish white, brownish hairy outside, minutely hairy inside; petals oblong, narrower than the sepals but with the same length, white, hairy outside; corona consisting of c. 3 mm long threads arranged in 5 bundles fused at the base, glabrous below and hairy towards the apex; stamens exserted, filaments c. 5 mm long, anthers c. 2 mm long; ovary superior, rusty-hairy, styles usually 3, c. 1 mm long. Fruit a globose to ovoid capsule 1.5–2 cm × 1–2 cm, rusty hairy, 6–7-seeded. Seeds ovoid, c. 8 mm × 4 mm, compressed, brown with gelatinous orange aril.

Paropsia comprises 12 species, 5 of which occur in mainland tropical Africa, 6 in Madagascar and 1 in South-East Asia.

Ecology *Paropsia brazzeana* occurs in wood-

land, fringing forest, gallery forest and secondary forest, and thickets on sandy or clay soils up to 1100(–1600) m altitude.

Genetic resources and breeding *Paropsia brazzeana* is widespread and there are no indications that it is threatened by genetic erosion.

Prospects *Paropsia brazzeana* has shown antibacterial, anti-amoebic and antispasmodic activities, but more research is needed to assess the chemical compounds and pharmacological possibilities.

Major references Bouquet, 1969; Fernandes & Fernandes, 1978; Neuwinger, 2000; Sleumer & Bamps, 1976; Sleumer, 1970.

Other references Tona et al., 1999; Tona et al., 1998; Watt & Breyer-Brandwijk, 1962.

Authors A. de Ruijter

PAROPSIA GREWIOIDES Welw. ex Mast.

Protologue Oliv., Fl. trop. Afr. 2: 505 (1871).

Family Passifloraceae

Origin and geographic distribution *Paropsia grewioides* occurs from Cameroon south to Angola, and in Tanzania and Mozambique.

Uses In Congo a bark decoction is used as a vapour bath, leaf sap is drunk to treat rheumatism, and leaf pulp is rubbed on the painful area. In DR Congo pulverized leaves of *Paropsia grewioides* mixed with those of *Utricularia inflexa* Forssk. are rubbed into scarifications on the chest or a decoction is used as a rectal wash to treat respiratory diseases in children.

Properties *Paropsia grewioides* contains flavones, tannins, saponins and hydrocyanic acid.

Botany Shrub or small tree up to 12(–20) m tall; bole up to 30 cm in diameter; young branches with dense, short, brown hairs. Leaves alternate, more or less in 2 rows, simple; stipules lanceolate, up to 2 mm long, soon falling; petiole slender, 4–8 mm long, yellowish hairy; blade oblong to elliptical-oblong, (3.5–)5.5–11(–13) cm × (2–)2.5–4(–7) cm, base cuneate, apex slightly acuminate to acute, margin finely toothed, papery to leathery, glabrescent. Flowers usually solitary in leaf axils, bisexual, regular, 5-merous; pedicel 1–2(–3) cm long; sepals lanceolate-oblong to oblong, (6–)10–14(–25) mm × 3–5(–10) mm, brownish hairy outside, greyish hairy inside; petals narrower and slightly shorter than sepals, greenish yellow or creamy; corona consisting of 3–4 mm long hairy threads; stamens exserted, filaments 6–10 mm long, anthers 2.5–3.5 mm long; ovary superior, with stipe up to 1.5 mm long, globose to ovoid, hairy, styles usually 3, slender, 2–3 mm long, hairy. Fruit a globose to ovoid capsule 1.5–3 cm × 1.5–2.5 cm, usually hairy. Seeds ovoid, compressed, 5–7 mm long, testa hard, grooved and pitted, with aril.

Paropsia comprises 12 species, 5 of which occur in mainland tropical Africa, 6 in Madagascar and 1 in South-East Asia. In Tanzania and Mozambique *Paropsia grewioides* plants have larger flowers and smaller fruits in comparison with plants from Central Africa. They have been distinguished as var. *orientalis* Sleumer. *Paropsia guineensis* Oliv. occurs from Ghana east to Uganda and south to Cabinda (Angola); in Congo the bark is used in the same way as that of *Paropsia grewioides*, to treat rheumatism.

Ecology *Paropsia grewioides* occurs in semi-deciduous forest, littoral forest and dry forest, also in secondary forest and thickets.

Genetic resources and breeding *Paropsia grewioides* is widespread and there is no indication that it is threatened by genetic erosion.

Prospects More research is needed to assess the pharmacological possibilities of *Paropsia grewioides*.

Major references Bouquet, 1969; de Wilde, 1975; Neuwinger, 2000; Sleumer, 1970; Sleumer & Bamps, 1976.

Other references Burkill, 1997; Disengomoka & Delaveau, 1983; Disengomoka, Delaveau & Sengele, 1983; Tona et al., 1999; Tona et al., 1998.

Authors A. de Ruijter

PASSIFLORA SUBEROSA L.

Protologue Sp. pl. 2: 958 (1753).

Family Passifloraceae

Chromosome number $2n = 12, 24, 36$

Vernacular names Corky passionflower, corkystem passionflower, devil's pumpkin, indigo berry, wild passionfruit (En). Grenadille, passiflore (Fr). Maracujá (Po).

Origin and geographic distribution *Passiflora suberosa* originates from tropical America and is a locally established weed in many tropical countries. In Africa it occurs in Kenya, Uganda and Tanzania, South Africa, and also in the Indian Ocean islands.

Uses In Mauritius a leaf decoction is applied externally to treat urticaria and itch. A root decoction is taken to induce menstruation and

to treat hysteria. On Rodrigues a decoction of the plant mixed with either a pinch of salt or with a decoction of young leaves of *Momordica charantia* L. is taken to treat indigestion.

Properties The aerial parts of *Passiflora suberosa* contain simple indole alkaloids, tannins, coumarines, sterols, terpenes and the cyanogenic glycosides passisuberosin and epipassisuberosin. The fruits contain several anthocyanins.

Botany Perennial herbaceous climber, glabrous or hairy; stem up to 6 m long, angular, corky when older, purplish. Leaves alternate, usually deeply 3-lobed; stipules linear, 5–8 mm long; petiole 1–2.5 cm long, with 2 opposed wart-like glands at the middle; blade circular to ovate or oblong in outline, 4–10 cm × 4–14 cm, the central lobe largest, base rounded or cordate, apex acute. Flowers in leaf axils, 1–2 together with a simple tendril 3–12 cm long, bisexual, regular, 5-merous, 1–2 cm in diameter, pale greenish yellow; pedicel 1–2 cm long, jointed about half way; hypanthium saucer-shaped, 3–5 mm wide; sepals ovate to lanceolate, 5–10 mm long, obtuse; petals absent; corona threads in 2 series, 2–6 mm long, yellow with purple base; disk annular, androgynophore 2–4 mm long; stamens free, filaments 2–3 mm long, anthers 1–2 mm long; ovary superior, globose to ellipsoid, 1–2 mm in diameter, glabrous, 1-celled, styles 3, 2–3 mm long. Fruit an almost globose berry 1–1.5 cm in diameter, glabrous, purple-black, many-seeded. Seeds ovoid, 3–4 mm long, wrinkled.

Passiflora comprises about 400 species, most of them in tropical and subtropical America, but about 20 in Asia and Australia. *Passiflora* is not indigenous in Africa, but several species have been introduced, mostly for their edible fruits. *Passiflora suberosa* is a variable species and may include several cryptic species; it needs revision.

Ecology *Passiflora suberosa* is naturalized in grassland, shrub land, open dry forest, roadsides and disturbed shady localities, from sea-level up to 2500 m altitude. It is an aggressive weed, which may smother the natural vegetation. The seeds are dispersed by fruit-eating birds.

Genetic resources and breeding *Passiflora suberosa* is considered an invasive weed e.g. in South Africa where it is listed as harmful, and as such it is subject to eradication practices and not protection measures.

Prospects *Passiflora suberosa* is only locally used for medicinal purposes, and will remain of little importance unless pharmacological research shows other possibilities. It is subject to research because of its resistance against plant viruses and fungi that attack *Passiflora edulis* Sims.

Major references Adjanohoun et al., 1983b; de Wilde, 1975; Dhawan, Dhawan & Sharma, 2004; Gurib-Fakim, Guého & Bissoondoyal, 1997; Monteiro et al., 2000; Porter-Utley, 2003.

Other references Fischer et al., 2005; Gurib-Fakim et al., 1994; Gurib-Fakim et al., 1993; Kidøy et al., 1997; Spencer & Seigler, 1987.

Authors A. de Ruijter

PELTOPHORUM AFRICANUM Sond.

Protologue Linnaea 23: 35 (1850).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

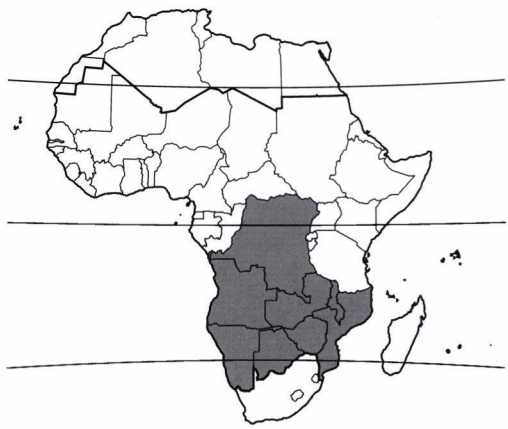
Chromosome number $2n = 26$

Vernacular names African wattle, African false wattle, Rhodesian black wattle, African blackwood, weeping wattle (En).

Origin and geographic distribution *Peltophorum africanum* is native from southern DR Congo to South Africa and Swaziland. It is cultivated in Kenya, Tanzania, Madagascar, Australia and the United States.

Uses Both the bark and roots of *Peltophorum africanum* are used medicinally in traditional African medicine.

Throughout southern Africa, bark and root decoctions are applied for the treatment of wounds, venereal diseases, toothache and taken internally as an anthelmintic. They are also gargled to treat a sore throat. In Zim-



Peltophorum africanum – wild

babwe they are taken internally as general tonics.

A decoction of the bark provides a cure for colic and other stomach disorders, for fever and a sore liver; it induces vomiting and is said to clean the liver and relieve pain. The fresh bark is also chewed to relieve abdominal pain. The steam from a hot decoction is applied against painful eyes.

In Namibia an infusion of the roots is an effective remedy for heavy, painful kicking of the foetus in pregnant women, but it is only applied if the problem lasts for at least 2–3 days. The infusion furthermore stops heavy bleeding on giving birth and is used for treating cough with blood and tuberculosis. The crushed bark in water is rubbed into the coats of pets to keep away fleas and maggots. In Zimbabwe, root decoctions and infusions are taken to treat nausea and chest pain and for blood purification. The Zulu people boil the roots with those of *Bridelia cathartica* G.Bertol. and *Ochna* sp. and drink the mixture to cure infertility. The boiled roots are applied as an enema to treat backache.

The wood is used for carving, turning, making furniture, grinding blocks, wooden buckets, tool handles and wagons. It is not suitable for fence poles or buildings as it is not borer-proof. The wood is widely used as fuel. *Peltophorum africanum* is a good source of bee forage. It is a very good garden, avenue and shade tree and is particularly beautiful when in flower. It is also popular as a bonsai tree. The pods are favoured by cattle and the pods and young leaves are browsed by goats; it is an important fodder plant during the dry season.

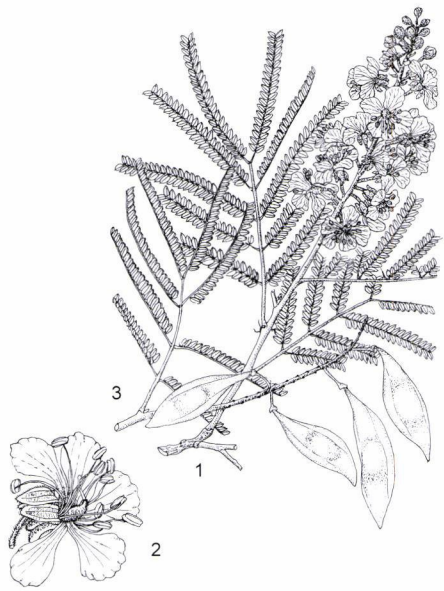
Production and international trade The trade in *Peltophorum africanum* bark is poorly documented and only locally important. In north-eastern South Africa the bark is in high demand and is traded for c. US$ 9/kg.

Properties The bark of *Peltophorum africanum* contains bergenin, an isocoumarin which inhibits DNA topoisomerase II, has hepatoprotective activity, anti-arrhythmic effects of the coronary artery and an inhibitory effect on the growth of the bloodstream form of *Trypanosoma brucei*. The bergenin derivatives coumaroylbergenin and norbergerin have been isolated as well. The seed contains a potent proteinase inhibitor (trypsin and α-chymotrypsin), which has not yet been characterized.

An aqueous extract of *Peltophorum africanum* roots reduced the magnitude of rabbit jejunum contractions. The effect was blocked by propanolol, suggesting an action on the β-adrenergic receptors. Both ethanolic and aqueous extracts of roots and bark showed inhibition in vitro of the gram-negative bacteria *Salmonella typhi*, *Shigella sonnei*, *Escherichia coli*, *Campylobacter jejuni* and *Aeromonas hydrophila*. The ethanol extract of the bark showed strong molluscicidal activity against the snail *Biomphalaria alexandrina*, a host of schistosomiases (causing bilharzia). An oxidized gallotannin isolated from the stem bark of *Peltophorum africanum* was shown to have strong activity against HIV-1 reverse transcriptase and integrase in an enzyme cell-free system.

Browse (leaves and twigs) contains 7% crude protein and its digestibility coefficient is low (0.37). The tannin content in the leaves increases in response to grazing damage. The heartwood is reddish to dark brown and distinctly demarcated from the dirty white to pale brown sapwood. It is heavy, with a density of about 900 kg/m^3 at 12% moisture content. The grain is commonly interlocked, texture fine. The wood works fairly easily, takes a good polish and produces a smooth finish.

Description Small tree, up to 9(–15) m tall, often branching from near the base; bark rough, longitudinally fissured; young twigs rusty hairy. Leaves alternate, bipinnate with 4–9 pairs of pinnae, hairy, deciduous; stipules



Peltophorum africanum – 1, flowering branch; 2, flower; 3, fruiting branch.
Redrawn and adapted by Iskak Syamsudin

up to 1.5 cm long, linear-subulate with up to 7 alternate appendages; petiole 0.5–2(–3) cm long, rachis up to 16 cm long; leaflets c. 8–22 pairs per pinna, oblong or linear-oblong, up to 12 mm × 4.5 mm, base asymmetric, apex rounded, mucronate. Inflorescence an erect, terminal or axillary raceme up to 24 cm long; peduncle velvety hairy, reddish. Flowers bisexual, zygomorphic, 5-merous, showy; pedicel reddish hairy, 3–10 mm long; calyx with tube c. 2 mm long, lobes reflexed, 4–7 mm × 2.5–4 mm; petals obtriangular-spatulate with short claw, 10–14(–17) mm long, yellow; stamens 10, free, 8–13 mm long; ovary superior, rusty pubescent, 1-celled, stigma broadly peltate. Fruit a flat, elliptical, indehiscent pod, 4–10 cm × 1.5–2 cm, base and tip acuminate, winged along both margins, thinly woody, pendulous, 1–2-seeded, bulging at the position of the seeds. Seeds ovoid, compressed, c. 1 cm × 5 mm × 1.5 mm.

Other botanical information *Peltophorum* comprises about 15 species, all native to tropical regions with *Peltophorum africanum* the only species indigenous to Africa. It is most closely related to *Bussea*, which differs in its thickly woody, dehiscent fruits.

The 'weeping' in the vernacular names of *Peltophorum africanum* refers to a phenomenon that occurs in spring just before the first rains: moisture drips from the branches of some of these trees. It is caused by nymphs of small frog-hoppers or spittle-bugs, *Ptyelus grossa*, which suck up the sap of the trees and excrete almost pure water, which drips to the ground.

Anatomy Wood-anatomical description (IAWA hardwood codes):

Growth rings: (1: growth ring boundaries distinct); (2: growth ring boundaries indistinct or absent). Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; 23: shape of alternate pits polygonal; 25: intervessel pits small (4–7 µm); 29: vestured pits; 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; (41: mean tangential diameter of vessel lumina 50–100 µm); 42: mean tangential diameter of vessel lumina 100–200 µm; 47: 5–20 vessels per square millimetre; 58: gums and other deposits in heartwood vessels. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 65: septate fibres present; 66: non-septate fibres present; 69: fibres thin- to thick-walled. Axial parenchyma: 80: axial parenchyma aliform; 81: axial parenchyma lozenge-aliform; (82: axial parenchyma winged-aliform); 83: axial parenchyma confluent; 89: axial parenchyma in marginal or in seemingly marginal bands; 91: two cells per parenchyma strand; 92: four (3–4) cells per parenchyma strand. Rays: 97: ray width 1–3 cells; 104: all ray cells procumbent; 115: 4–12 rays per mm. Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells. (D. Louppe, P. Détienne & E.A. Wheeler)

Growth and development The initial growth rate of *Peltophorum africanum* is 1–1.5 m per year. Flowering is from September–April and fruits develop from February–June in southern Africa. Fruits may persist for a long time. The flowers are visited by bees. *Peltophorum africanum* does not fix nitrogen.

Ecology *Peltophorum africanum* has a wide distribution in the warmer, lower and drier regions of southern Africa with an annual rainfall of 300–900 mm, at 300–2050 m altitude. It is most common in open savanna woodland, with temperatures varying from –6°C to 44°C, with an average of 23°C. Night temperatures of –9°C will cause branches of older plants to freeze back, but plants will regrow. *Peltophorum africanum* shows a definite preference for deep sandy or sandy-loam soils, and is encountered on very poor, acidic, sandy, loamy to gravelly soil derived from sandstone, quartzite or shale and is also found on shallow soils on norite, granite and laterite. In Zimbabwe it is often found on mine dumps and its dominance in the vegetation is taken as an indication of a high level of arsenic in the soil; indirectly this may indicate the presence of gold.

Propagation and planting The storage behaviour of the seed is orthodox. Viability is maintained after 3 years of hermetic storage at room temperature. The 1000-seed weight is 300–800 g. Fresh seed should be soaked overnight in hot water, after which it is sown in a mixture of river sand and compost (5:1) and kept moist. The seeds take 3–10 days to germinate and the germination percentage is usually high. Young plants transplant readily, are fairly fast growing, but need protection from frost for 2–3 years although they withstand slight frost.

Management *Peltophorum africanum* is easy to grow. The root system is not aggressive. After cutting the tree coppices readily. Increased cutting height has a strong positive effect on the number of new shoots.

Diseases and pests The larvae of the moths *Aurivillius arata* and *Alpenus investigatorum* (synonym: *Diacrisia investigatorum*) feed on

the leaves of *Peltophorum africanum*. The larvae of several *Charaxes* butterflies also feed on the leaves.

Genetic resources *Peltophorum africanum* does not appear to be endangered in its native range. Several genebanks hold seed, but the variation in the species has not been studied.

Prospects Interest of phytochemists in *Peltophorum africanum* will probably persist, because the bark and root extracts show interesting pharmacological activities, but only a few active compounds have as yet been isolated. The tree also has a future as an ornamental, but as a browse species it is of very limited value because the quality and digestibility is low. Its tolerance to adverse soil conditions makes it a candidate for reclaiming denuded sites such as abandoned mines and mine dumps.

Major references Bessong et al., 2005; Coates Palgrave, 1983; Ellis, 2003; Leng, 1997; Obi et al., 2003; Palmer & Pitman, 1972–1974; Ross, 1977; van Wyk, 1972–1974.

Other references Aganga, Kiazolu & Tsopito, 1994; Amusan et al., 2002; Evans et al., 1985; Gelfand et al., 1985; Grace et al., 2002; InsideWood, undated; Joubert, 1981; LCSV, 2004; Leger, 1997; Mebe & Makuhunga, 1992; Mlambo & Munjeri, 1998; Mølgaard et al., 2001; Setshogo & Venter, 2003; Shackleton, 2000; Steenkamp, 2003; van Wyk & Gericke, 2000; Wild, 1974; World Agroforestry Centre, undated.

Sources of illustration Ross, 1977.

Authors C.H. Bosch

PENIANTHUS LONGIFOLIUS Miers

Protologue Ann. Mag. Nat. Hist. ser. 3, 13: 124 (1864).

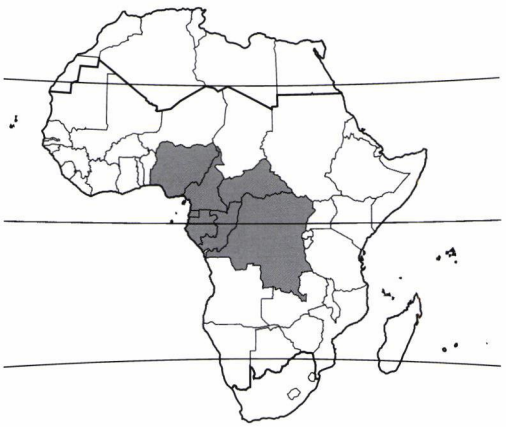
Family Menispermaceae

Chromosome number $2n = 26$

Vernacular names Ovoung grandes feuilles (Fr).

Origin and geographic distribution *Penianthus longifolius* occurs in tropical Africa, from Nigeria and Cameroon south to Cabinda (Angola) and east to eastern DR Congo.

Uses Throughout its distribution area, *Penianthus longifolius* is used as an aphrodisiac, the root and root bark being considered especially powerful. To cure sexual weakness, pulverized root is taken with *Aframomum melegueta* (Roscoe) K.Schum., a ripe banana in palm oil or pineapple wine, according to taste.



Penianthus longifolius – wild

A piece of fresh root may be chewed for the same purpose. Pulverized and macerated root, alone or with sugar-cane juice, is taken as an emetic, anthelmintic and against colic. Root gratings or powdered bark mixed with water, or sometimes leaf pulp are applied as a dressing to mature abscesses and moistened root is applied on infected wounds and nails affected by whitlow. Root sap or bark sap is used as ear drops to cure purulent ear troubles and deafness. In DR Congo pounded leaves are inserted into the ears to cure otitis. Root sap is also taken to treat coughs.

Bark sap is also widely used as an ingredient of arrow poisons for several kinds of game. Root bark ground with palm oil is applied to feet as a dressing to fight sand fleas. The leaves are eaten to treat hernia.

In Gabon and DR Congo the stem of *Penianthus longifolius* is used to make arrows and the leathery leaves are used as arrow-feathers, whereas the root is an important component of several arrow poisons. In Congo the root is sometimes used to lure fish into fish traps. The very hard wood is occasionally used as timber.

Production and international trade Dried bark and roots of *Penianthus longifolius* are sold in local markets throughout its area of distribution.

Properties Although *Penianthus longifolius* has many medicinal uses, its chemical and pharmaceutical properties have hardly been investigated. The aqueous leaf extract contains carbohydrates, proteins, tannins, saponins, alkaloids, steroidal aglycones and glycosides. The root and stem contain up to 1% alkaloids, the leaves only traces.

The aqueous leaf extract has shown a purgative effect on guinea-pig ileum in vitro.

Adulterations and substitutes Other species of *Penianthus* are also widely used for similar medicinal purposes, especially as an aphrodisiac and for local treatment of infections.

Description Dioecious shrub or small tree, up to 3(–4.5) m tall, sparsely branched, glabrous except the flowers. Leaves arranged spirally, simple and entire; stipules absent; petiole 3.5–12(–24) cm long, more or less angular, shallowly grooved lengthwise, swollen at both ends; blade obovate to elliptical or oblong-elliptical, 15–34(–40) cm × 6–15(–18) cm, base rounded to cuneate, apex long-acuminate, leathery, pinnately veined with 8–12(–16) pairs of looping lateral veins. Inflorescence a 10–15-flowered, globose head, borne on branches; peduncle 4–11(–17) mm long, enlarging in fruit, short-hairy; bracts up to 1 mm long. Flowers unisexual, regular; male flowers sessile, tepals 6–7(–8), in 2 whorls of 3(–4) tepals each, outer tepals triangular to oblong, 0.7–2.5(–3.5) mm long, short-hairy outside, inner tepals oblong to obovate, (1.5–)2–3(–3.5) mm long, stamens (3–)5–6, in 2 whorls, erect, 1.5–2(–3) mm long; female flowers sessile or with pedicel up to 4 mm long, enlarging in fruit, tepals 4–7, in 1–2 whorls, triangular to oblong or circular, glabrous, outer tepals, when present, c. 1.5 mm long, inner tepals 2–3 mm long, staminodes 6(–7), in 2 whorls, flattened, ellipsoid to circular or club-shaped, up to 1 mm long, ovary superior, consisting of 3 densely short-hairy carpels 1.5–2 mm × 1–1.5 mm, stigma 2-fid, strongly lobed. Fruit composed of 1–3 drupes, each drupe ellipsoid, (1.5–)2–3(–3.5) cm × 1–2 cm, leathery, nearly glabrous, yellowish orange to orange at maturity, 1-seeded. Seed ellipsoid, 2–2.5 cm long. Seedling with epigeal germination.



Penianthus longifolius – *1, branch with male inflorescences; 2, infructescence.*
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Penianthus* comprises 4 species and is restricted to humid tropical Africa.

Ecology *Penianthus longifolius* occurs in the understorey of rainforest, on riversides and in gallery forest, often in deep shade of high forest, up to 1000 m altitude. It also occurs on fallow land and in secondary forest. In Cameroon it is sometimes a weed in plantations. The plant thrives under a moist equatorial climate, with a mean minimum temperature of 20°C and a mean maximum temperature of 29°C. The mean annual rainfall in its area of distribution is about 1800 mm. The soil ranges from sandy to rocky.

Propagation and planting *Penianthus longifolius* is only propagated by stones. For planting, scarification of the stone probably promotes germination, as is the case for *Penianthus zenkeri* (Engl.) Diels. The seeds are then sown in polythene bags or in seed beds.

Management *Penianthus longifolius* is rarely cultivated. In Cameroon it is usually weeded when found in crop fields.

Harvesting The leaves and bark are collected from the plant when needed and the roots are dug up, usually after rain.

Handling after harvest The collected material is dried in the sun and kept in wrappers or pounded, powdered and made in balls for later use.

Genetic resources *Penianthus longifolius* is fairly common in its distribution area, but in Nigeria it is reported as threatened due to overexploitation for medicinal purposes.

Prospects So far, no attempts have been made to cultivate *Penianthus longifolius* for medicinal purposes. As the plant is widely used, it is recommended that local communities be encouraged to plant *Penianthus longifolius*

in home gardens. Very few studies have been done on the chemical compounds or the pharmacological activities of *Penianthus longifolius*, and there is an urgent need to carry out such studies. The conservation status also needs attention.

Major references Akah et al., 2001; Burkill, 1997; Dekker, 1983; Neuwinger, 1996; Neuwinger, 2000; Oliver-Bever, 1986; Raponda-Walker & Sillans, 1961; Troupin, 1951; Troupin, 1962.

Other references Adjanohoun et al. (Editors), 1988; Amponsah et al., 2002; Dalziel, 1937; de Wet, 2005; Kimpouni, 1999; Pauwels, 1993; Sarumi et al., 1996; Terashima & Ichikawa, 2003; Vergiat, 1970.

Sources of illustration Dekker, 1983; Troupin, 1962.

Authors D.M. Mosango

PENIANTHUS PATULINERVIS Hutch. & Dalziel

Protologue Fl. W. trop. Afr. 1(1): 74 (1927).

Family Menispermaceae

Chromosome number $2n = 26$

Synonyms *Penianthus zenkeri* auct. non (Engl.) Diels.

Origin and geographic distribution *Penianthus patulinervis* occurs from Sierra Leone east to Ghana. It is occasionally cultivated in Côte d'Ivoire.

Uses The root, bark and twigs of *Penianthus patulinervis* are used to prepare aphrodisiac potions, whereas roots and twigs are also chewed or sucked for this purpose. The root bark applied as an enema is also a sexual stimulant. Roots and twigs are used in decoction to treat infections and venereal diseases, and are chewed for dental care. Twigs are chewed to treat cough. In Côte d'Ivoire the leaf pulp is applied to the nails to treat whitlow. In Ghana a dressing prepared from the bark or root shavings is applied to heal wounds, abscesses and boils.

Properties From the stems and roots the alkaloid berberine, the protoberberine alkaloids dehydrodiscretine, jatrorrhizine, palmatine and pseudopalmatine, and the aporphine alkaloid magnoflorine were isolated, several of which have shown pharmacological properties. Other alkaloids identified include menispermine and feruloyltyramine. Berberine has been tested in animal models for activity in the treatment of diabetes, cardiac arrhythmia, leukaemia and in prostate cancer cell lines. Jatrorrhizine has antiplasmodial activity. The plant is also rich in terpenoids, including the triterpenes β-amyrin and 2α,3β-dihydroxyolean-12-ene, the sterol 20-hydroxyecdysone, and the diterpenes columbin, isocolumbin and peniankerine.

Botany Dioecious, evergreen, small shrub up to 1(–2) m tall, usually with a single stem, glabrous except flowers. Leaves arranged spirally, simple and entire; stipules absent; petiole 1–6.5(–8.5) cm long, channelled above, swollen at both ends; blade elliptical to oblanceolate, 15–23(–32) cm × 4–10(–13) cm, base cuneate, apex long-acuminate, thinly leathery, pinnately veined with 9–15 pairs of looping lateral veins. Inflorescence a 3–7-flowered, globose head, borne on the stems; peduncle 3.5–10 mm long, enlarging in fruit, short-hairy; bracts tiny. Flowers unisexual, regular; male flowers sessile, tepals in 3 whorls of 3–4, outer ones triangular to oblong, 0.5–2 mm long, short-hairy outside, tepals of inner whorls oblong to obovate, (1–)1.5–3.5(–4) mm long, tepaloid staminodes 6(–8) in 2 whorls, c. 2 mm long, each more or less enveloping a stamen, stamens 3–6(–7) in 2 whorls, 2.5–4.5 mm long, spreading; female flowers with pedicel c. 0.5 mm long, enlarging in fruit, tepals 8, more or less in 3 whorls, 2 outer ones narrowly triangular, c. 1 mm long, short-hairy outside, inner tepals oblong to obovate, 1.5–2.5 mm long, tepaloid staminodes 6 in 2 whorls, widely triangular, c. 1.5 mm long, stamen-like staminodes club-shaped, c. 0.5 mm long, ovary superior, consisting of 3 glabrous carpels, stigma large, sessile, bifid, each half 2-lobed. Fruit composed of 1–3 drupes, each drupe obovoid to ellipsoid, 2–3.5(–4) cm × 1–1.5 mm, glabrous, yellow to orange or red at maturity, 1-seeded. Seed ovoid to ellipsoid, 2–2.5(–3) cm long. Seedling with epigeal germination.

Penianthus comprises 4 species and is restricted to humid tropical Africa. *Penianthus patulinervis* was formerly included in *Penianthus zenkeri*, but their areas of distribution and morphology are clearly separate; the former occurs in West Africa, the latter in eastern Nigeria and Central Africa. *Penianthus patulinervis* has fewer-flowered heads, almost sessile flowers and shorter petioles than *Penianthus zenkeri*.

Ecology *Penianthus patulinervis* occurs in dense rainforest, also in secondary forest, from sea-level up to 200 m altitude. It is often found on sandy soil and in humid or marshy places.

Management Propagation is by stones; scarifying the stone promotes germination.

Genetic resources and breeding *Penianthus patulinervis* has a fairly wide distribution and there are no immediate threats to its genetic diversity, although continuing habitat destruction is a cause of concern.

Prospects The widespread use of *Penianthus* species, including *Penianthus patulinervis*, and their chemical properties call for more pharmacological research. Domestication and commercial production are recommended as demand is high and natural stands will continue to decline.

Major references Achenbach & Hemrich, 1991; Burkill, 1997; Cheek et al., 2004; Dekker, 1983; Keay & Troupin, 1954.

Other references Amponsah et al., 2002; de Wet, 2005; Duah et al., 1981; Duah et al., 1983; Irvine, 1961; Kryn & Fobes, 1959; Tane et al., 1997.

Authors L.P.A. Oyen

PENIANTHUS ZENKERI (Engl.) Diels

Protologue Engl., Pflanzenr. IV, 94: 101 (1910).

Family Menispermaceae

Synonyms *Heptacyclum zenkeri* Engl. (1899).

Origin and geographic distribution *Penianthus zenkeri* occurs in Nigeria and Cameroon and possibly also in DR Congo.

Uses Preparations of the roots of *Penianthus zenkeri* are used to treat male sexual impotence, cough and wounds. The roots and twigs are used as an aphrodisiac and in the treatment of local infections and venereal diseases. In Cameroon a bitter root decoction is employed as a vermifuge. A dressing made from the leaves is applied to the nails to treat whitlow.

Properties Several pharmacologically active terpenoids, protoberberine alkaloids and aporphine alkaloids have been isolated from *Penianthus* spp., but no chemical analyses have been done on *Penianthus zenkeri;* the analyses effected so far relate to the West African *Penianthus patulinervis* Hutch. & Dalziel.

Botany Dioecious, evergreen shrub to small tree up to 6 m tall, glabrous except the flowers. Leaves arranged spirally, simple and entire; stipules absent; petiole 10–25(–27) cm long, flattened above, swollen at both ends; blade elliptical to oblanceolate, 24–41 cm × 8–15 cm, base cuneate to obtuse, apex long-acuminate, leathery, pinnately veined with 11–19(–21) pairs of looping lateral veins. Inflorescence an umbel, often on older branches, 10–20-flowered; peduncle 4.5–8(–12.5) mm long, enlarging in fruit, sparingly short-hairy; bracts tiny. Flowers unisexual, regular; pedicel 3–7 mm long, enlarging in fruit; male flowers with 7–8 pale yellowish tepals in 3 whorls, 1–2 outer ones triangular, 0.5–1 mm long, short-hairy outside, tepals of middle whorl 3, oblong to obovate, 1.5–2.5(–3) mm long, tepals of inner whorl 3, oblong to obovate, 2.5–3.5 mm long, staminodes 6(–8) in 2 whorls, elliptical to oblong, c. 2 mm long, stamens 6(–7) in 2 whorls, (2–)2.5–3 mm long; female flowers with 7–8 greenish tepals in 3 whorls, 1–2 outer ones narrowly triangular, 0.5–1 mm long, sparsely short-hairy outside, tepals of middle whorl 3, oblong to obovate, 2–2.5 mm long, spreading, tepals of inner whorl 3, oblong to obovate, 2–3 mm long, tepaloid staminodes 6 in 2 whorls, elliptical to obovate, 1.5–2 mm long, stamen-like staminodes 6 in 2 whorls, narrowly triangular, 1–1.5 mm long, ovary superior, consisting of 3 carpels c. 2 mm long, stigma large, sessile, slightly bifid, strongly lobed. Fruit composed of 1–3 drupes, each drupe ellipsoid, 2–4 cm × 1–2 cm, yellow to orange, 1-seeded. Seed ellipsoid, 2–3 cm × c. 1 cm. Seedling with epigeal germination.

Penianthus comprises 4 species and is restricted to humid tropical Africa. *Penianthus patulinervis* was formerly included in *Penianthus zenkeri*, but their areas of distribution and morphology are clearly separate; the former occurs in West Africa and the latter occurs in eastern Nigeria and Cameroon. *Penianthus zenkeri* has many-flowered umbels, pedicellate flowers and longer petioles than *Penianthus patulinervis*.

Ecology *Penianthus zenkeri* occurs in rainforest undergrowth, occasionally also in semi-deciduous forest, at 300–700 m altitude.

Management The stone is used for planting, and its scarification promotes germination. Twigs and roots are collected from the wild when required.

Genetic resources and breeding The area of distribution of *Penianthus zenkeri* is rather small, its habitat is under pressure and high prices are paid for its products in the market. It is not listed in the IUCN Red List of threatened species, but its diversity should be guarded to ensure sustainable future supplies.

Prospects *Penianthus zenkeri* is widely used

in traditional medicine, but its chemistry and pharmacology have not been investigated. Research is therefore warranted.

Major references Dekker, 1983; Cheek et al., 2004.

Other references Achenbach & Hemrich, 1991; Burkill, 1997; Troupin, 1951.

Authors A.T. Tchinda

PENTADIPLANDRA BRAZZEANA Baill.

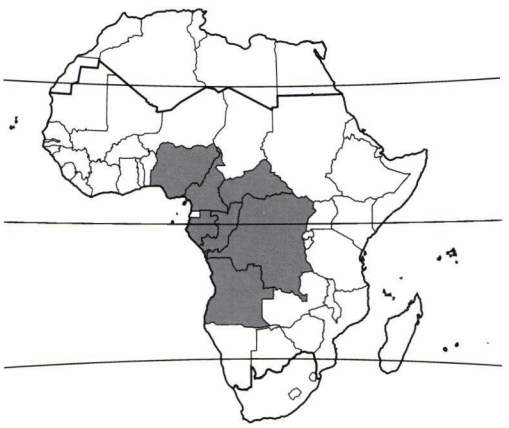
Protologue Bull. Mens. Soc. Linn. Paris 1: 611 (1886).

Family Pentadiplandraceae

Vernacular names l'Oubli (Fr).

Origin and geographic distribution *Pentadiplandra brazzeana* occurs from Nigeria east to the Central African Republic and south to DR Congo and Angola.

Uses The roots taste like horseradish and are used throughout Central Africa against several problems related to giving birth. The root bark is one of more than 20 constituents of the yellow, slimy 'nkui' sauce made by the Bamileke people of Cameroon; this sauce is given to mothers who have just given birth, to stimulate milk production. Among the Mezime people of Cameroon a root decoction is given orally or applied as an enema to facilitate the expulsion of the placenta; it also helps in reducing pain caused by hernia. In the Central African Republic a tuber decoction is said to prevent haemorrhages after parturition. The fresh root is pulped, or the dry root pounded and mixed with palm oil, to make an ointment for topical application to prevent infections of the navel in newborn babies. Because the plant is vesicant, the duration of treatment must be limited to avoid blistering.



Pentadiplandra brazzeana – wild

The crushed root or root bark is applied or an infusion drunk to soothe chest pain, toothache, lumbago, rheumatism and haemorrhoids. Powder of dried root bark is applied to scarifications to treat intercostal and abdominal pains. In Nigeria the crushed root is used to treat several skin infections and in south-western Cameroon a leaf decoction is used to wash the skin against scabies. In Cameroon and DR Congo the macerated roots, alone or mixed with other ingredients, are taken orally or applied as an enema against malaria. In Cameroon the Mezime people take a decoction of the root bark as an aphrodisiac. In the Central African Republic *Capsicum* pepper is added to macerated roots to prepare a drink that soothes cough. In Congo pulped roots are applied externally against itch and as an antiseptic, and to treat wounds, sores, ulcers and furuncles. A decoction of the bark mixed with bark and roots of other plants is taken against stiffness or weakness of the limbs and back. Roots and tubers are also commonly used in the treatment of intestinal problems such as dysentery, colic, urethritis, gonorrhoea and other uro-genital infections. The Monzombo people in Cameroon drink a decoction of the tuber, as well as the juice from macerated roots, mixed with pounded leaves as an anthelmintic. The roots of *Pentadiplandra brazzeana* also have laxative, purgative and cathartic properties, and are applied to the abdomen to treat oedema. A root decoction is taken to treat pneumonia and serious bronchitis, but administration to pregnant women is avoided owing to risk of miscarriage. It may even be used to induce abortion. Together with leaves of *Kalanchoe crenata* (Andrews) Haw., a root preparation is used as nose drops to stop epileptic crises.

The roots smell of aspirin and are hung over the doorway or are placed inside the roof to keep away snakes.

The red pulp of the fruits is eaten as a snack, or sometimes used to sweeten maize porridge. The protein brazzein, originally extracted from the fruit pulp, is being developed into a low-calorie sweetener for the food industry. The powdered root bark is said to be an ingredient of the cheap but dangerous 'African whiskey in sachets'. The fruit is used as fish poison. The root is reportedly occasionally eaten as a vegetable.

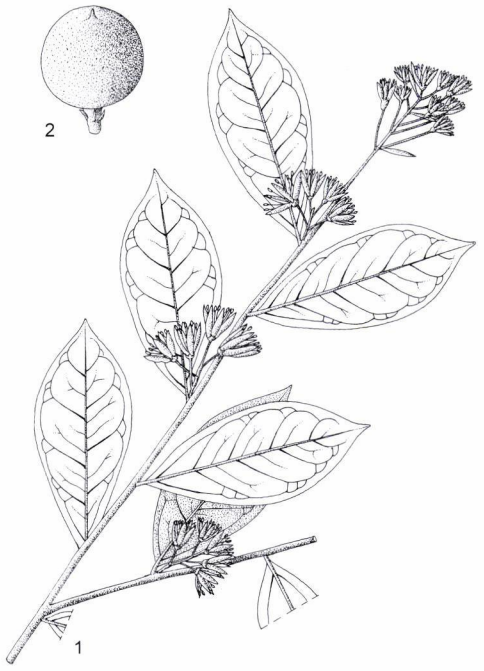
Production and international trade Com-

mercial interest in brazzein is strong. The technology to extract the protein from the fruit pulp as well as technologies to produce brazzein by transferring the gene coding for brazzein into other organisms have been patented, without the intention of benefit sharing.
The roots of *Pentadiplandra brazzeana* are sold for medicinal purposes in local markets. In 2006 pieces of root of c. 15 cm long were sold in the main markets of DR Congo for US$ 0.22–0.45. Dried roots are also sold via internet. A company from Cameroon sells a syrup of the root in the Congo Basin.

Properties An extremely sweet crude protein, named pentadin, was isolated from the fruits; in the 1990s the purified protein was isolated and called brazzein. Its temporal profile closely resembles that of sucrose, but develops somewhat more slowly and lasts longer. It is very thermo-stable and its sweetness profile does not diminish after incubation at 100°C for 4 hours. It is also stable over a wide pH-range and is the most water-soluble protein sweetener discovered so far. Brazzein is reported to be between 500 and 2000 times sweeter than sucrose depending on the method of measuring. However, in early 2008 brazzein had not yet been granted GRAS (generally recognized as safe) status in the United States nor has been granted permission for use in foods in the European Union. The gene encoding for brazzein has been transferred to the bacteria *Escherichia coli* and *Lactococcus lactis* and to maize. Bacterial production systems for brazzein have been developed. Mutants and sections of brazzein have been discovered with sweet-taste properties superior to those of the natural protein.
Phytochemical analyses of the root have led to the isolation of urea derivatives including sulphur-containing compounds. The carbamates (thiouretanes) methyl N-benzylthiocarbamate, methyl N-methoxybenzylthiocarbamate and ethyl N-methoxybenzylthiocarbamate have shown antibacterial properties in vitro against *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*, and against the yeast *Candida albicans*. Other compounds isolated include isopropyl N-methoxybenzylthiocarbamate, dibenzylurea, dibenzylthiourea and methylated derivatives. The root is also rich in glucosinolates and is believed to contribute to the revitalizing of collagen and to restore skin tonicity.
Crude extracts of tubers have revealed moderately strong antiplasmodial activity in vitro, but were not as effective as chloroquine. An aqueous extract of the root given to rats increased the weight of their testes and prostate and also their testosterone levels.

Adulterations and substitutes If brazzein or any of its derivatives are admitted as a sweetener in the food industry, they will compete with other protein and non-protein sweeteners and with sugars.

Description Monoecious shrub up to 5 m tall or liana up to 20 m long; root system a branched complex of bulging roots in shrubs to a large, fleshy tuber in lianas, branches glabrous. Leaves alternate, simple and entire; stipules absent; petiole 0.5–1 cm long; blade elliptical to oblanceolate, 5–15 cm × 1.5–5 cm, base cuneate, apex acuminate, glabrous, upper surface dull or shining dark green, lower surface dull dark green, pinnately veined with 5–11 pairs of lateral veins. Inflorescence an axillary or terminal raceme; peduncle up to 16 cm long. Flowers unisexual or bisexual, regular, 5-merous; pedicel 1–2 cm long; sepals free, elliptical to lanceolate, 0.5–1 cm long, green with violet margin; petals free, lanceolate to oblanceolate, 2–2.5 cm long, base widened and



Pentadiplandra brazzeana – 1, flowering branch; 2, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

with conspicuous scale, apex acute, white to yellowish; androgynophore present, stout; stamens 10–13, free, filaments c. 6 mm long, thin, in female flowers rudimentary; ovary superior, 4–5-celled, style short, with 5-lobed stigma, in male flowers ovary rudimentary. Fruit a globose berry 3.5–5 cm in diameter, red or mottled grey, pulp pink, many-seeded. Seeds kidney-shaped.

Other botanical information *Pentadiplandra* comprises a single species, and is the only genus in the family *Pentadiplandraceae*. Most recent analyses of floral development and anatomy conclude that *Pentadiplandra* represents a relict genus in a separate family at the evolutionary base of the *Brassicales*, with a strong affinity with the American *Tovaria* (*Tovariaceae*). It is also quite distinct on the basis of its chemotaxonomy.

Growth and development When *Pentadiplandra brazzeana* grows as a shrub it has an extended and ramified root system; when it grows as a liana, it has a single, fleshy tuber. Flowering starts in January and continues for several months; fruit production is low and spread out until September. Shrubby plants seem to have a shorter but more condensed fruiting season, with a peak in June–July. Unconsumed fruits rot on the plant, without falling. They serve as temporary nesting sites to arboreal ants.

Ecology *Pentadiplandra brazzeana* is common in upland primary forest dominated by *Scorodophleus zenkeri* Harms, and also commonly occurs on river banks and in secondary forest. In Cameroon, the plant is mainly found in forest edges bordering savanna. It is nowhere gregarious.

Propagation and planting Seed dispersal is facilitated by the contrast between the extreme sweetness of the pulp of the fruit and the unpleasant bitter taste of seeds, provoking consumers to spit out the seeds. In natural habitats, squirrels, monkeys and apes contribute to the distribution of the seed; in the vicinity of human habitation, distribution by children into secondary habitats is common.
Natural vegetative reproduction from portions of tubers seems unlikely as tubers and roots are buried too deeply, but it is incidentally encouraged by the harvesting of the roots and tubers for medicinal purposes.

Harvesting Tubers, roots, leaves and fruits are gathered from the wild. It is likely that the collection of the roots and tubers is often destructive for the plant.

Handling after harvest The sweet layer of pulp surrounding seeds is sucked fresh. The roots and tubers are dried before commercialization, but are locally used fresh immediately after collection.

Genetic resources *Pentadiplandra brazzeana* is widespread and common, also in secondary forest. Although harvesting for medicinal purposes is often destructive, there are no indications that the species is under threat of genetic erosion. No collections of germplasm, e.g. to conserve the variation in brazzein content or composition, are known to exist.

Prospects Prospects of sweet protein production have completely overshadowed the many medicinal uses of the roots and tubers of *Pentadiplandra brazzeana*, which indicate that the pharmacological properties should be further explored.
Lastly, the patents have problematic implications since they ignore any possible benefit sharing with the West and Central African peoples who have been using the fruits for their sweetness for centuries.

Major references Burkill, 1997; Hladik & Hladik, 1988; Keay, 1958b; Ming & Hellekant, 1994; Ming, Hellekant & Zhong, 1996; Neuwinger, 2000; Ronse de Craene, 2002; Tsopmo et al., 1999; van der Wel et al., 1988; Villiers, 1973b.

Other references Assadi-Porter et al., 2005; Assadi-Porter et al., 2000; Assadi-Porter, Aceti & Markley, 2000; Caldwell et al., 1998; El Migirab, Berger & Jabot, 1977; Eyog Matig et al. (Editors), 2006; Izawa et al., 1996; Jin et al., 2003; Kamtchouing et al., 2002; Latham, 2004; Ngamga, 2005; Tancredi et al., 2004; Temussi, 2002; Walters & Hellekant, 2002.

Sources of illustration Villiers, 1973b.

Authors E. Dounias

PEPEROMIA PELLUCIDA (L.) Kunth

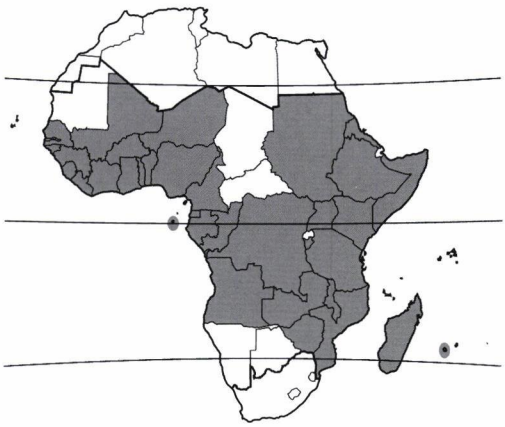
Protologue Humb., Bonpl. & Kunth, Nov. gen. sp. 1: 64 (1816).

Family Piperaceae

Chromosome number $2n = 44$

Vernacular names Pepper elder, shiny bush, cow foot, rabbit ear (En). Pépéromia, herbe à couleuvre, cresson, salade soda, salade soldat, herbe à couresse (Fr). Erva de jabuti, coraçãozinho, língua de sapo, erva de vidro (Po).

Origin and geographic distribution *Peperomia pellucida* is native to tropical Central and



Peperomia pellucida – naturalized

South America. It is now widely distributed throughout the tropics and is often naturalized as a weed and occasionally cultivated. In Africa it occurs from Senegal east to Eritrea and Somalia, and south to Angola, Zambia, Zimbabwe and Mozambique. It also occurs in Madagascar and Réunion.

Uses *Peperomia pellucida* is widely used medicinally throughout the tropics, also in tropical Africa. The aerial parts are applied against abdominal pain, abscesses, acne, rheumatic pain, gout, headache, kidney-problems, cardiac arrhythmia and fatigue. There are also reports of its use in the treatment of measles, smallpox, mental disorders and female sterility. In Nigeria and DR Congo it is used as an ingredient of an infusion for treating convulsions. In Sierra Leone, DR Congo, and also in the Philippines, the warmed leaves are applied to sores and boils. In Nigeria the leaves are applied as a poultice to treat breast cancer. In DR Congo an infusion of the plant or a maceration, mixed with salt and palm oil, is taken against cough. Worldwide, and especially in Brazil and China, the plant is used to cure furuncles, conjunctivitis and skin sores. In Surinam a solution of the fresh juice of stem and leaves is used against conjunctivitis. The leaves are used in a decoction to treat cough, fever and common cold, and are eaten fresh to treat headache, sore throat and kidney and prostate problems, and also against high blood pressure. In the Philippines a decoction or infusion of the plant is taken to treat rheumatic pain, gout and kidney troubles, and applied externally as a rinse against complexion problems.

In many parts of the tropics the plant is used as a condiment, and eaten as a spicy leafy vegetable, cooked or in salads. In Africa it is occasionally cultivated for this purpose. It is sometimes grown as an ornamental container plant.

Production and international trade *Peperomia pellucida* is sold for medicinal purposes and as a vegetable in local markets only.

Properties The essential oil from the aerial parts contains as major compounds dillapiole (40%) and trans-caryophyllene (10.7%), and smaller amounts of apiole, the related compound safrole (5-hydroxy-3,4-methylenedioxy-allylbenzene), carotol, farnesene, germacrene-D, bicyclogermacrene, acacetin, nerolidol and octyl-acetate. Extracts of the aerial parts of the plant yielded very complex compounds, including peperomins A, B, C and E, pellucidin A, flavonoids, secolignans, tetrahydrofuran lignans, a methoxylated dihydronaphthalenone, sesamin and isoswertisin. The aerial parts also contain β-caryophyllene and caryophyllene-oxide.

The secolignans and peperomin E showed growth inhibitory effects on several cancer cell lines. The whole plant and extracts from it are reported to have significant analgesic, antibacterial, antifungal and anti-inflammatory activities and they are used to lower cholesterol levels, against proteinuria and as a diuretic. Apiole has pectoral and antispasmodic actions. A methanol extract of the aerial parts given orally has shown a significant analgesic effect on acetic-acid-induced writhing in rats and mice. A water extract of the aerial parts given orally exhibited significant anti-inflammatory activity in the carrageenin test in rats and mice. The crude plant extract and methanol extract were found to exhibit good levels of broad-spectrum antibacterial activity in vitro. *Peperomia pellucida* showed low toxicity (LD_{50} = 5000 mg/kg).

The nutritional composition of the fresh leaves per 100 g is: water 92 g, energy 105 kJ (25 kcal), protein 0.5 g, fat 0.3 g, carbohydrate 5.9 g, Ca 124 mg, P 34 mg, Fe 3.2 mg, β-carotene 2.5 mg, thiamine 0.03 mg, riboflavin 0.07 mg, niacin 0.6 mg, ascorbic acid 10 mg (Leung, W.-T.W., Butrum, R.R. & Chang, F.H., 1972).

Adulterations and substitutes *Talinum triangulare* (Jacq.) Willd. and *Talinum paniculatum* (Jacq.) Gaertn. are used more commonly than *Peperomia pellucida* as a succulent vegetable; their taste is similar.

Description Fleshy annual herb up to 30(–

60) cm tall, glabrous; stems many, initially erect, becoming decumbent, rooting at nodes. Leaves arranged spirally, simple and entire; stipules absent; petiole up to 1.5(–2) cm long; blade elliptical-ovate to broadly ovate or almost triangular, 2–3.5 cm × 2–3.5 cm, base rounded to truncate, apex acute, thin, palmately 5–7-veined. Inflorescence a lax terminal or leaf-opposed spike up to 6.5 cm long; bracts rounded, up to 0.5 mm long. Flowers bisexual, sessile; perianth absent; stamens 2, filaments short, anthers oblong, tiny; ovary superior, rounded-ovoid, c. 0.5 mm in diameter, 1-celled, stigma 1, sessile. Fruit a globose drupe 0.5–1 mm in diameter, blackish brown to orange, sticky, papillate, 1-seeded.

Other botanical information *Peperomia* is a very large genus, and estimates of the number of species range from about 400 to over 1000. Tropical and subtropical Central and South America are richest in species. In tropical Africa about 17 species occur, in Madagascar 7 endemic species. *Peperomia pellucida* is variable; many impoverished specimens, growing under unfavourable conditions, have been described as separate species.



Peperomia pellucida – 1, flowering plant; 2, part of infructescence.
Source: PROSEA

Several other *Peperomia* species are medicinally used in tropical Africa. *Peperomia abyssinica* Miq. occurs from Ethiopia south to Malawi. In Kenya the liquid from the soaked root is given to pregnant women to treat malaria. *Peperomia molleri* C.DC. occurs from Ghana east to Kenya and south to Zimbabwe. In DR Congo a leaf infusion is drunk and a leaf maceration is applied to the head to treat mental illness. *Peperomia tetraphylla* (G.Forst.) Hook. & Arn., which is pantropical and occurs throughout nearly all tropical Africa, is used medicinally in Asia, as a tonic and to treat kidney disorders.

Growth and development *Peperomia pellucida* is short-lived, but its lifespan can exceed one year. It sets seed abundantly. Seed is probably dispersed by rain wash and more widely by man through contaminated soil. Seedlings emerge about 15 days after sowing and develop naturally during the rainy season. In cultivation, growth is very fast and stems may reach a length of 60 cm 100 days after transplanting. Inflorescences appear 4–6 weeks after transplanting.

Ecology *Peperomia pellucida* is common in disturbed localities and is a widespread weed of cultivated fields and gardens. It grows in moist shady places, near houses, along paths and roads, on seasonally flooded river banks and on wooded rocky hillsides, up to 1100 m altitude. It is particularly common on damp hard surfaces such as walls, roofs and steep gullies. It may also grow as an epiphyte on fallen and dead tree trunks. It requires a minimum temperature of 10°C and prefers soil rich in organic matter.

Propagation and planting Propagation is mostly by seed, but is also possible by stem, leaf and leaf-bud cuttings.

Management *Peperomia pellucida* is sometimes left during weeding operations as a ground cover to smother more harmful weeds. It is cultivated as a medicinal plant in southern China, Thailand, the Philippines and tropical America; in West Africa also as a vegetable. It may be grown as a container plant in well-drained pots filled with soil containing plenty of organic matter.

Diseases and pests Poor drainage may cause root rot. Cucumber mosaic virus (CMV) may cause ringspot, manifested by distorted leaves with chlorotic or necrotic rings. The only treatment is to destroy infected material. The plant is a host of mealy bugs. The leaves are often eaten by slugs.

Harvesting *Peperomia pellucida* is harvested from the wild or from home gardens whenever needed. The plant has a strong mustard-like odour and pulling it can cause asthma-like symptoms.

Yield Wild populations are so abundant during rainy seasons that they mostly provide the necessary quantities. No quantitative data on yield are available.

Handling after harvest Plant material is used fresh, or can be dried, powdered and kept for later use.

Genetic resources *Peperomia pellucida* is widely distributed and common throughout the tropics. Collection of leaves for food or medicinal purposes does not affect its genetic diversity as it is a weedy plant, which produces many seeds.

Prospects Because *Peperomia pellucida* is very widely used for medicinal purposes and because it contains a range of complex bioactive compounds, research into its pharmacological properties deserves more attention. Its use as an easily collected or cultivated spicy vegetable justifies research into possibilities for its domestication. Its great genetic diversity and wide ecological adaptability may make selection of cultivars and development of appropriate crop husbandry measures relatively easy.

Major references Adegoke, Akinsaya & Naqvi, 1968; Arrigoni-Blank et al., 2002; Arrigoni-Blank et al., 2004; Burkill, 1997; Diniz, 1997; Immelman, 2000; Khan & Omoloso, 2002; Kiew, 1999; Neuwinger, 2000; Pousset, 1989.

Other references Adjanohoun et al. (Editors), 1988; Aziba et al., 2001; Bayma et al., 2000; da Silva et al., 1999; Düll, 1973; Heine & Heine, 1988b; Keay, 1954b; Kerharo & Adam, 1974; Kokwaro, 1993; Leung, Butrum & Chang, 1972; Moreira et al., 1999; Oliver-Bever, 1986; Raponda-Walker & Sillans, 1961; Sofowora, 1996; van der Zon & Grubben, 1976; Wanke et al., 2006; Wome, 1985; Xu et al., 2006.

Sources of illustration Kiew, 1999.

Authors D.M. Mosango

PERICHASMA LAETIFICATA Miers

Protologue Ann. Mag. Nat. Hist. ser. 3. 18: 22 (1866).

Family Menispermaceae

Synonyms *Stephania laetificata* (Miers) Benth. (1867).

Origin and geographic distribution *Perichasma laetificata* occurs from south-eastern Nigeria east to Uganda and south to DR Congo and Angola.

Uses In Congo the leaf sap is applied to scarifications made in the forehead to cure very severe migraine. A maceration of the leaves is drunk to treat snakebites and a piece of stem is tied round the ankle to prevent snakebites. Stems are also made into girdles and bracelets for ankles and wrists for infants to assist them in walking. In the Central African Republic water with local salt in which leaves have been crushed is given to babies against constipation. The roots are considered edible.

Botany Dioecious liana with slender, ribbed, woody stem up to 5 m long, with stiff brown hairs and a tuberous rhizome. Leaves alternate, simple; stipules absent; petiole stout, 9–12 cm long, ribbed, base swollen and twisted; blade peltate, petiole inserted 4–4.5 cm from the base, ovate, 12.5–22 cm × 13–16 cm, base rounded, apex acute, margin wavy, papery, hairy below, glabrous above, palmately veined with (8–)9 veins, the 5 central ones most prominent. Inflorescence a large, much-branched, axillary panicle up to 50 cm long, 4 or more together, hairy or glabrous; female inflorescence smaller than male one, up to 20 cm long; bracts c. 2 mm long, long-hairy. Flowers unisexual; pedicel 1–1.5 mm long, thick; male flowers with 6 sepals in 2 whorls, free, obovate, inner ones 1.5–2 mm long, apex obtuse, with 1 prominent vein, petals 3, free, angular obovate, c. 0.5 mm long, apex rounded, with 1 prominent vein, stamens 6, merged into a staminal column up to 0.5 mm long; female flowers with 3 ovate to obovate sepals 1–1.5 mm long, hairy outside, petals 3, almost kidney-shaped, 0.5–1 mm × c. 0.5 mm, ovary superior, ovoid, up to 1 mm long, hairy to glabrous. Fruit an almost globose yellow drupe, 8–12 mm × 7–9 mm, hairy when immature, later glabrous, with 2 ridges, 1-seeded. Seed 6–9 mm long.

Perichasma comprises 2 species, both in tropical Africa. It is closely related to *Stephania* and differs mainly in its vegetative characters.

Ecology *Perichasma laetificata* occurs in rainforest, fringing forest, fallow fields and clearings, from sea-level up to 900 m altitude.

Genetic resources and breeding Because *Perichasma laetificata* is widespread and also occurs in secondary vegetation, there are no indications that it is in danger of genetic ero-

sion.

Prospects Too little is known about the uses and properties of *Perichasma laetificata* to assess its potential or prospects.

Major references Burkill, 1997; Kundu & Guha, 1977; Neuwinger, 2000; Troupin, 1951; Troupin, 1962.

Other references Bouquet, 1969; Motte, 1980.

Authors L.P.A. Oyen

PERRIERA MADAGASCARIENSIS Courchet

Protologue Bull. Soc. Bot. France 52: 281 (1905).

Family Simaroubaceae

Origin and geographic distribution *Perriera madagascariensis* is endemic to western Madagascar.

Uses The stem bark of *Perriera madagascariensis* is used as a tonic and against fever. Both bark and seeds are very bitter and were formerly used to treat amoebiasis and oedema. The roots and fruits are considered toxic. The wood is occasionally used for light construction in house building.

Properties Two major alkaloids were isolated from *Perriera madagascariensis*. From stems and root bark 4,7-dimethoxy-1-vinyl-β-carboline was isolated and a dimeric alkaloid, biogenetically related to the β-carboline, kirondrin, was isolated from the root bark. Kirondrin has been used to treat amoebiasis and is found to be cytotoxic.

The 4-substituted β-carbolines inhibit Ca^{2+} influx and interleukin-2 (IL-2) production, and some are well suited for preventing and treating immune disorders. Use and production of 4-substituted β-carbolines are patented.

The wood has a coarse texture, is hard, lightweight and yellowish.

Botany Medium-sized tree up to 30 m tall; outer bark grey, deeply longitudinally cracked, inner bark thick, yellow. Leaves arranged spirally, imparipinnately compound with 1–5 pairs of leaflets, often clustered at end of branches; stipules absent; rachis 4–23 cm long, densely hairy when young, slightly channelled at base; leaflets oblong to oblanceolate, up to 7 cm × 2.5 cm, base cuneate or rounded, apex rounded, shortly acuminate, often with 3–5 small, translucent glands, leathery, pinnately veined with 12–15 pairs of lateral veins almost perpendicular to midrib. Inflorescence an axillary panicle as long as the leaves or slightly longer, hairy. Flowers male or bisexual, regular, 5(–6)-merous; pedicel up to 5 mm long; calyx deeply lobed; petals free, c. 5 mm long, hairy; stamens 10(–12); ovary superior, consisting of 2–3 carpels. Fruit an ovoid drupe c. 5 cm long, becoming pale yellow when ripe.

Perriera is endemic to Madagascar and comprises 2 species.

Ecology *Perriera madagascariensis* occurs in dry deciduous forest from sea-level up to 500 m altitude, often on sandy soil.

Genetic resources and breeding *Perriera madagascariensis* is considered near threatened even though it was still abundant in the region around Morondava in 1961.

Prospects The main interest in *Perriera madagascariensis* will remain its medicinal and pharmacological properties. Its rareness precludes its wider commercial use as timber.

Major references Guéneau, Bedel & Thiel, 1970–1975; Gurib-Fakim & Brendler, 2004; Krebs et al., 1997; Perrier de la Bâthie, 1950.

Other references Boiteau, Boiteau & Allorge-Boiteau, 1999; Bourguignon-Zylber & Polonsky, 1970; Capuron, 1961; Lounasmaa & Tolvanen, 2000; Pari et al., 2000; Schatz, 2001.

Authors C.H. Bosch

PETCHIA MADAGASCARIENSIS (A.DC.) Leeuwenb.

Protologue Wageningen Agric. Univ. Pap. 97(2): 71 (1997).

Family Apocynaceae

Synonyms *Alyxia madagascariensis* A.DC. (1844), *Cabucala madagascariensis* (A.DC.) Pichon (1948).

Origin and geographic distribution *Petchia madagascariensis* is endemic to Madagascar.

Uses In Madagascar a leaf decoction of *Petchia madagascariensis* is drunk to cure stomach-ache, gonorrhoea, rheumatism, gout and alopecia. It is also taken as a tonic, diuretic, vermifuge and for the treatment of diseases of the spinal nerves. The crushed leaves are applied to insect stings. A decoction of the stem bark is taken against malaria. A decoction of the aerial parts is drunk as an ordeal poison. The leaves and stem bark are used as a bitter ingredient for the production of rum. The fruit pulp is sweet and edible.

Properties The root bark of *Petchia madagascariensis* contains the alkaloids reserpine, cabucine and cabucinine. Yohimbine has also been isolated; it has aphrodisiac properties.

Reserpine is considered the first modern drug for the treatment of hypertension. It is a sympatolytic agent acting directly on the peripheral and central nerve terminals. Reserpine has important side effects, notably depression, peptic ulcer, and hypersensitivity to the alkaloid. Cabucine, a methoxyheteroyohimbine derivative, also has sympatolytic activity, but with minimal side effects.

Botany Shrub or small tree up to 10 m tall, with white latex; bole up to 25 cm in diameter; bark smooth, often transversely fissured, pale grey and dark brown. Leaves in whorls of 3–4 or opposite, simple and entire; stipules absent; petiole 1–15 mm long; blade elliptical, up to 23.5 cm × 10.5 cm, base cuneate, apex acuminate to rounded, leathery, lateral veins straight, in 15–20 pairs, margins revolute. Inflorescence a terminal cyme, often several together, few- to many-flowered, lax; peduncle 2.5–6 cm long; bracts as long as the sepals. Flowers bisexual, regular, 5-merous; pedicel 2–11 mm long; sepals ovate, 1–3 mm long; corolla tube 8–25 mm × 1–3 mm, pale green or pale yellow, with a hairy belt below insertion of stamens, lobes ovate to elliptical, 3–15 mm long, creamy to yellow; stamens inserted in the upper part of the corolla tube, filaments short; ovary superior, consisting of 2 separate carpels, style slender, pistil head small. Fruit consisting of 2 follicles, cylindrical, each follicle composed of 1–13 drupes, orange, each drupe containing a single seed.

Petchia comprises 8 species: 5 are endemic to Madagascar, one to Madagascar and Comoros, one to Cameroon and one to Sri Lanka. *Petchia madagascariensis* is a variable species. The stem bark and root bark of *Petchia cryptophlebia* (Baker) Leeuwenb. are applied in Madagascar against hallucinations, malaria and hypertension, and are also used as an aphrodisiac. The leaves contain cabucine and 2 oxindole alkaloids, as well as some flavonoids. *Petchia erythrocarpa* (Vatke) Leeuwenb. is endemic to the Comoros and Madagascar. In Madagascar a bark decoction is drunk to cure viral hepatitis, malaria, stomach-ache and diarrhoea. The bark is used as a bitter ingredient of alcoholic beverages traditionally drunk during circumcision ceremonies as a symbol for virility, and considered strongly aphrodisiac. The crushed leaves are applied to skin infections, and a decoction is taken to treat hypertension and stomach-ache. The root, bark stem bark and leaves contain the alkaloids reserpine, cabucine, cabucinine, akuammine and vincorine (cabuamine).

Ecology *Petchia madagascariensis* occurs in humid evergreen forest, mostly near the coast. It grows up to 600 m altitude.

Genetic resources and breeding *Petchia madagascariensis* and *Petchia erythrocarpa* are fairly common and not threatened by genetic erosion. *Petchia cryptophlebia* occurs only in the rainforest area of Madagascar, which is seriously threatened, and the species has almost stopped regenerating. Thus, measures should be taken to ensure natural regeneration so that the genetic basis stays sound.

Prospects Some of the alkaloids present in *Petchia madagascariensis* and related species have found their way into modern medicine. Therefore, it may be rewarding to do more research on the alkaloids of *Petchia* species.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Douzoua et al., 1974; Leeuwenberg, 1997a; Pernet & Meyer, 1957; Rasoanaivo et al., 1999.

Other references Andriamanga, 1995; Boiteau & Allorge-Boiteau, 1993; Douzoua et al., 1972; Groebel, Lenoir & Pernet, 1970; Gurib-Fakim & Brendler, 2004; Laivao, 1999; Mansour et al., 1974; Rajerison, 1999; Ramananjanahary, 2002; Rasoanaivo et al., 2001a.

Authors M.J. Boone

PETIVERIA ALLIACEA L.

Protologue Sp. pl. 1: 342 (1753).

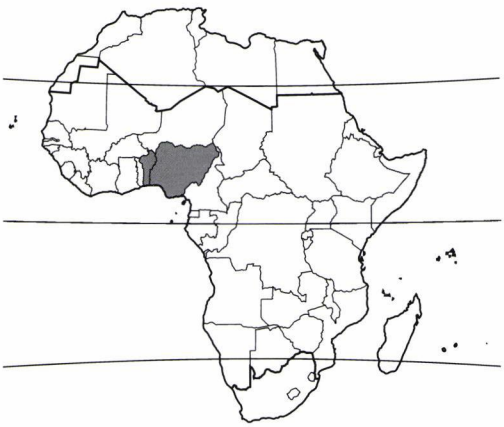
Family Phytolaccaceae

Chromosome number $2n = 34, 72$

Vernacular names Guinea-hen weed, Congo root, gully root, pipi root, garlic weed, skunk root (En). Herbe aux poules, douvant-douvant (Fr). Mucura, anamu, erva de tipi, guine (Po).

Origin and geographic distribution *Petiveria alliacea* is indigenous to tropical America, and has been introduced in West Africa and India. It is locally naturalized in Benin and Nigeria.

Uses In Benin a leaf maceration of *Petiveria alliacea* is applied to the belly to induce contractions in case of difficult delivery, and the liquid from the leaves is instilled as nose or eye drops to cure violent headache and as nose drops to cure sinusitis. A bath or vapour bath with a leaf decoction is taken in case of oedema. A leaf decoction is applied to abscesses. In Nigeria, Yoruba medicine men use the whole plant in ritual ceremonies.



Petiveria alliacea – naturalized

In tropical America *Petiveria alliacea* is widely used as medicine. The head is washed in water with mashed leaves to treat headache and to induce labour. A leaf decoction is applied externally as an analgesic against muscular pain and to treat skin diseases. An infusion of pounded bark is drunk to treat colic, rheumatism, cancer, syphilis, colds, fever, bronchitis and asthma. The grated roots soaked in sugar cane alcohol or a root decoction are taken to treat rheumatism, venereal diseases and intestinal worms, and as an antispasmodic, sudorific and diuretic for urinary tract infections. The pounded root mixed with lemon is applied to snakebites. In Cuba the juice of the leaves or whole plant is applied to treat skin problems, arthritis and toothache, and is taken to treat diabetes. Colombians chew the leaves to coat their teeth and prevent caries. A decoction of the whole plant is taken to treat diabetes, cancer, abortion, oedema and as a blood purifier. In Brazil the leaves are used as an insecticide. The plant is also widely used for magical purposes.

Milk of cattle that have eaten *Petiveria alliacea* smells of garlic.

Production and international trade Capsules or tablets with powdered *Petiveria alliacea* leaves are traded under the name 'anamu' or 'mapurite' through Internet and are used to treat a variety of diseases. The powder costs US$ 16–25 per 500 g. Several countries in tropical America supply this plant but statistics of the volumes of exports are not available. In general the plant is collected from the forest and sold in local markets.

Properties Many biologically active compounds have been isolated from all parts of *Petiveria alliacea*, the most important ones being sulphur compounds, but also flavonoids, triterpenes and steroids. The main volatile constituents obtained from the pentane extract of the roots are benzaldehyde (48.3%), dibenzyl-disulfide (23.3%), dibenzyl-trisulfide (9.4%) and stilbene (8.1%). The main compounds found in the inflorescences are benzaldehyde (54.8%), benzyl-thiol (20.3%) and dibenzyl-disulfide (18.0%). These sulphur-containing compounds are similar to the odour compounds in garlic and onion, but in the latter they have alkyl instead of benzyl parts.

Water, methanol and ethanol extracts of the whole plant have been shown to slow the growth of leukaemia cells and several other strains of cancerous tumour cells in vitro. The water extracts were toxic to leukaemia, lymphoma and several other cancer cell lines. The compounds responsible for these activities are dibenzyl-trisulfide, benzaldehyde, the benzopyran astilbin, and coumarin.

In both in-vivo and in-vitro studies, water extracts of the whole plant were found to stimulate the immune system (production of lymphocytes, interferon and several interleukins). The hexane and cyclohexane extracts of leaves and stems increased the phagocytotic index of human granulocytes. One of the active immunomodulatory compounds present in the extracts was dibenzyl-trisulfide.

A crude extract of the whole plant has shown a protective effect on the blood cells of mice infected with the pathogenic bacterium *Listeria monocytogenes*. Root extracts showed significant anti-inflammatory effects in rats and mice using various models, as well as a significant pain-relieving effect in rats. Some extracts also showed cyclooxygenase-1 (COX-1) inhibitory actions.

Methanol extracts of the seeds caused uterine contractions in rats. Other studies, using ethanolic, aqueous and chloroform fractions of leaf extracts, showed inhibitory activities on intestinal secretion and motility, as well as significant antihistamine activity in vitro, although less potent than the commercial anti-allergy drug disodiumcromoglycate. A preliminary test with extracts from leaves and stem powder showed a substantial decrease of blood sugar concentration in mice.

Many clinical reports and studies confirm that the extracts of the aerial parts and roots have significant broad-spectrum antimicrobial properties in vitro and in vivo against numerous

strains of bacteria, viruses, protozoa, fungi and yeast. The crude water extracts perform in a similar way to the alcohol extracts. A total of 18 organosulphur compounds from the roots have been tested for their antibacterial and antifungal activities. The thiosulfinates, trisulfides and benzylsulfinic acid were observed to be the most active compounds, with the benzyl-containing thiosulfinates exhibiting the broadest spectrum of antimicrobial activity. The lachrymatory principle from fresh roots is (Z)-thiobenzaldehyde S-oxide, which also has antibacterial and antifungal activities. The leaf extract and dibenzyl-trisulfide, isolated from the roots, showed significant acaricidal activity against the tick *Boophilus microplus* when topically applied, and this activity is in general higher than commercial acaricides such as dimethoate, lindane and carbaryl. Dibenzyl-trisulfide was also highly toxic to adult sweet potato weevil (*Cylas formicarius elegantulus*) and adult coffee borer beetle (*Hypothenemus hampei*). The leaf extract showed significant antifeedant activity in the grasshopper *Zonocerus variegatus*, as well as allelopathic activity on germinating seeds. Methyl-benzyl-sulfonic anhydride is an artificial transformation product of dibenzyl trisulfide, and was found to be much more effective than the commercial agents isoniazid and ampicillin in inhibiting the growth of *Bacillus subtilis* and *Pseudomonas fluorescens* and more effective against the fungus *Cladosporium cucumerinum* than ketoconazole or nystatin. Dibenzyl-trisulfide itself was inactive on *Bacillus subtilis* and showed little inhibitory activity on the fungus *Cladosporium cucumerinum*. The methanol and dichloromethanol leaf extracts showed allelopathic activity on the germination of seeds of several crop plants in vitro, but not in the soil.

Caution should be taken if *Petiveria alliacea* is fed to animals on a regular basis as this may cause adverse reactions. The plant can accumulate nitrates and has caused nitrate poisoning in cattle.

Description Erect herb or undershrub up to 1 m tall, with garlic smell; stems thin, angular, shortly hairy when young, later glabrous. Leaves alternate, simple and entire; stipules linear, 1.5–2 mm long; petiole 0.5–1.5 cm long; blade elliptical to ovate or oblong, 5–15(–20) cm × 2–5(–8) cm, base cuneate, apex acute to long-acuminate, glabrous to sparingly shortly hairy. Inflorescence a terminal or axillary, slender, nodding raceme 10–30(–40) cm long, sometimes branched; bracts 1.5–2.5 mm long. Flowers bisexual, zygomorphic, 4-merous; pedicel 2–3 mm long; sepals free, oblong, 3–4 mm long, rounded, greenish or white to pink; petals absent; stamens 4–8, irregularly inserted, filaments c. 2 mm long; ovary superior, oblong, shortly hairy, with 4 hooks, 1-celled, stigma sessile, lateral. Fruit a narrowly oblong achene 6–8 mm long, striate, apex 2-lobed, with recurved hooks, 1-seeded.



Petiveria alliacea – 1, flowering branch; 2, flower; 3, fruit.
Source: Flore analytique du Bénin

Other botanical information *Petiveria* comprises a single species and belongs to the tribe *Rivineae*.

Growth and development *Petiveria alliacea* flowers twice a year in South America. Seeds are wind dispersed.

Ecology In its native area of distribution *Petiveria alliacea* occurs in humid forest and open disturbed areas, from sea-level up to 1500 altitude. In West Africa it is found in forest edges and disturbed localities near habitations.

Propagation and planting *Petiveria alliacea* is only propagated by seeds. Seed germinates easily. In some countries in Central America it is propagated in nurseries and then

transplanted to the field.

Management *Petiveria alliacea* is planted in home gardens and agroforestry systems. The only known large-scale plantation is in Darién, Panama.

Harvesting *Petiveria alliacea* is usually collected from the forest when the plants are not full grown. The majority of the plants that are commercialized come from the forest or from home gardens.

Handling after harvest In local markets *Petiveria alliacea* is traded fresh immediately after harvest. Plants can also be dried in the shade and stored in sacs until they are sold.

Genetic resources In tropical America *Petiveria alliacea* is a common plant in forest undergrowth and ruderal areas, and is not at risk of genetic erosion. In Colombia a small germplasm collection has been made.

Prospects *Petiveria alliacea* has multiple medicinal uses, many of which are confirmed by pharmacological research. As the species has a real potential for commercialization on the international market, more efforts are needed for better characterization of the plant, to establish adequate management and to select cultivars that are rich in active compounds, productive and easily grown. It also needs to be established if there are chemical differences between plants with different morphologies. Although *Petiveria alliacea* has a restricted distribution in tropical Africa, it certainly has potential to be grown commercially there.

Major references Arévalo, 1994; Diaz, 2003; Fountoura et al., 2005; Gomes et al., 2005; Kim, Kubec & Musah, 2006; Lopes Martins et al., 2002; Perez & Rosa, 2005; Ruffa et al., 2002a; Stoffers, 1968; Taylor, 2006.

Other references Adjanohoun et al., 1989; Akoègninou, van der Burg & van der Maesen, 2006; Ayehoun et al., 1998; Bassi et al., 1997; Benevides et al., 2001; Berger et al., 1998; Burkill, 1997; Caceres et al., 1998; Johnson, Williams & Roberts, 1997; Kubec, Kim & Musah, 2003; Lores & Cires Pujol, 1990; Oluwole & Bolarinwa, 1998; Perez et al., 2005; Queiroz, Quadros & Santos, 2000; Ruffa et al., 2002b; Weber, Steffen & Siegers, 1998; Williams et al., 1997; Williams et al., 2003; Zoghbi, Andrade & Maia, 2002.

Sources of illustration Adjanohoun et al., 1989.

Authors J.C. Alegre & M. Clavo

PHYLLANTHUS AMARUS Schumach. & Thonn.

Protologue Schumach., Beskr. Guin. pl.: 421 (1827).

Family Euphorbiaceae (APG: Phyllanthaceae)

Chromosome number $2n = 26, 52$

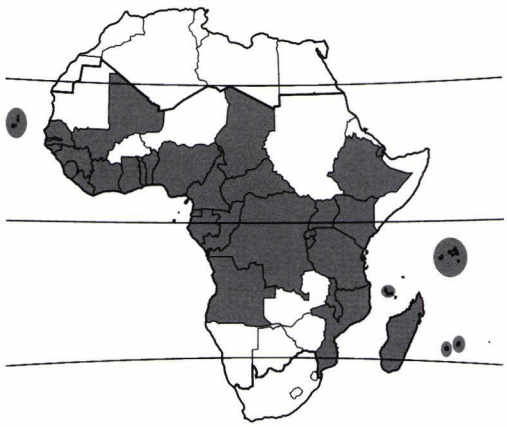
Synonyms *Phyllanthus niruri* auct. non L.

Vernacular names Black catnip, carry me seed, child pick-a-back, gale of wind, Gulf leaf flower, hurricane weed, shatterstone, stone breaker (En). Herbe au chagrin, petit tamarin blanc (Fr).

Origin and geographic distribution *Phyllanthus amarus* originates from tropical America and has spread as a weed throughout the tropics and subtropics. In tropical Africa it occurs in most countries. It also occurs throughout the Indian Ocean islands.

Uses *Phyllanthus amarus* is widely used as a medicinal plant. An infusion is considered a good tonic, diuretic and antipyretic. A decoction of the aerial parts or only of the leaves is taken to treat gonorrhoea, diarrhoea, dysentery, stomach-ache, pain in the sides, haemorrhoids and absence of menstruation or female sterility. A suppository of the leaf paste is applied to the vagina to treat absence of menstruation and polyps. Leaf sap, mixed with palm oil or not, is applied as ear drops to treat otitis and applied to abscesses, sores and wounds.

In Côte d'Ivoire a plant decoction is taken to facilitate childbirth, to treat oedema and pain caused by fever or a sore throat. In Mali a leaf decoction is drunk to treat jaundice. In Benin a decoction of leafy twigs is drunk to treat palpitations. A root decoction, mixed with other plants or not, is taken to treat colic and rectal



Phyllanthus amarus – naturalized

prolapse. A decoction of leafy twigs, mixed with other plants, is drunk to treat cough. Leaves mixed with crushed nuts of *Cola acuminata* (P.Beauv.) Schott & Endl. and water is applied to shingles. A decoction of the aerial parts is drunk to treat candidosis, and sap is applied locally. In Congo and DR Congo the plant sap is drunk to treat diabetes and tachycardia. Ripe fruit is eaten as an anthelmintic. In Kenya a cold leaf maceration is drunk to treat stomach-ache. A plant decoction is drunk to induce vomiting. In Uganda ground aerial parts are applied to snakebites; the ground material in water is also drunk to treat poisoning by snakebites. In the Indian Ocean islands a leaf or plant decoction is taken to treat diarrhoea and abdominal pain and externally applied to treat skin problems. An infusion of the stem and leaves is used as eye drops to treat eye infections.

Throughout the American and Asiatic tropics the medicinal uses are similar as cited for tropical Africa. Furthermore, *Phyllanthus amarus*, as well as several other closely resembling species, are widely in use as folk medicine in treatment of liver related troubles.

Phyllanthus amarus is said to have sand-binding properties. In West Africa it is used in medico-magical ceremonies.

Production and international trade Recent research results have increased the demand for *Phyllanthus amarus* in international markets. According to a survey conducted in India, in 2004–2005 there was a demand of almost 3000 t of fresh *Phyllanthus* plants, including *Phyllanthus amarus*. The annual growth rate is estimated at about 10%, and as such *Phyllanthus amarus* has a bright future.

In South-East Asia *Phyllanthus amarus* is sometimes cultivated on a small scale and sold on local markets.

Properties The following chemical constituents have been isolated from *Phyllanthus amarus*: lignans (e.g. phyllanthin, hypophyllanthin, phyltetralin, nirtetralin, niranthin), ellagitannins (phyllanthusiin D, amariinic acid, elaeocarpusin, repandusinic acid A and geraniinic acid B), flavonoids (quercetin-3-O-glucosides), tannins (geraniin, amariin, gallocatechin, corilagin and 1,6-digalloylglucopyranoside), alkaloids of the quinolizidine type (phyllantine (= methoxy-securinine), securinine, norsecurinine, isobubbialine, epibubbialine), phenolic compounds (gallic acid, ellagic acid, dotriacontanyl docosanoate, triacontanol, oleanolic acid and ursolic acid) and a chroman derivative (4,4,8-trimethoxy chroman). The alkaloid phyllanthine must not be confused with the lignan phyllanthin. The leaves were found to contain the highest amounts of phyllanthin (0.7%) as compared to the whole plant: phyllanthin (0.4%), hypophyllanthin (1.2%), gallic acid (0.4%) and ellagic acid (0.2%).

Phyllanthus amarus extracts were found to significantly inhibit DNA polymerase of the hepatitis B virus and other hepatitis-DNA-viruses, such as the woodchuck hepatitis virus, together with in-vitro activity against the enzyme reverse-transcriptase of retroviruses. The activity of the extracts in test animals as well as in clinical studies was controversial: both success and failure have been reported. Callus induced from *Phyllanthus amarus* showed less activity against viral DNA polymerase and reverse transcriptase than extracts from field-grown plants. In a clinical trial, a plant extract had a remarkable effect for chronic viral hepatitis B in recovery of liver function and inhibition of the replication of hepatitis B virus.

Phyllanthin and hypophyllanthin have protective activity in rat hepatocytes against cytotoxicity induced by CCl_4 and galactosamine, and it has been suggested that phyllanthin is responsible for antigenotoxic effects reported for the extracts. However, phyllanthin has also been reported to be toxic to the nervous system and liver. A crude extract given orally to rats showed significant liver regenerative effects against alcohol-induced liver cell injury. An ethanolic extract administered orally to mice possessed a potent protective effect against aflatoxin B-1-induced hepatic damage. A crude aqueous extract of in-vitro cultured roots caused a dose-dependent reduction of bovine viral diarrhoea virus with no cytotoxic effect. In another test, extracts of in-vitro grown hairy or adventitious roots showed about 85% inactivation of hepatitis B virus surface antigen. A chroman derivative, 4,4,8-trimethoxy chroman, isolated from the dichloromethane fraction, exhibited very little in-vitro cytotoxicity.

Phyllanthus amarus aqueous extracts show potent anticarcinogenic activity against development of different tumour types. Administration of the extract after tumour development increased survival of rats and mice up to 1 year. An alcoholic extract was found to significantly reduce cytochrome P450 enzymes both in vitro as well as in vivo when orally administered to mice. A hexane extract, the lignans-rich fraction and the lignans nirtetralin, niranthin and phyllanthin exerted cytotoxic effects

in 2 human leukaemia cell lines, as well as multidrug resistance reversing properties, mainly due to their ability to synergize with the action of conventional chemotherapeutics. An ethanolic extract showed significant preventive effect against benign prostatic hyperplasia in rats.

Aqueous and alcohol-based extracts potently inhibit HIV-1 replication in human cell lines. A gallotannin enriched fraction showed enhanced activity, and the purified gallotannins geraniin and corilagin were most active. A concentration-dependent inhibition of HIV-1 reverse transcriptase and protease could be demonstrated in vitro. A potent anti-HIV activity was also demonstrated in blood of volunteers who had ingested the plant material. A 50% methanol extract, a water extract, as well as isolated corilagin and brevifolin carboxylic acid have demonstrated strong β-glucuronidase inhibitory action. However, phyllanthin and hypophyllanthin were ineffective.

Fresh plant material and a methanol extract showed strong antioxidant activity in various antioxidant assays. A correlation between the antioxidant activity and total phenolic content was observed. Drying of the plant material caused a significant reduction in antioxidant properties. On the other hand, boiling water extracts exhibited significantly stronger antioxidant potentials even from dried plant material due to greater solubility of compounds, breakdown of cellular constituents as well as hydrolysis of tannins. A whole plant extract showed significant radioprotective activity when given orally to mice, by decreasing the damage to intestinal cells, decreasing the lipid peroxidation levels, decreasing the percentage of chromosomal aberrations and by elevating the antioxidant enzymes in the intestine, blood and liver.

Methanol and aqueous extracts inhibited all the phases of inflammation in standardized tests in rats. A hydroalcoholic extract, given intraperitoneally to rats, exhibited pronounced antinociception. Given orally, the extract was less potent. The hexane extract, the lignan-rich fraction and the lignans phyltetralin, nirtetralin and niranthin, but not hypophyllanthin or phyllanthin, inhibited carrageenan-induced rat paw oedema and neutrophil influx. Furthermore, niranthin exhibited anti-inflammatory and anti-allodynic activities. An ethanol and a hexane extract showed significant anti-inflammatory potential in vitro and in vivo in mice.

Aqueous and methanolic extracts of the aerial parts showed antidiabetic activity in mice, rats and rabbits. However, a 1-week treatment with the aqueous extract was incapable of lowering blood glucose in untreated non-insulin dependent diabetic patients. Oleanolic acid, ursolic acid and lupeol isolated from this fraction were shown to inhibit α-amylase.

An aqueous crude extract caused varying degrees of declining fertility when given orally to male mice. An alcohol extract of the whole plant showed significant contraceptive effects in female mice at a dose of 100 mg/kg body weight, when given orally for 30 days.

The antidiarrhoeal and gastrointestinal protective potentials of aqueous extract of *Phyllanthus amarus* leaves were investigated in mice. An aqueous extract delayed the onset of castor oil-induced diarrhoea in mice. In another experiment with rats, a whole plant extract reduced digestive tract motility and delayed gastric emptying, whereas it caused relaxation of isolated rat fundus and ileum.

Methanolic extracts of leaves, roots and fruits showed significant concentration-dependent antibacterial activity in vitro against a range of gram-positive and gram-negative bacteria; leaf extracts showed the highest activity. A chloroform fraction of the aerial parts showed a significant inhibitory effect against the dermatophytic fungus *Microsporum gypseum* and against the yeast *Candida albicans*.

Norsecurinine, isolated from the aerial parts, showed significant activity against spore germination of the crop fungi *Alternaria brassicae*, *Alternaria solani*, *Curvularia pennisetti*, *Erysiphe pisi* and *Helminthosporium frumentacei* under glasshouse conditions.

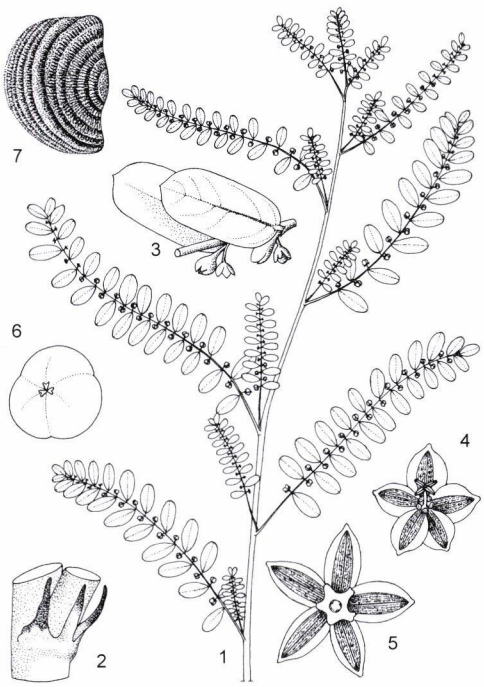
Chloroform and ethanolic extracts of the aerial parts and roots showed significant larvicidal activity against *Anopheles stephensi* larvae. An ethanolic root extract possessed significant activity against *Tribolium castaneum*, a pest of stored grain.

Fresh leaves from *Phyllanthus amarus* plants of Nigerian origin were found to contain high levels of Mn (465 ppm), Cu (21.8 ppm), Zn (75.1 ppm), and NO_3 (7,200 ppm). Varying proportions of Fe, Mg, K, Ca and Na were found. The levels of several toxic compounds are high enough to constitute a threat to animals consuming them and the use of the leaves for medicinal purposes should also be monitored.

Adulterations and substitutes In India a herbal medicine called 'Bhumyamlaki' is sold which may be pure *Phyllanthus amarus* or

pure *Phyllanthus maderaspatensis* L. or a mixture with *Phyllanthus fraternus* G.L.Webster. It is marketed as a medicine especially for liver troubles.

Description Monoecious, annual, erect, glabrous herb up to 60 cm tall, reddish; branchlets flattened, often slightly winged and sparsely hairy. Leaves alternate, distichous and crowded along lateral branchlets, simple and entire, sessile; stipules ovate-lanceolate to lanceolate; blade oblong to elliptical-oblong, 7–12(–20) mm × 3–6(–9) mm, base obtuse to rounded and slightly unequal, apex rounded, often pointed. Flowers 1–2 in the axils of leaves, unisexual, pale green, often flushed red; male flowers at the base of branches, other leaf axils with 1 female flower and 1 male flower; pedicel c. 1 mm long; perianth lobes 5(–6), 0.5–1 mm long; male flowers with 5-lobed disk, stamens 3, filaments fused, anthers free; female flowers with cup-shaped, 5-lobed disk, ovary superior, ovoid, warty, 3-celled, styles 3, free, shallowly 2-fid at apex. Fruit an obtusely 3-lobed capsule 2–2.5 mm in diameter, smooth, hanging, 6-seeded. Seeds c. 1 mm long, with transverse ridges.



Phyllanthus amarus – 1, flowering branch; 2, stem leaf and stipules; 3, part of flowering branchlet; 4, male flower; 5, female flower; 6, fruit; 7, seed.
Source: PROSEA

Other botanical information *Phyllanthus* is a large genus comprising about 750 species in tropical and subtropical regions, with about 150 species in mainland tropical Africa and about 60 in Madagascar and other Indian Ocean islands. A subgeneric classification of *Phyllanthus* is in preparation.
Until 20 years ago taxonomists placed a number of species, including *Phyllanthus amarus*, under *Phyllanthus niruri* L. Where the name *Phyllanthus niruri* has been applied in older literature to African or Asian specimens, usually *Phyllanthus amarus* is intended, but sometimes also *Phyllanthus debilis* Klein ex Willd., *Phyllanthus fraternus* G.L.Webster, *Phyllanthus maderaspatensis* L. or *Phyllanthus rotundifolius* Klein ex Willd. Specimens of true *Phyllanthus niruri* have actually never been confirmed from outside the Americas.

Growth and development The branching pattern of *Phyllanthus amarus* is 'phyllanthoid', i.e. the spiralled leaves on the main axes are strongly reduced to 'cataphylls', which subtend a deciduous branchlet with distichous leaves, the branchlet resembling a compound leaf.

Ecology *Phyllanthus amarus* occurs in open localities, waste ground, grassy scrub vegetation and dry deciduous forest, usually on humid, sandy soils, from sea-level up to 1000 m altitude. It is reported as a troublesome weed in pulses, soya bean, groundnut, cereals, sugar cane, cassava, taro, sesame, sunflower and cotton.

Propagation and planting Seed requires light to germinate. Germination is often less than 50%; germination of freshly harvested seeds is slower than that of older seeds. Scarification by immersion in water at 30°C for 2 hours rendered seeds inviable. Seeds dried to 8% moisture content and treated with turmeric rhizome powder under ambient conditions maintained viability for up to 6 months; untreated seeds stored poorly.
In-vitro propagation can be done by culturing shoot tips, and less successfully by nodal and internodal segments.

Management In India *Phyllanthus amarus* is grown as a medicinal crop. The crop duration is 100–300 days. Seeds are mixed with sand and the mixture is broadcast in the field. Sandy loam and black soils with pH 7.5–8 are considered best. The cultivar 'Navyakrit' has

been developed, which has a high yield of plant material and a high yield of active constituents. About 7.5–10 kg seed/ha is used, and a plant population of 282,500 plants/ha is maintained. The plants are raised without irrigation. One or 2 weedings are considered sufficient. Farm manure is applied as an organic fertilizer. Plant height, leaf area index, dry matter production and yield of the lignans phyllanthin and hypophyllanthin were highest in a field experiment with *Phyllanthus amarus* treated with poultry manure, the biofertilizer Azospirillum and phosphate-solubilizing bacteria. *Phyllanthus amarus* grown in greenhouses at 15°C showed much less inhibitory activity on DNA polymerase of woodchuck hepatitis virus than when grown at 25°C.

Diseases and pests In India the commercial cultivation of *Phyllanthus amarus* has led to the outbreak of stem blight caused by *Corynespora cassiicola*. Phytoplasma-induced yellowing, small leaf development, proliferation of axillary shoots and overall retarded growth of infected plants were found in experimental fields in 1999–2000.

Yield In India the mutant *Phyllanthus amarus* line 'CIM-Jeevan', produced by γ-radiation, showed a yield of 1–1.2 kg/m^2 fresh plant material, compared with about 0.8 kg/m^2 of the control. 'CIM-Jeevan' also produced a higher phyllanthin (0.7–0.8%) and hypophyllanthin (0.3–0.4%) yield than the control (0.3–0.4% and 0.1–0.2%, respectively). The cultivar 'Navyakrit' yields about 1 t/ha dry plants at the end of the rainy season. Each plant yields 20–25 g seed. Under experimental conditions in Florida, 6–7-month-old plants reached an average dry weight of about 40 g/plant.

Handling after harvest Plants are uprooted and dried in the shade.

Genetic resources *Phyllanthus amarus* is widespread and common throughout its distribution area and is therefore not threatened by genetic erosion.

Breeding Although several cultivars have been developed with higher yield and higher concentration of active compounds, more breeding efforts are needed to increase crop yield under different field conditions.

Prospects *Phyllanthus amarus* is widely used in local medicine in Africa and Asia. A wealth of research findings have shown interesting antiviral, anti-HIV, anti-inflammatory, antioxidant, antibacterial and antidiabetic activities. More research is needed though, especially well-controlled clinical trials, to evaluate the extracts and the individual compounds. More research is needed as well to improve cultivation methods.

Major references Burkill, 1994; Kassuya et al., 2006; Khatoon et al., 2006; Lim & Murtijaya, 2007; Naaz, Javed & Abdin, 2007; Neuwinger, 2000; Pramyothin et al., 2007; Radcliffe-Smith, 1996a; Unander, Webster & Blumberg, 1991; van Holthoon, 1999.

Other references Adedapo et al., 2003; Adeneye, Amole & Adeneye, 2006; Ajaiyeoba & Kingston, 2006; Bhattacharyya & Bhattacharya, 2004; Chattopadhyay, Agrawal & Garg, 2006; Chezhiyan, Saraswathy & Vasumathi, 2003; Gupta et al., 2003a; Kumar & Kuttan, 2006; Leelarasamee et al., 1990; Leite et al., 2006; Mahat & Patil, 2007; Mazumder, Mahato & Mazumder, 2006; Notka, Meier & Wagner, 2004; Odetola & Akojenu, 2000; Onocha et al., 2003b; Raphael, Sabu & Kuttan, 2002; Revathi, Vanangamudi & Sasthri, 2003; Sripanidkulchai et al., 2002; Unander, Webster & Blumberg, 1995; Wang et al., 2001.

Sources of illustration van Holthoon, 1999.

Authors P. Oudhia

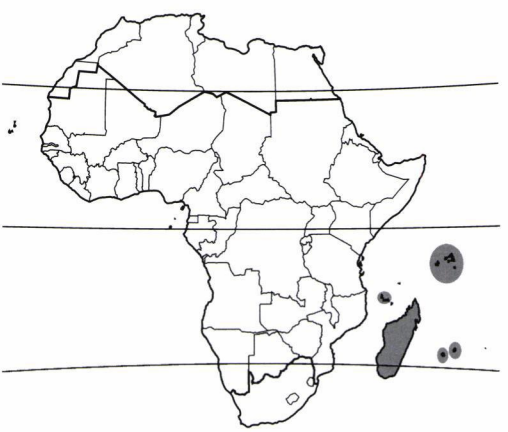
PHYLLANTHUS CASTICUM Willemet

Protologue Ann. Bot. (Usteri) 18: 55 (1796).

Family Euphorbiaceae (APG: Phyllanthaceae)

Vernacular names Leaf-flower (En). Bois caustique, bois castique, caustique rouge, bois de demoiselle (Fr).

Origin and geographic distribution *Phyllanthus casticum* occurs throughout the Indian



Phyllanthus casticum – wild

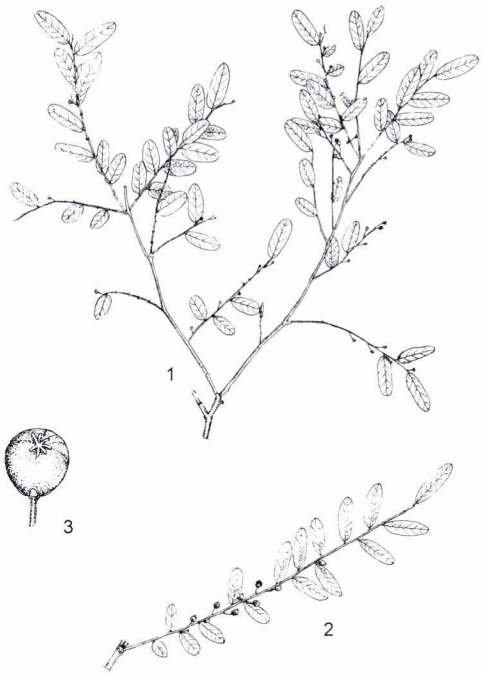
Ocean islands.

Uses In the traditional medicine of the islands of the Indian Ocean a twig, stem bark or powdered wood decoction is considered astringent and taken to treat severe diarrhoea, dysentery, amoebic dysentery, colic, ulcers and infections of the urogenital tract. Powdered bark and the pulp of the fresh branches or crushed young leaves are applied as a poultice to treat wounds, abscesses, eczema and syphilitic ulcers. A twig decoction is gargled to treat a sore throat, toothache and infections in the mouth. A leaf decoction is drunk to treat asthma. In Madagascar a root decoction is taken to treat tiredness after severe diarrhoea, and also to treat nervous depressions and impotence. Crushed roots are applied to furuncles and abscesses. Root powder is applied to the forehead of children suffering from dizziness and fainting. A leaf decoction is used to massage swollen limbs. In Réunion a plant infusion is taken to induce menstruation in cases of irregular menstruation as well as for treatment of haemorrhoids and gastric ulcers. In Rodrigues and the Seychelles a decoction of the branches and leaves is taken as a refreshing drink.

The fruits are edible and have a sour taste; they are also slightly antipyretic. They are used to make an alcoholic drink of inferior quality. The leaves are sometimes used for dyeing basketry and cloth, but the colours are not stable. The twigs are used as disinfecting toothbrushes. In Madagascar the flexible branches are used in wickerwork and fishing nets.

Properties The bark contains proanthocyanidol, saponosides and traces of terpenes, the leaves contain polyphenols, flavonoids, proanthocyanidol, steroids, 2-deoxysugars, phyllanthin, hypophyllanthin and traces of alkaloids. The flavonoids quercetin-3-O-β-D-glucopyranosyl(1–4)-α-L-rhamnopyranoside and 3,5,7,4'-tetrahydroxyflavone were isolated from the aerial parts. The roots contain the alkaloids securinine and allosecurinine.

Description Monoecious shrub or small tree up to 5 m tall; trunk up to 15 cm in diameter; bark brownish grey; twigs sparsely or densely hairy. Leaves alternate, distichous and crowded along lateral twigs, simple and entire, glabrous; stipules oblong, up to 1.5 mm long, fringed, persistent; petiole c. 1 mm long; blade oblong, 7–25 mm × 3–12 mm, base unequal, rounded, apex acute or obtuse and pointed. Inflorescence a small fascicle in leaf axils, male flowers c. 4 together, female flowers 1–2, usually only male or female flowers present at a time. Flowers unisexual, regular, dark red; pedicel thin, 1–5 mm long, enlarging in fruit; perianth lobes 5(–6), elliptical; male flowers with perianth lobes 1.5–2 mm long, hardly opening, disk with 5 free lobes, stamens 5, 3 stamens completely fused, 2 almost free, anthers exserted; female flowers with perianth lobes c. 1 mm long, spreading, disk 5-lobed, ovary superior, ovoid, 3-celled, styles 3, mostly fused, deeply bifid at apex. Fruit a fleshy, globose berry 6–9 mm in diameter, green changing to red then black, 6-seeded. Seeds trigonous, 1.5–2 mm × c. 1.5 mm, orange, smooth.



Phyllanthus casticum – 1, flowering branch; 2, fruiting branchlet; 3, fruit.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Phyllanthus* is a large genus comprising about 750 species in tropical and subtropical regions, with about 150 species in mainland tropical Africa and about 60 in Madagascar and the Indian Ocean islands.

Several other *Phyllanthus* spp. in Madagascar have similar uses as *Phyllanthus casticum*. Crushed leaves of *Phyllanthus betsileanus* Leandri, *Phyllanthus isalensis* Leandri, *Phyl-*

lanthus madagascariensis Müll.Arg. and *Phyllanthus seyrigii* Leandri are applied to eczema and wounds. A leaf decoction is applied as lotion or taken in baths to reduce oedema caused by sprains. Scraped stem bark is applied as a poultice to abscesses and wounds. Root powder is applied to the forehead of children suffering from dizziness and fainting. A root decoction is taken to treat syphilis. A root decoction of *Phyllanthus mantsakariva* Leandri, *Phyllanthus fuscoluridus* Müll.Arg., *Phyllanthus decipiens* (Baill.) Müll.Arg. and *Phyllanthus seyrigii* is considered stimulant and is drunk to improve endurance during hard physical work or as an aphrodisiac, and also to treat impotence and tiredness after prolonged diarrhoea. Twigs of *Phyllanthus seyrigii* are used as dental sticks. The crushed roots of *Phyllanthus fuscoluridus* and *Phyllanthus decipiens* are applied as a poultice to abscesses and furuncles. A root decoction is also taken to treat a nervous depression. A leaf decoction of *Phyllanthus decipiens* is taken to treat malaria. A twig or stem bark decoction of *Phyllanthus madagascariensis*, *Phyllanthus seyrigii* and *Phyllanthus fuscoluridus* is furthermore taken to treat colic, amoebic dysentery and persistent diarrhoea. The flexible branches are used to make large fishing nets and baskets. The fruits are edible and have a sour taste; they are used to make an alcoholic drink of low quality. The roots are used as a low quality dye for baskets.

Growth and development *Phyllanthus casticum* flowers from August to October and fruits from November to January.

Ecology *Phyllanthus casticum* occurs in dry deciduous savanna and on sandy soils, also along roads, from sea-level up to 1600 m altitude.

Handling after harvest All harvested plant parts are used fresh or dried and stored for future use.

Genetic resources Although *Phyllanthus casticum* is relatively common in Madagascar, it is less common in other Indian Ocean islands.

Prospects *Phyllanthus casticum* has many interesting medicinal uses, but very little chemical and pharmacological information is available. Additional research is therefore recommended.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Coode, 1982; Gurib-Fakim & Brendler, 2004; Gurib-Fakim, Guého & Bissoondoyal, 1996; Rasoanaivo et al., 1992; Unander, Webster & Blumberg, 1990.

Other references Andriamihaja, 1986; Andrianaivoravelona, 2004; Boiteau, 1986; Gurib-Fakim et al., 1994; Gurib-Fakim et al., 1996; Laivao, 1999; Lavergne, 2001; Rabearivelo, 1986; Randriamahavorisoa, 1993; Rasoanaivo et al., 1999; Razafindrazaka, 1991; Unander, Webster & Blumberg, 1991.

Sources of illustration Coode, 1982.

Authors N.S. Alvarez Cruz

PHYLLANTHUS ENGLERI Pax

Protologue Engl., Pflanzenw. Ost-Afrikas C: 236 (1895).

Family Euphorbiaceae (APG: Phyllanthaceae)

Vernacular names Spurred phyllanthus (En).

Origin and geographic distribution *Phyllanthus engleri* is distributed in Tanzania, Malawi, Zambia, Zimbabwe, Mozambique and South Africa.

Uses In the Tabora region of Tanzania a cold water extract of the powdered roots is taken to treat epilepsy. The leaves and fruits are chewed as a cure for cough and stomach-ache; chewing the fruit also cures constipation. A root decoction is taken as a remedy for bilharzia, gonorrhoea, stomach-ache, chest pain and menstrual cramps. In Zambia a cold root bark infusion mixed with food is taken as a cough remedy. Leaves are chewed to treat indigestion and constipation.

The fruits are edible and eaten raw when picked young or mature. The taste is acidic and the smell is said to be unpleasant, but nevertheless the fruits are much liked. The fruit juice is mixed with lemon and onions and the mixture is consumed as an appetizer. In Tanzania the fruits are sold in urban markets.

Livestock browses on the plants which resist grazing very well. The wood is used as firewood and to make utensils, and the stems are used as poles. In Zambia the twigs are used as toothbrushes.

Properties Smoking the roots can lead to unconsciousness or death and the use of the roots as a suicide poison has been reported from Tanzania, Zambia and Zimbabwe. Alcohol extracts of the roots are highly toxic to rodents, and stem bark and roots are poisonous to sheep and cattle. Contradicting views exist on the toxicity of the above-ground parts.

The root bark contains the triterpenoid phyllanthol. Ethanol extracts of the root show high

toxicity against brine shrimps (LC_{50} of 0.47 µg/ml). Experiments with rodents have not confirmed the toxicity of the smoke but the extract was highly toxic (lethal intravenous and oral doses 0.32 mg/kg and 0.07 g/kg, respectively). Symptoms are a slower and irregular heartbeat, followed by convulsions.

Botany Dioecious glabrous shrub or small tree up to 4.5 m tall; trunk up to 15 cm in diameter; bark smooth, grey; branches long, stout, covered with prickly conical cushions. Leaves alternate, distichous, simple and entire, glabrous; stipules lanceolate or linear-lanceolate, 1–2 mm long; petiole 1–3 mm long; blade elliptical to ovate-orbicular, 1.5–3 cm × 1–2 cm, base rounded to cuneate, apex rounded or truncate and pointed. Inflorescence a small axillary fascicle, c. 4-flowered. Flowers unisexual, regular, white; male flowers with pedicel c. 1 mm long, perianth lobes (4–)5, ovate, 1–2 mm long, disk with 5 free lobes; female flowers with superior ovary, styles free, c. 1 mm long, stigma filiform, 2-fid. Fruit a fleshy, globose or 3-lobed berry 2.5–3(–4) cm in diameter, pale yellow-green, smooth, pulp spongy, 6-seeded. Seeds trigonous, c. 1 cm long, purplish brown blotched chestnut brown and yellowish brown, dull, smooth.

Phyllanthus is a large genus comprising about 750 species in tropical and subtropical regions, with about 150 species in mainland tropical Africa and about 60 in Madagascar and the Indian Ocean islands. A subgeneric classification of *Phyllanthus* is in preparation.

Phyllanthus polyanthus Pax (synonyms: *Phyllanthus delpyanus* Hutch., *Phyllanthus cedrelifolius* Verd.) is very similar to *Phyllanthus engleri*, but differs in having acuminate or acute leaves and smaller fruits and seeds. The 2 species hybridize. In coastal Kenya and Tanzania the Digo people use a root decoction of *Phyllanthus polyanthus* to cure sexually transmitted diseases. In Gabon a decoction of bark and fruit is drunk to cure cough. In Congo the Bokiba people use the bark as a vomit inducer and for treatment of general oedemas. Phyllanthol, phyllanthone and dammarane-type triterpene saponins have been isolated from the stem bark.

Ecology *Phyllanthus engleri* occurs in dry deciduous woodland, including *Colophospermum* and *Acacia* bushland, often on termite mounds, at 300–1850 m altitude.

Management The fruits have a long shelf life and can be stored in the shade for about 3 months. Harvesting the fruits is done in Tanzania from April till August and in Zimbabwe mainly in June and July.

Genetic resources and breeding As *Phyllanthus engleri* is widespread and relatively common, it is not threatened by genetic erosion.

Prospects Increased interest in *Phyllanthus engleri* and the closely related *Phyllanthus polyanthus* is likely since the recent identification of a number of triterpenoids.

Major references Ndlebe, Crouch & Mulholland, 2008; Radcliffe-Smith, 1996a; Ruffo, Birnie & Tengnäs, 2002; Unander, Webster & Blumberg, 1990.

Other references Alberman & Kipping, 1951; Coates Palgrave, 1983; Kokwaro, 1993; Mbwambo, 2000; Moshi et al., 2006; Msangi, Otsyina & Kusekwa, 2004; Verdcourt & Trump, 1969.

Authors C.H. Bosch

PHYLLANTHUS FRATERNUS G.L.Webster

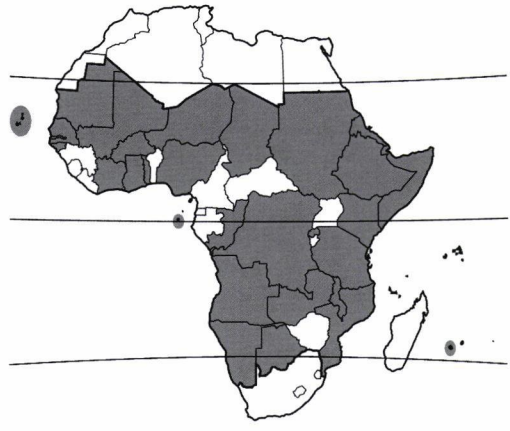
Protologue Contr. Gray Herb. 176: 53 (1955).

Family Euphorbiaceae (AGP: Phyllanthaceae)

Chromosome number $2n = 24$

Vernacular names Gripe weed (En). Herbe du chagrin, herbe au chagrin (Fr). Erva poubinha, erva pombinha (Po).

Origin and geographic distribution *Phyllanthus fraternus* is a pantropical weed and probably originates from Pakistan and western India. In tropical Africa it occurs from Cape Verde east to Somalia and south to South Africa, except in the most humid regions.



Phyllanthus fraternus – naturalized

Uses In Côte d'Ivoire a leaf decoction is drunk to facilitate childbirth, and against oedema, costal pain and fever. In Ghana a plant extract is reported to be strongly diuretic and taken to allay spasms, such as griping in dysentery, and the plant is also used as a laxative and to treat gonorrhoea and malaria. It is externally applied to treat skin infections. In Sudan the leaves are given against dysentery. In Réunion the plant is also used against gonorrhoea, dropsy and diarrhoea.

In India *Phyllanthus fraternus*, in a mixture with other *Phyllanthus* spp., is sold in a herbal medicine called 'Bhumyamlaki', which is widely used against jaundice and is considered acrid, carminative, cooling and useful in the treatment of thirst, bronchitis, asthma, leprosy, anaemia, venereal diseases, problems of the genito-urinary tract, anuria, biliousness and hiccups. The fruits are used in the treatment of ulcers, wounds, sores, scabies, ringworm and other skin problems. Fresh roots are taken against jaundice, and crushed with milk as a galactagogue. A decoction of roots and leaves is used to treat malaria. The plant sap is applied to treat bruises, sores and ulcers, and mixed with oil against ophthalmia and conjunctivitis. Powdered roots and leaves are made into a poultice with rice-water to treat oedema and ulcers.

Phyllanthus fraternus is browsed by all livestock. In East Africa, India and Indonesia a black dye is obtained from the stem and leaves, which is used to dye cotton and can also be used as an ink.

Production and international trade Although plant material of *Phyllanthus fraternus* is exported from India, there are no data on amounts and value.

Properties The lignans phyllanthin and hypophyllanthin have been isolated from the leaves, but some reports indicate that this may be due to confusion with *Phyllanthus amarus*. The leaves also contain the lignans niranthin, nirtetralin and phyltetralin. Other compounds isolated from the plant include alkamides (2,4-octadienamide and 2,4-decadienamide), a quinolizidine alkaloid (norsecurinine), the flavone tricin, triterpenoids (friedelin, epifriedelinol, kokoonol and sorghumol), the tetraterpenoid phyllanthusone, and waxes (octacosane, tetracosyl alcohol, tricosyl alcohol). Some of the alcohols are also present as esters, e.g. phyllanterpenyl ester and pentacosanyl ester. An alcohol extract of the root contained the secosterols phyllanthosterol, phyllanthosecosteryl ester, phyllanthostigmasterol and fraternusterol. The seed oil contains ricinoleic acid, linoleic acid and linolenic acid.

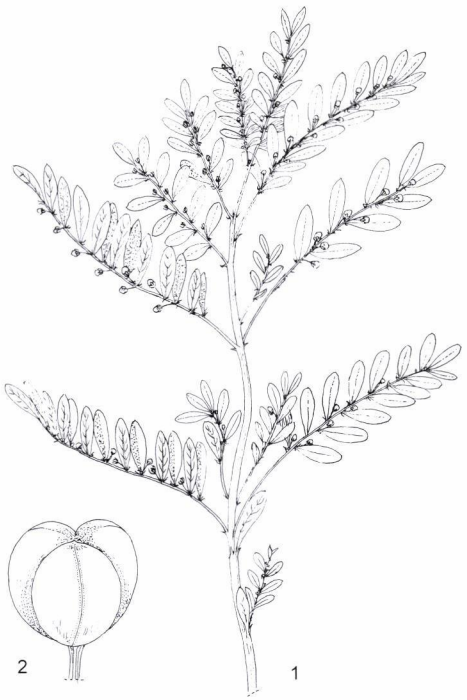
The two isolated alkamides possessed moderate antiplasmodial activity in vitro. An aqueous extract of the plant showed protection against the effect of chronic alcohol consumption on the liver in rabbits. The decrease in cytochrome content of the cells was partly undone by the extract. Rats were administered allyl alcohol to cause oxidative stress in liver cells. The extract showed a beneficial effect on mitochondria of the cells. An aqueous ethanol extract of the dried plant showed protection of the liver against the effects of arsenic trioxide in chickens.

An aqueous alcohol extract exhibited pronounced antinociception in rats. Given orally, the extract was less potent than when given intraperitoneally.

A root extract of plants from Sudan showed high toxicity to *Bulinus* and *Biomphalaria* snails, but the plant extracts are also poisonous to frogs and fish.

Adulterations and substitutes In India a herbal medicine called 'Bhumyamlaki' is sold, which may be pure *Phyllanthus amarus* Schumach. & Thonn. or pure *Phyllanthus maderaspatensis* L. or a mixture with *Phyllanthus fraternus*. It is marketed as a medicine especially for liver troubles.

Description Monoecious, annual herb up to 45(–60) cm tall, glabrous to short-hairy; vertical shoots angular, pale brown, lateral shoots up to 10 cm long. Leaves alternate, distichous, almost sessile; stipules c. 1 mm long, linear-lanceolate, whitish; blade elliptical-oblong, 5–13 mm × 2–5 mm, base cuneate to rounded, apex obtuse or rounded, glabrous, with 4–7 pairs of lateral veins. Flowers in the axils of leaves, male flowers (1–)3 per axil at the base of branches, other leaf axils usually with 1 female flower. Flowers unisexual; pedicel c. 0.5 mm long; male flowers with 6 perianth lobes, obovate-orbicular, c. 0.5 mm long, in 2 whorls, translucent, disk glands 6, free, flattened, stamens 3, filaments fused; female flowers with 6 perianth lobes c. 1 mm long, the outer ones oblong-lanceolate, the inner ones oblong to oblanceolate, white, disk c. 0.5 mm across, fringed, ovary superior, c. 0.5 mm in diameter, 3-celled, styles 3, c. 0.5 mm long. Fruit a 3-lobed nearly globose capsule c. 1 mm × 1.5 mm, smooth, yellowish, 6-seeded. Seeds c. 1 mm long, segmented, yellowish brown, one side with dark brown tubercles, with concentric



Phyllanthus fraternus – 1, flowering branch; 2, fruit.
Redrawn and adapted by Iskak Syamsudin

ridges on the other side.

Other botanical information *Phyllanthus* is a large genus comprising about 750 species in tropical and subtropical regions, with about 150 species in mainland tropical Africa and about 60 in Madagascar and other Indian Ocean islands. A subgeneric classification of *Phyllanthus* is in preparation. Until about 20 years ago taxonomists placed a number of species, including *Phyllanthus fraternus*, under *Phyllanthus niruri* L. Where the name *Phyllanthus niruri* has been applied in older literature to African or Asian specimens, usually *Phyllanthus amarus* is intended, but sometimes also *Phyllanthus debilis* Klein ex Willd., *Phyllanthus fraternus*, *Phyllanthus maderaspatensis* L. or *Phyllanthus rotundifolius* Klein ex Willd. Specimens of true *Phyllanthus niruri* have actually never been confirmed from outside the Americas. In pharmacological literature the confusion between *Phyllanthus fraternus* and *Phyllanthus amarus* still persists.
Several other annual or short-lived perennial *Phyllanthus* spp. have medicinal uses in tropical Africa. *Phyllanthus leucanthus* Pax occurs from eastern DR Congo and Kenya south to Botswana and Mozambique. In northern Tanzania root sap is given to babies to speed up the detachment of the umbilical cord. *Phyllanthus leucocalyx* Hutch. occurs in Kenya, Uganda, Tanzania and Mozambique. In Kenya and Tanzania a leaf infusion is drunk to get relief from childbirth pains and a decoction of the whole plant is drunk to cure stomach-ache and as an emetic.
Phyllanthus odontadenius Müll.Arg. (synonym: *Phyllanthus bequaertii* Robyns & Lawalrée) occurs from Guinea Bissau through the coastal countries of West Africa to Congo and from Rwanda, Kenya and Uganda south to southern Africa. In Ghana the leaves are eaten to cure hiccups. In Rwanda a stem extract is used to treat diarrhoea and cholera. Alcohol extracts of leaves and stems reduced castor oil-induced diarrhoea in mice. A water extract of the whole plant inhibited DNA polymerase of hepadnavirus. *Phyllanthus pentandrus* Schumach. & Thonn. has a similar distribution as *Phyllanthus odontadenius*, but occurs also in the Sahelian zone from Senegal east to Sudan. In Senegal a plant decoction is drunk and used for bathing as a cure for syphilis. A root decoction is drunk to treat female sterility. In Niger a decoction of the shoots is given as a tonic to nursing mothers. In Nigeria a decoction of the whole plant is drunk to treat earache or the ashes of the plant are dissolved in water and used as ear drops. The dried leaves, mixed with butter, are applied to boils and dislocated limbs. In West Africa the leaves are used in a protective dressing with insecticidal properties for wounds in livestock. *Phyllanthus pentandrus* is eaten by all livestock.
Phyllanthus rotundifolius Klein ex Willd. (synonym: *Phyllanthus aspericaulis* Pax) is fairly widespread in dry West and Central Africa, in East Africa and also in Asia but rare in large parts of its distribution area. In Kenya the sap from pounded leaves is applied to wounds. From West Africa it is reported that cattle refuse to eat it, whereas in Kenya plants are reported to be browsed by camels, cattle, donkeys, goats and sheep.

Ecology *Phyllanthus fraternus* occurs in deciduous woodland, on mud-flats and shady damp ground in bushland, on termite mounds, in grassland, on rocks and sandy soils and on gravelly plateau soils, from sea-level up to 1800 m altitude. It is a widespread weed. It tolerates dry conditions but does not survive in waterlogged conditions.

Genetic resources and breeding There are no indications that *Phyllanthus fraternus* is at risk of genetic erosion. Small germplasm collections exist in India.

Prospects The widespread medicinal use of *Phyllanthus fraternus* warrants further pharmacological research. Proper identification of research material and a thorough screening of earlier work is essential. Because of its very wide distribution, the possible variability of its chemical constituents also needs attention.

Major references Gupta & Ali, 2003; Parrotta, 2001; Radcliffe-Smith, 1996a; Sittie et al., 1998; Unander, Webster & Blumberg, 1991.

Other references Bâ, 1994; Ahmed, Al Howiriny & Mathew, 2002; Gupta & Ali, 1999; Habib-ur-Rahman et al., 2004; Keay, 1958a; Khatoon et al., 2006; Maïkere-Faniyo et al., 1989; Oudhia & Pal, 2001; Oudhia, Shrivastava & Tripathi, 1996; Padma & Setty, 1999; Radcliffe-Smith, 1987; Rajasubramaniam & Pardha Saradhi, 1997; Santos et al., 2000; Sharma & Singh, 2002.

Sources of illustration Radcliffe-Smith, 1986.

Authors P. Oudhia

PHYLLANTHUS MADERASPATENSIS L.

Protologue Sp. pl. 2: 982 (1753).

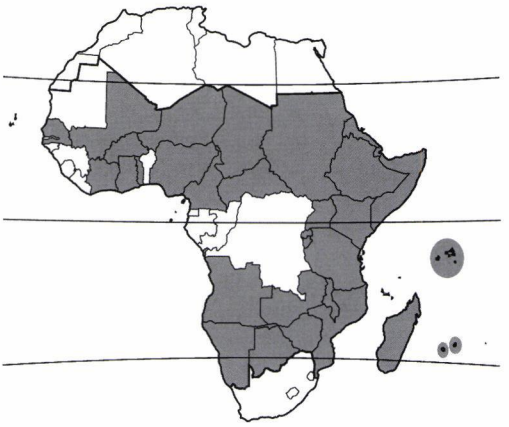
Family Euphorbiaceae (APG: Phyllanthaceae)

Chromosome number $2n = 26, 52$

Vernacular names Seaside laurel, canoe weed (En).

Origin and geographic distribution *Phyllanthus maderaspatensis* is widespread in tropical Africa and the Indian Ocean islands. It occurs throughout the Old World tropics and subtropics.

Uses The plant sap and leaf decoction are credited with emetic and purgative activities. In Tanzania the whole plant is pounded and the solution applied to scabies. A root decoction is taken to cure constipation, diarrhoea, lack of appetite, intestinal pain, menstrual problems, gastrointestinal disorders, testicular swelling, chest complaints and snakebites. Gastrointestinal trouble in infants is treated by giving them a root decoction of *Phyllanthus maderaspatensis* and *Chamaecrista mimosoides* (L.) Greene. Plant sap is used as nose drops to treat toothache. Ground leaves are rubbed on the skin with lemon juice as treatment for rheumatism. In Niger the plant is used as an aphrodisiac. In Somalia *Phyllanthus maderaspatensis* is considered poisonous.



Phyllanthus maderaspatensis – wild

In India *Phyllanthus maderaspatensis* is widely medicinally used to treat headache, bronchitis, earache and ophthalmia. Powder from dried plant material mixed with milk is drunk to treat jaundice.

In Kenya smoke from the burning plants is used to kill caterpillars in maize. Cattle will browse *Phyllanthus maderaspatensis* but only when green.

Production and international trade *Phyllanthus maderaspatensis* is of subsistence value in most parts of Africa; the plants are traded locally in market places. Commercial value is attributable to industrially produced pharmaceutical products for which different plant parts are harvested from naturally occurring plants.

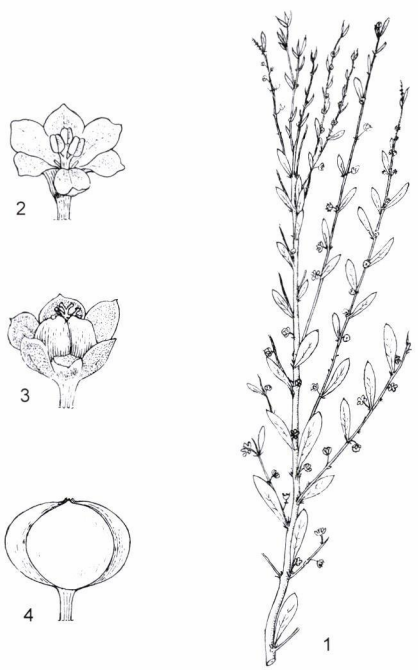
Properties Extracts of the above-ground parts of *Phyllanthus maderaspatensis* were found to contain resins, steroids, triterpenoids, alkaloids, phenolic compounds, tannins and saponins, but no glycosides. The plant also contains the lignans phyllanthin and hypophyllantin, which are responsible for hepatoprotective activity, but in low concentrations.

Butanol, ethanol and water extracts of the whole plant were found to bind hepatitis B virus and E antigens. The n-hexane extract was found to have pronounced hepatoprotective activity and showed antioxidant activity and stimulation of bile production. The antioxidant activity is attributed to the phenolic compounds. The results of tests in mice clearly indicated that an ethanol extract has a protective effect against adriamycin-induced toxicity

and it also showed an antioxidant effect.
Phyllanthus maderaspatensis has shown antibacterial and antifungal activities. The seeds have confirmed laxative, carminative and diuretic properties. Many of the medicinal uses of *Phyllanthus maderaspatensis* are related to the astringent action of tannins. Though short-term effects may be beneficial, the frequent systemic use of tannins might be dangerous, because of their antinutrient effects.
A clear deep yellow oil can be extracted from the seeds; it contains myristic, palmitic, stearic, oleic and linolenic acids and β-sitosterol. The defatted seed cake contains a fibrous mucilage which can be hydrolyzed to galactose, arabinose, rhamnose and aldobionic acid.

Adulterations and substitutes In India a herbal medicine called 'Bhumyamlaki' is sold which may be pure *Phyllanthus amarus* Schumach. & Thonn., or pure *Phyllanthus maderaspatensis*, or a mixture with *Phyllanthus fraternus* G.L.Webster. It is marketed as a medicine especially for liver troubles.

Description Monoecious, annual or perennial, erect to spreading, unbranched to much branched, glabrous herb up to 90(–120) cm tall; branches angular, red- or brown-tinged. Leaves arranged spirally, simple and entire; stipules asymmetrical triangular-lanceolate, up to 4 mm long, persistent; petiole c. 1 mm long; blade linear to oblanceolate, 10–30 mm × 2–7 mm, base cuneate to rounded, apex acute to rounded. Inflorescence a small axillary fascicle; female flowers solitary near the base of the branch, 1–4 male flowers and 1 female flower together towards the end of the branch. Flowers unisexual, regular; perianth lobes 6, in 2 whorls, disk with 6 free glands; male flowers with pedicel up to 1 mm long, perianth lobes elliptical, c. 1 mm long, stamens 3, c. 1 mm long, filaments fused, anthers exserted; female flowers with pedicel c. 2 mm long, perianth lobes c. 2 mm long, ovary superior, ovoid, 3-celled, styles 3, free, bifid at apex. Fruit a globose capsule, flattened at both ends, c. 3 mm in diameter, shiny greenish with red tinge, 6-seeded. Seeds trigonous, c. 1.5 mm long, dark brown, shiny.



Phyllanthus maderaspatensis – 1, flowering branch; 2, male flower; 3, female flower; 4, fruit.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Phyllanthus* is a large genus comprising about 750 species in tropical and subtropical regions, with about 150 species in mainland tropical Africa and about 60 in Madagascar and the Indian Ocean islands. A subgeneric classification of *Phyllanthus* is in preparation. *Phyllanthus maderaspatensis* is a variable species and several varieties have been recognized.
A few other *Phyllanthus* spp. have the same branching pattern with all stems and branches similar; 2 of them are also used medicinally. *Phyllanthus beillei* Hutch. (synonym: *Phyllanthus welwitschianus* Müll.Arg. var. *beillei* (Hutch.) A.R.-Sm.) occurs from Guinea east to Kenya and Tanzania and throughout southern Africa. A root decoction is taken as an aphrodisiac in Kenya. *Phyllanthus welwitschianus* Müll.Arg. occurs in southern Africa; in Angola the leaves are used for wound dressing.

Growth and development Plants may flower 3 months after germination of the seed.

Ecology *Phyllanthus maderaspatensis* occurs in deciduous woodland, wooded savanna and grassland, on beaches and dunes, and also along streams and ponds, in cultivated and disturbed localities, from sea-level up to 1400 m altitude. It grows on a wide variety of soils, usually on heavy clay and alluvial soils of low-altitude river valleys, on river banks and in flood plains. Outside tropical Africa, *Phyllanthus maderaspatensis* is often considered a weed. It shows a marked preference for cal-

careous sites in humid tropical areas.

Propagation and planting Seeds of *Phyllanthus maderaspatensis* require light to germinate. Germination rates increase linearly with temperature from 15–35°C and decline from 36°C. Below 15°C and above 40°C, germination is very poor. Germination is poor under moisture stress. *Phyllanthus maderaspatensis* is generally grown from seed, but vegetative propagation by budding, grafting, cutting and root sprouting is possible.

Management No information is available about cultivation methods of *Phyllanthus maderaspatensis;* it is rarely cultivated. All plant parts are probably only collected from the wild. Mature plants are fast growing and require little or no management once established.

Genetic resources Neither germplasm collections nor breeding programmes are known for *Phyllanthus maderaspatensis*. Since it is widespread and rather common, it is not liable to genetic erosion.

Prospects *Phyllanthus maderaspatensis* seems under-exploited, but it will probably continue to be regarded as an important medicinal plant species. There is no commercial seed production, although this aspect deserves more attention given the ease of propagation. Considering the many medicinal uses, there is a large scope for future research and further phytochemical and pharmacological investigations are warranted. A number of compounds may provide interesting leads for pharmacological evaluation and therefore merit further research. *Phyllanthus maderaspatensis* deserves to be part of germplasm collection.

Major references Bommu et al., 2008; Burkill, 1994; Khatoon et al., 2006; Neuwinger, 2000; Radcliffe-Smith, 1987; Unander, Webster & Blumberg, 1990.

Other references Adjanohoun et al., 1993; Asha et al., 2004; Brunel, 1987; Calixto et al., 1998; CSIR, 1959; Kumaran & Karunakaran, 2007; Radcliffe-Smith, 1996a; Rizk, 1987; Saadou, 1993; Srivastava et al., 2008; Unander, 1991; van Holthoon, 1999.

Sources of illustration Radcliffe-Smith, 1986.

Authors A. Maroyi

PHYLLANTHUS MUELLERIANUS (Kuntze) Exell

Protologue Cat. vasc. pl. S. Tomé: 290 (1944).

Family Euphorbiaceae (APG: Phyllanthaceae)

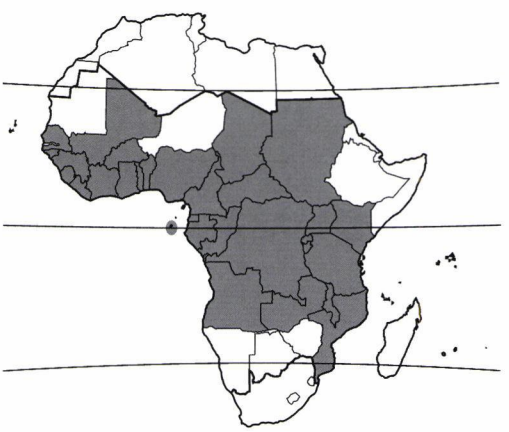
Chromosome number $2n = 26, 52$

Synonyms *Phyllanthus floribundus* (Baill.) Müll.Arg. (1863).

Origin and geographic distribution *Phyllanthus muellerianus* occurs from Senegal and Guinea Bissau east to Sudan and Kenya and south to northern Angola and northern Mozambique.

Uses *Phyllanthus muellerianus* is widely used to treat intestinal troubles. An infusion of the young shoots is taken to treat severe dysentery. In Sierra Leone a leaf decoction is taken to treat constipation. In Ghana and Nigeria cooked roots, sometimes with maize meal or other plants, are taken to treat severe dysentery. In Congo powdered roasted roots with palm oil are taken to treat stomach problems and as an anti-emetic. In Tanzania roots are pounded in water and the liquid is drunk to treat diarrhoea. Boiled roots are also applied as enema to treat stomach-ache.

In West Africa leaf sap or sap from the thick hollow stem is applied as eye drops to treat pain in the eyes, eye infections or to remove a foreign body. In Côte d'Ivoire and Burkina Faso twigs are sucked to prevent toothache. Powdered roots are used as a snuff and a bark decoction is taken to treat a sore throat, cough, pneumonia and enlarged glands. Pulped leafy twigs are rubbed on the body to treat paralysis. In Nigeria a root bark decoction is taken as an alterative and to treat fever. A twig and root



Phyllanthus muellerianus – wild

decoction is taken to treat jaundice and urethral discharges. In the Central African Republic fresh root bark is crushed and macerated in water or palm wine, and the liquid drunk as an aphrodisiac. In Gabon roasted powdered twigs are eaten with plant ash to treat dysmenorrhoea. In DR Congo dried bark powder is sniffed to treat colds and sinusitis. A root bark decoction is applied to swellings and is drunk to treat gonorrhoea. Stem ash is applied to scarifications to treat rheumatism and intercostal pain. In Tanzania a root decoction is taken to treat hard abscesses; powdered dried roots and stem bark are sprinkled on wounds as a dressing.

Throughout West Africa pounded leaves are applied as wound dressing. In Côte d'Ivoire the leaves are eaten, together with young leaves of *Funtumia elastica* (Preuss) Stapf, to improve male fertility. In Ghana and Nigeria leaves boiled with palm fruit are given to women after delivery as a general tonic. In Cameroon a maceration of the leaves and roots is used to wash the body to treat rash with fever in children. In DR Congo a leaf decoction is taken to treat anaemia and also used as a mouthwash to treat toothache. A leaf extract is used as a bath and a vapour bath to treat venereal diseases. Cooked leaves are applied to the gums to treat toothache. A flower infusion is cooling and gently aperient.

The fruits are edible and slightly acidic. In Sierra Leone and Nigeria the sap from the hollow branches is considered potable. In Cameroon the bark is sometimes added to palm wine to render it strongly intoxicating. In Kenya the stems are considered excellent firewood; branches thicker than 15 cm become hollow and are less used. In East Africa the brown dye from the bark is used to dye mats and fishing lines. From the whole plant a black dye is obtained used to colour fibres. In Zambia the wood is used for rafters and other construction work. It is also used to make fish traps and basketry. The leaves are used as fodder. In Sierra Leone and Nigeria leaves are sometimes cooked with food or in soup as a seasoning. In Nigeria twigs are used as chew-sticks after removal of the spines. Fruit pulp is used as a hair fixative. In Gabon *Phyllanthus muellerianus* is used in magic to lift taboos.

Properties A preliminary phytochemical screening of the leaves and stem bark showed the presence of tannins, flavonoids, saponins, alkaloids and anthraquinones. From the stem bark the triterpenoids 22β-hydroxyfriedel-ene and 1β,22β-dihydroxyfriedelin were isolated.

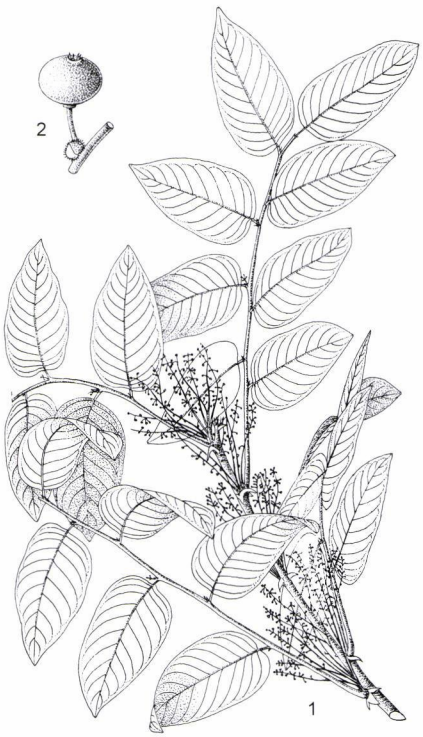
A leaf extract showed moderate antiplasmodial activity (IC_{50} = 9.4 µg/ml) and low cytotoxicity in mammalian cell lines. Both the aqueous and methanol extracts of the leaves and stem bark showed high antibacterial activity against *Staphylococcus aureus* and *Pseudomonas aeruginosa*. The activity of the extracts was relatively stable at high temperatures and was enhanced at low pH. In another test a chloroform extract showed high antifungal activity against *Candida albicans* and antibacterial activity against *Escherichia coli*.

A crude aqueous extract orally administered to rats caused significant changes in haematological and biochemical parameters, which are used as indices of toxicosis.

An aqueous leaf extract was found to induce behavioural sedation in young chicks resulting in decreased locomotor activity as well as pecking behaviour. The extract also relaxed rabbit and rat ilea. At doses ranging from 5–30 mg/kg, the extract produced a dose-dependent rise in blood pressure in cats. The extract also produced a significant analgesia in mice and was found to possess dose-dependent anti-inflammatory properties.

The dry fruit contains per g: 77 mg water, 9.7 mg protein, 4.3 mg fat, 62.7 mg sugar, 21 mg fibres, 500 mg Ca, 200 mg P and 15 mg Fe. It has an energetic value of 1228 kJ (294 kcal).

Description Monoecious, glabrous, straggling or climbing shrub or small tree up to 12 m tall; branches spreading or pendulous, main branches stout, angular, reddish tinged, branchlets 15–20(–25) cm long, with several short axillary shoots; branch basis transformed into a pair of spines c. 4 mm long, purplish brown. Leaves alternate, distichous along lateral twigs, simple, glabrous; stipules lanceolate, c. 2 mm long, acuminate; petiole 3–5 mm long; blade ovate, elliptical-ovate to ovate-lanceolate, 3–9 cm × 2–4.5 cm, base cuneate to rounded, apex acute to obtuse, with 10–14 pairs of lateral veins. Inflorescence a false raceme on short axillary shoots, 2–6 cm long, solitary or several together, with flowers in clusters having 2–3 male flowers and 1 female flower in each cluster. Flowers unisexual; perianth lobes 5, elliptical, c. 1 mm long, rounded, greenish white or greenish yellow; male flowers with pedicel c. 1.5 mm long, disk glands 5, free, minutely warted, fleshy, stamens 5, free, unequal, anthers very small; female flowers with stout pedicel c. 1 mm long, disk glands 5, free or fused, knobbly, fleshy, ovary superior, ellip-



Phyllanthus muellerianus – 1, flowering branch; 2, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

soid, warty, 4–5-celled, styles 4–5, free, c. 0.5 mm long, 2-fid at apex. Fruit a fleshy, nearly globose capsule 3–4 mm in diameter, usually smooth, green, becoming red, later black, 6-seeded. Seeds angular, c. 1 mm long, with faint ridges, bright reddish brown or yellowish brown.

Other botanical information *Phyllanthus* is a large genus comprising about 750 species in tropical and subtropical regions, with about 150 species in mainland tropical Africa and about 60 in Madagascar and the Indian Ocean islands. A subgeneric classification of *Phyllanthus* is in preparation.

Several other *Phyllanthus* spp. with a similar growth form as *Phyllanthus muellerianus* are medicinally used in tropical Africa. *Phyllanthus kaessneri* Hutch. occurs in DR Congo, Kenya, Tanzania and Zambia. In Kenya the plant is used in a mixture as a cough medicine. *Phyllanthus ovalifolius* Forrsk. (synonym: *Phyllanthus guineensis* Pax) occurs from Ethiopia south to Angola, Zimbabwe and Mozambique; it possibly also occurs in Nigeria and Cameroon. In Kenya a plant decoction is drunk and used as a vapour bath to treat corneal ulcers. In Malawi a root and bark infusion is used to bathe sore eyes. In Uganda a leaf decoction is taken in the treatment of measles; the leaves, mixed with butter, are applied to the skin for the same purpose. A root decoction is drunk to treat cough. *Phyllanthus sepialis* Müll.Arg. occurs from Sudan and Ethiopia south to Tanzania. In Kenya boiled roots are given to pregnant women as a tonic. The wood is used for house construction and as firewood; sticks are used as toothbrushes. *Phyllanthus ovalifolius* and *Phyllanthus sepialis* are much appreciated as a browse plant by sheep and goats.

Growth and development *Phyllanthus muellerianus* flowers at the end of the dry season, shortly after new leaves have formed.

Ecology *Phyllanthus muellerianus* occurs in riverine forest and wooded grassland, on deep and well-drained soils, from sea-level up to 1600 m altitude. In Nigeria *Phyllanthus muellerianus* is reported as a weed of rice fields.

Propagation and planting *Phyllanthus muellerianus* can be propagated through seeds and stem cuttings.

Management *Phyllanthus muellerianus* can be coppiced.

Harvesting Young shoots are harvested at the beginning of the rainy season; leaves, stem bark and roots can be harvested throughout the year, although it is easier to harvest the roots during the rainy season.

Handling after harvest Harvested plant parts are used fresh or are dried, as a whole or powdered, for future use.

Genetic resources *Phyllanthus muellerianus* is fairly common in its area of distribution and there are no signs of genetic erosion.

Prospects *Phyllanthus muellerianus* has many local medicinal uses, especially to treat intestinal problems, against body pain and as an antiseptic. Preliminary pharmacological analyses confirm these uses, although virtually nothing is known concerning the compounds responsible for these activities. More research is therefore warranted.

Major references Anuka et al., 2005; Arbonnier, 2004; Burkill, 1994; Chilufya & Tengnäs, 1996; Doughari & Sunday, 2008; Malaisse, 1997; Neuwinger, 2000; Radcliffe-Smith, 1987.

Other references Adedapo, Abatan & Olorunsogo, 2007; Adesida, Girgis & Taylor, 1972;

Adjanohoun & Aké Assi, 1979; Hamill et al., 2003; Heine & Heine, 1988a; Kiptot, 2007; Koné et al., 2004; Lorougnon Guédé & Aké Assi, 1989; Nacro & Millogo-Rasolodimbi, 1993; Onocha et al., 2003b; Oppong-Anane, 2001; Ssegawa & Kasenene, 2007; Tra Bi et al., 1999; Zirihi et al., 2005.

Sources of illustration Keay, 1958a.

Authors K.D. Ben-Bala

PHYLLANTHUS NIRUROIDES Müll.Arg.

Protologue Journ. Bot. 2: 331 (1864).

Family Euphorbiaceae (APG: Phyllanthaceae)

Chromosome number $2n = 26$

Origin and geographic distribution *Phyllanthus niruroides* occurs from Guinea Bissau and Guinea east to Nigeria and São Tomé. It is not clear whether it also occurs in mainland Central Africa.

Uses In Côte d'Ivoire and Burkina Faso a decoction of the whole plant is given as a diuretic and purgative in the treatment of jaundice. With *Capsicum* pepper added, it is used as a wash or an enema to reduce menstrual pain. The plant sap is mixed with lemon juice and drunk to ease delivery. The strained juice of the pulped plant is given orally to treat infant bronchitis, and is applied as ear drops to ease pain caused by otitis. It is one of several plants that was macerated and sprinkled on smallpox pustules. In Ghana the whole plant is used in the treatment of malaria.

Properties Niruroidine, a norsecurinine-type alkaloid has been isolated from the leaves of *Phyllanthus niruroides* collected in DR Congo, but the presence of *Phyllanthus niruroides* in DR Congo has not yet been confirmed by botanists.

Botany Monoecious, annual, erect, glabrous herb up to 25 cm tall, few-branched. Leaves alternate, distichous and crowded along lateral twigs, simple and entire; stipules lanceolate, reddish, 0.5–2 mm long; petiole c. 0.5 mm long; blade oblong, 2.5–12.5 mm × 1.5–4.5 mm, base rounded, apex obtuse. Flowers axillary, male flowers 2–3 per axil at the base of branches, female flowers solitary towards apex of branches. Flowers unisexual, pale green; perianth lobes 5; male flowers with pedicel c. 0.5 mm long, stamens 3, filaments fused; female flowers with pedicel 1.5–2.5 mm long, disk cup-shaped, 5-lobed, ovary superior, ovoid, warty, 3-celled, styles 3, free, deeply 2-fid at apex. Fruit a 3-lobed capsule 2–3 mm in diameter, hanging, up to 6-seeded. Seeds c. 1 mm long, with 13–16 transverse ridges.

Phyllanthus is a large genus comprising about 750 species in tropical and subtropical regions, with about 150 species in mainland tropical Africa and about 60 in Madagascar and the Indian Ocean islands. As the annual herbs in *Phyllanthus* are morphologically close, it is not easy to identify them correctly and as a result there is a lot of confusion. Records of *Phyllanthus niruroides* for eastern and southern Africa most probably refer to *Phyllanthus taylorianus* J.E.Brunel ex Radcl.-Sm. Several other West and Central African *Phyllanthus* species are used medicinally. *Phyllanthus sublanatus* Schumach. & Thonn. is an annual herb distributed from Guinea east to Nigeria. In Benin a decoction of fresh leaves is applied externally to cure skin rash, a decoction of the whole plant is drunk to treat bleeding gums and diarrhoea, and pulverized, roasted, leafy twigs are swallowed to stop vomiting. *Phyllanthus diandrus* Pax is a poorly known shrub from Cameroon, Gabon and Congo. A leaf decoction is drunk to correct a rapid and irregular heartbeat. *Phyllanthus profusus* N.E.Br. is a shrub occurring from Guinea east to Ghana. Sap from the cut stems is used as eye drops to treat sore eyes. The fruit is edible. *Phyllanthus profusus* is mentioned in the IUCN Red List of threatened species as vulnerable due to habitat loss.

Ecology *Phyllanthus niruroides* occurs in wet grassland in deciduous woodland. It also occurs on waste ground and in disturbed localities, from 900–1500(–2300) m altitude. As a weed it is especially frequent in sorghum on dark brown, heavy soils.

Genetic resources and breeding As *Phyllanthus niruroides* is common, also as a weed, there is no concern about genetic erosion.

Prospects For a good understanding of the prospects of *Phyllanthus niruroides* and related species an unambiguous taxonomical classification is required, especially for West and Central Africa. Such a classification is needed as a basis for meaningful pharmacological and phytochemical investigations.

Major references Brunel, 1987; Kerharo & Bouquet, 1950; Unander, Webster & Blumberg, 1991.

Other references Babady-Bila, Gedris & Herz, 1996; Burkill, 1994; Keay, 1958a; Köhler et al., 2002; Neuwinger, 2000; Radcliffe-Smith, 1996b; Stäuble, 1986.

Authors N.S. Alvarez Cruz

PHYLLANTHUS NUMMULARIIFOLIUS Poir.

Protologue Encycl. 5: 302 (1804).

Family Euphorbiaceae (APG: Phyllanthaceae)

Chromosome number $n = 13$

Synonyms *Phyllanthus capillaris* Schumach. & Thonn. (1827), *Phyllanthus stuhlmannii* Pax (1895).

Origin and geographic distribution *Phyllanthus nummulariifolius* occurs throughout tropical Africa, except in the drier parts of the Sahel region and southern Africa. It also occurs throughout the Indian Ocean islands, as well as in South Africa and Egypt.

Uses In Kenya a decoction of the plant is taken as an emetic and the crushed roots are taken against stomach-ache. The Kipsigi people of Kenya eat the boiled fruits against intestinal worms. The Haya people of Tanzania apply the leaves to suppurative swellings on the legs and to other inflammations. The Shambaa people use the leaves to treat asthma. In Uganda an infusion of the leaves is given to babies against colic and powdered leaves are sprinkled on wounds. An infusion of leaves and bark is taken against premature ejaculation and to treat morning sickness in early pregnancy. In Burundi a mixture of leaf sap of several plants, including *Phyllanthus nummulariifolius*, is used as eye drops, or a decoction of the leafy stems of a similar selection of plants is applied as an enema against eye diseases including cataract. The leaves are also used in mixture with other plants to treat general weakness, especially in pregnant women, diarrhoea and cough. Powdered leaves diluted with water are taken against chest problems. Leafy stems are applied against haemorrhoids. In the Comoros a decoction of the whole plant is drunk against high blood pressure in pregnant woman and oedema.

In Ethiopia the plant is used as an anthelmintic for horses.

Properties In a test in DR Congo aqueous and alcoholic extracts of *Phyllanthus nummulariifolius* showed strong activity against the snails *Biomphalaria pfeifferi* and *Lymnaea natalensis*, both intermediate hosts of schistosomiasis and fascioliasis parasites.

Botany Monoecious or dioecious erect or semi-scandent, annual or perennial herb or weak-stemmed sparingly branched shrub up to 50(–300) cm tall; stem often reddish at base, variously hairy with multicellular hairs; lateral leafy shoots (5–)10–15(–25) cm long. Leaves alternate, distichous, simple and entire; stipules linear-lanceolate, 1–1.5 mm long; petiole 0.5–1 mm long; blade almost orbicular to obovate or elliptical, 2–25 mm × 1–15 mm, usually glabrous, with 4–12 pairs of lateral veins. Inflorescence a fascicle in the upper leaf axils of lateral shoots, composed of a few male flowers and 1 female flower. Flowers unisexual, regular, 5(–6)-merous; perianth lobes c. 1 mm long; male flowers with pedicel 5–6 mm long, perianth lobes almost orbicular to obovate, cream-coloured or whitish with a green midrib, sometimes pink-tinged, disk glands 5, minute, free, stamens 5, free; female flowers with pedicel (5–)7–20 mm long, perianth lobes elliptical-ovate, yellowish green, often reddish- or brownish-tinged, disk c. 1 mm in diameter, flat, ovary superior, depressed globose, c. 1 mm in diameter, smooth, 3-celled, styles 3, free, c. 0.5 mm long, 2-fid at apex. Fruit a depressed globose 3-lobed fleshy berry, c. 1 mm × 2 mm, smooth, pale green, sometimes reddish-tinged, 6-seeded. Seeds c. 1 mm × 0.5 mm, trigonous, pale brown, with 10–12 rows of minute tubercles on one side and 9–10 concentric rows of tubercles on the other side.

Phyllanthus is a large genus comprising about 750 species in tropical and subtropical regions, with about 150 species in mainland tropical Africa and about 60 in Madagascar and the Indian Ocean islands.

Several other shrubby *Phyllanthus* spp. have medicinal uses in East and southern Africa. *Phyllanthus fischeri* Pax occurs from Ethiopia south to Tanzania. In Kenya the Nandi people take a fruit decoction to treat roundworms. In Tanzania a root decoction, mixed with roots of other plant species, is drunk to treat threatened abortion, female sterility and general malaise. *Phyllanthus fischeri* is considered a good forage for all livestock. The twigs are used as toothbrush. *Phyllanthus hutchinsonianus* S.Moore occurs in Tanzania, Zimbabwe and Mozambique. In Tanzania the bitter leaves are eaten by women after childbirth as a stomach medicine. *Phyllanthus sacleuxii* Radcl.-Sm. (synonym: *Phyllanthus mittenianus* Hutch.) occurs in montane woodland of Kenya and Tanzania. In Kenya a leaf decoction is drunk to treat diarrhoea. Leaf sap is used as ear drops to treat otitis. It is listed as rare in Kenya on the IUCN Red List of threatened plants. *Phyllanthus somalensis* Hutch. occurs in Somalia and northern Kenya. In Somalia a root decoction is drunk to cure blood in the urine, including schistosomiasis. A root decoction or mac-

eration is taken to treat bilharzia. In Kenya the leaves are suspected of poisoning livestock. An ethanol extract of the roots showed antibacterial activity in vitro. *Phyllanthus volkensii* Engl. occurs in Kenya, Uganda and Tanzania. In Uganda a leaf infusion is drunk to treat headache.

Ecology *Phyllanthus nummulariifolius* occurs in dense riverine forest, woodland, forest edges and grassland, often in seasonally wet and disturbed localities, but also in shallow pockets of soil on granite inselbergs in *Acacia-Commiphora* vegetation, up to 2100 m altitude.

Genetic resources and breeding *Phyllanthus nummulariifolius* has a very wide area of distribution and there are no signs that its genetic variability is diminishing.

Prospects *Phyllanthus nummulariifolius* has many uses in local medicine, but virtually nothing is known concerning its chemistry and pharmacology. Therefore, more research is needed to evaluate its properties.

Major references Burkill, 1994; Keay, 1958a; Neuwinger, 2000; Radcliffe-Smith, 1996a; Unander, Webster & Blumberg, 1991.

Other references Adjanohoun et al. (Editors), 1982; Andrianaivoravelona, 2004; Baerts & Lehmann, 2008c; Chifundera, Baluku & Mashimango, 1993; Hamill et al., 2000; Heine & Heine, 1988b; Kokwaro, 1993; Macleod, 1998; Tabuti, Lye & Dhillion, 2003; Yamada, 1999.

Authors L.P.A. Oyen

PHYLLANTHUS RETICULATUS Poir.

Protologue Encycl. 5: 298 (1804).

Family Euphorbiaceae (APG: Phyllanthaceae)

Chromosome number $2n = 26$

Synonyms *Kirganelia reticulata* (Poir.) Baill. (1858).

Vernacular names Potato plant, potato smell, seaside laurel (En). Mwino, mfuungozi, mkasiri, mchunguchungu, mviongozi, mzizima (Sw).

Origin and geographic distribution *Phyllanthus reticulatus* is widespread in the Old World tropics, from tropical Africa to India, China and South-East Asia, and south to Queensland (northern Australia). It has been introduced into the West Indies. It occurs throughout tropical Africa, except in the most humid, equatorial areas, and also in Egypt and northern South Africa.

Uses The Asante people in Ghana give a soup made of *Phyllanthus reticulatus* leaves boiled with palm oil to women after childbirth. Sap from the stem is used as eye drops to cure conjunctivitis and soreness. In southern Africa powdered leaves are topically applied to sores, including venereal sores, burns, suppurations and chafes. In Tanzania crushed leaves are rubbed on the body of malaria patients. In Sudan and southern Africa the leaves and bark are reputed to be diuretic and cooling. In Zanzibar the plant is considered a remedy for anaemia and intestinal haemorrhage. Sap from pounded roots is used as ear drops to treat ear infections. Powdered root is sprinkled on infected wounds and chancre. A decoction of the roots is drunk against dysmenorrhoea and to increase fertility. It is also taken to treat abscesses, general pain or spasms, and is used as a purgative and as part of treatment against hookworm. The Sukuma people of Tanzania drink water mixed with the pounded roots against headache. Leaves and roots also enter in a treatment of paralysis. In Tanzania the fruit and root are used for criminal poisoning. In India the powdered leaves are pounded with cubebs (*Piper cubeba* L.) and camphor into tablets for sucking against bleeding gums; the leaves are also used in the treatment of diabetes. In the Philippines leaves are applied locally against pinworms. A root decoction is taken against gonorrhoea and other venereal diseases and also against diarrhoea accompanied by mild anal bleeding. In the Malaysia the stem and leaves are rubbed on the chest against asthma; a leaf decoction is drunk to treat a sore throat, against snakebites, mental problems and diarrhoea.



Phyllanthus reticulatus – wild

The foliage and young shoots are browsed by all livestock, e.g. in Kenya and Tanzania. The fruits are edible. They are traded in Freetown (Sierra Leone) as sour grapes and are occasionally eaten in East Africa, but probably only as an emergency food.

In Sudan and East Africa a red or black dye is obtained from the fruit, bark and roots; it is used for tanning and dyeing fishing lines and nets. In Angola a mixture of crushed leaves and black mud is used traditionally to dye cloth. In Indonesia a decoction of stems and leaves is used for dyeing cotton black. It was also used as a mordant. In India the root is reported to produce a red dye. In the Philippines a black ink is prepared from the ripe fruits. The Swahili name 'mwino' suggests a similar use in East Africa. Stems are used in Nigeria as roof binders. Twigs are widely used as chew sticks. The wood is suitable for local construction and as firewood or tinder; it produces charcoal of good quality. In Tanzania it is used to make flails for threshing, utensils and other small objects and was formerly used in fire-drills.

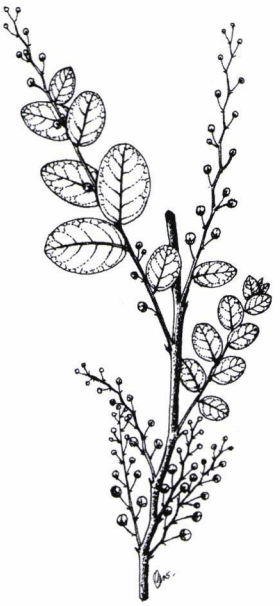
Production and international trade *Phyllanthus reticulatus* is of subsistence value in most parts of Africa, and root bark, stem bark and leaves are collected and traded in local markets. Production figures are not available.

Properties *Phyllanthus reticulatus* contains tannins, which are partly responsible for its medicinal and dyeing properties. A number of triterpenoids have been isolated from the stems and leaves, including sitosterol, friedelin and betulinic acid. The stem bark contains pentacosane, 21-α-hydroxyfriedelan-3-one, taraxerol and lupene-24-diol.

Petroleumether and ethanol extracts of the leaves showed hypoglycaemic effects in alloxan-induced diabetic mice. An ethanolic extract of the stem bark showed in-vitro antiviral properties against polio and measles viruses, and antitumour activity. In Kenya extracts of the leaves showed promising antiplasmodial activity against chloroquine-resistant and -sensitive malaria parasites.

Phyllanthus reticulatus has been a test plant in trials to remove heavy metals from contaminated soil. Although it was effective, *Pluchea indica* (L.) Less. performed significantly better. The wood is fairly hard and tough, and greyish white to reddish.

Description Monoecious, deciduous, much-branched shrub or small tree up to 5(–10) m tall; bole up to 25 cm in diameter; bark pale reddish brown, longitudinally fissured; branches slender, spreading and drooping almost to the ground, pale grey or brownish white, lateral leafy shoots up to 25 cm long. Leaves alternate, distichous, simple and entire; stipules linear to narrowly lanceolate, 1–1.5 mm long, pale brown; petiole 1–4 mm long; blade elliptical to ovate-oblong or nearly orbicular, 1–5 cm × 0.5–3 cm, base cuneate to rounded or truncate, apex acute or notched, usually glabrous, pinnately veined with 7–13 pairs of lateral veins. Inflorescence a fascicle on lateral shoots, with 1 female and several male flowers per fascicle, or female flowers solitary in upper leaf axils. Flowers unisexual, regular, 5(–6)-merous, fragrant; perianth lobes elliptical-ovate to obovate-orbicular, c. 2 mm × 1–2 mm, glabrous or short-hairy outside, white with a green or yellowish green median stipe, sometimes tinged pinkish to purplish; male flowers with pedicel 2–4 mm long, disk glands 5(–6), free, stamens 5(–6), usually free, c. 1.5 mm long; female flowers with shorter and stouter pedicels, disk c. 1 mm in diameter, 5-lobed, ovary superior, almost globose, 1–1.5 mm in diameter, 3–4(–many)-celled, smooth, styles 3–8, free, apex shortly 2-fid. Fruit a depressed globose, fleshy berry 3–5 mm × 4–6 mm, 3–many-lobed, smooth, green turning



Phyllanthus reticulatus – flowering branch.
Source: PROSEA

reddish purple or bluish black, 6–many-seeded. Seeds irregularly ovoid-trigonous, 2–2.5 mm long, minutely ridged, shiny, reddish brown.

Other botanical information *Phyllanthus* is a large genus comprising about 750 species in tropical and subtropical regions, with about 150 species in mainland tropical Africa and about 60 in Madagascar and the Indian Ocean islands.

Growth and development In the Sahel region flowering occurs towards the end of the dry season, shortly after the plants have come into leaf, and continues during the rainy season. In Sudan *Phyllanthus reticulatus* flowers in March–October and fruits in October–December. In southern Africa it is reported to flower before or when coming into leaf, mainly in September–October, but flowering may start as early as July. The flowers have a very characteristic smell of potatoes.

Ecology *Phyllanthus reticulatus* occurs in rainforest and mixed deciduous forest, miombo woodland, on river banks, in forest fringes, mostly on deep moist soil. It is also found in littoral scrub and dune vegetation and occasionally on termite mounds. It often forms thickets, e.g. in floodplain grassland. *Phyllanthus reticulatus* can become an invasive weed of cultivated land.

Management In Africa *Phyllanthus reticulatus* only occurs in the wild, but in India it is occasionally also cultivated. It can be coppiced.

Genetic resources *Phyllanthus reticulatus* is common and widespread; it is therefore not in danger of genetic erosion.

Prospects The numerous medicinal uses of *Phyllanthus reticulatus* warrant much more detailed studies of its chemical and pharmacological properties. The dye and tannin properties also deserve attention.

Major references Arbonnier, 2004; Indi & Chinta, 2007; Jain et al., 1998; Neuwinger, 2000; Radcliffe-Smith, 1987; Radcliffe-Smith, 1996a; van Holthoon, 1999; Watt & Breyer-Brandwijk, 1962.

Other references Calixto et al., 1998; Chhabra, Uiso & Mshiu, 1984; Diallo et al., 2002; d'Oliveira Feijão, 1961; El Amin, 1990; Grace et al., 2002; Hedberg et al., 1983a; Jain & Nagpal, 2002; Khan, 2001; Kumar et al., 2008; Lam et al., 2007; Lee et al., 2006a; Omulokoli, Khan & Chhabra, 1997; Samantaray, Rout & Das, 1999; Sampanpanish et al., 2007; Unander, Webster & Blumberg, 1990.

Sources of illustration Phuphathanaphong, 1991.

Authors A. Maroyi

Based on PROSEA 12(1): Medicinal and poisonous plants 1.

PHYLLANTHUS URINARIA L.

Protologue Sp. pl. 2: 982 (1753).

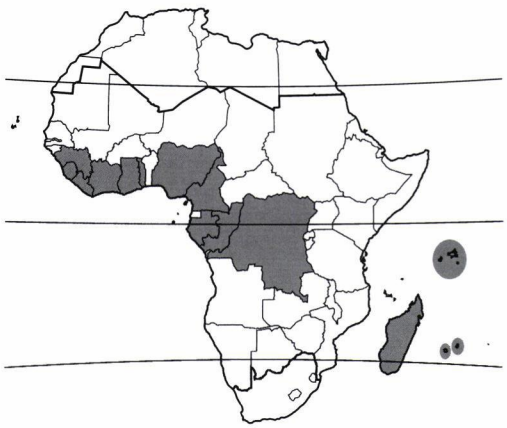
Family Euphorbiaceae (APG: Phyllanthaceae)

Chromosome number $2n = 26, 48, 52$

Vernacular names Common leaf-flower, shatterstone, chamber bitter (En). Kikilé, petit tamarin rouge, curanellie rouge, urinaire de Malabar (Fr).

Origin and geographic distribution *Phyllanthus urinaria* is probably native to Asia and has spread as a weed throughout the tropics. It also occurs in tropical Africa and the Indian Ocean islands, but it is not common there.

Uses Sap of leafy twigs or a twig decoction is drunk in Côte d'Ivoire and DR Congo to treat pain in the side. In Côte d'Ivoire and Nigeria a paste of fresh crushed leaves and kaolin in water is drunk and applied to the body to treat convulsions, colic, constipation and urethral discharges. In Nigeria a plant decoction is drunk and plant ash in water is applied as ear drops to treat earache. The bitter leaves are eaten to treat hiccup and cough. In DR Congo a decoction of young shoots or roots is taken to treat dysentery, malaria and typhoid fever. A decoction of the whole plant is taken to fight jaundice and gonorrhoea and is topically applied as a poultice to treat skin problems such as ulcers, sores, swelling and itch. In Madagascar, Réunion and Mauritius a plant decoction is drunk as a diuretic and purgative to treat diar-



Phyllanthus urinaria – naturalized

rhoea, painful urination, syphilis and liver problems, and also to treat fever. In Madagascar a stem or leaf infusion is taken to treat asthma and bronchitis and is externally applied to treat parasitic skin diseases. In Rodrigues a leaf infusion is taken to treat cough.

Worldwide, *Phyllanthus urinaria* is used as a diuretic and purgative to treat a wide variety of uro-genital disorders, diarrhoea and diabetes, as a bitter tonic and to treat fever, including malaria. In Asia extracts are also widely used against hepatitis B infections. Externally, crushed plant parts or an infusion are applied to treat ulcers, sores and tumours. In India the crushed plant is used as fish poison.

Production and international trade Dried *Phyllanthus urinaria* plant parts or extracts are sold on the internet. Dried herbs are sold at US$ 70 (2.3 kg) to US$ 1100 (22.7 kg). Seeds are sold at US$ 3 (60 seeds) to US$ 40 (1000 seeds).

Properties The chemical composition and pharmacology of *Phyllanthus urinaria* have been subject to many investigations. The following chemical constituents have been found: lignans (e.g. phyllanthin, phyltetralin, hypophyllanthin, urinatetralin, dextrobuschernin, 5-demethyoxynirathin and urinaligran), ellagitannins (e.g. corilagin, geraniin, hippomanin A, phyllanthusin F and G, repandinin B and phyllanthusiin U), terpenoids (e.g. β-amyrin, lupeol acetate and β-sitosterol), flavonoids (quercetin, astragalin, quercitrin, rhamnocitrin, isoquercitrin, kaempferol, daucosterol, triacontanol and rutin), phenolic compounds (e.g. caffeic acid, ellagic acid, gallic acid, methylester dehydrochebulic acid, methyl brevifolincarboxylate, hexacosanoic acid, brevifolin, brevifolin carboxylic acid, pyrogallol, n-octadecane, methylgallate, trimethyl-3,4-dehydrochebulate, 1,3,4,6-tetra-O-galloyl-β-d-glucose) and waxes (montanoic acid methyl ester, triacontanol).

Phyllanthus urinaria has been found to inhibit in-vitro DNA polymerase of the hepatitis B virus and other hepatitis-DNA-viruses, such as the woodchuck hepatitis virus. Aqueous extracts have significant antiviral effects and a protective effect on liver cells. It was found that ellagic acid, isolated from the plant, showed significant antihepatotoxic activity. Triacontanol showed hepatoprotective properties, e.g. against galactosamine-induced cytotoxicity in rat hepatocytes. The lignan phyllanthin showed protective activity in rat hepatocytes against cytotoxicity induced by CCl_4 and galactosamine. However, phyllanthin has also been reported to be toxic to the nervous system and liver. In a double-blind placebo-controlled study of *Phyllanthus urinaria* for the treatment of chronic hepatitis B no delayed virological or biochemical response was shown at 24 weeks after the cessation of treatment. An acetone extract was found to suppress herpes simplex virus (HSV). Several bioactive compounds were isolated from the extract. Hippomanin A and geraniin were found to inhibit only HSV-2 and 1,3,4,6-tetra-O-galloyl-β-d-glucose only HSV-1. Derivatives of corilagin showed inhibitory activity against Epstein-Barr virus DNA polymerase.

A water extract of *Phyllanthus urinaria* induced apoptosis and significantly decreased the number of Lewis lung carcinoma cells and human myeloid leukaemia cells (HL-60 cells) in a dose- and time-dependent manner. It did not exert any cytotoxic effect on normal cells. The oral administration of an aqueous alcohol extract to mice caused significant inhibition of tumour development, without toxic effects.

A plant extract containing corilagin showed significant anti-thrombosis activity in rats in a dose-dependent manner due to its inhibition of platelet-neutrophil adhesion. It did not cause serious bleeding side effect as compared with aspirin or urokinase. Corilagin, however, had no influence on rabbit platelet aggregation.

A methanol extract showed significant antioxidant activity in vitro. A correlation between the antioxidant activity and several phenolic compounds, ellagitannins and flavonoids, was observed. Extracts of *Phyllanthus urinaria* also showed cardioprotective in vitro and antidiabetic effects in streptozotocin-induced diabetic rats. An aqueous alcoholic extract of stems, leaves and roots caused graded contraction in guinea-pig trachea and urinary bladder. It also exhibited potent and long-lasting antinociceptive activity in several pain models in mice, especially when given orally. Gallic acid ethyl ester, isolated from the aerial parts, produced dose-dependent and pronounced systemic, spinal and supraspinal antinociception in mice.

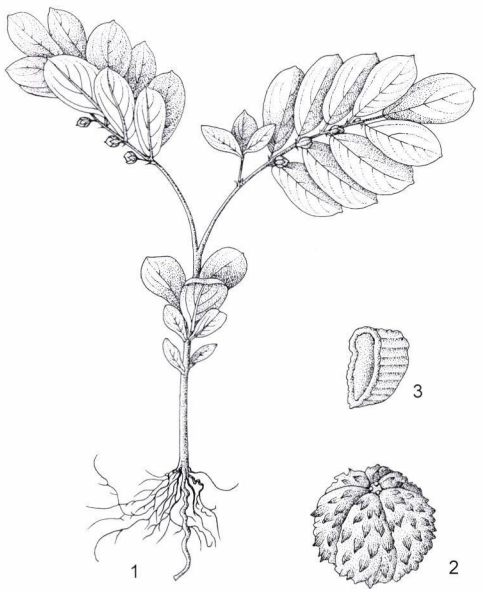
An aqueous extract showed significant in-vitro antiplasmodial activity against a chloroquine-resistant *Plasmodium falciparum* strain. The n-hexane fraction of an aqueous alcohol extract from leaves, stems and roots exhibited antibacterial activity against *Escherichia coli*, *Proteus vulgaris*, *Salmonella typhimurium*, *Shigella flexneri*, *Klebsiella pneumoniae*, *Vibrio parahaemolyticus* and *Staphylococcus aureus*.

Callus culture and root culture protocols were

developed using single node explants, but callus extracts showed less activity against viral DNA polymerase and reverse transcriptase than extracts from field-grown plants. The compounds β-sitosterol, glochidonol and glochidone were isolated from the callus extracts.

Adulterations and substitutes *Phyllanthus urinaria* is similarly medicinally used as *Phyllanthus amarus* Schumach. & Thonn. and *Phyllanthus fraternus* G.L.Webster.

Description Monoecious, annual or short-lived perennial herb, erect or sprawling, up to 60 cm tall, reddish; branchlets (3–)5–13 cm long, flattened, often slightly winged and sparsely hairy. Leaves alternate, distichous and crowded along lateral branchlets, simple, glabrous, sessile; stipules ovate to lanceolate, long-acuminate, those of main stems with auricles at base; blade oblong to elliptical-oblong, 7–12(–20) mm × 3–6(–9) mm, base cuneate to rounded and slightly unequal, apex rounded, often pointed, margins finely toothed. Flowers 1–2 in the axils of leaves, male flowers towards the apex of branchlets, female flowers at the basal part of branchlets, unisexual, regular, 6-merous; pedicel c. 1 mm long; male flowers with obovate perianth lobes c. 1 mm long, disk lobes 6, stamens 3, filaments fused, anthers free; female flowers with triangular-ovate perianth lobes c. 1 mm long, disk cup-shaped, ovary superior, ovoid, warty, 3-celled, styles fused at base into a triangular plate, 2-fid at apex. Fruit a globular capsule 2–2.5 mm in diameter, usually warty, hanging, 6-seeded. Seeds c. 1 mm long, with sharp transverse ridges.



Phyllanthus urinaria – 1, plant habit; 2, fruit; 3, seed.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Phyllanthus* is a large genus comprising about 750 species in tropical and subtropical regions, with about 150 species in mainland tropical Africa and about 60 in Madagascar and the Indian Ocean islands.

Phyllanthus urinaria is highly variable. Several other *Phyllanthus* spp. indigenous to the Indian Ocean islands have similar medicinal uses as *Phyllanthus urinaria*. A decoction of the leafy twigs of *Phyllanthus lanceolatus* Poir., a rare species from Mauritius, and of *Phyllanthus phillyreifolius* Poir., an endangered species from Réunion and Mauritius, is taken as a diuretic and to treat diarrhoea. A leaf or stem bark decoction is taken as a diuretic to treat venereal diseases and pain caused by kidney stones. An infusion of the young leaves of *Phyllanthus pervilleanus* (Bail.) Müll.Arg., from Comoros and Madagascar, is considered a strong diuretic.

Phyllanthus angavensis (Leandri) Leandri occurs in south-western Madagascar. A stem bark decoction is taken to treat persistent diarrhoea and amoebic dysentery. A root decoction of *Phyllanthus melleri* Müll.Arg., from central and eastern Madagascar, is drunk to treat fatigue, diarrhoea and amoebic dysentery. Root powder or the crushed roots are applied to abscesses and ulcers. The small fruits are edible and made into a low-quality alcoholic drink. The roots give a low-quality dye for baskets. The branches are used in wickerwork. A root decoction of *Phyllanthus mocquerysianus* A.DC. from eastern Madagascar is drunk to treat malaria. *Phyllanthus tenellus* Roxb. occurs naturally in Tanzania, Mozambique, the Indian Ocean islands and Yemen and has been introduced in several countries of the Old and New tropics. In Madagascar preparations of the leaves and stem are taken to treat asthma, bronchitis and parasitic skin diseases. A bark extract is taken as an astringent and a plant extract to treat blenorrhagia. A decoction of the whole plant is used to treat fever in children.

Growth and development The branching pattern of *Phyllanthus urinaria* is 'phyllanthoid', i.e. the spirally arranged leaves on the

main axes are strongly reduced to so-called 'cataphylls', which subtend deciduous branchlets with distichous leaves, the branchlets resembling a compound leaf. Flowering and fruiting may occur throughout the year if enough water is available. Seeds are dispersed by water and animals.

Ecology *Phyllanthus urinaria* is a common weed of waste places, clearings, gardens and along paths, but is also found in evergreen forest. It grows on well-drained, fertile, sandy soils, sometimes on limestone, often in humid localities or even in marshy ground, up to 1500 m altitude. It prefers full sun, but may grow under partial shade.

Propagation and planting *Phyllanthus urinaria* is a prolific seed producer. The seeds can remain dormant for an extended period of time. They germinate massively during the rainy season and the seedlings are very fast growing. Seed requires light to germinate. A germination rate of up to 80% was observed at temperatures of 25–35°C, but germination was poor at 20°C or 40°C. Germination of seed is also poor under moisture stress conditions. Stratification significantly improved the germination of the seeds.

Management In experiments in the United States soil fertility and soil moisture affected morphology and yield of *Phyllanthus urinaria*, with plants being more branched and with a higher dry weight under favourable conditions. Differences in soil fertility and soil moisture generally did not affect the in-vitro inhibitory activity on woodchuck virus DNA polymerase. *Phyllanthus urinaria* shows a marked preference for calcareous sites in humid tropical areas. In China, warm, well-drained sandy soils and fertilization with N and K are recommended for cultivation.

Diseases and pests In Indian rice fields *Phyllanthus urinaria* is a host of the rice root-knot nematode (*Meloidogyne graminicola*).

Harvesting *Phyllanthus urinaria* is usually harvested from the wild. The plant is often uprooted, but sometimes only aerial parts are collected.

Handling after harvest The harvested plant material is usually washed and used fresh, but it may also be dried and kept in a dry place for future use.

Genetic resources *Phyllanthus urinaria* is a widespread weedy species and is not threatened by genetic erosion.

Prospects Pharmacological research of *Phyllanthus urinaria* has shown interesting anti-tumour, antiviral, antioxidant, antithrombosis and antinociceptive activities, and further research is merited. More research is warranted concerning its husbandry and growth conditions for optimal production of active compounds.

Major references Burkill, 1994; Coode, 1982; Fang, Rao & Tzeng, 2008; Huang et al., 2006; Kang et al., 2006; Lee et al., 2006b; Liao, Chang & Koo, 2006; Neuwinger, 2000; Yang et al., 2007a; Yang et al., 2007b.

Other references Adjanohoun et al. (Editors), 1982; Bharali, Tabassum & Azad, 2003; Catapan et al., 2002; Chan et al., 2003; Chularojmontri et al., 2005; Cruz et al., 1994; Gurib-Fakim & Brendler, 2004; Higashino et al., 1992; Hout et al., 2006; Lavergne, 2001; Paulino et al., 1999; Santos et al., 1999; Shen et al., 2008; Shen et al., 2003; van Holthoon, 1999; Ueda et al., 1999; Unander, Webster & Blumberg, 1991; Wang et al., 1995; Xu et al., 2007; Zhou et al., 1997.

Sources of illustration Radcliffe-Smith, 1986.

Authors D.M. Mosango

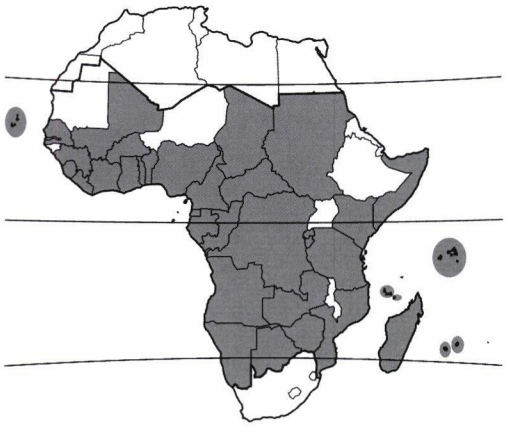
PHYSALIS ANGULATA L.

Protologue Sp. pl. 1: 183 (1753).
Family Solanaceae
Chromosome number $2n = 48$
Synonyms *Physalis minima* L. (1753).

Vernacular names Gooseberry, hogweed, balloon cherry, angular winter cherry, cut-leaf ground cherry (En). Coqueret, coqueret anguleux (Fr). Alquequenje amarelo, balão rajado, joá de capote, camapú (Po).

Origin and geographic distribution *Physalis angulata* is native to tropical America, and is now distributed pantropically as a weed. In tropical Africa it occurs in most countries.

Uses The leaves are analgesic and used externally throughout tropical Africa to treat skin ailments such as itch, smallpox pustules, whitlow lesions, infected scarification wounds and rheumatic pain, and to relieve muscular stiffness and pain. The leaves are also applied to Guinea worm sores, killing the worms and easing extraction. In Côte d'Ivoire sleeping sickness is treated with a mixture of leaves of *Physalis angulata* and *Anchomanes difformis* (Blume) Engl. A lotion prepared from the leaves is applied to treat ophthalmia in children. Leaves are eaten or applied as an enema to cure stomach-ache, colic, lithiasis and anu-



Physalis angulata – naturalized

ria, and are added to palm wine to cure fever and to calm attacks of asthma, vomiting and diarrhoea.

In Central and South America *Physalis angulata* is also widely used as a medicinal plant. It is used to treat malaria, toothache, liver ailments including hepatitis, rheumatism, and is considered a diuretic and relaxant. Plant infusions are taken to treat gonorrhoea, indigestion, nephritis and fever.

In South-East Asia an infusion of the aerial parts, including the fruits, is taken to cure digestive and intestinal problems, and is externally applied to treat various skin problems such as sores, boils and cuts. In Papua New Guinea a leaf decoction is drunk to treat constipation. The sap of the leaves mixed in water is taken as an abortifacient, although the use of the leaves to treat sterility is also mentioned.

In tropical Africa the fruit is eaten as a snack, but eating too many fruits may cause dizziness. The leaves are eaten as a salad, although the taste is bitter. In larger quantities the plant is poisonous to cattle and sheep, and it gives the meat a musk-like smell.

Properties The aerial parts of *Physalis angulata* contain several steroidal lactones belonging to the physaline and withanolide types: physalins A–I, physagulin A–G, withangulatin A and withanolide T. They further contain several vitasteroids, e.g. vamonolide. The pyrrolidine alkaloid phygrine (bis-hygrine) was isolated from the roots and aerial parts. The physalins B and F were found to inhibit the growth of several types of human leukaemia cells in vitro and physalin F showed cytotoxicity in vitro on 5 other human cancer cell lines. In addition, physalin F had an antitumour effect in mice in vivo. In vitro withangulatin A was found to be a topoisomerase II inhibitor and a cytotoxin. In tests on rats and mice, vitanolides (isolated from aerial parts) and hyperoside (quercetin-3-O-galactoside; from the leaves) were confirmed to have anti-inflammatory activity. Extracts of *Physalis angulata* have proven effectiveness against both human African sleeping sickness (*Trypanosoma brucei rhodesiense*) and Chagas' disease (*Trypanosoma cruzi*). They also have an inhibitory effect against several strains of *Neisseria gonorrhoeae* and molluscicidal properties (*Biomphalaria tenagophila*).

Adulterations and substitutes Some *Solanum* spp. are used in a similar way as *Physalis angulata* to cure digestive and intestinal problems, including stomach-ache and diarrhoea, and for various skin problems such as sores, boils and cuts. Several other *Physalis* spp. are also employed to treat fever, malaria, headache and rheumatism. Several other *Solanaceae* also contain steroidal lactones of the physaline and withanolide types, e.g. *Withania* and *Nicandra*.

Description Annual herb up to 100 cm tall, with procumbent or prostrate stem, glabrous or with a few short appressed hairs; stems sharply angled, hollow. Leaves arranged spirally, simple; stipules absent; petiole 2–11 cm long; blade ovate to lanceolate, 4–15 cm × 2.5–10 cm, base cuneate, apex obtuse, margin irregularly toothed or entire. Flowers axillary, solitary, erect or nodding, bisexual, regular, 5-merous; pedicel 6–12 mm long, elongated in fruit up to 22 mm; calyx campanulate, 5-lobed, 3–5 mm long, angled or ribbed, in fruit 2–4 cm long; corolla campanulate, 5–10 mm long, pale yellow with or without 5 dark spots; stamens inserted near the base of the corolla tube, filaments 1.5–5 mm long, anthers pale blue; ovary superior, 2-celled, style filiform, stigma head-shaped. Fruit a globose berry 10–16 mm in diameter, yellow, viscid, many-seeded, enclosed in the persistent, inflated bladdery calyx. Seeds kidney-shaped, 1.5–2 mm × 1–1.5 mm. Seedlings with epigeal germination.

Other botanical information *Physalis* comprises about 90 species, all but one being native to tropical and temperate America. The species are variable and taxonomically confusing, and no comprehensive study of the genus exists. *Physalis* is closely related to *Margaranthus* and *Nicandra*. *Physalis minima* L. is a



Physalis angulata – 1, plant habit; 2, flower in front view; 3, flower in side view; 4, fruit with calyx partly removed; 5, seed.
Source: PROSEA

synonym of *Physalis angulata*, but in Africa the name *Physalis minima* has been misapplied to specimens of *Physalis lagascae* Roem. & Schult. and *Physalis ixocarpa* Brot. *Physalis angulata* is very similar to the American *Physalis philadelphica* Lam. of which a larger-fruited, cultivated type ('Japanese gooseberry' or 'tomatillo') and a smaller-fruited, wild type exist. *Physalis philadelphica* has been cultivated in southern Africa for its edible fruits and is locally naturalized.

Growth and development When free of stress *Physalis angulata* can grow to 80–100 cm tall before flowering, but where growing under stress flowering may start when the plants are 25–30 cm tall. It is cross-pollinated. Plants raised from seed may start flowering after 6 weeks, and fruits are ripe 6 weeks later.

Ecology *Physalis angulata* grows best in moist, fertile soils, is tolerant of partial shade and occurs widely as a weed of crops and pastures, and in waste areas. It can be found up to 3000 m altitude. Light frost does not kill it. At high temperatures the plants do not develop well.

Propagation and planting *Physalis angulata* can be easily propagated by seed. Shallow sowing and alternating temperatures, e.g. 10 hours at 21°C and 14 hours at 30°C, will give best germination results.

Management Although *Physalis angulata* is reported to be cultivated occasionally, both for its edible fruits and for medicinal use, optimal cultivation techniques are not documented.

Diseases and pests *Physalis angulata* is sensitive to many fungal diseases and is a host of the causal agent of tomato bacterial spot *Xanthomonas campestris* pv. *vesicatoria*. *Physalis angulata* hosts viruses found in tobacco, potato, okra, capsicum pepper, beans and several other crops, as well as physalis mottle virus (PhyMV), and also several root-knot nematodes (*Meloidogyne* spp.)

Yield In a field test in Indonesia, the maximum number of fruits per plant was about 130, and the number of seeds per fruit was 130 at most.

Handling after harvest The fruits will keep for 3 months if stored in their calyx under dry conditions.

Genetic resources *Physalis angulata* is widespread as a pantropical weed and is not liable to genetic erosion. Large collections of *Physalis*, including *Physalis angulata*, are kept in Mexico, Guatemala, Germany and the Netherlands.

Prospects The steroidal lactones of the physaline and withanolide types isolated from *Physalis angulata* show very interesting activities, e.g. in the field of tumour inhibition. More research on their toxicity toward non-malignant cells is, however, needed to fully evaluate their possibilities as lead compounds in cancer research. A taxonomic monograph of *Physalis* will contribute to botany and other areas of research that currently publish research results under wrong or doubtful names.

Major references Burkill, 2000; Chiang et al., 1992; Chiang, Jaw & Chen, 1992; Damu et al., 2007; Goncalves, 2005; Jarvis, C., 2007; Slamet Sutanti Budi Rahayu, 2001b; Whitson & Manos, 2005.

Other references Abe et al., 2006; Adjanohoun et al., 1989; Akoègninou, van der Burg & van der Maesen, 2006; D'Arcy & Rakotozafy, 1994; dos Santos et al., 2003; Edeoga, Okwu & Mbaebie, 2005; Elkhalifa, Ibrahim & Elghazali, 2006; Freiburghaus et al., 1996a; Geissler et al., 2002; Heine & Heine, 1988a; Neuwinger, 2000; QingPing et al., 2007; Raju, Reddy &

Rajarao, 2007.

Sources of illustration Slamet Sutanti Budi Rahayu, 2001b.

Authors F.S. Mairura

Based on PROSEA 12(2): Medicinal and poisonous plants 2.

PHYSALIS LAGASCAE Roem. & Schult.

Protologue Syst. veg. 4: 679 (1819).

Family Solanaceae

Chromosome number $2n = 24$

Synonyms *Physalis micrantha* Link (1821), *Physalis minima* auct. non L.

Origin and geographic distribution *Physalis lagascae* is native to tropical America, and now distributed pantropically as a weed. In tropical Africa it occurs in most countries.

Uses Leaves are used externally to treat yaws and measles. Pain in the joints is relieved by rubbing or dressing them with pounded leaves. The leaves are also applied to Guinea worm sores, killing the worms and easing extraction. Leaf sap is taken orally to treat tonsillitis, jaundice, angina pectoris, tachycardia and stomach-ache, and as an anthelmintic. The ground leaves are used in the treatment of abdominal and vaginal pain and are taken as a cold infusion shortly before childbirth to help expel the placenta. The whole plant mashed up and added to palm wine is taken to cure fever. In Ethiopia and Kenya the leaves are boiled and eaten as a vegetable. The fruits are edible and are eaten raw.

Properties The leaf sap of *Physalis lagascae* is very bitter and haemostatic. Chemical and pharmacological work done on the species has been published under the name *Physalis minima* and cannot be distinguished from that done on other species of *Physalis* for which this name has been used. In view of the medicinal uses, it is probable that *Physalis lagascae* contains steroidal lactones belonging to the physaline and withanolide types: physalins, physagulins, withangulatins, withanolides; it may further contain vitasteroids.

Botany Annual herb up to 100 cm tall, with erect, decumbent or prostrate stem, hairy with simple, multicellular hairs 1–4 mm long and minute hairs, also with sessile glands. Leaves arranged spirally or opposite, simple and entire; stipules absent; petiole 0.5–4.5(–8) cm long, slightly winged; blade ovate to lanceolate, 1.5–7.5(–10.5) cm × 1–4.5(–7.5) cm, base cuneate, apex acuminate to obtuse. Flowers axillary, solitary, erect or nodding, bisexual, regular, 5-merous; pedicel 2–5(–9) mm long, elongated in fruit up to 10 mm; calyx campanulate, 5-lobed, 2–3.5 mm long, angled to ribbed, in fruit 1–2 cm long; corolla campanulate, 4–5 mm long, greenish yellow, yellow, white or greenish cream, with or without purplish marks or blotches; stamens inserted near the base of the corolla tube, filaments 1.5–3 mm long, anthers yellowish; ovary superior, 2-celled, style filiform, stigma head-shaped. Fruit a globose berry 6–10 mm in diameter, greenish yellow, pale yellow or yellow, viscid, many-seeded, enclosed in the persistent, inflated bladdery calyx. Seeds round or ovate in outline, sometimes kidney-shaped, c. 2 mm × 1.5 mm. *Physalis* comprises about 90 species, all but one being native to tropical and temperate America. The species are variable and taxonomically confusing, and no comprehensive study of the genus exists. In tropical Africa the name *Physalis minima* has often been misapplied to *Physalis lagascae*.

Ecology *Physalis lagascae* is a common weed and also occurs on disturbed ground, especially in seasonally dry areas.

Management Cultivation of *Physalis lagascae* is reported for its edible fruits and leaves as well as for medicinal use, but details on optimal cultivation techniques are not recorded.

Genetic resources and breeding *Physalis lagascae* is widespread as a weed and thus not liable to genetic erosion. Large collections of *Physalis*, including *Physalis lagascae*, are kept in Mexico, Guatemala, Germany and the Netherlands.

Prospects The steroidal lactones of the physaline and withanolide types isolated from *Physalis* spp. show very interesting activities, e.g. in the field of tumour inhibition. More research on their toxicity toward non-malignant cells is, however, needed to fully evaluate their possibilities as lead compounds in cancer research. A taxonomic monograph of *Physalis* will contribute to botany and other areas of research that currently publish research results under wrong or doubtful names.

Major references Burkill, 2000; Goncalves, 2005; Raju, Reddy & Rajarao, 2007; Tabuti, 2007; Whitson & Manos, 2005.

Other references Adjanohoun et al., 1989; Geissler et al., 2002; Hamill et al., 2003; Neuwinger, 2000; Tabuti, Lye & Dhillion, 2003; Yamada, 1999.

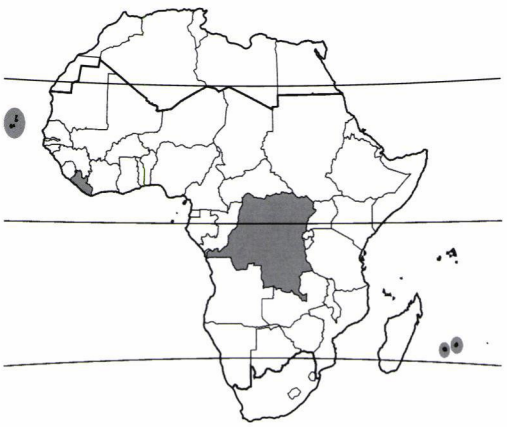
Authors C.H. Bosch

PHYTOLACCA AMERICANA L.

Protologue Sp. pl. 1: 441 (1753).
Family Phytolaccaceae
Chromosome number $2n = 36$
Synonyms *Phytolacca decandra* L. (1763).
Vernacular names Pokeweed, poke, inkberry, common pokeberry, red ink plant, poke root (En). Phytolaque, raisin d'Amérique, teinturier (Fr). Capa rosa, tintureira, uva de América, uva de macaco (Po).

Origin and geographic distribution *Phytolacca americana* originates from southern and eastern North America and Mexico and has been introduced into South America, Europe, Africa and Asia. In Africa its occurrence is documented in Cape Verde, Liberia, DR Congo, Réunion, Mauritius, South Africa and Swaziland. It has probably been introduced into other countries of tropical Africa as well, but documentation is lacking.

Uses In Réunion and Mauritius the powdered roots are applied to haemorrhoids. The crushed roots in alcohol are externally applied to rheumatic pains. The fruits and aerial parts have emetic and intestinal worm-expelling properties. In South Africa the root extract is taken to treat lung diseases. All plant parts, but especially the roots, are poisonous when taken fresh and in quantity. Symptoms of poisoning are burning of mouth and throat, salivation, severe stomach irritation, vomiting, bloody diarrhoea, spasms and convulsions; death may result from ingestion.
In the United States and Europe different plant parts are widely used to treat haemorrhoids, rheumatism, inflammations, skin diseases including skin parasites and cancer, general pain (fruit, roots), swellings, wounds and ulcers (leaves). The root extract is taken as an abortifacient and to treat sore throat and tonsillitis. The powdered roots are applied in a poultice to treat cancer. The fruit and seed extract is taken as a purgative, emetic, and to treat venereal diseases, scurvy and snakebites. In Cape Verde the fruits are used as food colorant, but the toxic substances must be removed first. In the United States and Europe the fruits have been used in traditional textile dyeing. They provide the red pigment 'Phytolacca red', but fruits are not permitted as a food dye, e.g. in Germany. The fruits were formerly used to reinforce the red colour of wine. In Réunion and Mauritius the young shoots are thoroughly cooked and eaten as a vegetable. This use is also widespread in the United States. *Phytolacca americana* is planted as an ornamental in temperate climates.



Phytolacca americana – naturalized

Production and international trade Although much research is currently being done on different compounds of *Phytolacca americana*, no quantitative information is available on production and trade of these compounds. In human and veterinary herbal medicine the root tincture is sold as an emetic.

Properties The leaves, fruits and roots contain several saponins (triterpenoid glycosides), i.e. phytolaccosides and esculentosides, with phytolaccosides B, E and G as main compounds. The anti-inflammatory activity of the roots has been attributed to the phytolaccosides and esculentosides. Phytolaccosides cause haemolysis of red blood cells. Phytolaccoside B prevents genetic modification of plants via *Agrobacterium tumefaciens*. It acts as a genuine plant transformation inhibitor, having neither anti-agrobacterial nor phytotoxic activity.
The roots, fruits and leaves contain several lectins, mitogenic-acting cysteine-rich glycoproteines, also known as pokeweed mitogens (PWMs) and pokeweed antiviral proteins (PAPs). The mitogens have a stimulating effect on the immune system, especially on the proliferation of T- and B-lymphocytes, and play an important role in fundamental leukocyte research. For several decades, PWMs have been investigated as a therapeutic agent for cancer treatment in animal models. PAPs represent a group of ribosome-inactivating proteins (RIPs). They are N-glycosidases that catalytically remove a specific adenine residue from ribosomal RNA. They not only inactivate both eukaryotic and prokaryotic protein synthesis, but also inhibit the mechanical transmission of viruses.

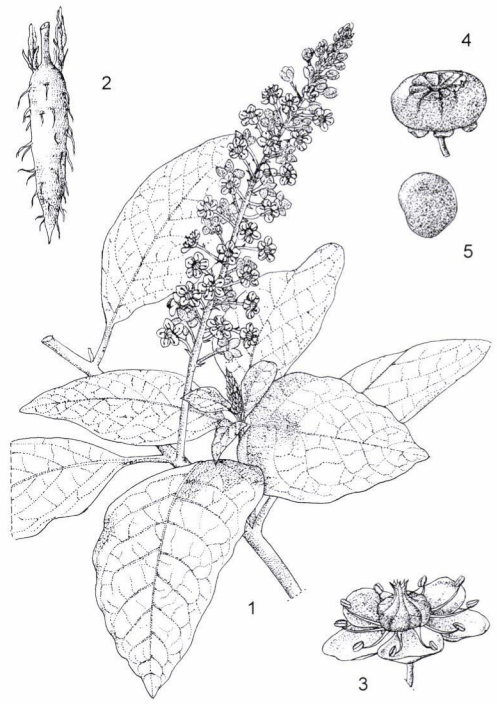
They have potent antiviral activity against many plant and animal viruses, including T-cell leukaemia virus, lymphoma virus, as well as human immunodeficiency viruses. PAPs show unique clinical potential to become the active ingredient of an antivirus drug because of their potent in-vivo anti-HIV activity and non-interference with in-vivo sperm functions. Some PAPs (PAFPs) also exhibit a broad spectrum of antifungal activity, including inhibition of certain saprophytic fungi and some plant pathogens.

The saponins and lectins are responsible for the toxicity of the plant, especially of the roots and seeds. Lethal poisoning of horses caused by eating the roots has been reported. The roots also have hypotensive properties; they contain the hypotensive compounds histamine and γ-aminobutyric acid. When ingested, leaves typically produce severe gastro-enteritis, characterized by intense vomiting and frothy diarrhoea. Aerial parts have been found to have antigalactagogic effects in cattle. Toxicity tests from extracts of the roots and fruits showed that only ripe fruits have significant molluscicidal properties, and are not toxic to other organisms at recommended doses. The methanol extract of dried seeds contains several antihepatotoxic neolignans, of which americanin A showed significant anti-inflammatory activity with very weak toxicity in tests with rats. α-Spinasterol has been isolated from the chloroform extract of the roots, shows anti-inflammatory properties, acts as an antimutagen and has therapeutic potential to modulate the development and progression of diabetic nephropathy.

The fruits contain the red pigment phytolaccanin, which is identical to betanine, commercially extracted from beetroot (*Beta vulgaris* L.).

Several phytolaccosides have been isolated from callus mass derived from the stems and roots.

Description Climbing or scrambling, semi-succulent, reddish herb up to 3.5 m tall, glabrous, with a fleshy taproot becoming very large. Leaves alternate, simple and entire; stipules absent; petiole 2–6 cm long; blade lanceolate to elliptical or ovate, 14–22 cm × 6–12 cm, base rounded, often asymmetrical, apex acute. Inflorescence an erect, axillary raceme up to 30 cm long, many-flowered; bracts up to 3 mm long, lanceolate. Flowers bisexual, regular, 5-merous, sweet-scented; pedicel up to 12 mm long, pink; sepals c. 2 mm long, rounded, whitish to pinkish; petals absent; stamens c. 10, free, filaments c. 2 mm long; ovary superior, consisting of c. 10 carpels, united or with free apices, styles connected, c. 1 mm long, stigmas linear. Fruit consisting of fused 1-seeded berries, smooth or sometimes ribbed, up to 6–8(–10) mm in diameter, ripening purplish black. Seeds kidney-shaped, laterally flattened, 3–4 mm long.



Phytolacca americana – 1, flowering branch; 2, root; 3, flower; 4, fruit; 5, seed.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Phytolacca* comprises about 25 species, most of which are native to the tropical and subtropical regions of South and Central America, with a few species in Africa, Madagascar and Asia. Other *Phytolacca* species with united carpels are *Phytolacca octandra* L. (inkberry, dyeberry) and *Phytolacca dioica* L. (belhambra tree, pokeberry tree), both originating from South America and now pantropical. In Africa *Phytolacca octandra* occurs in Nigeria, Kenya, Zimbabwe, Mozambique and South Africa. In South Africa the leaves are applied to septic wounds. A root maceration is drunk to treat lung ailments. Pulverized roots are taken as an emetic and applied externally to treat snakebites. Young

sprouts and leaves can be used as a vegetable. The roots contain triterpenoid saponins and lectins. *Phytolacca dioica* has been introduced in the drier regions of tropical Africa, and occurs in Cape Verde, Mali, Namibia, Botswana, Zimbabwe and South Africa. The leaves are eaten as a purgative. The fruit is poisonous. It is grown as an ornamental, roadside and shade tree. The leaves and seeds contain several ribosome-inactivating proteins (RIPs). The leaves are used in dying wool.

Growth and development *Phytolacca americana* has a lifespan of 3–10 years. It flowers in spring or at the beginning of the rainy season. Fruits develop 2–3 months later. Fruit set is usually high, suggesting a high degree of selfing. In North America the relative density of the plants in a population increases with decreasing soil pH and decreasing content of available phosphate. The seeds are dispersed by birds.

Ecology *Phytolacca americana* occurs in sunny anthropogenic localities, such as disturbed forest, forest margins, roadsides, river banks, fallow land and waste places at low altitudes. It prefers humus-rich and acidic soil in well-drained to moist habitats. It tolerates short periods of drought.

Propagation and planting *Phytolacca americana* is propagated by seed or stem cuttings. Prior to sowing, the fruits should be soaked in water for 48 hours to permit seed extraction. The seeds are sown in pots with humus-rich soil and regularly watered. Germination of unstratified seeds is generally high (about 80%), but may vary greatly both within as well as between plants. After one year, the seedlings can be transplanted into the field or in larger pots.

Mass multiplication is done by non-woody stem cuttings. It is advantageous to dip the end of the cutting in rooting powder or a rooting solution, plant in a slightly acid soil medium and to water regularly. After 6–8 weeks rooted cuttings can be planted in the field, usually at a spacing of 1–3 m × 2–3 m.

Management Regular watering and weeding are important until the crop is established.

Diseases and pests In Africa diseases and pests have not been reported for *Phytolacca americana*. However, it is an alternative host to a number of viral diseases, including mosaic, ringspot and yellow viruses that affect *Amaryllidaceae*, *Liliaceae* and *Solanaceae*. In Italy wilt and die-back symptoms were observed on plants cultivated for ornamental purposes caused by *Phytophthora nicotianae*.

Harvesting Very young, green leaves and sprouts are harvested in early spring for use as a vegetable. Roots are harvested at the end of the fruiting season.

Handling after harvest The harvested plant parts are usually used fresh.

Genetic resources *Phytolacca americana* is a common herb in its natural distribution area and therefore not threatened by genetic erosion. A number of ornamental cultivars of *Phytolacca americana* have been selected for their larger infructescences.

Prospects *Phytolacca americana* has an interesting chemistry as it contains glycoproteins and molluscicidal saponins. The first category includes compounds that have a stimulating effect on the immune system, play an important role in fundamental leukocyte research, and have potent antiviral activity, offering possibilities for future antiviral medicine development. *Phytolacca americana* is also an attractive ornamental plant.

Major references Aldea & Allen Gil, 2005; Balle, 1951; D'Cruz, Waurzyniak & Uckun, 2004; Gurib-Fakim, Guého & Bissoondoyal, 1997; Jeong et al., 2004; Nowicke, 1968; Watt & Breyer-Brandwijk, 1962.

Other references Belisario Maccaroni & Corazza, 2003; Bonness et al., 1994; Burkill, 1997; Clark, Appleton & Drewes, 1997; Di Maro et al., 1999; Fukuyama et al., 1992; Kang et al., 1997; Kanzaki et al., 1999; Kino et al., 1995; Kobayashi et al., 1995; Neuwinger, 2000; Razali Yusuf, 1999a; Shao et al., 1999; Tachibana et al., 1996; Takahasi et al., 2003; van Wyk, van Heerden & van Oudtshoorn, 2002; Yamaguchi, Mori & Funatsu, 1996; Yang et al., 2006a.

Sources of illustration Walter, 1909.

Authors G. Aweke

PHYTOLACCA DODECANDRA L'Hér.

Protologue Stirp. nov. 6: 143, pl. 69 (1791).

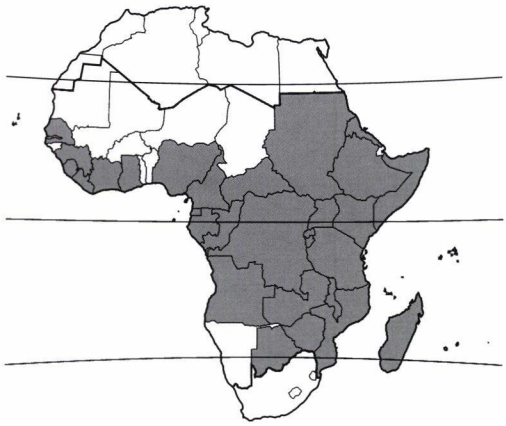
Family Phytolaccaceae

Chromosome number $2n = 36$

Vernacular names Endod, soap berry, African soap berry (En). Phytolaque, endod (Fr). Fitolaca, endod (Po).

Origin and geographic distribution *Phytolacca dodecandra* is native to sub-Saharan Africa and Madagascar. It has been introduced in Asia and tropical America.

Uses In Central and East Africa and Mada-



Phytolacca dodecandra – wild

gascar various parts of *Phytolacca dodecandra* are widely used as a medicine for numerous ailments, despite the toxicity of the plant. An extract of the roots, leaves, fruits and seeds is taken as a purgative for humans and animals, as an anthelmintic and to treat oedema and intestinal problems such as diarrhoea and abdominal pain, as a laxative, emetic, sudorific and diuretic. The leaf sap, and sometimes the crushed roots and fruits, are applied to wounds and skin ailments such as ringworm, scabies, eczema, psoriasis, leprosy, boils and vitiligo; the sap is cicatrizing and haemostatic and causes a burning sensation on the skin. In DR Congo the fresh, dried or powdered leaves are used for the same purposes. An infusion of the fruit or roots is taken orally and the young leaves and shoots are chewed to induce abortion. A large lump of butter is taken to stop further contractions. An infusion of the fruit or the root decoction is also widely taken to treat venereal diseases, bilharzia, rabies, malaria, sore throat and other respiratory problems, rheumatic pain, jaundice, as well as anthrax and leeches in animals. In southern Nigeria the leaf decoction is given to newborn babies as a gentle laxative. In Central Africa the mashed leaves are eaten with banana as a stimulant and tonic, especially after childbirth. In Congo the leaf sap is used as eye drops to cure conjunctivitis and river blindness. In Rwanda leaf sap is used as ear drops to treat otitis. In DR Congo the boiled leaves with chicken are given to children with asthma and tuberculosis. In East Africa ground leaves are applied to tumours; the root decoction is also drunk to cause vomiting as treatment of enlarged glands. In Tanzania macerated leaves or root bark are used to treat epilepsy. In Madagascar a decoction of the aerial parts is applied to treat haemorrhoids. In South Africa the root infusion is taken to treat infertility. In Uganda and DR Congo certain cattle tribes use the plant to increase milk production of cows.

The fruits, when dried, powdered and mixed with water, yield a foaming detergent, traditionally used in Ethiopia, Somalia and Uganda for washing clothes, and also to wash the body. Soap has also been made from the ashes of burnt plants in southern Nigeria, or from the fresh leaves in Angola.

In Ethiopia and Zimbabwe unripe fruits are widely applied to control bilharzia-transmitting snails, as they contain molluscicidal saponins. It is a cheaper and less toxic product than synthetic molluscicides. In East Africa the pounded plant is also used as a poison to catch fish.

There is considerable difference in opinion about the edibility of the leaves. In Côte d'Ivoire and southern Nigeria a sauce or soup is prepared from the young shoots and young leaves, and in DR Congo the leaves are cooked as a vegetable. In eastern and southern Africa the whole plant is considered poisonous, and it is said to have caused accidental death of people eating the leaves as a vegetable. In West Africa and Ethiopia the leaves are considered edible for cattle and goats, whereas in most of eastern and southern Africa they are considered poisonous. In Gabon the fruits are eaten. In East Africa the stems are used as ties in the construction of huts and fences. The fruits yield a red dye and the leaves a yellow dye. In Zimbabwe the most common use of the fruits is to colour the floor in houses. In Ethiopia *Phytolacca dodecandra* is planted as a hedge, and the leaf or fruit extract is sometimes added to drinks and foods as a stimulant, and to curdle milk. The plant is usually not used as firewood, as the smoke is believed to reduce the male sexual ability.

Production and international trade Small plantations of *Phytolacca dodecandra* exist in Ethiopia, Zambia, Zimbabwe and Swaziland, and in Ethiopia the fruits are commonly sold in the market for washing clothes.

Properties The leaves, fruits and roots contain numerous saponins (triterpenoid glycosides). These compounds cause haemolysis of red blood cells. The aglycones of the glycosides are mainly composed of oleanolic acid (66%), bayogenin (15%), hederogenin (9%), and 2-hydroxyoleanolic acid (6.5%). On a dry weight

basis the fruit pulp contains 25% saponins, and the non-saponin fraction contains a lipid fraction (palmitic acid, oleic acid, stearic acid and a non saponifiable bright orange, waxy material), sugars, starches, pectins and gums and a water insoluble fraction. The saponins have become important as they have strong molluscicidal activity against a range of water snails, and are readily soluble in water and easy to isolate. These properties are useful in the destruction of these snails, including vectors of human diseases such as bilharzia (schistosomiasis), which is caused by parasitic *Schistosoma* worms. However, the saponins are not active against the egg clusters of the snails. The active saponins have oleanolic acid as the aglycon, the 3 most important being oleanoglycotoxin A, lemmatoxin and lemmatoxin-C. The saponins in the fruit pulp are not molluscicidal, but become active after hydrolytic removal of one of the sugars. The hydrolytic enzyme is contained in the seed and to secure contact between saponins and enzyme and ensure the release of the molluscicidal saponins it is important to finely crush the fruits before soaking them in water. Green unripe fruits contain more active saponins than ripe ones.

Eating fruits or leaves may cause acute poisoning resulting in nausea, bloody diarrhoea, intense congestion of the stomach and intestines, vomiting, weakness, weak and irregular pulse, dilated pupils, swelling of the mucous membrane in the mouth and stupor; death may occur within a few days. Although the solutions of crushed fruits kill a range of aquatic life forms, including small fish, leeches, mosquito larvae, other stages of the bilharzia life-cycle (miracidia and cercariae), zebra mussels and tadpoles, the active ingredients are easily biodegradable and are eliminated from the water within 48 hours. Insect larvae and tadpoles are not affected at the concentrations that kill fish and snails. The molluscicidal potency remains stable over a wide range of pH (5–9), in the presence of various concentrations of organic and inorganic matter and also after irradiation with ultraviolet light. In acute mammalian toxicity tests the fruit extracts were classified as either non-toxic or slightly toxic, except for the eye, in which they can cause severe irritancy. Eye protection is therefore recommended during fruit crushing and handling of dry powders. Ecotoxicity tests indicated that the crushed fruits are no more toxic than currently recommended synthetic molluscicides. Toxicological studies also showed that the fruit extracts do not have mutagenic or carcinogenic properties.

The roots contain saponins of the phytolaccoside or esculentoside types. These compounds showed anti-inflammatory activity. The aqueous extract from the roots showed fungicidal activity against *Trichophyton mentagrophytes*. Hydroalcoholic extracts of the aerial parts showed significant activity against *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Histoplasma capsulatum* var. *farciminosum*, which causes epizootic lymphangitis. The leaf extract showed moderate activity against coxsackie virus in vitro. Butanol extracts of the fruits inhibit the growth of *Trichomonas vaginalis*, but fermented fruits were inactive. Butanol extracts of the fruits showed spermatocidal properties in vitro and blastocidal activity when injected directly into the uterus of rabbits. Oral administration of a water extract of the aerial parts did not show a significant effect on reproduction in mice.

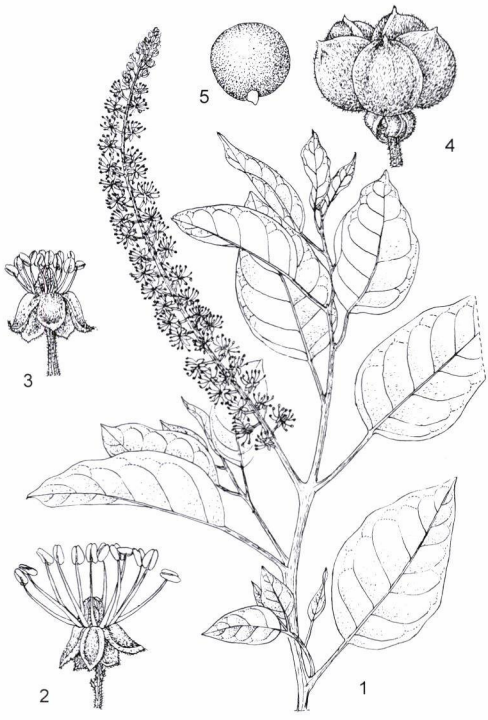
The leaves and stems produce the antiviral protein dodecandrin, which is a ribosome-inactivating protein (RIP), similar to pokeweed antiviral protein (PAP), isolated from *Phytolacca americana* L.

Application of the fruit and leaf extract reduced the levels of damage caused by larvae of the maize stalk borer (*Busseola fusca*), but 2 applications were not sufficient to provide complete protection of maize against second generation larvae.

Studies with callus and cell suspension cultures of *Phytolacca dodecandra* have established that significant amounts of triterpenoid saponins are produced and retained intracellularly by these cultures. These cultures also produce dodecandrin.

Adulterations and substitutes Several other plant species contain saponins with molluscicidal activity, including *Sapindus saponaria* L. and *Crossopteryx febrifuga* (G.Don) Benth., but the compounds responsible for the activity are often potent fish poisons and harmful to the environment.

Description Climbing or scrambling dioecious, semi-succulent shrub, sometimes a liana with stems up to 10(–20) m long, with a taproot; trunk sometimes up to 35 cm in diameter; stems usually glabrous. Leaves alternate, simple and entire; stipules absent; petiole 1–4 cm long; blade ovate to broadly elliptical, 3–14 cm × 1.5–9.5 cm, base rounded to slightly decurrent into the petiole, apex acute to rounded, mucronate, glabrous to shortly hairy.



Phytolacca dodecandra – 1, leafy branch with male inflorescence; 2, male flower; 3, female flower; 4, fruit; 5, seed.
Redrawn and adapted by Iskak Syamsudin

Inflorescence an axillary or terminal raceme 5–30 cm long, many-flowered, axis hairy; bracts up to 2.5 mm long, shortly hairy. Flowers functionally unisexual, 5-merous, sweet-scented; pedicel 2–8 mm long; male flowers with narrowly oblong, c. 2.5 mm long, reflexed, whitish to yellowish green sepals, petals absent, stamens 10–20 in 2 whorls, free, filaments 3–7 mm long, ovary usually rudimentary; female flowers with oblong to ovate, c. 2.5 mm long, reflexed sepals, accrescent in fruit, turning yellow to red, petals absent, stamens 8–12, rudimentary, ovary superior, consisting of (4–)5 free, ovoid carpels, styles 1–2 mm long, curved, stigmas linear. Fruit consisting of (4–)5 1-seeded berries fused at base, up to 15 mm in diameter, fleshy, remains of style pointing outwards at apex, ripening orange or purplish red. Seeds kidney-shaped, laterally flattened, 2–4 mm long, shiny black.

Other botanical information *Phytolacca* comprises about 25 species, most of which are native to the tropical and subtropical regions of South and Central America, with a few species in Africa and Asia. *Phytolacca dodecandra* shows extreme morphological variability in leaf hairiness, plant size and growth form.

Another medicinally used *Phytolacca* species with partly free carpels is *Phytolacca heptandra* Retz., occurring in Zimbabwe and South Africa. The Xhosa people in South Africa consider the plant very poisonous. A leaf or root extract is commonly drunk as a purgative and emetic. A leaf paste in beer or pulverized root in water is drunk to treat venereal diseases in men. A root decoction is used as an enema to treat enlarged prostate glands. Small amounts of plant pulp are taken as an emetic and applied externally to snakebites. A root maceration is drunk to treat chest pain and delirium. The root is used as bait to kill crows, jackals and stray dogs. In Zimbabwe the plant is also used as a purgative. Lung ailments in cattle are treated by letting them drink a root maceration. The fruit is edible.

Growth and development In Ethiopia *Phytolacca dodecandra* flowers and fruits throughout the year, but with a peak during the dry season, from October to April. However, in some parts of Ethiopia it fruits twice a year, in December–February and in June–July. Pollination is effected by insects such as ants, flies and spider wasps. The fruits are often eaten by birds and monkeys, which disperse the seed.

It is reported that the female flowers open later than the male flowers. A well-established plant has only a few but long roots that reach great depths.

Ecology *Phytolacca dodecandra* occurs in forest, forest margins, riparian forest, thickets, wetter bushland, in fences along cultivated land and around houses, on mountain slopes and in open fields, at (0–)1500–3000 m altitude. The plants grow best under direct sunlight in humid, weakly acidic soils that contain high levels of organic matter, in areas with an annual rainfall of about 1400 mm and a distinct dry period. In areas with high evapotranspiration, especially at lower elevations (below 1500 m) partial shade should be available so that the plants do not burn and wilt. Full shade substantially lowers both fruit yield and saponin concentration.

Propagation and planting Propagation of *Phytoloacca dodecandra* is by seed or by cuttings. Seed propagation results in equal chances of producing male and female plants, and plants start flowering 2 years after sowing.

Germination can be improved by scarification with sand. Fruits can be stored for up to one year without loss of viability, but after 4 years of storage, germination declines by 14%. Propagation by seed is only appropriate for selection purposes. Seed of *Phytolacca dodecandra* takes about 14 days to germinate. Clonal propagation is possible through non-woody cuttings with 2–3 nodes taken from the top or middle part of the plant. Rooting occurs with or without application of plant growth regulators. Rooted cuttings flower after about 6 months. Tissue culture has been successful for propagation, but the plants take about 18 months to flower. Procedures for routine micropropagation by shoot tip and nodal culture have been developed.

In Ethiopia six-week-old cuttings are transplanted in the field in holes of 60 cm × 60 cm, in a mixture of soil and manure or peat, at the beginning of the rainy season. Survival of transplants depends on availability of water for irrigation during the first and possibly during the second dry season, control of pests, evapotranspiration and soil salinity.

Management Plantations of *Phytolacca dodecandra* must be shaded in the first weeks after planting. Occasional watering and weeding are important until the crop has become established. For large-scale cultivation, plants should be spaced 2 m between rows and 1–2 m between plants. For each 10 female plants 1 male plant must be planted to ensure pollination. Annual pruning is necessary to maintain size and shape and to obtain maximum yield. Without pruning the plants become a tangled mass and the fruits are difficult to harvest. Pruning is done by removing the long horizontal branches and shortening erect branches. Intercropping with annual crops is possible because the plant develops few and deep taproots and does not compete much with annual crops for moisture and plant nutrients.

In a field test the best growth and the highest fruit yield were obtained with plants grown in full sunlight, under irrigation and with application of cattle manure. Irrigation was beneficial to fruit yield but reduced the saponin concentration; however, irrigation is beneficial for the total saponin yield. Addition of manure significantly increased growth and fruit yield, but the saponin concentration was lower. The combination of cattle manure and irrigation resulted in the highest total saponin yield.

Diseases and pests *Phytolacca dodecandra* is attacked by the larva of different stem- and leafminers (*Gitona* spp.), which bore through the stem and leaves into the phloem and tunnel in a spiral downwards, leaving a hollow sprout which is easily broken, killing the young shoots. Wilting of young shoots and abortion of inflorescences and fruits are symptoms of infestation. The insects can be chemically controlled by spraying insecticides. Some plants seem to have some natural resistance to the miner; the hairiness of the plant, the presence of raphid crystals in the tissue or the saponin content might contribute to this resistance. Nematodes are also a problem and can infest entire plantations, after which a new plantation site needs to be found.

Harvesting The fruits of *Phytolacca dodecandra* are harvested when full grown, but still green, because the saponin content is then highest. Also, ripe fruits are hard to harvest as they fall from the plant and are eaten by birds. Complete fruit bunches are collected manually.

Yield Annual fruit yield increases with the age of the plant up to about 15 years, with the greatest increase occurring between the first and third year.

In Ethiopia several highly molluscicidal and productive cultivars have been selected, and agronomic trials have been effected in eastern and southern Africa. In a field trial in Ethiopia different cultivars yielded between 1050 kg/ha to 2750 kg/ha of dried fruits, with a saponin content of 20–25%. The yield of dry fruits can increase to 3000 kg/ha 4 years after planting, slowly rising to a maximum of about 4000 kg/ha. The content of saponins varies seasonally: fruits harvested during the dry season just before the onset of the rains have the highest content.

Handling after harvest The harvested fruits must be dried immediately after collection in the open under shade or in the sun. Whole and powdered fruits can be stored at room temperature for up to 4 years without losing potency. Crushed fresh fruits or solutions prepared from them lose their potency within a few days. While grinding the dried fruits care should be taken protect the eyes from the irritating dust.

There are 2 ways of applying the fruits for snail control. The first is to make a slurry of the dried and ground fruits in water. Shortly before application the solution is diluted with river water and administered by siphoning the liquid into the river from a barrel. The rivers are treated when the water level is low and the snails are concentrated in relatively small ar-

eas. The second way is to extract the active principles only. This method is suitable for larger water bodies such as lakes, where focal application of the molluscicide is required and sprayers have to be used. In order to avoid blockage of the spray nozzle, an extract has to be prepared. The best results are obtained by soaking the dried and powdered fruits overnight and using butanol to make the extract.

Genetic resources *Phytolacca dodecandra* is widespread in Africa and is unlikely to be liable to genetic erosion. A major threat is the loss of habitats due to increasing demand for agricultural land. In Ethiopia most populations of *Phytolacca dodecandra* disappeared during the severe droughts in the 1970s and 1980s. Surviving populations are now almost exclusively confined to protected areas. It is important to preserve the genetic variation of the remaining plants.
In Ethiopia, germplasm collections of *Phytolacca dodecandra* are maintained at the Institute of Pathobiology and the Ethiopian Plant Genetic Resources Centre in Addis Ababa.

Breeding Among 500 different accessions from Ethiopia, 3 strains - E3, E17 and E44 - have been selected for exceptional growth, molluscicidal potency, yield and resistance to insect pests and drought. Based on the colour of the fruits, two types of plants can be distinguished in Ethiopia: 'Arabe' with pinkish to red fruits, and 'Ahiyo', with yellowish green fruits. The first type has a higher saponin content than the latter one.
A breeding programme needs to be launched to obtain cultivars with high fruit and saponin yields, pest resistance and the ability to grow under the agro-ecological conditions of the lowlands.

Prospects *Phytolacca dodecandra* fruits have great potential as a molluscicide. Agronomic studies to select cultivars with high fruit and saponin yields and pest resistance have been effected, but more research is needed to find ways of making the fruits serve as a supplement or substitute for other detergents. Socio-economic research is needed to evaluate the use of the fruits for local schistosomiasis control.

Major references Adams et al., 1989; Bonness et al., 1994; Esser, Semagn & Wolde Yohannes, 2003; Jansen, 1981; Lugt, 1986; Ndamba et al., 1996; Neuwinger, 2000; Nowicke, 1968; Tadeg et al., 2005; Wolde Yohannes, Esser & Semagn, 1999.

Other references Abebe et al., 2005; Bekele-Tesemma, Birnie & Tengnäs, 1993; Burkill, 1997; Chishimba, Lingumbwanga & Chongo, 1999; Demeke, Hughes & Lee, 1992; Getahun, 1976; Johns, Kokwaro & Kimanani, 1990; Kambu et al., 1989; Lambert et al., 1991; Lemma, Heyneman & Silangwa, 1984; Makhubu, Lemma & Heyneman, 1987; Mølgaard et al., 2000; Murengezi, 1993; Ndamba, Lemmich & Mølgaard, 1994; Polhill, 1971; Razali Yusuf, 1999a; Semagn, Stedje & Bjornstad, 2004; Yimtubezinash, Getahun & Chryssanthou, 2005.

Sources of illustration Polhill, 1971.

Authors C. Zimudzi

PICRALIMA NITIDA (Stapf) T.Durand & H.Durand

Protologue Bull. Jard. Bot. Brux. 2: 338 (1910).

Family Apocynaceae

Chromosome number $2n = 22$

Vernacular names Obéro, demouain à gros fruits, ebam (Fr). Lutete-lumene (Po).

Origin and geographic distribution *Picralima nitida* occurs from Côte d'Ivoire east to Uganda and south to DR Congo and Cabinda (Angola).

Uses Throughout its distribution area the seeds, bark and roots of *Picralima nitida* have a reputation as a febrifuge and remedy for malaria. They are also extensively used for pain relief and to treat chest and stomach problems, pneumonia and intestinal worms. Usually, the seeds or bark are crushed or chewed and eaten for this purpose, or a decoction from the roots, seeds or bark is drunk.



Picralima nitida – wild

In Côte d'Ivoire, Benin and Nigeria a bark or root decoction is taken against jaundice, and a leaf decoction is taken by mouth or used as a lotion against measles. The intensely bitter seeds are crushed and eaten with lemon juice to treat hernia, vomiting or diarrhoea. The crushed seeds are applied to abscesses. A paste of pulverized seeds and shea butter is rubbed on the abdomen to treat leucorrhoea in women. In Ghana a decoction of the seeds is employed as an enema and analgesic. The seeds are chewed as a tonic and stimulant. Dry leaves are boiled in water and taken to treat guinea worm. In Cameroon a fruit decoction is taken to cure cough or typhoid fever; in DR Congo the bark is used similarly. In Gabon people from the Pahouin tribe chew a little of the fruit and bark to allay hunger while on long marches in the bush. The bitter bark is boiled with sugar and the decoction is drunk against food poisoning or venereal diseases. In Congo a bark decoction is taken as a purgative or to treat hernia, and with other plants to relieve gonorrhoea. In southern Cameroon and Congo, a bark decoction is drunk to cure sterility in men. Leaf sap is dripped into the ear to treat otitis. The crushed seeds, roots or fruit pulp are also ingredients for arrow poison. In Ghana and DR Congo, immature fruits are pounded and thrown in the water as a fish poison.

The wood, called ebam in trade, is used to make a variety of small utensils, e.g. paddles, shuttles for weaving, dolls, combs, walking sticks, pestles and mortars, incense holders, bows and arrows, spade handles or spoons. Spoons or dippers are also made of the hard shell of the fruit.

Production and international trade The dried powdered seeds of *Picralima nitida* are encapsulated and marketed in Ghana under the brand name 'Picap capsules' for the treatment of diarrhoea and various types of pain. In Cameroon the seeds, bark and fruits are commonly sold in local markets. In 2002, the market price was about 2400 Fcfa (about US$ 5) for 550 g seed and bark.

Properties The stem bark, fruit and seeds of *Picralima nitida* contain as major compounds the indole alkaloids akuammine, akuammicine (strychnan class), akuammidine and akuammiline (both corynanthean class), akuammigine and the very similar alstonine, pseudo-akuammigine and picraline. The seeds are particularly rich in alkaloids (3.5–4.8%); akuammine is the principal alkaloid of the mature seeds, while minor alkaloids are pseudo-akuammicine, picranitine, picratidine (N-methylpicraline), eburnamine (desacetylpicraline) and desacetylakuammiline (rhazimol). The root bark contains akuammigine, akuammicine, picracine and desacetylpicraline, and the leaves akuammine, akuammigine, picraphylline and melinonine A. The stem bark also contains picracine.

Akuammine has strong sympathomimetic and local analgesic activities; its effects are comparable to that of cocaine. It causes marked and lasting hypotension in dogs, without affecting respiration. In higher doses it causes a strong inhibitory effect on intestinal peristaltic movements. At such doses it also has hypertensive activity with a weaker, but longer lasting effect than yohimbine.

Akuammigine shows clear sympatholytic activity and antagonizes the effect of adrenaline on the heart, vessels and regulatory centre of the circulation system. Akuammidine has hypotensive, skeletal muscle relaxant and local analgesic activities. Its local analgesic activity is about 3 times as potent as cocaine. It acts selectively as a sympatholytic, unaccompanied by parasympatholytic effects. It inhibits the irritability of the sympathetic nervous system and opposes akuammine. Pseudo-akuammigine acts as an indirect reversible and competitive parasympathomimetic. In low doses it excites and in high doses it inhibits the central nervous system, respiration, contraction of the skeletal muscles and contraction of the smooth muscles. It increases hexobarbital-induced sleeping time and has local analgesic, anti-inflammatory, cholinesterase-inhibiting and hypotensive activities. Pericine and pericalline, only present in cell suspension cultures of *Picralima nitida*, showed in vitro opium-antagonist activity.

In tests with mice, alstonine has shown antipsychotic effects in the treatment of schizophrenia, without some of the side effects of the commonly used drug clozapine. Alstonine appears to lack the proconvulsant properties of clozapine.

Extracts of the seeds have analgesic activities comparable to those of morphine in rats. It was demonstrated that the alkaloids akuammidine, akuammine, pseudo-akuammigine and akuammicine possess varying degrees of agonist and antagonist activities at opioid receptors in vitro. Akuammigine showed little or no efficacy in the opioid bioassays. As the analgesic actions are mediated via interaction with opioid receptors, the potential for causing addiction and dependence should also be investigated.

The seed extracts showed also significant anti-inflammatory activities in several rat models.
The extracts of roots, stem bark and fruit rind showed highly significant inhibitory effects in vitro against *Plasmodium falciparum*, including chloroquine-resistant strains, even in low concentrations. The dichloromethane extract of the fruit rind was the most active. The antimalarial activity is also present in the seeds and leaves, but at a lower level. Akuammine showed weak antimalarial activity against chloroquine-resistant *Plasmodium* strains. The basic fraction of the methanol extract of the stem bark exhibited significant antimicrobial activity against a wide range of gram-positive bacteria and fungi, but limited activity against gram-negative bacteria. The basic fraction had a similar minimum inhibitory concentration (MIC) for *Staphylococcus aureus* as the control drug ampicillin, and lower MIC values against *Aspergillus flavus* and *Aspergillus niger* than those of tiaconazole. In clinical trials, a cream formulation of the methanol extract of the stem bark of *Picralima nitida* exhibited impressive effectiveness against skin conditions of pityriasis versicolor, tinea pedis interdigitalis (athlete's foot), tinea capitis (ringworm of the head), and tinea corporis (ringworm of the body). A methanol extract of the stem bark was also found to be active against a visceral *Leishmania* isolate at concentrations of 50 µg/ml or less. A hot water extract of the stem bark had a significant effect against *Trypanosoma brucei*, which was statistically comparable to that of diminazene aceturate (Berenil), commonly used in the treatment of sleeping sickness. Bark and seed extracts caused hypoglycaemia in both normal and alloxan-induced diabetic rabbits by a mechanism independent of the availability of insulin from pancreatic β-cells. The seed extract exhibited faster hypoglycaemic activity than the standard drug tolbutamide. Acute toxicity tests in rats showed a dose-dependent acute intraperitoneal toxicity.
The wood is pale yellow, hard and elastic, and polishes and finishes well.

Adulterations and substitutes In Cameroon the stem bark of *Alstonia boonei* De Wild. is used by several traditional healers for treating typhoid fever, jaundice and malaria, and is most often used as a substitute for *Picralima nitida*. The leaves and bark of *Thomandersia hensii* De Wild. & T.Durand, the leaves and roots of *Mangifera indica* L. and the roots of *Carica papaya* L. are sometimes used as antimalarial drugs and febrifuge as a substitute for *Picralima nitida*. Similar indole alkaloids are found in *Tabernaemontana* species.

Description Shrub or tree up to 35 m tall, with white latex in all parts, glabrous; bole up to 60 cm in diameter; bark hard, brittle, pale to dark greyish black or brown, smooth to slightly rough or finely striped. Leaves opposite, simple and entire; stipules absent; petiole 1–2 cm long; blade elliptical to oblong, (5–)10–26 cm × 2–13 cm, base cuneate, apex abruptly acuminate, thickly papery to thinly leathery, pinnately veined with 14–23 pairs of lateral veins. Inflorescence a terminal or sometimes axillary, compound, umbel-like cyme 6–10 cm long, 10–35-flowered; peduncle 2–35 mm long, with 3 primary branches; bracts very small. Flowers bisexual, regular, 5-merous, fragrant or not, open during the day; pedicel 2–20 mm long; sepals almost free, imbricate, broadly ovate to almost orbicular, 5–7 mm long; corolla with fleshy cylindrical tube 25–45 mm long, hairy inside and narrowed below the insertion of the stamens, often greenish, lobes ovate, 14–30 mm × 6–10 mm, apex obtuse, spreading or erect, white to yellow; stamens inserted above the middle of the corolla tube, included, anthers ovate, 3–4 mm long; ovary superior, consisting of 2 separate carpels, united at the ex-



Picralima nitida – 1, flowering branch; 2, leafy branch; 3, flower from above.
Redrawn and adapted by Iskak Syamsudin

treme base by a disk-like thickening, style slender, 5–7 mm long, pistil head with an oblong basal part and a filiform stigmoid apex up to 1.5 mm long. Fruits consisting of 2 free obovoid to ellipsoid follicles 11–20 cm long, smooth, apex rounded, yellow to orange, 2-valved, several- to many-seeded. Seeds obliquely ovate, obovate to oblong, flattened, 2.5–4.5 cm long, smooth, brown to orange, embedded in soft white to orange pulp. Seedling with epigeal germination; cotyledons ovate to obovate or oblong, 10–13 mm long, base slightly cordate to rounded, apex obtuse to rounded.

Other botanical information *Picralima* comprises a single species and is restricted to Africa. It is related to *Hunteria* and *Pleiocarpa*.

Anatomy Wood-anatomical description (IAWA hardwood codes):
Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; 9: vessels exclusively solitary (90% or more); 13: simple perforation plates; 22: intervessel pits alternate; 23?: shape of alternate pits polygonal; 25: intervessel pits small (4–7 µm); 29: vestured pits; 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; (40: mean tangential diameter of vessel lumina ≤ 50 µm); 41: mean tangential diameter of vessel lumina 50–100 µm; 48: 20–40 vessels per square millimetre. Tracheids and fibres: (61: fibres with simple to minutely bordered pits); 62: fibres with distinctly bordered pits; 66: non-septate fibres present; (69: fibres thin- to thick-walled); 70: fibres very thick-walled. Axial parenchyma: 76: axial parenchyma diffuse; 77: axial parenchyma diffuse-in-aggregates; 78: axial parenchyma scanty paratracheal; 93: eight (5–8) cells per parenchyma strand; 94: over eight cells per parenchyma strand. Rays: (97: ray width 1–3 cells); (98: larger rays commonly 4- to 10-seriate); 108: body ray cells procumbent with over 4 rows of upright and/or square marginal cells; 115: 4–12 rays per mm; 116: ≥ 12 rays per mm.
(M. Thiam, P. Détienne & E.A. Wheeler)

Growth and development Trees growing at the same location generally have the same height and are probably of the same age. Young plants have a high competition capacity. *Picralima nitida* can be found flowering and fruiting throughout the year. The flowers are visited by insects during sunny days. Fruits of *Picralima nitida* are eaten by elephants, which disperse the seeds.

Ecology *Picralima nitida* is an understorey tree in rainforest, also in mature secondary forest and semi-deciduous forest along river banks, up to 900 m altitude.

Propagation and planting There are about 300–400 *Picralima* seeds/kg.

Harvesting Seeds, bark and other plant parts of *Picralima nitida* intended for trade or for local medicinal use are collected from wild plants.

Handling after harvest *Picralima nitida* seeds can be dried and stored for 0.5–2 years without loss of pharmacological activity.

Genetic resources *Picralima nitida* is a common species of the African forest zone, and is not threatened by genetic erosion. However, in some areas with a high human population pressure, the species has become scarce because of its use as medicinal plant or timber.

Prospects The specific indole alkaloids from *Picralima nitida* have very interesting properties, which have only partly been evaluated in tests, including some clinical trials. Extracts from different parts of *Picralima nitida* showed a marked activity against malaria; akuammine and alstonine were shown to be the most active alkaloids. These alkaloids may represent an entirely new antimalarial chemotype with possible advantages over existing drugs. More research is needed to confirm these findings. It has also been demonstrated that *Picralima nitida* has a broad activity for treating parasitic diseases, which lends credibility for its use against diarrhoea, gonorrhoea and intestinal worms. In clinical trials, the methanol extract of the stem bark exhibited impressive effectiveness against different skin diseases. More work, however, is required to develop the extract into a clinically useful antimicrobial and antifungal agent.
Akuammidine, akuammine, pseudo-akuammigine and akuammicine are opioid compounds, having significant analgesic activities. The mechanism of action and the potential for causing addiction and dependence should be investigated, as well as the toxicity.

Major references Burkill, 1985; Corbett et al., 1996; Ezeamuzie et al., 1994; Fakeye, Itiola & Odelola, 2000; François et al., 1996; Iwu & Klayman, 1992; Menzies et al., 1998; Neuwinger, 1996; Omino, 1996; Ramirez & García-Ribio, 2003.

Other references Adjanohoun et al., 1996; Aguwa et al., 2001; Ansa-Asamoah & Ampofo, 1986; Arens et al., 1982; Betti, 2002; Betti, 2004; CE-FAO, 1999; Duwiejua et al., 1995;

Duwiejua, Woode & Obiri, 2002; Endress et al., 1996; Fakeye et al., 2004a; Fakeye et al., 2004b; InsideWood, undated; Inya-Agha, 1999; Iwu et al., 1992; Kapadia, Angerhofer & Ansa-Asamoah, 1993; Neuwinger, 2000; Normand & Paquis, 1976; Obiri, 1997; Wosu & Ibe, 1989.

Sources of illustration Omino, 1996.

Authors N. Nyunaï & N. Njifutié

PIERREODENDRON AFRICANUM (Hook.f.) Little

Protologue Phytologia 3: 156 (1949).

Family Simaroubaceae

Synonyms *Mannia africana* Hook.f. (1862), *Pierreodendron kerstingii* (Engl.) Little (1949), *Quassia grandifolia* (Engl.) Noot. (1962).

Origin and geographic distribution *Pierreodendron africanum* occurs from Côte d'Ivoire east to DR Congo and south to Angola.

Uses Throughout its distribution area *Pierreodendron africanum* is used as an insecticide and rat poison. In Nigeria the fruits are pounded, mixed with boiled yam and palm oil and used as a bait to kill rats. Whole seeds with salt added are equally efficient at killing rats. The fruit peel and leaves are used as a tonic and the seed oil as a lotion against lice.

Properties The stem bark of *Pierreodendron africanum* contains quassinoids with antineoplastic properties, e.g. dehydroailanthinone and glaucarubinone. The main quassinoid compound is glaucarubin. The stem bark also contains indole alkaloids, canthine-6-one alkaloids, which have anticancer and antimicrobial properties.

An alcohol extract of the stem bark showed significant activity in vivo against leukaemia of mice and human throat cancer cells in vitro. Oral application of a chloroform extract of stems and roots showed good results against avian malaria in poultry.

Botany Monoecious, straggling tree up to 30 m tall; bark rough with square scales. Leaves alternate, in tufts at ends of branches, up to 1 m long, imparipinnately compound with 5–15 pairs of leaflets; stipules absent; petiolules c. 4 mm long; leaflets almost opposite, entire, lanceolate to elliptical, 8–30 cm × 3–9 cm, base rounded, asymmetrical, very shortly and abruptly acuminate and often thickened at apex, leathery, slightly hairy in young leaves. Inflorescence a thyrse up to 40 cm long. Flowers unisexual or bisexual, regular, 5-merous; calyx lobes c. 1.5 mm long; petals free, oblong, 0.5–1 cm long, red; stamens 10–15(–18), free; ovary superior, consisting of 5 free carpels. Fruit an oblong-ellipsoid drupe, c. 7 cm × 4.5 cm, yellow, fibrous, woody, 1-seeded.

Pierreodendron comprises a single species. *Pierreodendron kerstingii* (Engl.) Little was distinguished mainly based on the number of stamens, but it is now considered a synonym of *Pierreodendron africanum*. However, taxonomic studies of this poorly known genus are needed because the existence of cryptic species has been suggested on the basis of the strangely versatile habitat.

Ecology *Pierreodendron africanum* occurs in wet evergreen and dry deciduous forest, with comparatively few trees in intermediate types of forest.

Management The stem bark and fruits of *Pierreodendron africanum* are harvested from the wild.

Genetic resources and breeding *Pierreodendron africanum* is widely distributed but rare throughout its range and therefore it is considered vulnerable to genetic erosion.

Prospects The antitumour properties of *Pierreodendron africanum* will continue to attract attention of pharmacologists.

Major references Burkill, 2000; Guo et al., 2005; Kenfack et al., 2007; Kupchan & Lacadie, 1975; Vanhaelen-Fastré, R. et al., 1990.

Other references Adomou, 2005; Ampofo & Waterman, 1985; Gilbert, 1958; Hawthorne & Jongkind, 2006; Neuwinger, 2000; Nooteboom, 1962; Polonsky, J., 1973; Valeriote et al., 1998.

Authors C.H. Bosch

PIPER CAPENSE L.f.

Protologue Suppl. pl.: 90 (1782).

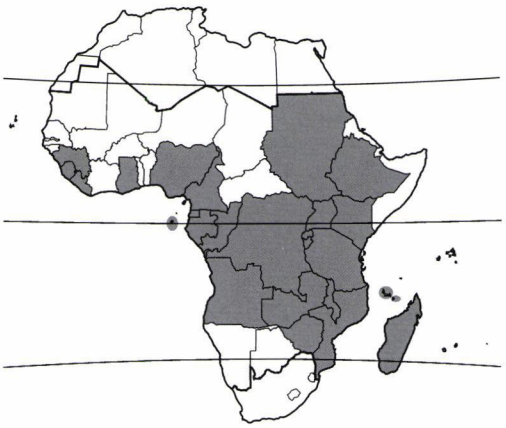
Family Piperaceae

Synonyms *Piper emirnense* Baker (1878).

Vernacular names Wild pepper (En). Poivrier du Cap (Fr). Fía boba pequena (Po). Mdeka (Sw).

Origin and geographic distribution *Piper capense* occurs from Guinea east to Ethiopia and south to Angola, Mozambique and South Africa. Its presence in West Africa is poorly documented. It also occurs in the Indian Ocean islands.

Uses Leaf preparations are widely used to treat abdominal disorders, kwashiorkor, bacterial skin infections and polio. A water extract of the leaves and stems is given as an enema to women a few days after delivery to remove the



Piper capense – wild

afterbirth. In Cameroon the aerial parts are used to treat epileptic attacks. In Madagascar a leaf infusion is considered one of the best remedies to treat bilious fever and haematuria. An ointment made from the root is applied to the soles of the feet to treat paralysis of patients suffering from cerebral bleeding. A sweetened root infusion or seed extract is taken against cough. A root infusion is also taken as an anthelminthic. The raw or cooked root is eaten as an aphrodisiac tonic. The bark is an ingredient of infusions given to treat sterility. Pulverized bark mixed with Vaseline is applied on wounds and against vaginal discharge, while a bark maceration is drunk to treat sore mouth and throat, chest complaints and venereal diseases. An infusion of the fruit in water or brandy is taken to treat stomach, heart and kidney problems and flatulence; it causes sweating and sleepiness. The fruits are taken in East Africa as a cough medicine, in South Africa as a vermifuge and diuretic, and in DR Congo as a vermifuge and stomachic. *Piper capense* also enters in herbal mixtures used in veterinary medicine, e.g. against rectal collapse, gastro-enteritis, hernia, anaplasmosis and rabies. In southern Tanzania the leaves are applied to swollen legs of cattle.

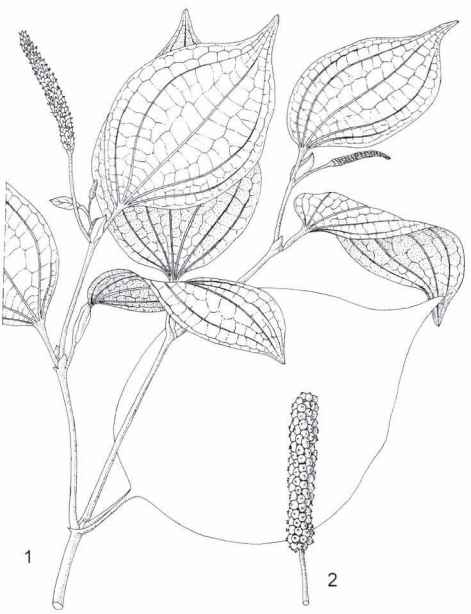
The fruits have been used as a spice in Ethiopia, Tanzania and South Africa because of their clove-like pungent-spicy flavour. In Tanzania the leaves are used as a forage.

Production and international trade *Piper capense* is only traded locally.

Properties Fresh leaves of *Piper capense* from Cameroon contain about 0.2% essential oil and the seeds 1.4%. Both essential oils are rich in monoterpene hydrocarbons and contain mainly α-pinene, β-pinene, camphene and sabinene. In an in-vitro test, the antifungal properties of the essential oils were weak. Aerial parts of plants from São Tomé contained mainly monoterpene and sesquiterpene hydrocarbons, including α-pinene, β-pinene, benzenepropanoic acid-ethyl ester, β-caryophyllene and smaller amounts of limonene, β-phellandrene, linalool, germacrene-D, (E)-nerolidol and γ-muurolene. From the roots the sesquiterpene capentin and several neo-lignans have been isolated. A crude root extract showed significant antibacterial activity against *Staphylococcus aureus*, *Streptococcus pyogenes* and *Corynebacterium xerosis* in vitro.

The above-ground parts of the plant, which are a common food of wild animals, contain 88% water and 12% dry matter; the latter contains per 100 g: crude protein 6 g, neutral detergent fibre 51 g, acid detergent fibre 34 g, acid detergent lignin 8 g, water soluble carbohydrates 12 g.

Description Aromatic, evergreen shrub or sometimes liana from a tuberous rootstock, up to 3 m tall or with trailing stems 4(–5) m long; stems terete, weak, greenish, glabrous to long-



Piper capense – 1, flowering twig; 2, infructescence.
Redrawn and adapted by Achmad Satiri Nurhaman

hairy at swollen nodes of 3 cm in diameter. Leaves alternate, simple and entire; stipules lanceolate, 1–1.5 cm long, adnate to petiole and enclosing the stem, soon falling; petiole 0.5–5(–8.5) cm long, grooved above near base, glabrous or hairy; blade broadly ovate to elliptical, 5–18 cm × 2.5–15 cm, base cuneate, rounded or slightly cordate, slightly asymmetrical, apex acuminate, dark green above, pale green or greyish to glaucous below, glabrous or hairy below, palmately veined with (3–)5–11 veins, 3 median ones reaching the apex. Inflorescence a solitary terminal or leaf-opposed spike, creamy white; peduncle 1–5 cm long, glabrous, rachis 2.5–8.5(–10) cm long. Flowers minute, bisexual or male in separate spikes, or male and bisexual flowers on one spike with male flowers towards the base, sessile; perianth absent; stamens 2–3; ovary superior, ovoid, 1-celled, with short style and 2 recurved stigmas. Fruit a globose-ovoid drupe 2–4 mm long, sessile, 1-seeded. Seed brown, shiny.

Other botanical information Estimates of the number of species included in *Piper* range from 1400 to more than 2000; about 15 species are native or naturalized in tropical Africa. In *Piper capense* 2 varieties are recognized: var. *capense*, which occurs throughout the distribution area of the species, and var. *brachyrhachis* (C.H.Wright) Verdc., which occurs from south-western Tanzania to Zambia. Var. *brachyrhachis* differs in more densely hairy leaves and shoots, and in shorter spikes (up to 2 cm long). *Piper capense* is closely related to the Asian *Piper nigrum* L. (black pepper).

Growth and development In southern Africa *Piper capense* flowers from August to February and fruits from October to June. It may flower throughout the year when enough water is available.

Ecology *Piper capense* occurs in the understorey of evergreen rainforest, swamp forest and moist riverine forest, but also in mixed bamboo forest, scrub and thicket vegetation near streams, from sea-level up to 2500 m altitude.

Propagation and planting *Piper capense* is mainly propagated by seeds, although stem cuttings can be planted successfully as well.

Management *Piper capense* is not cultivated, but collected from the forest when required.

Genetic resources *Piper capense* has a wide area of distribution and is not in danger of genetic erosion.

Prospects *Piper capense* is likely to remain important in traditional medicine. Its widespread and common use in traditional medicine warrants further research to fully evaluate its potential.

Major references Burkill, 1997; Diniz, 1997; Green & Wiemer, 1991; Immelman, 2000; Martins et al., 1998; Neuwinger, 2000; Rothman et al., 2006.

Other references Balagizi Karhagomba & Ntumba Kayembe, 1998; Balle, 1948; Boiteau, Boiteau & Allorge-Boiteau, 1999; Chen, Green & Wiemer, 1992; Chifundera, 1998; Coates Palgrave, 1983; Gilbert, 2000b; Green, Galinis & Wiemer, 1991; Keay, 1954b; Latham, 2007; Noumi & Fozi, 2003; Ntezurubanza & Ayobangira, 1987; Obi et al., 2002; Reilly et al., 1992; Van Puyvelde et al., 1985; Verdcourt, 1996; Verger, 1995; Yamada, 1999.

Sources of illustration Immelman, 2000.

Authors C. Zimudzi

PIPER UMBELLATUM L.

Protologue Sp. pl. 1: 30 (1753).

Family Piperaceae

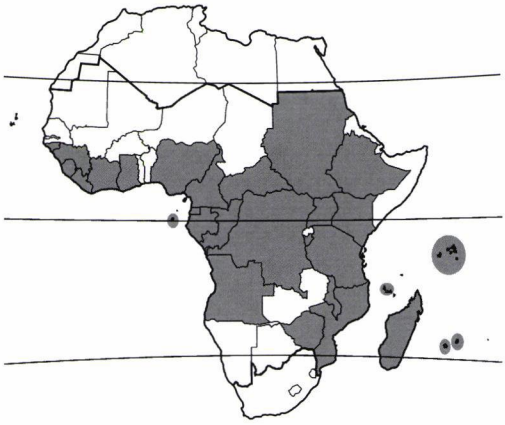
Chromosome number $2n = 24, 26, 28$

Synonyms *Piper subpeltatum* Willd. (1797), *Pothomorphe subpeltata* (Willd.) Miq. (1840), *Pothomorphe umbellata* (L.) Miq. (1840).

Vernacular names Cow-foot leaf (En). Bois d'anisette, grand baume (Fr). Algodãozinho do campo, pariparoba (Po). Mtunda ya mbwa (Sw).

Origin and geographic distribution *Piper umbellatum* originates from tropical America, and has been introduced and widely naturalized throughout the tropics, including mainland tropical Africa and the Indian Ocean Islands. In mainland Africa it occurs from Guinea and Sierra Leone east to Ethiopia and south to Angola and Mozambique.

Uses In tropical Africa and elsewhere in the tropics the leaves of *Piper umbellatum* are widely used as an emollient, vulnerary and antiseptic. They are employed in poultices on swellings, boils and burns; the juice is taken as an emmenagogue, galactagogue and diuretic, or used as ear drops against earache. A decoction of the leaves or roots is taken to relieve jaundice, malaria, urinary and kidney problems, syphilis and gonorrhoea, leucorrhoea, menstrual problems and stomach-ache, and is also applied on wounds and inflamed tumours. The root is considered stimulant, diuretic and to promote the flow of bile. A root decoction is used as a powerful digestive and as a treat-



Piper umbellatum – *naturalized*

ment for dyspepsia, constipation and stomachache. Throughout Africa, the leaves are used in massages for migraine and other forms of headache, and in decoction as a wash for feverish children. In Liberia an infusion of young ground leaves is taken to treat severe colic. In Côte d'Ivoire and Central Africa the aerial parts are commonly given to women to regulate menses and prevent abortion; as an enema the crushed leaves are applied to treat rectal prolapse. In Ghana the leaf pulp or roots are macerated in alcohol and taken to treat rheumatism. In Cameroon a leaf decoction is given to treat hypertension and toothache. The plant is used to expel tapeworms, e.g. in Guinea, whereas in DR Congo the leaves are considered a vermifuge. In the Central African Republic pounded twigs and seeds mixed with salt are taken against intestinal worms and in Congo suppositories of the leaves are given against pinworms. In Madagascar the leaves are applied in friction to relieve rheumatic pain. In Brazil *Piper umbellatum* is much used in baths to subdue oedema and uterine complaints. In Peninsular Malaysia the fruits are chewed with betel leaves (*Piper betle* L.) to treat cough. In the Philippines the juice of the leaves is applied in the eyes against conjunctivitis. In Indo-China the leaves and fruits are used to treat pain in the kidneys, oedema, anaemia and colic. In south-western Côte d'Ivoire, South-East Asia and South America *Piper umbellatum* is an ingredient of an arrow poison. In Ghana the plant is said to attract fish and is used in bait mixtures in game traps. It is a fetish for many peoples, e.g. in Gabon, where it is used for provoking compassion.

In many parts of the tropics the young leaves and inflorescences are eaten raw, steamed or boiled as a vegetable or condiment with fish or meat and rice. In Sierra Leone the leaves are a favourite leafy vegetable, eaten slightly cooked or minced with fish or meat. The Temne people use the basal part of the stem, which sometimes has a thick and corky bark, as a condiment with rice or palm oil sauce. In the Central African Republic the stem-pith and the inflorescence enter in the preparation of a mucilaginous condiment. In tropical Asia the sweet, ripe fruits are eaten as a delicacy.

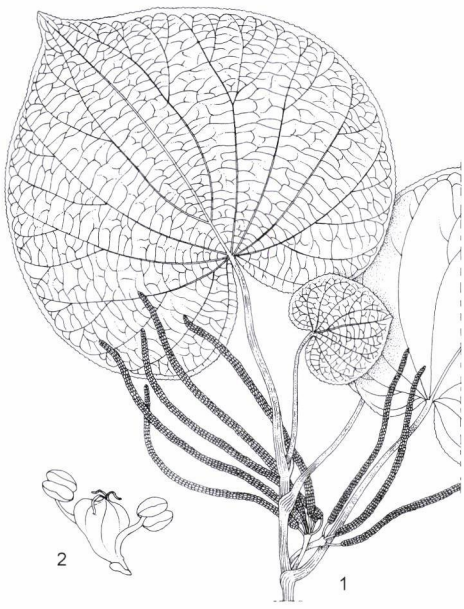
Production and international trade *Piper umbellatum* is only traded locally.

Properties The essential oil from the aerial parts of *Piper umbellatum* has a high content of β-pinene (27%), α-pinene (18%), (E)-nerolidol (12%) and β-caryophyllene (10%). Other compounds found include safrole, germacrene-D, β-cadinene, δ-cadinene and bicyclogermacrene. The roots and aerial parts contain 4-nerolidylcatechol, a powerful antioxidant with chemopreventative potential. This may explain the traditional use of *Piper umbellatum* in the treatment of skin cancer. In mice 4-nerolidylcatechol inhibits the effect of the myotoxic phospholipase venoms of several lancehead vipers (*Bothrops* spp.); however, the protective effect is slow, while the venoms act very fast. Therefore, 4-nerolidylcatechol is not a candidate antivenom, but may provide a lead structure to develop novel inhibitors.

A methanol extract of the leaves showed significant anti-malarial activity against *Plasmodium falciparum* in vitro. Subsequently, a crude ethanol extract of the leaves of *Piper umbellatum* was administered orally and subcutaneously to *Plasmodium berghei*-infected mice, and showed strong antimalarial activity, significantly reducing the level of parasites in a dose-dependent manner. An aqueous extract of the aerial parts administered intraperitoneally to rats caused a decrease in watchfulness for 48 hours, together with a fall of body temperature, a decrease of spontaneous motor activity and an increase of analgesic activity. A water-ethanol extract showed anti-inflammatory and analgesic effects in mouse and rat models.

The acrid compounds of the leaves and roots are irritant in high doses and cause severe inflammation of the gastrointestinal tract. They cause burning, salivation, stomatitis, vomiting, severe abdominal pain and diarrhoea.

Description Perennial herb or scrambling



Piper umbellatum – 1, flowering stem; 2, pistil and stamens.
Source: PROSEA

shrub up to 4 m tall, much-branched from near the base; stems from a woody rootstock, succulent, ribbed, rooting at the nodes. Leaves alternate, simple and entire; stipules absent; petiole 6.5–30 cm long, sheathing basally; blade almost circular to kidney-shaped, 5–36(–40) cm × 4.5–37(–42) cm, base deeply cordate, apex shortly acuminate to rounded, fairly thin, dark green above, greyish underneath, glandular black punctate, sparsely to densely hairy on the veins above and below, palmately veined with 11–15 veins. Inflorescence an axillary or leaf-opposed spike 5.5–15 cm long, 2–8 together in false umbels; peduncle 3–12 cm long; bracts on peduncle narrow, 6–8 mm long, white, caducous, floral bracts triangular to rounded, up to 1 mm wide, margins hairy, white, cream or yellow. Flowers minute, bisexual, sessile; perianth absent; stamens 2; ovary superior, 1-celled, stigmas 3. Fruit a 3-angled fleshy drupe 0.5–1 mm × c. 0.5 mm, brownish, 1-seeded. Seed globose, minute.

Other botanical information Estimates of the number of species included in *Piper* range from 1400 to more than 2000; about 15 species are native or naturalized in tropical Africa. Most species are primarily used as a spice, but also have medicinal uses. The leaves and stems of *Piper sylvestre* Lam., which occurs in India, Sri Lanka and the Indian Ocean islands, are chewed in Madagascar to make the teeth blackish or reddish, to protect them from caries. A leaf infusion is taken to prevent epileptic attacks. The fruits are used as a condiment. In Mauritius tea made from the leaves is taken to treat fever and haematuria, and as a diuretic and depurative.

Growth and development *Piper umbellatum* may flower throughout the year when enough water is available.

Ecology *Piper umbellatum* occurs in the undergrowth of evergreen rainforest, but also in clearings and on river banks; it always occurs in damp localities, up to 1800(–2100) m altitude. It is a common weed of plantations; in cacao farms in Ghana and in oil-palm plantations in Cameroon it can be troublesome.

Propagation and planting *Piper umbellatum* is propagated by seed. The seeds show dormancy, which can be broken by direct sunlight.

Management *Piper umbellatum* is only occasionally cultivated, mostly in home gardens. Production methods of 4-nerolidylcatechol based on in-vitro cultivation of parts of *Piper umbellatum* are being developed.

Harvesting The leaves, fruits and roots of *Piper umbellatum* are harvested whenever needed, usually from the wild.

Handling after harvest *Piper umbellatum* is mainly used fresh.

Genetic resources *Piper umbellatum* is very widely distributed and not in danger of genetic erosion.

Prospects 4-Nerolidylcatechol is an antioxidant with several promising pharmacological activities. It may also provide information leads for effective antivenoms to treat viper bites. Its widespread and common use in traditional medicine warrants further research to fully evaluate its potential as an analgesic and wound-healing plant, and also its antimalarial properties.

Major references Desmarchelier et al., 1997; Diniz, 1997; Gurib-Fakim, Guého & Bissoondoyal, 1997; Neuwinger, 2000; Núñez et al., 2005; Perazzo et al., 2005; Pino et al., 2005; Ropke et al., 2006; Schmelzer, 2001; Verdcourt, 1996.

Other references Adami et al., 1998; Agbor et al., 2005; Balle, 1948; Bioka & Abena, 1990; Boiteau, Boiteau & Allorge-Boiteau, 1999; Gilbert, 2000b; Gurib-Fakim, 1994; Gurib-Fakim

et al., 1993; Hammer & Johns, 1993; Keay, 1954b; Kijjoa et al., 1980; Luz eta al., 1999; Martins et al., 1998; Morton, 1981; Najib Nik a Rahman et al., 1999; Neuwinger, 1996; Noumi, Houngue & Lontsi, 1999; Viana, Tavares & Mattos, 2000.

Sources of illustration Schmelzer, 2001.

Authors M. Domis & L.P.A. Oyen

Based on PROSEA 12(2): Medicinal and poisonous plants 2.

PISONIA LANCEOLATA (Poir.) Choisy

Protologue DC., Prodr. 13: 442 (1849).

Family Nyctaginaceae

Synonyms *Pisonia calpidia* Steud. (1841).

Vernacular names Bois carotte, bois de joli cœur, bois mapou, mapou (Fr).

Origin and geographic distribution *Pisonia lanceolata* is endemic to Mauritius and Réunion.

Uses A leaf poultice of *Pisonia lanceolata* mixed with salt and wrapped in the leaves of *Ricinus communis* L. or *Terminalia catappa* L. is used to treat poisonous fish bites. The leaves are also used in the treatment of syphilis, chronic gastro-enteritis and childhood eczema, or as an astringent and depurative. The young sprouts are eaten as a cooked vegetable and taste like cabbage.

Properties The leaves and stems of *Pisonia lanceolata* contain alkaloids, phenols, tannins, coumarins, sterols, terpenes and traces of saponins.

Botany Small tree up to 8 m tall, with thick and short bole. Leaves alternate, opposite, or in whorls at the top of the branchlets, simple and entire; stipules absent; petiole 0.5–3 cm long; blade ovate, obovate to elliptical, sometimes almost circular, 5–18 cm × 2–8 cm, base cuneate to rounded, apex acute to obtuse, papery to leathery, lateral veins almost invisible. Inflorescence an axillary or terminal umbel-like panicle, 3–13 cm long, with reddish short hairs or almost glabrous, many-flowered; bracts absent or inconspicuous; peduncle 3–8 cm long. Flowers unisexual, regular, 5-merous, scented; pedicel short; perianth funnel-shaped, 6–8 mm long, lobes triangular to ovate, 2–3.5 mm long, curved at apex, with small, triangular lobes between the other lobes, pink; male flowers with 9–13 included stamens and rudimentary ovary; female flowers slightly smaller than male flowers, with superior, ovoid, 1-celled ovary, style included, stigma papillose and mushroom-shaped, staminodes c. 10, shorter than the style. Fruit an achene enclosed by the thickened lower part of perianth (anthocarp), anthocarp obconical, 4–6 cm long, 5-ribbed, with glandular hairs, 1-seeded. Seed oblong, with a deep longitudinal furrow.

Pisonia comprises about 35 species, of which about 20 occur in tropical America, 1 is pantropical (*Pisonia aculeata* L.), and the other species occur in the Old World tropics, from the Indian Ocean islands to South-East Asia and Oceania. *Pisonia aculeata*, occurring throughout tropical Africa, is listed officially in Mexico's Pharmacopoeia and is used as medicinal plant in the Philippines, Thailand and India. In Africa, the only recorded medicinal use is in Côte d'Ivoire, where the juice from the leaves is used as drops against earache.

Ecology *Pisonia lanceolata* occurs in the remains of natural forest, in rocky localities, in the mountains or along rivers and lakes.

Genetic resources and breeding The natural distribution of *Pisonia lanceolata* is restricted and it is considered vulnerable. In Mauritius in situ conservation is taking place in several national parks.

Prospects Because of the widespread medicinal use of several *Pisonia* species in Asia, more research into the chemical composition and pharmacological activities of the compounds of *Pisonia lanceolata* seems warranted.

Major references Gurib-Fakim & Brendler, 2004; Gurib-Fakim, Guého & Bissoondoyal, 1996; Philcox & Coode, 1994.

Other references Cavaco, 1954; Schmelzer & Bunyapraphatsara, 2001; Tra Bi, Kouamé & Traoré, 2005.

Authors A. de Ruijter

PLAGIOSTYLES AFRICANA (Müll.Arg.) Prain

Protologue Bull. Misc. Inform. Kew 1912: 107 (1912).

Family Euphorbiaceae

Origin and geographic distribution *Plagiostyles africana* occurs from Nigeria to Gabon and DR Congo.

Uses Throughout Central Africa, a bark decoction is drunk to treat pulmonary complaints and feverish stiffness. In Gabon a wood decoction is taken to promote milk production in nursing mothers. A decoction of the fresh leaves is drunk to treat constipation. Crushed fresh leaves are applied to burns. In Congo sap from the inner bark or leaves is drunk as a

purgative to expel intestinal worms in children. A leaf maceration is drunk to treat stomach spasms and heartburn. Pulverized bark with kaolin and palm oil is rubbed onto painful areas to treat side and kidney pain, headache and rheumatism. Plant sap is applied as eye drops to treat filariasis and conjunctivitis, and pounded leaves are applied to snakebites, scabies and areas of itch. Twig sap is given in water as a tranquilizer in case of fits of insanity, and is also used as a wash. In DR Congo a maceration of the inner bark is inserted into the ear to treat earache and deafness. In Gabon pounded leaves are used as fish poison. Throughout Central Africa the plant, especially the bark, is widely used in charms and religious rituals.

The wood is yellowish white and is used in Gabon to make spoons, combs and hair pins. It is suitable for flooring, poles, piles, joinery, interior trim, furniture, cabinet work, vehicle bodies, sporting goods, toys, novelties, boxes, crates, carving, turnery, veneer and plywood.

Properties The stem bark of *Plagiostyles africana* contains phorbol esters. An aqueous stem bark extract showed antifungal activity against several human and plant pathogens. A methanol extract of the stem bark showed significant antimicrobial activity against several Gram-positive bacteria, but not against Gram-negative bacteria.

The heartwood is greyish brown, often with attractive dark veins and lustrous. It is more or less distinctly demarcated from the pale yellow, very wide sapwood. The grain is straight, texture fine but often uneven.

The wood is heavy, with a density of about 910 kg/m^3 at 12% moisture content. It should be air dried slowly and carefully to avoid excessive splitting and warping. The rates of shrinkage are high, from green to oven dry 5.8% radial and 12.1% tangential. At 12% moisture content, the modulus of rupture is 192 N/mm^2, modulus of elasticity 16,660 N/mm^2, compression parallel to grain 85 N/mm^2, shear 13.5 N/mm^2, cleavage 27.5 N/mm^2 and Chalais-Meudon hardness 7.1.

The wood saws and works well considering its density, with both hand and machine tools. It can be planed to a smooth surface and takes a high polish. The nailing and screwing properties are good. The wood is suitable for peeling and slicing. It is moderately durable and susceptible to *Lyctus* attack.

Botany Dioecious, glabrous shrub or small to medium-sized tree up to 25 m tall; bole up to 80 cm in diameter, branchless for up to 12 m; bark surface brown, smooth, often with patches of horizontal ridges, with whitish latex. Leaves alternate, simple; stipules small; petiole 0.5–4(–5) cm long; blade elliptical to lanceolate, 8–20(–25) cm × 2.5–9(–10) cm, base cuneate, apex acuminate, margins undulate to shallowly toothed, shiny, pinnately veined with 7–10 pairs of lateral veins. Inflorescence an axillary raceme or panicle; male inflorescence 1–11 cm long, female inflorescence 1.5–3.5 cm long; peduncle reddish; bracts broadly ovate, c. 1 mm long. Flowers unisexual, petals absent; male flowers with pedicel 3–9(–12) mm long, calyx lobes 5–8, broadly ovate, up to 1 mm long, stamens 15–32, c. 1.5 mm long; female flowers with pedicel 1–2 mm long, enlarging to 5–10(–15) mm in fruit, calyx lobes 5, unequal, broadly ovate, up to 1 mm long, ovary superior, ellipsoid, c. 3 mm long, 1(–2)-celled, stigma almost sessile, thickened. Fruit a transversely oblong drupe c. 1.5 cm × 2.5 cm × 1.5 cm, glabrous, maturing red, finally black, 1(–2)-seeded. Seed transversely oblong, c. 1 cm × 2 cm × 1.5 cm. Seedling with epigeal germination.

In Gabon the fruits ripen in October–December. They are sweet and eaten by chimpanzees and gorillas, which may disperse the seeds.

Plagiostyles comprises a single species. It is markedly similar to the South-East Asian genus *Pimelodendron*.

Ecology *Plagiostyles africana* occurs in rainforest, commonly in secondary forest.

Management In many regions within its distribution area, *Plagiostyles africana* is quite common, e.g. in forest near Edéa (Cameroon) the average density of stems with a diameter of more than 15 cm is 0.5 per ha, with an average wood volume of 0.75 m^3/ha, and in Gabon the average wood volume is 2.1 m^3/ha.

Genetic resources and breeding *Plagiostyles africana* is relatively frequent in its area of distribution and therefore not likely to be threatened by genetic erosion.

Prospects *Plagiostyles africana* is commonly used as a medicinal plant, but apart from some encouraging antifungal and antibacterial activities of the stem bark, not much is known on the chemistry or pharmacology. More research is therefore warranted to evaluate its potential to develop lead compounds for the pharmaceutical industry. Although the wood is generally not highly valued, *Plagiostyles africana* may have prospects for sustainable harvesting from natural forest, but re-

search on ecology, regeneration and growth rate is needed.

Major references Bolza & Keating, 1972; Burkill, 1994; Gangoue Pieboji et al., 2006; Neuwinger, 2000; Takahashi, 1978.

Other references Adjanohoun et al. (Editors), 1988; Beutler, Alvarado Lindner & McCloud, 1996; Bouquet, 1969; de Saint-Aubin, 1963; Gassita et al. (Editors), 1982; Lainé et al., 1985; Léonard, 1962; Raponda-Walker & Sillans, 1961; Vivien & Fauré, 1985; Wilks & Issembé, 2000.

Authors G.H. Schmelzer & R.H.M.J. Lemmens

PLANTAGO LANCEOLATA L.

Protologue Sp. pl. 1: 113 (1753).

Family Plantaginaceae

Chromosome number $2n = 12, 18, 24$

Vernacular names Ribwort (plantain), rib grass, small plantain, narrow-leaved plantain (En). Plantain, herbe Caroline, plantain lancéolé, herbe-à-cinq-côtes (Fr).

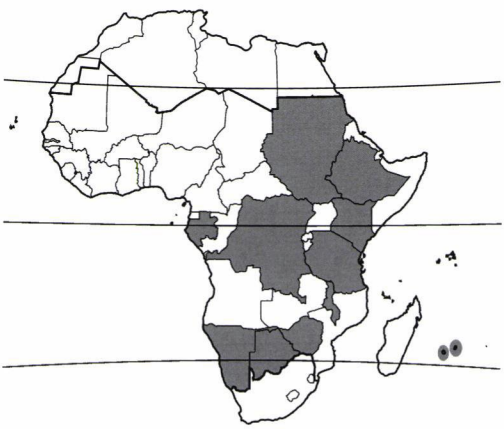
Origin and geographic distribution Originally from Europe and northern and central Asia, *Plantago lanceolata* is now cosmopolitan. In Africa it occurs mainly in the eastern and southern parts, including South Africa. It is common in Mauritius and Rodrigues.

Uses In temperate regions, *Plantago lanceolata* has largely the same traditional uses as *Plantago major* L.. The leaves are used as a diuretic and astringent, and to treat wounds, insect stings, sunburn, skin diseases, eye irritation and inflammation of mouth and throat. An infusion acts as a general detoxifier of the body, and is taken to treat colds, cough, hoarseness, asthma, emphysema, bronchitis, fevers, gastritis, ulcers, bladder problems, kidney stones, intestinal complaints, irregular menstrual flow, hypertension, rheumatism and hay fever. An infusion of the dried seeds is applied as a soothing eye lotion, taken as a treatment for diarrhoea and dysentery or for intestinal worms in children. In modern phytotherapy the leaves are used in cough syrups to alleviate irritation. Macerates, fluid extracts, syrups and juice from the fresh plant are all used for treating inflammation of the mouth and throat, and externally for inflamed skin.

In tropical Africa the uses in traditional medicine are largely the same. In Mauritius a tincture made from the mashed leaves in alcohol is applied to aching teeth caused by caries. The crushed leaves are applied as a poultice on wounds to stop bleeding. A leaf decoction or infusion is used to wash the eyes to treat eye infection. A tea made from the whole plant is taken against nausea and is used as a mouth wash for aphthae. It is also used to wash parts of the body to treat rheumatic pains. In Nigeria, the whole plants, including the seeds, are used to treat intestinal problems such as gastritis, gastro-enteritis, and salmonellosis, and many respiratory problems. In Ethiopia *Plantago lanceolata* is one of the 10 most used taenicidal herbs in local medicine, either as an infusion or in alcoholic beverages. The roots are traditionally used to treat fertility problems.

The seed mucilage is an excellent thickener used in cosmetics (e.g. in lotions and hair wave sets) and as a stabilizer in the ice-cream industry. It is also used in the preparation of chocolate. The seeds can be used as a source of a low-cost gelling agent for tissue culture. The quality is comparable to that of agar, but at about 10% of the cost. *Plantago lanceolata* is currently being marketed as a stop smoking aid in the United Kingdom, as it is said that it causes an aversion to tobacco. In the United States *Plantago major* has been patented and marketed for the same purpose. Leaves are edible and sometimes eaten as vegetable. *Plantago lanceolata* is occasionally grown as a fodder crop and considered to be of better quality than *Plantago major*.

Production and international trade For Africa, no information on production or trade of *Plantago lanceolata* is known and general information on production and trade is scarce. In the United Kingdom *Plantago lanceolata* is



Plantago lanceolata – wild

cultivated for medicinal purposes, and it is also imported from Bulgaria, Russia, former Yugoslavia, Hungary and Poland. Prices in 2004 were US$ 10.50/kg for dried material wholesale and US$ 58/kg for retail.

Properties A range of pharmacological activities has been found in tests with *Plantago lanceolata* extracts, including weak antibiotic, wound healing, anti-inflammatory, anti-ulcerogenic, laxative, analgesic, antioxidant and immunomodulatory activities. Biologically active compounds include polysaccharides, caffeic acid derivatives, flavonoids, iridoid glycosides and terpenoids.

The saccharides galacturonic acid, galactose, arabinose, rhamnose, glucose, xylose, as well as a pectic polysaccharide, a galactoarabin and a galactan have been isolated from the leaves. Extraction of the seeds in cold water yields a polysaccharide, which contains uronic acid, pentosans, methyl pentosan, and an oil. The seeds owe their laxative properties to the very hydrophilic polysaccharides. They absorb much water and form a gel that increases stool bulk, stimulates peristalsis and facilitates bowel movements. The effect has been confirmed by several clinical studies. The mucilage can also be used as supportive therapy in diarrhoea, because the transit period of the bowel contents is extended.

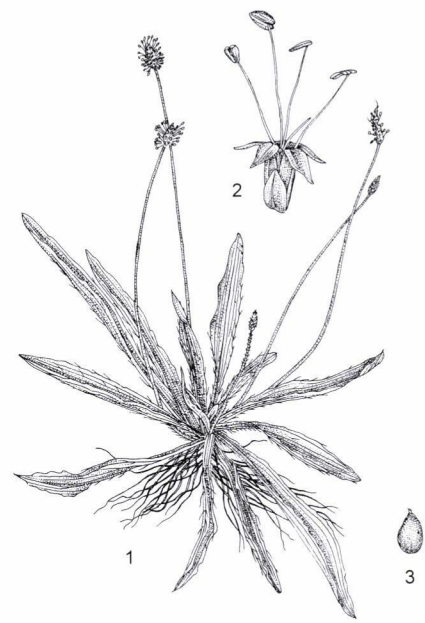
The leaves, seeds and roots contain caffeic acid and derivatives such as chlorogenic acid, neochlorogenic acid, plantamajoside, acteoside (verbascoside), syringic acid and vanillic acid. Plantamajoside showed anti-inflammatory activity in tests with mice, and some antibacterial activity. Both plantamajoside and acteoside have anti-oxidant activity and are DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavengers. Acteoside has antibacterial, antihypertensive, immunosuppressant and analgesic activities.

Among the flavonoids isolated are apigenin-7-O-monoglucoside, apigenin-6,8-diglucoside and luteolin-7-O-β-glucoside. The methanol extract of the plant showed no cytotoxic activity against a human tumour cell line of renal adenocarcinoma, but did show total inhibition of breast adenocarcinoma and melanoma growth in culture.

Plantago lanceolata leaves also contain iridoid glycosides (1.9–2.4%) such as aucubin, catalpol and asperuloside. Aucubin showed anti-inflammatory and hepatoprotective activities in tests with mice, spasmolytic activity in tests with rats, and antiviral activity against hepatitis B virus. Aucubigenin, the aglycone of aucubin, has antimicrobial activity. Two cultivars of *Plantago lanceolata* from Spain showed a strong increase in aucubin and acteoside concentrations in the leaves during the growing season.

In Ethiopia tests of the toxicity and therapeutic activities of *Plantago lanceolata* leaves as a taenicidal medicine in mice showed moderate toxicity and low taenicidal activity. The antimicrobial action is moderate. The roots were tested for uterotonic and anti-implantation activities in mice, but showed low activity.

Description Small perennial herb up to 60(–100) cm tall, with a thick rhizome and fibrous roots. Leaves in a dense rosette, arranged spirally; stipules absent; petiole up to as long as the blade; blade linear-lanceolate to narrowly ovate or spatulate, (2–)10–20(–40) cm × 1–3(–7) cm, base tapering into the petiole, apex acute to acuminate, both surfaces glabrous or appressed pubescent to villous, margins entire or shallowly dentate, veins 3–5, distinct, parallel. Inflorescence a short spike 0.5–5(–10) cm long, very densely flowered, peduncle 10–60(–100) cm long, grooved, silky hairy; bracts ovate, 2.5–4(–7) mm long. Flowers



Plantago lanceolata – *1, flowering plant; 2, flower; 3, seed.*
Redrawn and adapted by Achmad Satiri Nurhaman

usually bisexual, regular, 4-merous, sessile, brownish white; sepals rounded-ovate, 2.5–3.5 mm long, the lower pair joined; corolla c. 3 mm long, lobes ovate, 2–2.5 mm long; stamens inserted on the corolla lobes, exserted, anthers almost white; ovary superior, 2–4-celled, style 1, about twice as long as the flower. Fruit a circumscissile, ellipsoid capsule 3–5 mm long, (1–)2–3-seeded. Seeds oblong-ellipsoid, 2.5–3 mm long, yellow-brown to dark brown, mucilaginous when wet. Seedling with epigeal germination.

Other botanical information *Plantago* comprises nearly 270 species and is cosmopolitan, but mostly temperate in distribution. *Plantago lanceolata* is extremely variable, but much of the variation reflects differences in habitat (e.g. hairy plants in more dry habitats). The leaves tend to be upright and more linear-lanceolate when the surrounding cover is tall. In grazed areas, its habit is prostrate and the leaves are more ovate.

Growth and development In tropical climates, *Plantago lanceolata* may flower all year round, with a life cycle that may be accomplished in 6 weeks. In temperate regions, the plants overwinter below the ground in open areas, or as small rosettes if more cover is present. The longevity of *Plantago lanceolata* varies with the region and the disturbance of the site. Individual plants have been known to persist for at least 12 years. Old plants develop a thick rhizome producing new aerial shoots, which leads to clumping.

In general, *Plantago lanceolata* seems to be a strict outbreeder although other studies state that it is self-fertile. Genetic studies revealed that several sexual forms exist in *Plantago lanceolata*: bisexual plants with long anthers and viable pollen, bisexual plants with short anthers and pollen with poor viability and female plants with rudimentary stamens.

Seed production is highest in open, cultivated land, and least in mowed or grazed areas. The seeds are ripe 2–3 weeks after fertilization. They readily adhere to animals or people, which promotes dispersal. They can also be transported by water.

Ecology *Plantago lanceolata* occurs in disturbed areas. It is a very common weed of cultivated areas and roadsides, as well as open woodland and grassland. *Plantago lanceolata* is more drought resistant than *Plantago major*, but is less tolerant to water-logging; it does not tolerate saline soil.

Propagation and planting *Plantago lanceolata* can be multiplied by seeds or vegetatively. The seeds have a dormancy period of one to several months, which can be broken by dry storage at 5°C for several weeks or 20°C for several months. Germination is best for 1–6-year-old seeds and at temperatures of 25–30°C. Nitrate stimulates germination of *Plantago lanceolata*.

Management Pure stands of *Plantago lanceolata* respond well to fertilizer, but in mixed pastures N-fertilizer will increase competition from other plants. Its root system can exploit deeper soil layers than most other pasture plants. In mixed pastures *Plantago lanceolata* establishes quickly and is preferentially grazed, which may lead to its disappearance from the sward. The inflorescences are avoided by grazing animals.

Diseases and pests Seedling mortality of *Plantago lanceolata* is common, and is due to a complex of fungal species interacting with abiotic factors. Stalk disease is caused by the fungus *Phomopsis subordinaria*. *Plantago lanceolata* is a host of *Meloidogyne* nematodes.

Harvesting Care should be taken when collecting *Plantago lanceolata* from the wild for medicinal purposes, since plants may contain high concentrations of heavy metals such as lead and cadmium where they grow along roads.

Yield The forage yield of special cultivars has reached up to 20 t/ha in New Zealand.

Handling after harvest The drying temperature affects the content of the active compounds of the plant material. The concentrations of the active compounds steadily decrease in the initial stages of drying both under natural climatic conditions and at 60°C.

Genetic resources *Plantago lanceolata* is common and extremely widespread and not threatened by genetic erosion. Several small genebank collections exist, especially in South America and Europe.

Breeding Improved pasture cultivars have been bred in New Zealand; they include 'Grassland Lancelot' and 'Ceres Tonic'.

Prospects The uses of *Plantago lanceolata* orally to treat digestive and bronchial disorders, and topically to treat skin disorders and eye infections are very widespread. Recent research seems to substantiate traditional uses, although information is far from complete. Related species with similar uses are more easily and widely cultivated, e.g. *Plantago afra* L. and *Plantago ovata* Forssk. (ispaghul), which are cultivated in India for medici-

nal purposes.

Major references Bruneton, 1995; Desta, 1994; Desta, 1995; Fons et al., 1998; Holm et al., 1977; Lilis Pangemanan, 1999; Suomi et al., 2002; Tamura & Nishibe, 2002.

Other references Baerts & Lehmann, 2002d; Bisset, 1994; Brautigam & Franz, 1985; Calabozo, Barber & Polo, 2001; Ebrahimzadeh, Mirmasumi & Tabatabaei, 1997; Fleming (Editor), 1998; Galvez et al., 2003; Glen, 1998; Guil-Guerrero, 2001; Gurib-Fakim et al., 1994; Gurib-Fakim, Guého & Bissoondoyal, 1997; Lehmann, 1988; Lisowski, Malaisse & Symoens, 1972; Murai, Tamayama & Nishibe, 1995; Nostro et al., 2000; Rumball, 1997; Samuelsen, 2000; Sharma, Koul & Koul, 1992; Verdcourt, 1971; Wegener & Kraft, 1999.

Sources of illustration Holm et al., 1977.

Authors A. Gurib-Fakim

PLANTAGO MAJOR L.

Protologue Sp. pl. 1: 112 (1753).

Family Plantaginaceae

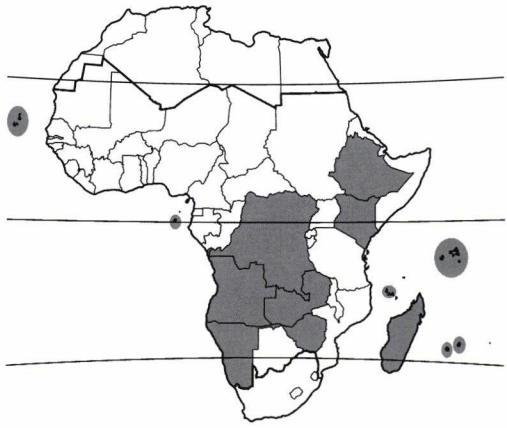
Chromosome number $2n = 12, 24$

Vernacular names Greater plantain, large plantain, common plantain, waybread (En). Gros plantain, plantain (Fr). Tanchagem-maior (Po).

Origin and geographic distribution *Plantago major* originated in Europe but has become cosmopolitan. It is essentially temperate in its distribution. In the tropics *Plantago major* is most common in mountainous regions. In Africa it is most common in southern Africa, including South Africa.

Uses The leaves of *Plantago major* are used almost worldwide as a diuretic and astringent, and to treat wounds, insect stings, sunburn, skin diseases, eye irritation and inflammation of mouth and throat. In modern phytotherapy they are used to alleviate irritation in catarrh of the upper respiratory tract. Macerates, extracts, syrups and fresh juice are applied for these purposes. The roots are considered astringent and febrifuge, and used in decoction to treat cough. The seeds are considered demulcent, stimulant, diuretic and tonic, and are mainly used as a remedy for dysentery and diarrhoea.

In tropical Africa *Plantago major* is commonly used in traditional medicine for the same purposes. In the Seychelles, Réunion and Mauritius leaf infusions or decoctions are used to treat conjunctivitis, toothache, gingivitis, nausea, asthma, constipation, rheumatic and intestinal pains and gout, and crushed leaves are applied externally to wounds, eczema and skin infections, and are put into the ear to treat earache. The sap of the plant in vinegar is taken as a vermifuge. In Cape Verde a leaf infusion, together with the leaves of *Jatropha curcas* L., is applied to infections and abscesses. In Ethiopia the leaves are used to treat stomach-ache, eye diseases and toothache, and the leaf sap is taken as a tonic and astringent. In South Africa the leaf juice is used against earache and to treat eye irritation, and a root decoction to treat diarrhoea. The leaves are used to treat malaria in Tanzania and South Africa.



Plantago major – wild

The seed mucilage is an excellent thickener used in cosmetics (e.g. in lotions and hair wave sets) and as a stabilizer in the ice-cream industry. It is also used in the preparation of chocolate. The seeds can be used as a low-cost gelling agent for tissue culture. The quality is comparable to that of agar at only about 10% of its cost.

Young leaves and immature peduncles are used as a vegetable, cooked or in salads. The seeds have a nutty flavour and can be added to foods or ground into flour. The seed oil has an agreeable odour and taste. In the United States boiled seeds are used as birdfeed, and *Plantago major* plants are sometimes marketed as ornamentals. In Europe whole mature spikes are fed to birds.

Production and international trade For Africa, no information on production or trade of *Plantago major* is known. General information on production and trade is very incomplete. In

the United Kingdom, Turkey and India, *Plantago major* is cultivated for medicinal purposes, while countries like China and Romania import dried plants for medicinal purposes. Romania bought dry plant material at US$ 500–600/ton in 2002, while the United Kingdom sells dried material at US$ 8–11.50/kg for trade with a retail price of US$ 54/kg. In the 1970s *Plantago major* was collected on a large scale from the wild in Russia for medicinal trade.

Properties A range of pharmacological activities has been found in tests with *Plantago major*, including wound healing, anti-inflammatory, anti-oxidant, antibiotic, immunomodulatory, diuretic and anti-ulcerogenic activities. Active compounds include polysaccharides, lipids, caffeic acid derivatives, flavonoids, iridoid glycosides and terpenoids.

Aqueous extracts exhibited dual immunomodulatory effects by enhancing lymphocyte proliferation and by secretion of interferon-γ at low concentrations (<50 µg/ml), but this effect was inhibited at high concentrations (>50 µg/ml). A decoction of dried leaves showed moderate diuretic activity when tested on rats. Ethanol and methanol extracts showed significant in-vitro activity against a wide variety of bacteria and fungi. Leaf extracts were also active against *Giardia duodenalis* trophozoites and the nematode *Ditylenchus dipsaci*, a pest of garlic.

The saccharides galacturonic acid, galactose, arabinose, rhamnose, glucose, xylose, as well as a pectic polysaccharide, a galactoarabin and a galactan have been isolated from the leaves. Together these are referred to as 'plantaglucid', which has been used to treat ulcers. Plantaglucid reduced the development of peptic ulcers in rats and reduced inflammatory oedema, without toxic effects even after prolonged administration. A highly esterified pectic polysaccharide (PMII) activated human monocytes in vitro to increase production of tumour necrosis factor α (TNF α) and also had prophylactic activity against *Streptococcus pneumoniae* in mice. The seeds contain mucilaginous matter consisting of hydrophilic polysaccharides, mainly in the seed coat. The polysaccharides have variable amounts of xylose, arabinose, galacturonic acid and glucuronic acid as main components. They swell in contact with water and form mucilage with high viscosity, which increases stool bulk, stimulates peristalsis and facilitates bowel movements.

A number of fatty acids have been isolated from the seed oil, of which oleic acid (37.5%) and linoleic acid (25.5%) are the main components. From fresh leaves 0.2% lipids were isolated, with palmitic acid and stearic acid as main components and smaller amounts of oleanolic acid and ursolic acid. The latter 2 compounds showed hepatoprotective, antitumour and antihyperlipidemic effects, whereas ursolic acid exhibited also anti-inflammatory activity.

The caffeic acid derivatives plantamajoside and acteoside (verbascoside) have been isolated from *Plantago major*. Plantamajoside showed anti-inflammatory activity in tests with mice, and some antibacterial activity. Acteoside has antibacterial, immunosuppressant, analgesic and antihypertensive effects. Both plantamajoside and acteoside have anti-oxidant activity and are DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavengers.

Among the flavonoids isolated are baicalein, hispidulin, plantaginin and scutellarein. These have free radical scavenging activity and inhibit lipid peroxidation, and the first 3 are antioxidants. Baicalein has anti-inflammatory, antiallergic and hepatoprotective activities, it showed inhibition of human and rat cancer cell lines, and it is a HIV-reverse transcriptase inhibitor in vitro. Hispidulin also showed anti-inflammatory activitiy and is an inhibitor of 5-lipoxygenase, whereas scutellarein has antiallergic and HIV-reverse transcriptase inhibiting activities. The glucosides luteolin-7-glucoside and homoplantaginin are also potent inhibitors of HIV-reverse transcriptase. A methanol extract of *Plantago major*, containing luteolin-7-O-β-glucoside, showed growth inhibition of human breast adenocarcinoma and melanoma cell lines.

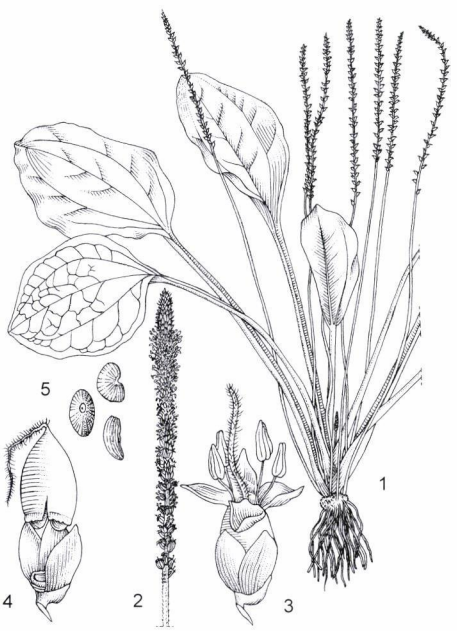
Aucubin is one of the major iridoid glycosides isolated from *Plantago major*; the content in dried leaves can be up to 1.3%. It showed anti-inflammatory and hepatoprotective activities in tests with mice, spasmolytic properties in rats, and antiviral activity against hepatitis B virus. The aglycone of aucubin, aucubigenin, has antimicrobial activity against bacteria and fungi.

The leaves have been used as a vegetable, and are rich in vitamins A, C and K, as well as calcium. The leaves taste saline, bitterish and acrid. The roots are saline and sweetish to taste.

In the United States, *Plantago major* has been patented as a natural smoking deterrent product called CIG-NO (available in spray, capsules or drops), which contains no nicotine and is not addictive. Exact cause and effect relationships

are not yet fully understood.

Description Small perennial herb up to 30(–70) cm tall, with numerous fibrous and whitish roots. Leaves in one or few basal rosettes, arranged spirally; stipules absent; petiole usually as long as the blade; blade ovate to elliptical, (1.5–)5–30(–40) cm × (0.5–)3–10(–15) cm, base abruptly narrowed into petiole, apex rounded, both surfaces glabrous or pubescent, margins entire or irregularly dentate, veins 3–5, distinct, parallel. Inflorescence a spike 5–20(–35) cm long, densely to rather laxly flowered; peduncle 5–15(–25) cm long; bracts ovate, 1–2.5 mm long, acute. Flowers minute, usually bisexual, regular, 4-merous, sessile, greenish or yellowish white; sepals broadly elliptical to rounded, 1.5–2 mm long, keeled; corolla 2–4 mm long, lobes elliptical-ovate, c. 1 mm long, acute or obtuse; stamens inserted on the corolla lobes, exserted, anthers conspicuous; ovary superior, 2–4-celled, style 1 with a stout pilose stigma, protruding. Fruit a circumscissile capsule 2–4 mm long, (4–)6–34-seeded. Seeds ellipsoid or ellipsoid-trigonous, 1–1.5 mm long, dark brown to dull black, mucilaginous when wet. Seedling with epigeal germination; cotyledons sessile or shortly petiolate, sheathed at base; hypocotyl elongate, epicotyl absent.



Plantago major – 1, fruiting plant; 2, inflorescence; 3, flower; 4, dehisced fruit; 5, seeds.
Source: PROSEA

Other botanical information *Plantago* comprises nearly 270 species and is cosmopolitan, but mostly temperate in distribution. *Plantago major* is a variable species in which several subspecies and varieties have been described, but these are connected by a series of intermediates. At higher altitudes the leaves tend to be more lanceolate and more pubescent, while the spikes tend to be more compact.

Growth and development In the tropics *Plantago major* may flower all year round, with a life cycle that may be accomplished in 6 weeks. In temperate regions the plants overwinter below ground in open areas, or as small rosettes if more cover is present. Self-pollination is common, but the flowers can also be wind-pollinated. A seed production per plant of 14,000–20,000 seeds/year has been reported. Seeds readily adhere to animals or people through their mucilaginous seed coat which promotes dispersal. They can also be transported by water. *Plantago major* may live up to 15 years under natural conditions and 5–8 years in cultivation in Turkmenistan.

Ecology *Plantago major* occurs mainly in disturbed areas. Because of its tough leaves appressed to the ground, it is well-adapted to withstand trampling by livestock and humans. *Plantago major* can tolerate more waterlogging and compacted soils than *Plantago lanceolata* L., and is found along roadsides, in gardens and open grassland, but also in wet and muddy localities. Once *Plantago major* has become established, it can become a noxious weed, as is the case in sugarcane fields in the Mascarene Islands. *Plantago major* is grown in India on medium to poor sandy soils but thrives best in well-drained loamy soils.

Propagation and planting The seeds can remain viable for up to 60 years in the soil. They have a dormancy period of one to several months, which can be broken by dry storage at 5°C for several weeks or at 20°C for several months. Germination is best at temperatures of 25–30°C, and a long photoperiod (16 hours). An efficient micropropagation protocol for *Plantago major* has been described, culturing shoot tips on a modified Murashige and Skoog medium.

Diseases and pests *Plantago major* acts as a reservoir for several viruses, such as potato virus Y (PVY) and cucumber mosaic virus (CMV), and also for bacterial leaf blight of rice (*Xanthomonas oryzae*).

Harvesting Care should be taken when collecting *Plantago major* from the wild for

medicinal purposes, since plants may contain high concentrations of heavy metals such as lead and cadmium where they grow along roads.

Yield A field trial with the Ukrainian cultivar 'Poltavskii' yielded 170 g/plant of fresh leaves; maximum seed yield/plant was 25 g, with a 1000-seed weight of 0.24 g. Leaf yield in 1986–87 was 5.2 t/ha. In Chile, a field trial showed that high plant densities of up to 200.000 plants/ha had no effect on dry matter yield.

Genetic resources *Plantago major* is common and extremely widespread and not threatened by genetic erosion. Several small genebank collections exist, especially in South America and Europe. Selections for ornamental purposes are marketed in the United States.

Prospects The uses of *Plantago major* orally to treat digestive and bronchial disorders, and topically to treat skin disorders and eye infections are very widespread. Recent research seems to substantiate traditional uses, although information is far from complete. Related species with similar uses are more easily and widely cultivated, e.g. *Plantago afra* L. and *Plantago ovata* Forssk. (ispaghul), which are cultivated in India for medicinal purposes.

Major references Adjanohoun et al., 1983b; Chiang et al., 2003a; Chiang et al., 2003b; Galvez et al., 2003; Gurib-Fakim, Guého & Bissoondoyal, 1997; Holm et al., 1977; Lilis Pangemanan, 1999; Nunez-Guillen et al., 1997; Samuelsen, 2000; Than et al., 1996.

Other references Adjanohoun et al., 1983a; Candia & Edgardo, 2000; Ebrahimzadeh, Mirmasumi & Tabatabaei, 1997; Glen, 1998; Gurib-Fakim et al., 1993; Gurib-Fakim et al., 1994; Hutchings et al., 1996; Insunza & Valenzuela, 1995; Jansen, 1981; Lavergne & Véra, 1989; Lehmann, 1988; Lisowski, Malaisse & Symoens, 1972; Mederos et al., 1998; Pinto Basto, 1996; Rouillard & Guého, 2000; Verdcourt, 1971; Watt & Breyer-Brandwijk, 1962; Weenen et al., 1990.

Sources of illustration Lilis Pangemanan, 1999.

Authors A. Gurib-Fakim

PLANTAGO PALMATA Hook.f.

Protologue Journ. Linn. Soc., Bot. 6: 19 (1861).

Family Plantaginaceae

Chromosome number $2n = 24$

Origin and geographic distribution *Plantago palmata* is indigenous in tropical Africa, where it occurs from Bioko (Equatorial Guinea) and Cameroon east to Ethiopia and Kenya, and south to Zimbabwe.

Uses In the eastern part of DR Congo, the sap of the leaves in water is externally applied to treat conjunctivitis and haemorrhoids, and internally against diarrhoea and vaginal prolapse. An infusion of the leaves or pounded roots in milk is taken to treat intestinal problems. Pounded leaves and inflorescences are applied to burns and skin diseases. The Nyindu people of DR Congo use the pounded leaves, mixed with honey, against heart problems. A grilled leaf is applied to aching joints. In Burundi the leaves are used in the treatment of oedema, threatening miscarriage, nausea during pregnancy and intestinal problems such as diarrhoea. In East Africa the leaves are macerated in banana beer, which is taken to treat hepatic diseases. In Rwanda the leaves are used internally for similar diseases and to expel intestinal worms and externally to treat breast infection. In eastern Congo the macerated leaves are given to young goats against cocciniosis, a protozoan intestinal disease.
Plantago palmata is well-liked by cattle in East Africa. The petioles are used for plaiting contrasting colours into baskets.

Properties The aerial parts of *Plantago palmata* contain the caffeic acid derivatives plantamajoside and acteoside (verbascoside), as well as the iridoid glycosides aucubin, geniposidic acid, epiloganic acid, arborescoside and gardoside. Plantamajoside has an inhibitory effect on arachidonic acid-induced mouse ear oedema (anti-inflammatory activity), and inhibitory effect on 5-lipoxygenase, 15-lipoxygenase, and cAMP phosphodiesterase. It also has some antibacterial activity. Both plantamajoside and acteoside have antioxidant activity and are DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavengers. Aucubin shows anti-inflammatory, spasmolytic, antidote and hepatoprotective activities as well as antiviral activity against hepatitis B.
The leaves, fruits and roots of *Plantago palmata* have been tested for antibacterial, antifungal and antiviral properties. There was no antibacterial activity, but all parts, especially the roots, expressed antifungal activity against *Microsporum canum* and *Trichophyton mentagrophytes*, while the leaves had moderate activity against the Coxsackie virus.

Botany Small perennial herb up to 40 cm tall, glabrescent to hairy, with short, stout rhizome and numerous whitish roots. Leaves in a

basal rosette, arranged spirally; petiole 5–25 cm long; blade ovate or rounded, distinctly palmately lobed, 5–12 cm × 3–10 cm, base cordate, apex acute or rounded, with 3–5 distinct parallel veins. Inflorescence a dense spike 1–11(–17) cm long; peduncle 5–30 cm long; bracts 2–2.5 mm long. Flowers bisexual, regular, 4-merous, sessile, white to greenish-white; sepals 2.5–3 mm long, keeled; corolla 3 mm long; ovary superior, style scarcely exceeding the corolla. Fruit a globose capsule 3–4 mm long, 2-seeded.

Plantago comprises nearly 270 species and is cosmopolitan, but mainly temperate in distribution. Like *Plantago major* L., *Plantago palmata* belongs to the section *Plantago*. Another species of this section is *Plantago tanalensis* Baker, which is endemic to Madagascar and used as a medicine for whooping-cough and tooth-ache.

Ecology *Plantago palmata* occurs on disturbed sites, along roadsides, in openings of sub-montane forest, grassland or (less often) as a weed of plantations and gardens. In East Africa, it is most often found in bamboo and *Juniperus* forest, often along streams or on boggy ground, at 1200–2400 m altitude.

Genetic resources and breeding *Plantago palmata* is quite common in its natural habitat, and does not seem to be threatened by genetic erosion.

Prospects *Plantago palmata* is quite extensively used as a medicinal plant in Central Africa. It contains, like *Plantago major* and *Plantago lanceolata* L., caffeic acid derivatives and iridoid glycosides, which have shown pharmacological activities supporting the uses in traditional medicine.

Major references Baerts & Lehmann, 2002e; Burkill, 1997; Rønsted et al., 2003; Vlietinck et al., 1995.

Other references Andriamihaja, 1988; Hepper, 1963a; Kokwaro, 1993; Lehmann, 1988; Lisowski, Malaisse & Symoens, 1972; Neuwinger, 2000; Samuelsen, 2000; Verdcourt, 1971; Yamada, 1999.

Authors G.H. Schmelzer

PLATYCLADUS ORIENTALIS (L.) Franco

Protologue Portugaliae Acta Biol., Sér. B, Sist. Julio Henriques: 33 (1949).

Family Cupressaceae

Chromosome number $2n = 22$

Synonyms *Thuja orientalis* L. (1753), *Biota orientalis* (L.) Endl. (1847).

Vernacular names Chinese arbor-vitae, biota, eastern thuja (En). Cyprès chinois, thuya de Chine (Fr). Biota da China, tuia da China (Po).

Origin and geographic distribution The natural distribution of *Platycladus orientalis* is obscured by its long history of cultivation in large parts of Asia. It is assumed to have originated from northern and north-eastern China, Korea and Siberia. Its distribution has extended to Japan, Taiwan and Central Asia, and it is locally naturalized in Indo-China. It has been cultivated in Europe since the first half of the 18th century. In cooler areas of tropical Africa it has been planted primarily as an ornamental.

Uses In Réunion the main use of *Platycladus orientalis* is as an antirheumatic. The cones are crushed and soaked in alcohol for 2–3 days. Painful joints are rubbed with the extract. Small branches are used to make a tea which is drunk to overcome varicose veins, haemorrhoids and menopausal problems. They are used to improve the circulation, to bring down fever and to treat gastric ulcers. In Mauritius tea from branches and leaves is used to cure throat inflammation, fever and influenza.

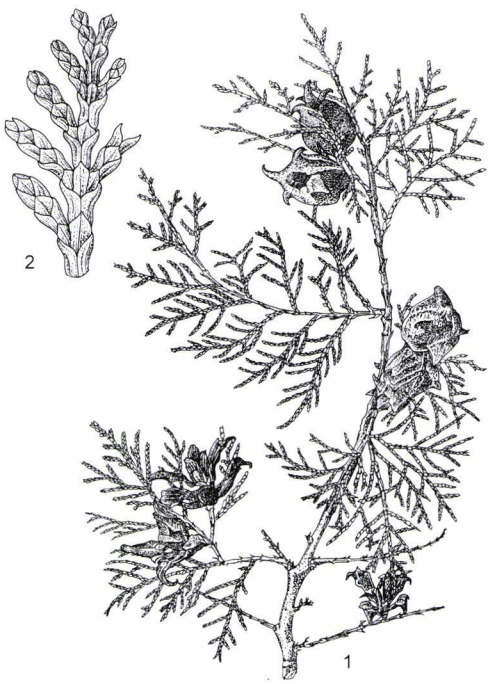
In traditional Chinese medicine the leaves are credited with bitter stomachic, refrigerant, astringent, diuretic, tonic and antipyretic properties. A decoction or the juice of the leaves has been used to relieve all kinds of bleeding, gastric ulcers, gonorrhoea and colds. The seeds are prescribed as a sedative, tranquillizer, antitussive and haemostatic. In Indo-China the ground leaves are used as an emmenagogue and antitussive, the seeds as a tonic, sedative, tranquillizer and aphrodisiac. A decoction of the twigs is prescribed to treat dysentery, skin affections and cough.

In Zimbabwe, Mozambique and South Africa *Platycladus orientalis* is grown as an ornamental and has no documented medicinal uses. The essential oils extracted from leaves, cones and wood are important in body care products used in the Western world.

Production and international trade Dried herbal materials of *Platycladus orientalis* are traded from Asia. Retail prices in 2001 amounted to US$ 7 for 500 g dried leaves, US$ 8.7 for 100 g of extract granules of leafy parts and US$ 12 for 100 g of extract granules of charred leafy parts. Essential oils from leaves, cones and wood are also traded internationally.

Properties The leaves and cones of *Platy-*

cladus orientalis contain an essential oil with high amounts of α-pinene, sabinene, 3-carene, limonene and cedrol. In Egyptian material the highest yield was obtained from fresh cones. Pinusolide, a labdane-type diterpene, and pinusolidic acid were isolated from leaf extracts. Pinusolide is a potent platelet-activating-factor (PAF) antagonist. The results of tests on mice suggest that pinusolide may prove of therapeutic value in the treatment of hypotension and pinusolide analogues may provide the possibility of new PAF specific antagonists. Pinusolidic acid has similar activity.
Chronic oral administration of the seed extract to mice improved impaired memory acquisition and disturbed memory retention in a dose-dependent way. Other proven effects of leaf extracts include the haemostatic properties, in-vitro and in-vivo antitumour activity and an activity similar to that of vitamin K. In an antibacterial screening the aqueous leaf extract inhibited the growth of gram-positive bacteria, and significantly inhibited aflatoxin production of *Aspergillus parasiticus* on products such as rice, wheat, maize and groundnut. Methanol extracts of leaves and cones inhibited the growth of *Candida albicans*. Immunosuppressant activity was observed in mice fed with a diet containing 10% seed oil.



Platycladus orientalis – 1, twig with cones; 2, detail of shoot.
Source: PROSEA

Botany Monoecious shrub or small to medium-sized tree up to 20 m tall, in cultivation often forming multiple stems; bark thin, reddish brown, peeling in thin longitudinal strips; branches ascending. Leaves decussately opposite, scale-like, those of finer lateral sprays c. 2 mm long, tightly appressed. Male cones terminal, 2–3 mm long; female cones axillary, oblong, 20–25 mm × 10–18 mm, with 6–10 fleshy scales, with a recurved horn below the tip of each scale, central 4 scales fertile with 2(–3) seeds. Seeds ovoid, flattened, 5–7 mm × 3–4 mm, wingless.
Platycladus comprises only one species and is closely related to *Thuja*. It can easily be distinguished by the vertical arrangement of its sprays of foliage, which lack odour when crushed, the strongly hooked cone scales and its wingless seeds.

Ecology In Asia *Platycladus orientalis* usually grows on steep rocky hillsides and cliffs. This explains the success of plantings on poor, excessively drained soils, as well as the success of smaller cultivars in rock and succulent gardens. *Platycladus orientalis* is also tolerant of soils with a high pH. It prefers full sun but is tolerant of partial shade.

Management *Platycladus orientalis* can be raised easily from cuttings and seed. Cultivars are best raised from cuttings, but side-veneer grafting is possible as well.
Growth of seedlings is enhanced by NPK 10:20:10 application. This markedly increases stem diameter growth. A high level of P in NPK mixtures increases root length and the number of branches. The fresh and dry weight of leaves greatly increases with increasing N and P levels.
After harvesting the leafy parts can be dried and stored for future use. The seeds are obtained by opening the dried cones and used fresh. The essential oil from leaves and cones can be extracted by steam distillation.

Genetic resources and breeding *Platycladus orientalis* has a large area of distribution and is widely cultivated, and is therefore not at risk of genetic erosion.
Numerous cultivars are registered in horticultural trade, ranging from dwarf types to trees, types with needle-like leaves when young, golden green or slightly variegated types or with filamentous branches.

Prospects The potential for cultivation of *Platycladus orientalis* in tropical Africa is best at higher elevations with a cooler climate. Pinusolide shows interesting activity in relation to hypertension and PAF-antagonism. Although more research will be needed, the compound or its (semi-)synthetic analogues may have potential in future medicinal research.

Major references Aggarwal, 2001; Gurib-Fakim, Guého & Bissoondoyal, 1996; Lavergne & Véra, 1989; Morgan, 1999; Poynton, 1966.

Other references Chen, Lin & Namba, 1987; Da Graça Silva, 1983; Ezzat, 2001; Farjon, 1998; Hassanzadeh et al., 2001; Kim et al., 1999; Lai et al., 1994; Nishiyama, Chu & Saito, 1995; Singh & Sinha, 1986; Yang & Han, 1998.

Sources of illustration Aggarwal, 2001.

Authors C.H. Bosch

Based on PROSEA 12(2): Medicinal and poisonous plants 2.

PLEIOCARPA MUTICA Benth.

Protologue Hook.f., Icon. pl. 12: 71, t. 1181 (1876).

Family Apocynaceae

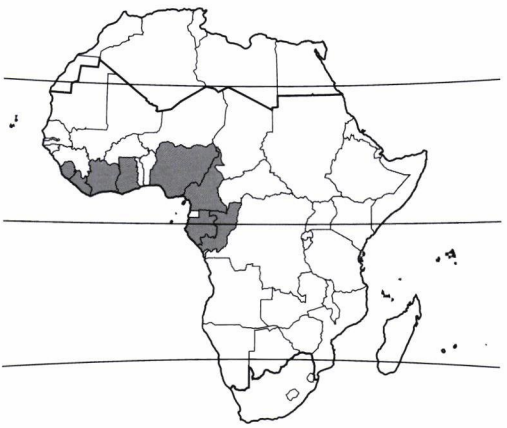
Chromosome number $2n = 22$

Vernacular names Arbre huileux (fr).

Origin and geographic distribution *Pleiocarpa mutica* occurs in West and Central Africa, from Sierra Leone to Ghana, and from eastern Nigeria to Gabon. It has been collected once in northern Congo.

Uses In Sierra Leone, ground bark is rubbed on the body against fever. People from the Agni tribe in Côte d'Ivoire drink a decoction of the grated bark to treat stomach pains, and a similar preparation is used by people of the Ebrié tribe against oedema of the legs. A decoction of the root bark is used against kidney diseases and malaria. In Ghana the roots are taken in decoction as a febrifuge, antimalarial and to treat jaundice and convulsions. The ground bark in palm wine is taken as a laxative.

The wood is used to make combs, canoe paddles, pestles, weaving shuttles, plane-blocks, hooks for hunting nets and various other small objects.



Pleiocarpa mutica – *wild*

Production and international trade Products from *Pleiocarpa mutica* are not traded internationally, but are a valuable commodity at local markets.

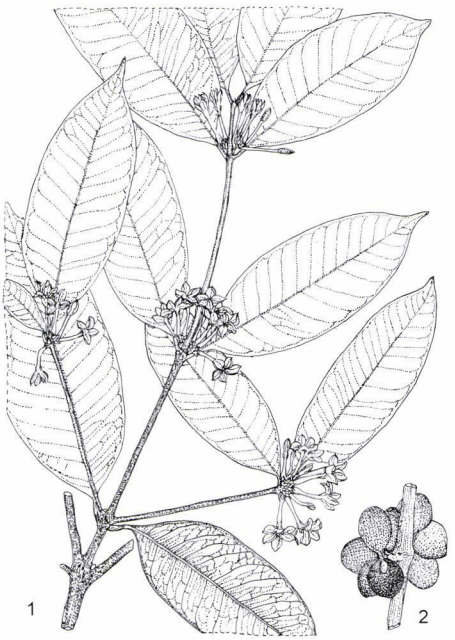
Properties A number of indole alkaloids have been isolated from the roots and bark of *Pleiocarpa mutica*. The roots contain pleiocarpine (pleiocine), kopsinine, pleiocarpamine, eburnamine (desacetylpicraline) and the dimeric pleiomutinine. These 5 alkaloids were tested against *Plasmodium falciparum* in vitro but only pleiomutinine was found to have significant activity, although at a lower level than the standard drug chloroquine diphosphate. pleiocarpine was inactive against malaria parasites in vitro, but moderately active in vivo against *Plasmodium berghei* in mice. The methanolic root extract showed no toxicity in the brine shrimp lethality test.

Kopsinine has hepatoprotective activity against CCl_4-toxicity in mice, and it was found to shorten the barbital-induced sleeping time in mice. Eburnamine shows some sympathomimetic properties and a strong and lasting hypotensive action. Other alkaloids isolated from the bark are eburnamonine and the dimeric pleiocarpinine (pleiocinine) and pleiomutine. Eburnamonine has the same pharmacological effect as strychnine and is useful as a cerebrovascular agent. It is a stimulant of the central nervous system, and seems to have a positive effect on the general blood circulation.

The wood is hard, heavy, close-grained, tough and yellow.

Adulterations and substitutes Leaves of *Ageratum conyzoides* L. (*Asteraceae*) or *Lantana camara* L. (*Verbenaceae*) are used as substitutes for *Pleiocarpa mutica* decoctions in Cameroon, as a febrifuge.

Description Shrub or small tree up to 7.5 m tall, rarely a climbing shrub with stems up to 9 m long; trunk 1.5–5 cm in diameter; bark smooth, dark brown to pale grey. Leaves oppo-



Pleiocarpa mutica – *1, flowering branch; 2, infructescence.*
Redrawn and adapted by Iskak Syamsudin

site, sometimes in whorls of 3, simple and entire; stipules absent; petiole 5–15 mm long; blade elliptical, oblong or ovate, 5–20(–30) cm × 2–8(–11.5) cm, base obtuse or cuneate, apex acuminate, glabrous, pinnately veined with 9–12 pairs of lateral veins. Inflorescence an axillary cluster, 1.5–2.5 cm × 2–3 cm, about 10(–35)-flowered; bracts very small. Flowers bisexual, regular, 5-merous, very fragrant, sessile; sepals ovate or elliptical, 1.5–2 mm long, free or connate at base, apex obtuse; corolla tube almost cylindrical, 11–22 mm × 1–3 mm, widened around the anthers, with a belt of hairs 2.5–6 mm wide inside just below the insertion of the stamens, lobes ovate, elliptical to narrowly oblong, (5–)6–13 mm long, apex rounded or obtuse, spreading, recurved later, white; stamens inserted just below the top of the corolla tube, included, 1–2 mm long, anthers narrowly ovate to oblong, yellow with red stripes; ovary superior, almost globose, consisting of 5 separate carpels united at base by a disk-like thickening, style 9–18 mm long, pistil head oblong to ellipsoid, 0.5–1 mm long, white. Fruit consisting of 5 obovoid to globose or ellipsoid follicles, 13.5–20 mm long, apex pointed, yellow to bright orange, slightly wrinkled to finely warted, 1-seeded. Seed globose to oblong, 7.5–12 mm long, brown.

Other botanical information *Pleiocarpa* comprises about 5 species and is confined to mainland tropical Africa. It is related to *Hunteria* and *Picralima*. *Pleiocarpa pycnantha* (K.Schum.) Stapf is also used in traditional medicine, but its use as a timber is more important.

A cold infusion of the bark of *Pleiocarpa rostrata* Benth. (synonym: *Pleiocarpa talbotii* Wernham) from the rain forest of Nigeria, Cameroon and Gabon is used in Cameroon against stomach-ache. Several alkaloids have been isolated from the bark: talbotine, talpinine, talcarpine and 16-epi-affinine. Talpinine and 16-epi-affinine were also isolated from the root bark.

Growth and development *Pleiocarpa mutica* can be found flowering and fruiting throughout the year.

Ecology *Pleiocarpa mutica* occurs in dense primary or secondary forest in swampy areas or along river banks, on sandy soil or limestone outcrops, up to 600 m altitude.

Harvesting The bark, roots and leaves of *Pleiocarpa mutica* are harvested whenever the need arises.

Handling after harvest The root or stem bark and leaves may be dried in the sun for several days, after which they can be stored for later use.

Genetic resources *Pleiocarpa mutica* does not yet seem threatened by genetic erosion because it is widespread and locally common.

Prospects *Pleiocarpa mutica* is locally well appreciated as a medicinal plant. Further studies are needed to elucidate the specific pharmacological activities of the active components, especially pleiomutinine and pleiocarpine, and to determine whether the other alkaloids and the crude extracts have in vivo antimalarial activities. *Pleiocarpa mutica* has clusters of white, sweet-scented flowers which make it ornamental and worthy of cultivation.

Major references Addae-Kyereme et al., 2001; Bouquet & Debray, 1974; Naranjo et al., 1972; Omino, 1996.

Other references Abbiw, 1990; Burkill, 1985; Dalziel, 1937; Neuwinger, 2000.

Sources of illustration Omino, 1996.

Authors N. Nyunaï

PLEIOCERAS BARTERI Baill.

Protologue Bull. Soc. Linn. Paris 1: 759 (1888).

Family Apocynaceae

Chromosome number $2n = 22$

Origin and geographic distribution *Pleioceras barteri* occurs from Sierra Leone to Cameroon and the Central African Republic.

Uses The bark and, more frequently, the seeds are used in Côte d'Ivoire as an emmenagogue. In Nigeria, the fruits are used similarly. A strong dose is abortifacient and careless usage may cause death. Nevertheless it is taken by women once or twice a month during late pregnancy to induce the turning down of the head of the baby. The bark crushed together with the fruit of *Ricinodendron heudelotii* (Baill.) Pierre ex Heckel is applied to boils in the groin to hasten maturation. A plaster of leaves is applied against rheumatism and the fruit pericarp, prepared as an ointment, is used to treat nosebleed. In Nigeria, *Pleioceras barteri* is also used in traditional medicine to treat malaria. The ash of dried and burnt whole plants is applied against burns.

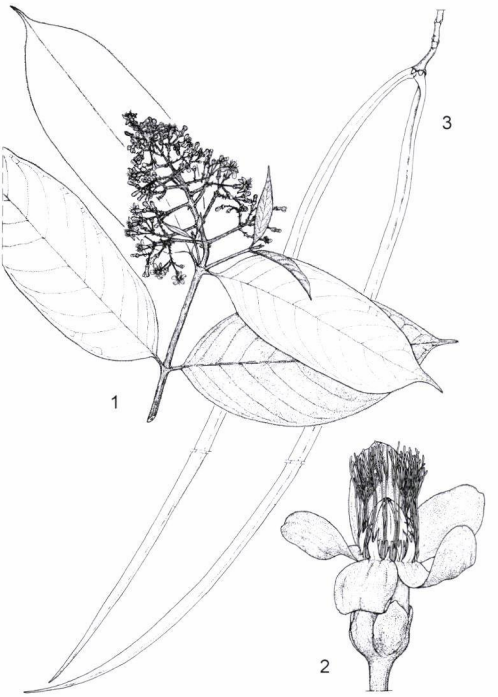
Production and international trade *Pleioceras barteri* is collected from the wild and traded locally.

Properties *Pleioceras barteri* contains alkaloids, saponins, tannins and flavonoids. The seeds are the most toxic part of the plant with total alkaloids amounting to 0.3%. The fruit wall contains 0.1% and the root bark 0.01% alkaloids. From the leaves, 0.6% ursolic acid has been isolated; this compound has antiinfective properties.

Pleioceras barteri shows antibacterial activity against gram-positive bacteria. The methanol extract is active against several pathogenic bacteria, with *Bacillus subtilis* being most susceptible. The extracts showed limited activity against fungi. The stem, stem bark, root bark, seed and fruit extracts showed abortifacient properties and depressant or stimulant effects on the central nervous system in rats.

Secondary amines (including alkylamine, dimethylamine, diethylamine and ethylaniline) have been isolated from the roots of *Pleioceras barteri*. The use of this plant could thus result in the accumulation of amines in the body, which could lead to the formation of carcinogenic nitrosamines.

Botany Shrub, small liana or small tree up to 4 m tall, with white latex in bark and leaves; bark dark brown; branchlets terete, hairy.



Pleioceras barteri – 1, flowering twig; 2, flower; 3, fruit.
Source: Flore analytique du Bénin

Leaves opposite, simple and entire; stipules absent; petiole 2–5 mm long, hairy; blade narrowly ovate or obovate, 5–9 cm × 2–7 cm, base rounded or cuneate, apex acuminate, sparsely hairy to glabrous above, hairy on the main veins beneath. Inflorescence a lax terminal panicle, 5–14 cm long, many-flowered; bracts small; peduncle 1–4 cm long, sparsely hairy. Flowers bisexual, regular, 5-merous; pedicel 5–10 mm long, hairy; sepals 1–2 mm long, connate at base, calyx persistent in fruit; corolla tube 2–3 mm × 2–3 mm, lobes elliptical, 3–5 mm long, apex rounded, ciliate, dark red or violet, apex of lobes yellow, inside with up to 7 bright yellow appendages, 4 appendages broom-like, 2–5 mm long with 3–4 branches, central appendage oblong, 2–3 mm long, with 2 narrowly oblong lobes, 2 appendages filiform to oblong, 0.5–1.5 mm long, or absent or fused with appendages of neighbouring lobe; stamens inserted just below the corolla mouth, exserted, covered by the corolla appendages, base of anthers sagittate, apex acuminate; ovary superior, almost globose, consisting of 2 free carpels, styles fused except at the base, slender,

2–5 mm long, pistil-head small, almost cylindrical, covered by the anthers and inside with triangular swellings of the connectives adnate to the clavuncula. Fruit consisting of 2 linear almost free follicles, 25–65 cm long, spreading, pendulous, dark green, glabrous, dehiscent with a longitudinal slit, many-seeded. Seeds linear to very narrowly oblong, 13–27 mm long, finely grooved, pale yellow, with a dense 3–7 cm long tuft of hairs at apex.

Pleioceras comprises 5 species, all occurring in tropical continental Africa. It is closely related to *Wrightia*. *Pleioceras barteri* flowers throughout the year.

Ecology *Pleioceras barteri* occurs in forest, bush or open localities, mostly near the coast, up to 500 m altitude.

Genetic resources and breeding *Pleioceras barteri* is widespread mainly in the western Africa coastal regions and does not seem to be in danger of genetic erosion.

Prospects Not much is known of the pharmacological properties of *Pleioceras barteri*, although it has some interesting uses in traditional medecine. The strong abortifacient effect of the seeds warrants further investigation, as do the antibacterial activities.

Major references Adjanohoun et al., 1989; Agbedahunsi, Oloke & Aladesanmi, 1993; Aladesanmi, Sofowora & Leary, 1986; Barink, 1983; Uhegbu & Maduagwu, 1995.

Other references Bisset, 1983; Burkill, 1985; Neuwinger, 2000.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors A. de Ruijter

PLESIATROPHA CARPINIFOLIA (Pax) Breteler

Protologue Adansonia, sér. 3, 27(2): 329 (2005).

Family Euphorbiaceae

Synonyms *Mildbraedia carpinifolia* (Pax) Hutch. (1912).

Vernacular names Mtapatapa, mtapatapa mkufu, mchunga ng'ombe (Sw).

Origin and geographic distribution *Plesiatropha carpinifolia* occurs in Kenya, Uganda, Tanzania and Mozambique.

Uses In Kenya root powder is taken to treat chest complaints.

Botany Dioecious, much-branched, evergreen shrub or small tree up to 5(–9) m tall; twigs stellate-hairy, pale grey-brown. Leaves alternate, simple; stipules linear, up to 9(–17) mm long, soon falling; petiole 1–3(–5) cm long, stellate-hairy; blade oblanceolate-oblong to elliptical-oblong, 3–12(–20) cm × 2–5(–11) cm, base rounded to shallowly cordate, apex acuminate, margins almost entire to shallowly or sharply toothed, especially in the upper half, membranous to papery, stellate-hairy, pinnately veined with 6–8 pairs of lateral veins. Inflorescence an axillary cyme; peduncle up to 7(–13) cm long, stellate-hairy; bracts linear, up to 1 cm long. Flowers unisexual, regular, 5-merous; pedicel up to 4 mm long; male flowers with broadly ovate sepals c. 2.5 mm long, petals broadly ovate to almost round, c. 3 mm long, greenish white or yellow-green, stamens 14–17; female flowers with broadly ovate sepals c. 3.5 mm long, petals broadly ovate to almost round, c. 4 mm long, ovary superior, almost globose, 1.5 mm in diameter, stellate-hairy, 3-celled, styles 3, c. 2.5 mm long, bifid towards apex. Fruit a 3-lobed capsule c. 7 mm × 10 mm, stellate-hairy, 3-seeded. Seeds ovoid to almost globose, c. 6 mm × 5 mm, mottled purplish brown and grey.

Plesiatropha comprises 3 species, which all occur in tropical Africa. In Côte d'Ivoire a leaf decoction of *Plesiatropha paniculata* (Pax) Breteler (synonym: *Mildbraedia paniculata* Pax), occurring from Liberia to DR Congo, is taken orally or as a bath to treat serious cases of jaundice.

Ecology *Plesiatropha carpinifolia* occurs in forest and forest edges, coastal woodland and riverine and secondary vegetation, from sea-level up to 1700 m altitude.

Genetic resources and breeding *Plesiatropha carpinifolia* has a relatively large area of distribution and there are no signs that it is threatened by genetic erosion.

Prospects *Plesiatropha carpinifolia* is little used in local medicine and nothing is known concerning its chemistry and pharmacology. Therefore it is likely that it will remain of local importance only.

Major references Breteler, 2005; Kokwaro, 1993; Radcliffe-Smith, 1987.

Other references Atindehou et al., 2002; Burkill, 1994.

Authors G.H. Schmelzer

PLUMBAGO APHYLLA Bojer ex Boiss.

Protologue DC., Prodr. 12: 694 (1848).

Family Plumbaginaceae

Vernacular names Balai sur terre (Fr).

Origin and geographic distribution *Plumbago aphylla* occurs in Madagascar, the Aldabra Islands (Seychelles) and in Tanzania on a small island a few kilometres off the coast.

Uses In Madagascar a decoction of the whole plant of *Plumbago aphylla* is taken to treat diarrhoea and infections of the mouth and applied as an eyewash in case of cataract. A root decoction is taken as an analgesic and antispasmodic. A decoction of the aerial parts is used for a massage in case of dislocation. *Plumbago aphylla* is sold at the medicinal herb market of Antananarivo, Madagascar.

Properties The active ingredient of *Plumbago aphylla* is a naphthoquinone, probably plumbagin. The aerial parts tested positive for alkaloids and saponins. An extract of the aerial parts was active against cercariae of *Schistosoma mansoni*.

Botany Slender shrub up to 1 m tall, with taproot; stems erect or ascending, few-branched, glabrous, with numerous fine longitudinal ridges, pale yellow-green, rooting at the nodes. Leaves alternate, simple and entire, soon disappearing except on sterile shoots, only the petiole bases remaining as brown scales; stipules absent; petiole short, winged; blade obovate, 5–15 mm × 5–6(–10) mm, apex acute, mucronate, leathery, glandular. Inflorescence a terminal raceme, sometimes paniculate, 2–6 cm long, many-flowered; bracts ovate to lanceolate, small, hairy inside; peduncle 7–15 cm long, with short white hairs. Flowers bisexual, regular, 5-merous; pedicel up to 1 mm long; calyx tubular, 6–7(–9) mm × 3 mm, 5-toothed, slightly ribbed, with stalked glands and short white hairs; corolla tube 10–13 mm long, lobes obovate, 6 mm long, mucronate, spreading or not, white; stamens free, included; ovary superior, 1-celled, style filiform, stigma lobes 5. Fruit an oblong, membranous capsule up to 7 mm long, enclosed in the persistent calyx, tardily dehiscent, 1-seeded. Seed oblong, c. 6 mm long, slightly flattened, dark brown or black.
Plumbago comprises about 25 species and occurs almost throughout the world. In tropical Africa about 10 species are found.

Ecology *Plumbago aphylla* occurs mostly on the coast on coral rock and is probably dependent on bird guano there. It also occurs on volcanic soil.

Genetic resources and breeding *Plumbago aphylla* is restricted to coastal habitats in Madagascar and some other Indian Ocean islands and may be in danger of genetic erosion.

Prospects In view of the pharmacologically interesting compounds found in other *Plumbago* species, further research into the bioactive substances of *Plumbago aphylla* might be worthwhile.

Major references Debray, Jacquemin & Razafindrambao, 1971; Gurib-Fakim & Brendler, 2004; Peltier, 1981; Wilmot-Dear, 1976.

Other references Fosberg, 1974; Kokwaro, 1993; Rakotozafy, 1997; van Steenis, 1949; Wood, 1970.

Authors A. de Ruijter

PLUMBAGO AURICULATA Lam.

Protologue Encycl. 2: 270 (1786).
Family Plumbaginaceae
Chromosome number $2n = 14, 16$
Synonyms *Plumbago capensis* Thunb. (1794).

Vernacular names Blue plumbago, Cape leadwort, Cape plumbago, skyflower (En). Dentelaire du Cap (Fr). Plumbago azul (Po).

Origin and geographic distribution *Plumbago auriculata* is native to South Africa and introduced as an ornamental into most tropical and subtropical countries.

Uses In southern Africa a decoction of the aerial parts or roots of *Plumbago auriculata* is taken to treat blackwater fever. A root infusion is taken as an emetic. Root powder is put on warts to make them disappear and is also used as snuff to relieve headache. The powdered, roasted root is rubbed into scarifications over fractures to promote healing, and is rubbed on the body to cure stitch. These treatments are not without danger if large areas are rubbed in, as death by irritation has been recorded. The root extract also acts as a styptic in scrofula.
Plumbago auriculata is grown in gardens throughout the tropics as an ornamental and as a hedge or live fence; in temperate regions it is grown as a pot plant or greenhouse plant. Several cultivars with flowers in different shades of blue exist, as well as a white cultivar. In East Africa the flowers and leaves of *Plumbago auriculata* are used as a dye for textiles: beige, lemon, yellow (if combined with alum) or gold (if combined with chrome). The sap of the roots is grey-blue, and is used for tattoos. Poultry and sheep readily eat the leaves, but poisoning has been recorded.

Production and international trade *Plumbago auriculata* is produced commercially and traded as an ornamental throughout the world.

Properties All parts of *Plumbago auriculata* contain the naphthoquinone plumbagin (2-methyl juglone), which blisters the skin. Plumbagin possesses a variety of pharmacological activities, i.e. antimicrobial, anticancer, cardiotonic and antifertility actions. It has insecticidal properties as an antifeedant and as a moulting inhibitor. Plumbagin is also a yellow pigment, occurring in a colourless combined form in the plant and is liberated by acid treatment. *Plumbago auriculata* contains an antifungal protein that inhibits spore germination in *Macrophomina phaseolina*.

Botany Perennial herb or small shrub up to 2(–3) m tall; stems erect, trailing or climbing, diffusely branched. Leaves alternate, simple and entire; stipules absent; petiole short with large, amplexicaul auricles at base; blade obovate, elliptical, oblanceolate or spatulate, 2.5–9 cm × 2–6 cm, base long attenuate, apex acute or obtuse, mucronate, pale yellowish-green. Inflorescence a compact terminal spike or raceme, many-flowered, up to 10(–15) cm long; bracts lanceolate, small; peduncle 1–6 cm long, densely hairy. Flowers bisexual, regular, 5-merous; pedicel 0–1 mm long; calyx tubular, 10–12 mm long, 5-ribbed, with sparse short hairs and stalked glands on the upper part; corolla tube cylindrical, 2–3(–4) cm long, lobes broadly obovate, 10–15 mm long, spreading, usually pale blue, sometimes darker blue or white; stamens free, exserted; ovary superior, 1-celled, style filiform, stigma lobes elongated. Fruit an oblong, membranous capsule up to 8 mm long, tapering to the apex, enclosed in the persistent calyx, dehiscent, 1-seeded. Seed oblong, c. 7 mm long, slightly flattened, dark brown or black.

Plumbago comprises about 25 species and occurs almost throughout the world. In tropical Africa about 10 species can be found. *Plumbago auriculata* flowers all year round, except if the temperature drops below 10°C. The flowers attract large numbers of butterflies.

Ecology *Plumbago auriculata* prefers fertile, well-drained, slightly acidic, sandy soils in sunny localities and is drought resistant once established. It grows best in regions with a pronounced dry season. It can withstand some frost; even if killed to the ground, it usually recovers quickly. *Plumbago auriculata* is salt tolerant.

Management *Plumbago auriculata* is propagated by seed, division of older plants, rooted suckers or semi-ripe cuttings. The seeds are sown in seedling trays in a light soil, after which the soil needs to remain moist. The plants are often pruned to form low hedges or borders and are sometimes trained as climbers on arches. Periodic heavy pruning and bright sunlight induce prolific flowering. In temperate regions, *Plumbago auriculata* can be grown in containers, and kept in a nursery during winter.

Genetic resources and breeding *Plumbago auriculata* is widely cultivated and there is no risk of genetic erosion. Several ornamental cultivars are available, e.g. 'Imperial Blue', 'Royal Cape' with deep blue flowers, 'Blue Dark' with dark blue flowers and 'Alba' with white flowers.

Prospects Plumbagin possesses various interesting pharmacological activities, but because of its toxicity the use of *Plumbago auriculata* in traditional medicine is not without risk. Decoctions of plant parts from *Plumbago auriculata* in local medicine should therefore be taken with caution.

Major references Burkill, 1997; Hindmarsh, 1982; Dyer, 1963; Neuwinger, 2000; van Wyk, van Oudtshoorn & Gericke, 1997.

Other references Elgorashi et al., 2002; Kubo, Uchida, & Klocke, 1983; Modhumita et al., 2002; Pharkphoom Panichayupakaranant & Supinya Tawtrakul, 2002; Smith, 2005; van Steenis, 1949; Vickery, 1983a; Watt & Breyer-Brandwijk, 1962; Whistler, 2000; Wilmot-Dear, 1976.

Authors A. de Ruijter

PLUMBAGO INDICA L.

Protologue Herb. amb.: 24 (1754).
Family Plumbaginaceae
Chromosome number $2n = 14$
Synonyms *Plumbago rosea* L. (1762).

Vernacular names Indian leadwort, rose-coloured leadwort, scarlet leadwort (En). Plumbago de flor vermelha (Po).

Origin and geographic distribution *Plumbago indica* originates from India and South-East Asia, where it is widely used as a medicinal plant. It is cultivated as an ornamental throughout the tropics and in temperate regions in greenhouses. In tropical Africa, *Plumbago indica* is cultivated, sometimes as a medicinal plant, in countries with large populations of Indian immigrants: Kenya, Tanzania, Zimbabwe, Mozambique and Madagascar.

Uses In eastern Africa, *Plumbago indica* is used medicinally in a similar way by the In-

dian population as it is traditionally used in India itself, where many households keep some plants in their backyard. Especially the root has many uses: it is acrid, vesicant, alterative, digestive, stimulant and a powerful abortifacient and oral contraceptive. High doses are dangerous and may cause death. An infusion of the roots is taken to treat dyspepsia, colic, cough and bronchitis. A liniment made from bruised root mixed with a little vegetable oil is used as a rubefacient to treat rheumatism and headache. The milky juice of the leaves is applied on the skin in treatment of scabies, ringworm and haemorrhoids.
Plumbago indica is commonly planted as an ornamental garden plant.

Production and international trade *Plumbago indica* root is an important ingredient in herbal mixtures used in Ayurvedic medicine (originating from India) and traded as such.

Properties The root of *Plumbago indica* contains the naphthoquinone plumbagin (2-methyl juglone). Other compounds isolated from the aerial parts include 6-hydroxyplumbagin, plumbaginol (a flavonol), leucodelphinidin and steroids (e.g. β-sitosterol, stigmasterol, campesterol). Plumbagin possesses several pharmacological activities i.e. antimicrobial, anticancer, cardiotonic and antifertility actions. It is also a powerful irritant. In small doses, the compound is a sudorific and it stimulates the central nervous system; large doses may cause death from respiratory failure and paralysis. Plumbagin has shown anti-implantation and abortifacient activities in rats. Because of its toxicity, the use of plumbagin in traditional medicine is a dangerous practice. In-vitro tests showed that *Plumbago indica* contains one or more antimutagens. At low doses, plumbagin showed significant tumour inhibitory effects against Ehrlich ascites carcinoma in mice. The ethanol extract of the leaves is active against herpes simplex virus type 1 (HSV-1).

Botany Perennial herb or small shrub up to 2 m tall; stems erect, trailing or climbing, simple or branched from the base, sometimes rooting at the nodes. Leaves alternate, simple and entire; stipules absent; petiole short, auricles absent; blade narrowly ovate to elliptical-ovate, 5–15 cm × 2–8 cm, base rounded to obtuse, apex acute, papery. Inflorescence an elongated spike or raceme, many-flowered, 10–30 cm long, glabrous; bracts ovate, 2–3 mm long, apex acuminate; peduncle 2–10 cm long. Flowers bisexual, regular, 5-merous; pedicel 0–1 mm long; calyx tubular, 8–9 mm long, glandular, red; corolla tube 2.5–4.5 cm long, lobes obovate, 1.5–3 cm in diameter, apex rounded, mucronate, purple to red; stamens free, exserted; ovary superior, ellipsoid-ovoid, 1-celled, style filiform, stigma lobes 5.



Plumbago indica – 1, plant habit; 2, roots; 3, flower.
Source: PROSEA

Plumbago comprises about 25 species and occurs almost everywhere throughout the world. In tropical Africa about 10 species can be found. *Plumbago indica* can be found flowering throughout the year. Fruits have never been found.

Ecology *Plumbago indica* thrives very well at temperatures of 25–35°C. It prefers rich, moist and well-drained soils, with a pH of 5.5–6, whereas a pH below 5 or above 7 may lead to stunted growth. When escaped, it occurs in (former) anthropogenic localities and abandoned farmland.

Management *Plumbago indica* can be mass produced using in vitro clonal production of nodal explants, callus cultures, cell suspension cultures or root cultures. The roots of the plants produced this way have a significantly higher percentage of plumbagin than control plants.
In India tests on root yield of *Plumbago indica*

showed an optimum harvesting stage between 12 and 18 months after planting in the field. *Plumbago indica* is a short-day plant and needs a prolonged dark period treatment in the temperate zone in order to produce compact plants and flowers. Successful plant regeneration through micropropagation using different growth media is practised.

Genetic resources and breeding *Plumbago indica* is a common ornamental in the tropics and therefore not threatened. As fruits are not known for this species, it is only vegetatively propagated, indicating that the genetic variability might be small.

Prospects *Plumbago indica* roots contain high levels of plumbagin. The cultivation and extraction methods deserve more attention from research and extension. Besides, *Plumbago indica* is also an interesting ornamental plant, and it could be grown on a much wider scale in Africa using micropropagation or vegetative propagation.

Major references Devi, Solomon & Sharada, 1999; Komaraiah et al., 2004; Valsaraj et al., 1997; van Steenis, 1949; Wongsatit Chuakul, Noppamas Soonthornchareonnon & Promjit Saralamp, 1999c.

Other references Akanitapichat et al., 2002; Burkill, 1997; Das & Rout, 2002; Komaraiah et al., 2002; Komaraiah et al., 2003; Menon, Amma & Nybe, 2001a; Rajwani, Prabhu & Desai, 2001; Rojanapo, Tepsuwan & Siripong, 1990; Satheeshkumar & Seeni, 2003.

Sources of illustration Wongsatit Chuakul, Noppamas Soonthornchareonnon & Promjit Saralamp, 1999c.

Authors J.M. Okeyo

PLUMBAGO ZEYLANICA L.

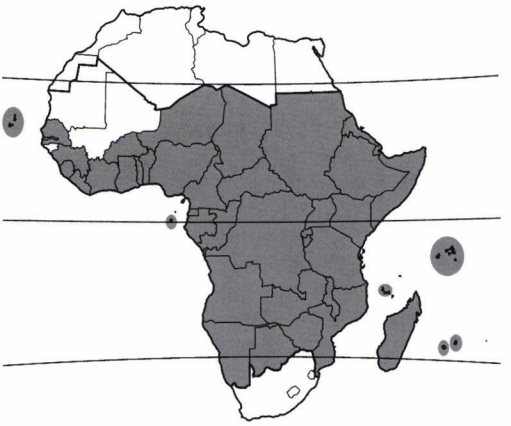
Protologue Sp. pl. 1: 151 (1753).

Family Plumbaginaceae

Chromosome number $2n = 28$

Vernacular names Ceylon leadwort, wild leadwort, wild white plumbago (En). Dentelaire de Ceylan (Fr). Joelho de cabra, kadinga puna (Po). Mwambula (Sw).

Origin and geographic distribution *Plumbago zeylanica* occurs throughout the tropics and subtropics. It possibly originates from South-East Asia, from where it may have been distributed as a medicinal plant and ornamental. It occurs throughout most of tropical Africa.



Plumbago zeylanica – planted and naturalized

Uses *Plumbago zeylanica* is very popular throughout Africa and Asia as a remedy for skin diseases, infections and intestinal worms, especially leprosy, scabies, ringworm, dermatitis, acne, sores, ulcers of the leg, haemorrhoids and hookworm. All parts of the plant are used, but the root is considered to have the highest activity. In West Africa the root, or the leaves crushed with lemon juice, are used as a counter-irritant and vesicant. The pulped roots or aerial parts are inserted into the vagina as an abortifacient. This is a dangerous practice as it sometimes results in death. In Nigeria the roots pounded with vegetable oil are applied to rheumatic swellings. In Ethiopia powdered bark, root or leaves are used to treat gonorrhoea, syphilis, tuberculosis, rheumatic pain, swellings and wounds. In DR Congo and Gabon the pounded root is applied to treat itch. In East Africa pounded roots are applied to swollen legs. In Zambia a root decoction with boiled milk is swallowed to treat inflammation in the mouth, throat and chest. In southern Africa a paste of the root in vinegar, milk and water is used to treat influenza and blackwater fever. *Plumbago zeylanica* root cooked with meat in soup is eaten in Zimbabwe as an aphrodisiac, and it also helps digestion. A root infusion is taken orally to treat shortness of breath. In Madagascar the roots are applied as a vesicant, while in Mauritius and Rodrigues a root decoction is used to treat diarrhoea and dyspepsia.

A paste of powdered root or the root sap is used for tattooing by different tribes in eastern Africa. The paste or sap causes blisters and the new skin has a darker colour. The long white inflorescence of *Plumbago zeylanica* makes it attractive as an ornamental. Despite the plant

being poisonous, it is readily eaten by goats and sheep in West Africa.

Production and international trade In Africa *Plumbago zeylanica* is only locally used. Herbalists collect the plants from the wild or cultivate them in their backyard for personal use and to supply the local markets. *Plumbago zeylanica* is sometimes cultivated and traded as ornamental. *Plumbago zeylanica* products are traded worldwide as Ayurvedic and homeopathic medicine.

Properties The root and leaves of *Plumbago zeylanica* contain the naphthoquinone plumbagin. Other compounds that have been isolated are mainly plumbagin-derivatives, biplumbagin-derivatives and coumarins.

Plumbagin possesses several pharmacological activities, e.g. antimicrobial, antiplasmodial, anticancer and antifertility actions. It is also a powerful irritant. In small doses, it is a sudorific and stimulates the central nervous system; large doses may cause death from respiratory failure and paralysis. Plumbagin showed anti-implantation and abortifacient activities in rats and produced testicular lesions and testis-weight reduction in dogs. Because of its toxicity, the use of plumbagin in traditional medicine is a dangerous practice, and casualties have been recorded. In low concentrations, plumbagin has an antimitotic activity comparable to that of colchicine. In larger doses, it also has nucleotoxic and cytotoxic effects. Plumbagin significantly suppresses growth of several tumour cell lines in vitro and in vivo in mice, especially in combination with gamma-irradiation.

Plumbagin has shown antibacterial activity against both gram-positive (e.g. *Staphylococcus*, *Streptococcus*, *Pneumococcus* spp.) and gram–negative (e.g. *Salmonella*, *Neisseria*) bacteria, whereas it is also active against certain yeasts and fungi (*Candida*, *Trichophyton*, *Epidermophyton* and *Microsporum* spp.) and protozoa (*Leishmania*). It has been found to prevent *Escherichia coli* and *Staphylococcus aureus* developing resistance to antibiotics. Plumbagin also has strong antifeedant and moulting inhibiting effects on insects and has nematicidal and acaricidal activities.

An ethanolic extract of *Plumbago zeylanica* stems inhibited immediate allergic reactions in tests with mice and rats. The ethanol extract of the root showed significant antioxidant activities in vitro. It also caused significant hyperglycaemia in rats.

Adulterations and substitutes At present, the most exploited source of plumbagin is the root of *Plumbago* spp., but the compound also occurs in *Drosera* spp.

Description Straggling shrub up to 3 m tall; stems erect, trailing or climbing, wiry, diffusely branched, glabrous, with prominent longitudinal ridges and often with white waxy dots. Leaves alternate, simple and entire; stipules absent; petiole 0–5 mm long with small auricles present in young leaves; blade ovate, ovate-lanceolate, elliptical or oblong, 2.5–13 cm × 1–6 cm, base cuneate, apex acute, acuminate or obtuse, with white waxy dots underneath. Inflorescence a terminal raceme, 6–30 cm long, sometimes paniculate, many-flowered; bracts ovate to lanceolate, 3–7 mm long; peduncle 1–1.5 cm long, with prominent sessile glands. Flowers bisexual, regular, 5-merous, sweet-scented; pedicel 1–2 mm long; calyx tubular, 7–11 mm long, 5-ribbed, with stalked glands along ribs, lobes up to 1.5 mm long; corolla tube 15–30 mm long, lobes oblong to ovate, 5–12 mm long, spreading, mucronate, white; stamens free, included; ovary superior, 1-celled, style filiform, with 5 elongated stigma lobes. Fruit an oblong capsule 7.5–8 mm long, apex acute with 5 furrows, 1-seeded. Seed oblong, 5–6 mm long, reddish brown to dark brown.



Plumbago zeylanica – flowering branch. Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Plumbago* comprises about 25 species and occurs almost throughout the world. In tropical Africa about 10 species can be found. The sap of *Plumbago* spp. causes discoloration of the skin resembling the colour of lead, from which the Latin name *Plumbago* and the popular name leadwort are derived. *Plumbago dawei* Rolfe occurs naturally in East Africa from Ethiopia to Tanzania and in Madagascar. It is a laxly branched, creeping or scandent herb or shrub. In Madagascar a leaf decoction of the leaves is drunk as a purgative, and a root decoction is taken to treat bacterial infections of urethra and bladder.

Growth and development *Plumbago zeylanica* flowers throughout the year. The flowers are produced in profusion on the shoots of the current year, and are insect pollinated. The fruits are easily dispersed by animals because of the sticky glands on the persistent calyx.

Ecology *Plumbago zeylanica* occurs in deciduous woodland, savanna and scrubland, often near rivers and on lake margins or on termite mounds, from sea-level up to 2000 m altitude.

Propagation and planting *Plumbago zeylanica* can be propagated by seeds, rooted shoots from the base of the plant or by semi-ripe cuttings, treated with a growth hormone. Germination is almost 100% if both ends of the seed are cut before sowing. Seeds germinate in 21–30 days at 21°C. After 3 months storage, germination decreased to 40%. In Assam, India sowing *Plumbago zeylanica* seeds in a nursery and transplanting into the field at a density of 60 × 60 cm has given good results. *Plumbago zeylanica* can be mass-produced using in vitro cultivation of nodal explants, axillary buds, leaf or root explants and callus cultures. The roots of the plants produced this way have a significantly higher content of plumbagin than control plants, and there is potential for commercial cultivation.

Management *Plumbago zeylanica* needs full sun to partial shade with intermediate to warm temperatures. The plants needs a slightly acidic potting mix. The plants are kept moist for optimum growth and flower production. They are fertilized weekly, which also helps flower production. After flowering, the plants should be cut back to keep them growing vigorously.

Diseases and pests *Plumbago zeylanica* contains plumbagin, a natural insect antifeedant and growth inhibitor and is quite resistant to insect pests.

Yield The yield of plumbagin from the root is variable, with an average of 4%. In Indian experiments, the largest and heaviest roots were obtained from 12–18-month-old plants grown in loamy soils, but in Assam the highest yield (7 t dry root/ha) was obtained when plants were harvested when 3 years old.

Handling after harvest Leaf poultices of *Plumbago zeylanica* can be dried and stored for several weeks only, before they lose their vesicant properties. Dried roots contain less plumbagin and show less activity than fresh ones. Plumbagin is obtained from the roots by steam distillation and shaking the distillate with ether. Fine, bright orange tufts of plumbagin crystals are obtained after evaporating the ether. The crystals have a peculiar odour and a very acrid taste.

Genetic resources *Plumbago zeylanica* has a wide distribution and is not in danger of genetic erosion. No germplasm collections or breeding programmes are known to exist.

Prospects *Plumbago zeylanica* is widely used for its medicinal properties in Africa, and many uses are being confirmed by scientific research. Although plumbagin may have medicinal potential, e.g. for its antimicrobial and antitumour activity, the use of plumbagin or plumbagin-containing plant material as medicine for humans is dangerous because of the high toxicity. Plumbagin may have potential as a compound in synthetic insecticides.

Major references Abebe & Hagos, 1991; Beg & Ahmad, 2000; Bopaiah & Pradhan, 2001; Burkill, 1997; Dhar & Rao, 1995; Neuwinger, 2000; Nguyen et al., 2004; Ram, Bhakshu & Raju, 2004; Verma, 2002; Wongsatit Chuakul, Noppamas Soonthornchareonnon & Promjit Saralamp, 1999c.

Other references Ahmad, 2000-2001; Dai et al., 2004; Gelfand et al., 1985; Gurib-Fakim et al., 1993; Heine & Heine, 1988a; Kanjilal et al., 2004; Karnick, Tiwari & Majumber, 1982; Kavimani et al., 1996; Kini et al., 1997; Kumar & Banerji, 2002; Lemma et al., 2002; Lin, Yang & Chou, 2003; Menon, Amma & Nybe, 2001a; Menon, Amma & Nybe, 2001b; Olagunju, Kazeem & Oyedapo, 2000; Pernet & Meyer, 1957; Rout, 2002; Tilak, Adhikari, & Devesagayam, 2004; Watt & Breyer-Brandwijk, 1962; Wilmot-Dear, 1976.

Sources of illustration Hepper, 1963b.

Authors Y. Mungwini

PSEUDOLACHNOSTYLIS MAPROUNEIFOLIA Pax

Protologue Bot. Jahrb. Syst. 28: 20 (1899).

Family Euphorbiaceae (APG: Phyllanthaceae)

Vernacular names Kudu berry, duiker berry (En).

Origin and geographic distribution *Pseudolachnostylis maprouneifolia* occurs from DR Congo and Tanzania south throughout southern Africa including northern South Africa.

Uses In East Africa a root decoction is taken as a purgative to treat stomach-ache and abdominal problems. In Tanzania the roots and bark mixed with poisonous insects are burned and the ashes applied to incisions as a cure for tumours. The leaves pounded together with leaves, bark and roots of pigeon pea (*Cajanus cajan* (L.) Millsp.) in water are used as ear drops to treat earache. In southern Africa the smoke of burning roots is inhaled to treat pneumonia. The pulverized bark mixed in porridge is taken to treat pneumonia, tuberculosis and aenemia. A bark extract is drunk or dried powdered root mixed in porridge is taken to treat diarrhoea, dysentery and as an aphrodisiac. In Zambia the pulp of peeled roots is applied to leprous sores. In Zimbabwe the leaves are boiled and the strained liquid is rubbed into incisions on the side to treat pain in the side. A leaf decoction is taken to treat cough and fever. A root infusion is taken to treat abdominal pain, gonorrhoea and female sterility. A bark infusion is taken to treat dizziness and vomiting. Dried, pulverized root is sniffed to treat nosebleed and headache. It is sprinkled on fresh wounds to heal them. An infusion of leaves and roots is given to cattle to threat haematuria.

The wood is used to make toys, joinery, turnery and handicrafts, and is also used as firewood and to make charcoal. The fruits are edible. The leaves and fruit are used as fodder. In Zambia *Pseudolachnostylis maprouneifolia* is a popular host plant of edible caterpillars. In Malawi the tree enters into religious ceremonies.

Properties No information is available concerning the phytochemistry and pharmacology. The wood is moderately heavy, with an even texture.

The fresh fruit pulp contains per 100 g: water 60 g, energy 35 kJ (147 kcal), protein 3.3 g, fat 1.8 g, carbohydrate 33.5 g, cellulose 8 g, Ca 0.03 g, Mg 0.05 g, P 0.04 g, Fe 2.7 mg, Zn 2.6 mg, riboflavin 0.06 mg, niacin 1.09 mg.

Botany Dioecious, deciduous small tree up to 10(–18)m tall; bole straight, branchless for c. 3.5 m; bark smooth, becoming transversely fissured and flaking, dark grey to blackish; crown compact and rounded, or lax with drooping branches; twigs glabrous to densely hairy. Leaves alternate, simple and entire; stipules lanceolate, 3–5 mm long, soon falling; petiole 2–10 mm long; blade broadly ovate to elliptical-ovate, 1.5–10(–12.5) cm × 1–6 cm, base cuneate to shallowly cordate, apex obtuse to rounded, glabrous or short-hairy, pinnately veined with 6–12 pairs of lateral veins, orange-red before falling. Inflorescence an axillary cyme; bracts up to 3 mm long; male inflorescence up to 2 cm long; female inflorescence up to 4 cm long. Flowers unisexual, regular; sepals 5(–6), ovate to elliptical, 3–5 mm × 1–3 mm, obtuse, glabrous to sparingly short-hairy, yellowish green; petals absent; disk c. 2 mm in diameter, pinkish; male flowers sessile, stamens 5–7, staminal column 1–2 mm long; female flowers with 1.5–2 mm long pedicel, ovary superior, ovoid, c. 1.5 mm × 1 mm, 3-celled, smooth, densely short-hairy to glabrous, styles 3, 1.5–2 cm long, fused at base, stigmas 2-fid. Fruit an ovoid to rounded drupe-like capsule 1.5–2 cm long, scarcely 2–4-lobed, tardily septicidally dehiscent, glabrous, yellowish green, yellow or pinkish green, 3-seeded by abortion. Seeds ellipsoid-ovoid, c. 7 mm × 5 mm long, slightly shiny, pale brown streaked with dark brown.

Pseudolachnostylis comprises a single species, but up to 6 species have been recognized in the past, which are distinguished as varieties in recent treatments. *Pseudolachnostylis maprouneifolia* flowers from July to December, fruits remain long on the tree.

Ecology *Pseudolachnostylis maprouneifolia* occurs in mixed deciduous woodland, wooded grassland and riverine vegetation, usually on sandy soils, but also on rocky outcrops and disturbed soils near cultivation, at 200–1600 m altitude. Mature trees are moderately fire resistant.

Management Seeds can be stored for later use; the germination rate is increased when seeds are soaked in hot water and allowed to cool for 24 hours before sowing. The plants can be pruned and coppiced.

Genetic resources and breeding *Pseudolachnostylis maprouneifolia* is common in its area of distribution and not threatened by genetic erosion.

Prospects *Pseudolachnostylis maprouneifolia* has many interesting medicinal uses, e.g.

against different infectious ailments. However, no phytochemical or pharmacological research has been done so far, and it would be worthwhile evaluating the different plant parts for their activities.

Major references Chilufya & Tengnäs, 1996; Neuwinger, 2000; Radcliffe-Smith, 1996a; Williamson, 1955.

Other references Chinemana et al., 1985; Coates Palgrave, 1983; Oliveira, 1974; Kokwaro, 1993.

Authors G.H. Schmelzer

PYCNOBOTRYA NITIDA Benth.

Protologue Hook.f., Icon. pl. 12: 72, t. 1183 (1876).

Family Apocynaceae

Synonyms *Pycnobotrya multiflora* K.Schum. ex Stapf (1902).

Origin and geographic distribution *Pycnobotrya nitida* occurs in West and Central Africa, from Nigeria to the Central African Republic and DR Congo.

Uses In Congo the leaves of *Pycnobotrya nitida* are eaten with other food to treat chest infections and the latex is taken to treat haematuria, diarrhoea and dysentery. These treatments are supplemented by wearing a cord made from the bark of *Pycnobotrya nitida* and *Haumantia* sp. round the neck or chest. Leaves are also eaten either as a vegetable or to treat bronchitis. Fibre obtained from the bark is used to make cords, e.g. for crossbows.

Properties There is no information on the chemical composition of *Pycnobotrya nitida* except that it contains steroids and terpenes.

Botany Large liana, up to 40 m long, with white latex, turning pale yellow; stem up to 12 cm in diameter; bark dark brown, smooth; branches terete, dark red-brown. Leaves opposite or in whorls of 3, simple and entire; stipules absent; petiole 3–7 mm long, inserted on distinct leaf cushions; blade narrowly elliptical, 8–15 cm × 2–5 cm, base cuneate, apex obtuse or acuminate, leathery, glossy, dotted with many black glands, pinnately veined with many straight, parallel, inconspicuous lateral veins. Inflorescence an axillary or terminal panicle 3–15 cm × 2–20 cm, first ramifications lax, others congested, rusty-hairy; peduncle 1–5 cm long; bracts ovate to narrowly elliptical, up to 6 mm long. Flowers bisexual, regular but with the sepals unequal, 5-merous, fragrant; pedicel 1–3 mm long; sepals free or nearly so, ovate, c. 1 mm long, apex obtuse, ciliate; corolla tube campanulate, 1–2 mm long, lobes oblong, 3–5(–7) mm long, with obtuse apex, upcurved at the left side, contorted and overlapping to the left, spreading, dark pink, usually turning paler at anthesis, with or without pale yellow throat; stamens inserted near the base of the corolla tube, included, anthers narrowly triangular, with auricles at base, apex acuminate; ovary superior, almost globose, consisting of 2 free carpels; styles fused, very short, stigma conical, bifid. Fruit composed of two free, obliquely elliptical, laterally compressed follicles 5–7 cm long, widely spreading, 2-valved, 1–4-seeded. Seeds flattened, obliquely oblong, 4–6 cm long, surrounded by a papery wing, transparent except for the margins.

Pycnobotrya comprises a single species and seems related to the American genus *Aspidosperma*.

Ecology *Pycnobotrya nitida* occurs in forest, often on river banks, at low altitudes.

Genetic resources and breeding Because it is widespread and in several regions common, *Pycnobotrya nitida* does not seem to be threatened by genetic erosion.

Prospects *Pycnobotrya nitida* will remain a medicinal plant of only local importance. Information is needed on its pharmacological properties and phytochemistry. Its value as a vegetable deserves further research.

Major references Burkill, 1985; Neuwinger, 2000; van der Ploeg, 1983.

Other references Bouquet, 1969.

Authors A. de Ruijter

PYCNOCOMA MACROPHYLLA Benth.

Protologue Hook., Niger Fl.: 508 (1849).

Family Euphorbiaceae

Origin and geographic distribution *Pycnocoma macrophylla* is native from Sierra Leone and Liberia eastwards to Gabon and DR Congo.

Uses All parts of *Pycnocoma macrophylla* are strongly purgative. Root bark, the most widely used plant part throughout West Africa, is not administered to children in Côte d'Ivoire because of its strong purgative action. In Ghana the stem bark is ground, mixed with water and lemon juice and drunk as an emetic. It is also used as a fish poison.

Properties Highly active protein kinase C-agonizing compounds were isolated from the leaves and identified as esters of the diterpe-

noid 11,18-dehydro-phorbol and of 4,12-dideoxy-16-hydroxy-phorbol. These phorbol derivatives stimulated the central nervous system by markedly inhibiting amphetamine-induced locomotor activity in mice. A root extract exhibited antitumour activity in the P388 lymphocytic leukaemia test; scopoletin was found to be partly responsible for this effect.

Botany Monoecious shrub up to 3 m tall; stems glabrous. Leaves alternate, clustered towards end of branches, simple; stipules falling early; petiole up to 1 cm long, glabrous; blade oblanceolate, 25–60 cm × 5–14 cm, base rounded to cordate, apex acuminate, margins entire, toothed or rarely lobed, glabrous, with 16–22 pairs of lateral veins, small pustules below and paired glands at lower surface towards the base. Inflorescence an axillary, solitary raceme 11–20 cm long with flowers in clusters of usually 3 male flowers and 1 terminal female flower; peduncle glabrous to densely short-hairy; bracts ovate, 4–8 mm long. Flowers unisexual, regular, with strong, repellent smell; petals absent; male flowers with pedicel 1.5–2.5 cm long, calyx lobes c. 6 mm long, stamens many, free, anthers small; female flowers with pedicel 2–7 mm long, calyx lobes 6–9 mm long, ovary superior, 2–3 mm in diameter, slightly 3-lobed, densely short-hairy, 3-celled, styles 3, fused below. Fruit a 3-lobed, 6-horned capsule c. 2 cm in diameter, glabrous to densely short-hairy, 3-seeded. Seeds globose, c. 13 mm in diameter, smooth, brown.

The growth of *Pycnocoma macrophylla* follows Corner's architectural model implying that vegetative growth of a single meristem produces a single unbranched axis with lateral inflorescences.

Pycnocoma comprises about 18 species, all in tropical Africa. About 10 occur in DR Congo, several with a very localized distribution.

Pycnocoma angustifolia Prain occurs in Sierra Leone, Liberia, Côte d'Ivoire, Ghana and Nigeria and *Pycnocoma cornuta* Müll.Arg. occurs in Ghana and Nigeria. In Ghana intermediates between *Pycnocoma macrophylla* and these two species occur, indicating that they could well belong to a single species. Their medicinal uses are similar to those of *Pycnocoma macrophylla*.

Pycnocoma chevalieri Beille occurs in gallery forest in the Central African Republic, northern DR Congo, Sudan and Uganda. In DR Congo ground roots are added to wine and the mixture is drunk as an emetic. They are also eaten with palm nuts or rice as a purgative. In the Central African Republic the leaves are used as a cure for diabetes. *Pycnocoma littoralis* Pax is a vulnerable species restricted to the coastal belt of southern Kenya and northern Tanzania. In Tanzania a root decoction is drunk to expel a retained placenta. *Pycnocoma minor* Müll.Arg. occurs in Equatorial Guinea and Gabon. In Gabon the macerated roots are added to wine and the mixture is drunk as a diuretic. A root extract of *Pycnocoma thonneri* Pax, endemic to DR Congo, is drunk as an abortifacient, purgative and anthelmintic. Root scrapings are eaten to cure stomach-ache and to kill internal parasites. Root powder or leaf sap is applied as eye drops to stop convulsions in children. Root scrapings are applied as a dressing to counteract inflammation in the knee.

Ecology *Pycnocoma macrophylla* occurs in the undergrowth of forests. In DR Congo it is restricted to 500–750 m altitude.

Genetic resources and breeding *Pycnocoma macrophylla* is widespread and not under serious threat.

Prospects More chemical and pharmacological research is needed to evaluate the potential of *Pycnocoma macrophylla*.

Major references Hawthorne & Jongkind, 2006; Léonard, 1996a.

Other references Adjanohoun & Aké Assi, 1979; Apema et al., 2007; Bergquist, Obianwu & Wickberg, 1989; Hallé, Oldeman & Tomlinson, 1978; Hulstaert, 1966; Léonard, 1996c; Neuwinger, 2004; Vergiat, 1970.

Authors C.H. Bosch

RAUVOLFIA CAFFRA Sond.

Protologue Linnaea 23: 77 (1850).

Family Apocynaceae

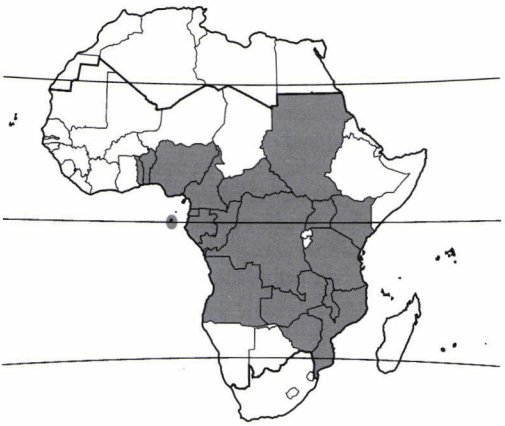
Chromosome number $2n = 44$

Synonyms *Rauvolfia macrophylla* Stapf (1894).

Vernacular names Quinine tree (En). Mseswe, msesawe, mwembe mwitu, mkufi (Sw).

Origin and geographic distribution *Rauvolfia caffra* occurs from Togo east to southern Sudan, Uganda and Kenya and south through Central and East Africa to eastern South Africa.

Uses In East Africa the bark is commonly used in local medicine. The crushed bark is applied against measles or itching rash. A bark decoction is taken as an astringent, purgative or emetic to treat fever, swellings, rheumatism,



Rauvolfia caffra – wild

hepatitis, pneumonia, abdominal pain and as a tranquilizer. A piece of bark is chewed to cure cough and toothache. Dried pulverized leaves are sniffed to cure headache. A root decoction is taken to treat fever, swollen legs, insomnia and palpitation of the heart. The root is used for treating insomnia and insecurity. A root or bark decoction cooked in porridge is applied to hardened abscesses, whereas the powdered unopened inflorescences are applied to sores. A stem or root bark decoction is taken to treat internal parasites, such as roundworm and tapeworm. Root sap, mixed with honey, is applied to fractures. In Tanzania a root decoction is taken to treat abdominal pain, constipation and irregular periods or hypertension. The vapour of a bark decoction is inhaled to treat epilepsy and eye diseases. In Zambia stem bark is used to treat venereal diseases. In Zimbabwe the sap of pounded fruits is used as ear drops to cure earache. In South Africa a decoction of the bark is taken as a tranquilizer for hysteria, and to treat insomnia.

In the Arusha and Kilimanjaro districts of Tanzania the root extract and ground stem bark are added to a local beer made from cooking bananas to add a bitter flavour and increase the alcohol percentage of the drink. The wood is suitable for making fruit boxes, kitchen furniture and shelving. Household utensils and drums are sometimes carved from it. In Kenya poles are used in hut building and for making bee hives. *Rauvolfia caffra* is used as a shade tree in coffee plantations, and is an important species in bee keeping in Tanzania due to its multitude of flowers. The tree is a good source of fuel wood. The thickened latex is used as a bird lime in Kenya. The bark contains a fibre which is used in Cameroon and Gabon to make bow strings and cords. *Rauvolfia caffra* is a decorative fast-growing tree for sheltered gardens. It is planted as an ornamental shade tree in southern Africa.

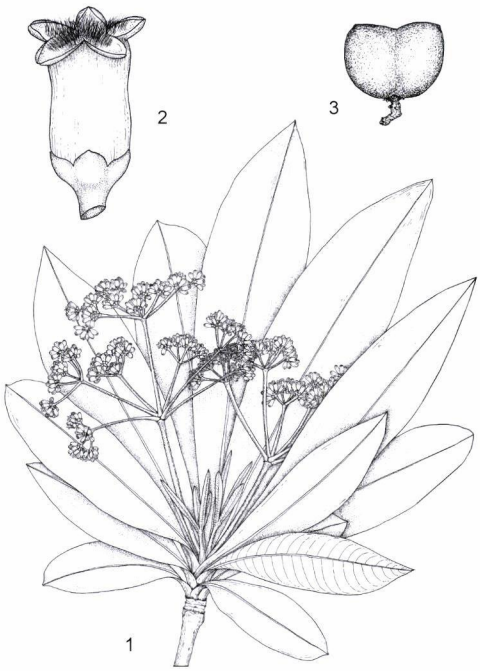
Properties *Rauvolfia caffra* contains a large number of indole alkaloids. The total alkaloid content of young root bark is 3%, with as major components ajmaline (1.25%) and serpentine (1.09%), followed by ajmalicine (0.16%), reserpine (0.08%), reserpinine (0.02%) and reserpiline (0.01%). The principal alkaloids from the stem bark are ajmaline, norajmaline, ajmalicinine, ajmalicine, and geissoschizol. The principal alkaloids isolated from the leaves are from the less common indolenine type (raucaffrinoline, perakine and vomilenine) and from the peraksine type (peraksine and dihydroperaksine). The seeds yielded 0.012% alkaloids, comprising mainly yohimbine and related compounds, and normacusine B. Five of the *Rauvolfia* alkaloids are used in Western medicine: reserpine, reserpinine, deserpidine, ajmalicine and ajmaline. Reserpine, now no longer widely used, is a well-known antihypertensive, antipsychotic and sedative, although an important side effect is depression. Reserpinine and deserpidine are reserpine analogues. Both alkaloids have the same effects as reserpine, and can be used to treat the same conditions, but their side effects are reported to be less pronounced. Ajmalicine is an α-adrenergic blocking spasmolytic which, at high doses, reverses the effects of adrenaline, and moderates the activity of the vasomotor centres, especially in the brain stem. It causes an increase of the blood flow to the brain. Ajmalicine is mainly used in products that treat the psychological and behavioural problems associated with senility, as well as stroke and head injuries. Ajmaline is an anti-arrhythmic, which substantially decreases the rate of depolarization of atrial and ventricular cells. Its toxicity has limited its uses and it is mainly prescribed against rapid irregular cardiac beat, and some other cardiac dysfunctions. Because of its toxicity it is no longer marketed in several countries.

The root extract showed antibacterial activity against *Enterobacter cloacae* in vitro, but was not active against a range of other human pathogens. The stem bark extract showed antibacterial activity against *Staphylococcus aureus* in vitro. The root extract showed low to moderate activity against *Plasmodium falcipa-*

rum in vitro.
The wood is yellowish-white, soft and moderately light weight (density about 540 kg/m^3 at 15% moisture content).

Adulterations and substitutes Commercially, *Rauvolfia* alkaloids are obtained from *Rauvolfia vomitoria* Afzel. and to a lesser extent from *Rauvolfia serpentina* (L.) Benth. ex Kurz.

Description Medium-sized to fairly large tree up to 40 m tall; bole up to 1 m in diameter; bark grey to brown, smooth or rough and corky, fissured; branchlets often 4–5-angular or 4–5-winged, with conspicuous leaf scars. Leaves in whorls of 3–6, crowded at the top of branches, simple and entire; stipules absent; petiole up to 6 cm long; blade narrowly elliptical to narrowly obovate, 2–50(–70) cm × 1–15(–20) cm, base decurrent into the petiole, apex acute, glabrous. Inflorescence a congested cyme, in terminal whorls of 1–4, many-flowered; peduncle 1.5–13.5 cm long, glabrous. Flowers bisexual, regular, 5-merous, fragrant; pedicel up to 2 mm long; sepals fused at base, unequal, ovate, 0.5–1.5 mm long; corolla tube cylindrical, 3–5.5 mm long, glabrous outside, inside glabrous in the basal 1.5–4.5 mm, then shortly hairy to the mouth and hairy at the base of the lobes inside, lobes ovate to obovate, 0.5–1.5 mm long, white, greenish white or yellowish white; stamens inserted at 2–4 mm above the corolla base, included; ovary superior, globose to obovate, composed of 2 partly fused or free carpels, style 0.5–3 mm long, pistil head cylindrical with a basal collar and a stigmoid apex. Fruit a globose to ellipsoid drupe 5–20 mm long when 1 carpel developed, obcordate, 2-lobed, 10–30 mm long when both carpels developed, dark red, 1–2-seeded. Seeds ellipsoid, 7–13 mm long, laterally compressed.



Rauvolfia caffra – *1, flowering branch; 2, flower; 3, fruit.*
Source: Flore analytique du Bénin

Other botanical information *Rauvolfia* is a pantropical genus of about 60 species, of which 7 occur in continental Africa, 2 in Madagascar, and 1 in Madagascar and the Comoros. *Rauvolfia mombasiana* Stapf occurs in Kenya, Tanzania and Mozambique, mainly along the coast. A decoction from the root or sometimes from the bark is taken to treat malaria, venereal diseases, asthma, tuberculosis, stomach complaints and skin problems. The ground leaves are applied to breast abscesses. Dried grated root bark mixed with coconut oil is applied externally to treat scabies. Root powder mixed with porridge is taken to treat constipation and abdominal pain. In Kenya and Tanzania the grated root or stem bark is used with cassava flour as a rat poison. It is also used as a suicide poison. *Rauvolfia mombasiana* contains similar alkaloids to those of *Rauvolfia vomitoria* Afzel. *Rauvolfia volkensii* (K.Schum.) Stapf is an endemic of north-eastern Tanzania. Its root and bark are locally taken in infusion to treat snakebites, gonorrhoea and to increase lactation in nursing mothers. The principal alkaloids in the roots are reserpiline (0.15%) and ajmaline (0.08%); the reserpine content in the roots is very low.

Anatomy Wood-anatomical description (IAWA hardwood codes):
Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; 9: vessels exclusively solitary (90% or more); 13: simple perforation plates; 22: intervessel pits alternate; 25: intervessel pits small (4–7 µm); (26: intervessel pits medium (7–10 µm)); 29: vestured pits; 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 41: mean tangential diameter of vessel lumina 50–100 µm; 42: mean tangential diameter of vessel lumina 100–200 µm; 48: 20–40 vessels per square millimetre. Tracheids and fibres: 62:

fibres with distinctly bordered pits; 63: fibre pits common in both radial and tangential walls; 66: non-septate fibres present; 69: fibres thin- to thick-walled; (70: fibres very thick-walled). Axial parenchyma: 76: axial parenchyma diffuse; 77: axial parenchyma diffuse-in-aggregates; 92: four (3–4) cells per parenchyma strand; 93: eight (5–8) cells per parenchyma strand. Rays: 98: larger rays commonly 4- to 10-seriate; 106: body ray cells procumbent with one row of upright and/or square marginal cells; 107: body ray cells procumbent with mostly 2–4 rows of upright and/or square marginal cells; (114: ≤ 4 rays per mm); 115: 4–12 rays per mm. Mineral inclusions: 136: prismatic crystals present; 137: prismatic crystals in upright and/or square ray cells; 140: prismatic crystals in chambered upright and/or square ray cells; 154: more than one crystal of about the same size per cell or chamber.
(M. Thiam, P. Détienne & E.A. Wheeler)

Growth and development In Tanzania *Rauvolfia caffra* flowers during the long rainy season, extending into the dry season up to the onset of the short rainy season; fruit ripens during the dry season extending into the short rainy season up to the long dry season.
When established, the plants have a fast growth rate, up to 1.5 m/year. *Rauvolfia caffra* needs shade when young; old trees, however, do not tolerate shade.

Ecology *Rauvolfia caffra* occurs in rainforest, riverine forest, montane forest and old secondary forest, from sea-level up to 2500 m altitude. It is frost-sensitive. It appears to prefer fairly fertile soils that are well drained. It grows on loamy sands to sandy clay-loam soils. When growing away from rivers and streams it is always associated with the availability of ground water.

Propagation and planting *Rauvolfia caffra* regenerates by seed, cuttings and suckers. The number of seeds/kg is 4500–5000. Before sowing, the fruit pulp is removed by washing the seeds in water. The seeds are sown in seedling trays filled with a mixture of river sand and compost (1:1), and covered with a thin layer of sand or left on the surface. Germination is fast and reaches up to 80% after two weeks. The seedlings are transplanted into nursery bags when they reach the 3-leaf stage and are 25–30 cm tall. They need regular watering for the first 3 months after transplanting into the field. Seeds retain viability only for a short period of about 1 month at room temperature, although other sources mention that seed germinates even after staying on the forest floor for a long time.
Vegetative propagation of *Rauvolfia caffra* from leaf explants in vitro is successful.

Management *Rauvolfia caffra* can be coppiced or pollarded. Trees should not be grown near houses, as some parts may be toxic to children and livestock. Its large size and invasive root system make it unsuitable for smaller gardens.

Harvesting Roots may be harvested annually in a non-destructive way by cutting them 10 cm from the taproot. All plant parts are harvested whenever the need arises.

Handling after harvest The stem bark or roots of *Rauvolfia caffra* can be used fresh or dried and powdered and stored in a closed container for later use. The leaves are usually used fresh.

Genetic resources *Rauvolfia caffra* is relatively common throughout its distribution area, and not in danger of genetic erosion.

Prospects *Rauvolfia caffra* has multiple uses in local medicine. More research is needed to validate these uses. As the quantity of pharmacologically interesting compounds is lower than in *Rauvolfia vomitoria*, *Rauvolfia caffra* has no future for large-scale exploitation. Its prospects as a shade tree in agroforestry systems in East Africa, especially highland systems with coffee and banana, are promising, although its invasive root system requires further study.

Major references Burkill, 1985; FAO, 1986; Iwu, 1993; Neuwinger, 2000; van Dilst & Leeuwenberg, 1991; van Wyk & Gericke, 2000.

Other references Akinloye & Court, 1981; Amer & Court, 1981; Coates Palgrave, 1983; Hines & Eckman, 1993; Höft, Verpoorte & Beck, 1998a; InsideWood, undated; Iwu & Court, 1979; Iwu & Court, 1978; Iwu & Court, 1980; Madati et al., 1977; Mbuya et al., 1994; Nasser & Court, 1983a; Nasser & Court, 1983b; Nasser & Court, 1984; Omino, 2002; Omino & Kokwaro, 1993; Tshikalange, Meyer & Hussein, 2005; Upadhyay et al., 1992; World Agroforestry Centre, undated; Zirihi et al., 2005.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors N.P. Mollel

RAUVOLFIA MANNII Stapf

Protologue Bull. Misc. Inform. Kew 1894: 21 (1894).

Family Apocynaceae

Chromosome number $2n = 22, 44$

Synonyms *Rauvolfia obscura* K.Schum. (1895), *Rauvolfia rosea* K.Schum. (1895), *Rauvolfia cumminsii* Stapf (1902).

Origin and geographic distribution *Rauvolfia mannii* occurs from Liberia east to Kenya and south to northern Angola and Malawi.

Uses In Côte d'Ivoire and DR Congo dried or fresh pulverized roots in palm wine or water are taken to treat gastro-intestinal disorders, poisoning, jaundice, gonorrhoea or female sterility. The root powder is applied to wounds to improve healing. Root powder, fruit pulp or pulped seeds are rubbed on the head to kill lice and to other parts of the body to kill skin parasites. Bark sap is applied to the eyes to treat epilepsy. In Nigeria the bark in gin is taken as a general tonic. In DR Congo a root decoction is taken to treat fever and diabetes. As a gargle, it is used to treat dental caries. In Kenya the boiled root mixed with fat is rubbed on the body of a person suffering from itch and pimples. In Kenya and DR Congo the roots are used as an arrow poison supplement.

Properties The roots of *Rauvolfia mannii* contain the indole alkaloids reserpine and ajmaline, whereas ajmalicine (δ-yohimbine), reserpiline, serpentine and alstonine occur as minor components. Vincamajine has been isolated as major component of the leaves. Extracts from the roots are highly toxic. Reserpine is hypotensive, reducing heart beat; it is sedative and tranquilizing. Reserpiline is hypotensive. Ajmalicine is a coronary and peripheral vasodilator.

An extract from the root caused skeletal muscle relaxation in rats following intraperitoneal administration. In another experiment a root extract showed in-vitro antibacterial and anti-amoebic activities against a range of human pathogens, and also antispasmodic activity.

Botany Shrub or small tree up to 8 m tall; bark greenish- to grey-brown, scaly. Leaves in whorls of 3–6, crowded at the top of branches, simple and entire; stipules absent; petiole up to 2.5 cm long; blade ovate to obovate or elliptical, 2.5–28 cm × 0.5–10.5 cm, base cuneate, apex acuminate. Inflorescence a terminal or pseudo-axillary, lax to congested cyme, 3–50-flowered; peduncle up to 6 cm long, glabrous. Flowers bisexual, regular, 5-merous, fragrant; pedicel 1–8 mm long; sepals fused at base, unequal, ovate to narrowly elliptical, 0.5–3 mm long; corolla tube cylindrical, 2.5–10.5 mm long, widening at the insertion of the stamens, green to white or yellowish-white, often with pink or red stripes, glabrous outside, short hairy at base inside, lobes axe-shaped to elliptical or ovate, 1–3.5 mm long, white to pink or red-brown, or yellow; stamens inserted at 2–8 mm above the corolla base, included or exserted; ovary superior, globose to oblong or ovoid, composed of 2 partly fused or free carpels, style 1–6 mm long, pistil head cylindrical with a basal collar and a stigmoid apex. Fruit an obcordate drupe 5–12 mm long, laterally compressed, when only 1 carpel developed ellipsoid or ovoid, red, 1–2-seeded. Seeds ellipsoid, 4–11 mm long, laterally compressed.

Rauvolfia is a pantropical genus of about 60 species, of which 7 occur in continental Africa, 2 in Madagascar, and 1 in Madagascar and Comoros. *Rauvolfia mannii* can be found flowering and fruiting throughout the year.

Ecology *Rauvolfia mannii* occurs in rainforest, riverine forest and old secondary forest, from sea-level up to 2500 m altitude.

Genetic resources and breeding *Rauvolfia mannii* is relatively common in its area of distribution and therefore not likely to be endangered by genetic erosion.

Prospects *Rauvolfia mannii* contains similar pharmacological compounds to those found in other *Rauvolfia* species, but the quantities are not known. More research is needed to evaluate the possible future of *Rauvolfia mannii* as a source of pharmacologically important alkaloids. If the alkaloid quantities are low, the species will remain of local importance only.

Major references Harris, Stewart & Court, 1968; Iwu & Court, 1977; Neuwinger, 1996; Neuwinger, 2000; van Dilst & Leeuwenberg, 1991.

Other references Adjanohoun et al. (Editors), 1988; Burkill, 1985; Eno & Itam, 2001; Omino & Kokwaro, 1993; Patel et al., 1965; Ruppert, Ma & Stockigt, 2005; Sandberg & Cronlund, 1982; Timmins & Court, 1975; Tona et al., 1999.

Authors G.H. Schmelzer

RAUVOLFIA MEDIA Pichon

Protologue Bull. Soc. Bot. France 94: 36 (1947).

Family Apocynaceae

Synonyms *Rauvolfia confertiflora* Pichon (1947).

Origin and geographic distribution *Rauvolfia media* is endemic to Madagascar and Comoros.

Uses The bark of young twigs and the leaves are crushed and applied to the eyes to cure viral conjunctivitis. The crushed roots or a decoction of the roots and bark, mixed with food, are used to poison dogs with rabies and also pest animals. The latex can be used as glue for small utensils.

Production and international trade The bark and roots are exported to Europe for the pharmaceutical industry. Between 1986 and 1995, about 16.5 t/year were exported.

Properties All parts are very bitter and are considered very toxic. The bark and roots contain several monomeric indole alkaloids, of which reserpiline is pharmacologically active. It has sympatholytic and hypotensive properties, with no noticeable depressant effects on the central nervous system. In comparison with reserpine, which is present in other *Rauvolfia* spp., reserpiline does not induce the formation of gastric ulcers, has no laxative effects and lacks other side effects.

Botany Shrub or small tree up to 10(–15) m tall; bark grey or pale brownish-grey, smooth. Leaves in whorls of 4–7, crowded at the top of branches, simple and entire; stipules absent; petiole 0.5–1.5 mc long; blade ovate or elliptical to narrowly oblong, 1–18 cm × 0.5–8.5 cm, base cuneate, apex obtuse. Inflorescence a terminal, lax to congested cyme; peduncle 1.5–5.5 cm long, hairy to glabrous. Flowers bisexual, regular, 5-merous, fragrant; pedicel 1–4 mm long; sepals fused at base, unequal, ovate to narrowly oblong, c. 2 mm long; corolla tube cylindrical, 3–6 mm long, widening at the insertion of the stamens, slightly narrowed at the mouth, lobes axe-shaped, 1.5–2.5 mm long, shortly hairy or glabrous on both sides, white to dull yellow; stamens inserted at 2.5–4.5 mm above the corolla base, barely included or exserted; ovary superior, globose, oblong to ovoid, composed of 2 partly fused carpels, style 1–4 mm long, pistil head cylindrical with a basal collar and a stigmoid apex. Fruit an obcordate to ovoid or subglobose drupe 6–10 mm long, laterally compressed, 1–2-seeded. Seeds ellipsoid, 4–10 mm long, laterally compressed.

Rauvolfia is a pantropical genus of about 60 species, of which 7 occur in continental Africa, 2 in Madagascar, and 1 in Madagascar and the Comoros. The 2 other *Rauvolfia* species present in Madagascar are confined to the northern region. The roots of *Rauvolfia obtusiflora* A.DC. are used as a fish poison, whereas the aerial parts in decoction were formerly used as an ordeal poison. The roots are rich in indole alkaloids, but do not contain reserpine. A decoction of the aerial parts of *Rauvolfia capuronii* Markgr. was formerly taken as ordeal poison. *Rauvolfia media* flowers from September to December and fruits from November to February. Young leaves appear just before or with the flowers.

Ecology *Rauvolfia media* occurs in dry forest and savanna, from sea-level up to 800 m altitude.

Genetic resources and breeding Because of the rapid destruction of the forests in which it occurs and harvesting for local use and export, *Rauvolfia media* may become rare and locally threatened.

Prospects More research is needed to identify the pharmacologically active alkaloids in the different plant parts. The exploitation of *Rauvolfia media* as well as the decline of its natural habitat have caused the species to become rare, and unless it is domesticated and planted, the exploitation will come to a halt.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Markgraf, 1976; van Dilst & Leeuwenberg, 1991.

Other references Andriatsiferana, 1997; Kan et al., 1986; Neuwinger, 1996; Rasoanaivo, Petitjean & Conan, 1993.

Authors G.H. Schmelzer

RAUVOLFIA VOMITORIA Afzel.

Protologue Stirp. Guinea med.: 1 (1817).

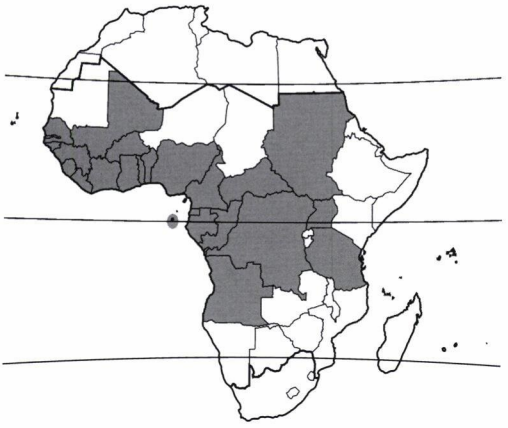
Family Apocynaceae

Chromosome number $2n = 22, 66$

Vernacular names Poison devil's pepper, African snakeroot, African serpent wood, swizzle stick (En). Berenquete (Po).

Origin and geographic distribution *Rauvolfia vomitoria* occurs from Senegal east to Uganda and Tanzania and south to DR Congo and Angola. It is cultivated in many parts of the tropics and subtropics.

Uses In the entire distribution area of *Rauvolfia vomitoria* a root decoction, root macerate



Rauvolfia vomitoria – wild

or powdered root in water is taken to treat diarrhoea, rheumatism, jaundice, venereal diseases and snakebites. Root products are also widely taken to treat hypertension, and as a sedative to calm people with epilepsy, and people who are psychotic or mentally ill; they are also used to wash children with colic or fever. Externally, macerated or powdered root or sometimes pulped fruit are applied to a range of skin problems, such as rash, pimples, chicken pox, wounds, scabies, psoriasis, leprosy, haemorrhoids, head lice and parasitic skin diseases. A root decoction is used as a mouth wash against gingivitis or thrush. The stem bark or leaves are also used for these purposes, but to a lesser extent. The stem bark, leaf decoction and latex of young twigs are widely used as purgative or emetic.

In Guinea the root maceration is applied to tumours. In Liberia a bark infusion is taken to cure fever. A leaf infusion is rubbed in against yaws. Dried or fresh pulverized roots in palm wine or oil are taken to treat female sterility. A root decoction is used in massages and baths to treat rheumatism, tiredness and rachitis. In Togo pulverized root bark in brandy is taken to treat tuberculosis. In Cameroon a decoction of powdered roots is taken to treat diabetes and malaria. In the Central African Republic a root decoction is taken to treat hernia. In Côte d'Ivoire leaf sap is rubbed between the toes to treat infections caused by humidity. A leaf maceration is used for bathing children with fever. In Gabon chopped and boiled leaves mixed with fat are applied to the skin to cure rheumatism and sprains. A mixture of pulverized root or leaf sap with plant oil or lemon juice is applied to the hair to stop hair loss. In Nigeria the root and leaves in decoction are taken to treat indigestion, as a tonic, and as abortifacient. In Equatorial Guinea the latex is used for cicatrization of wounds.

In the Central African Republic the roots of *Rauvolfia vomitoria*, alone or together with seeds of *Strophanthus gratus* (Wall. & Hook.) Franch., are pounded to a paste, which serves as arrow poison. In DR Congo the roots are a common additive to *Periploca nigrescens* Afzel. hunting poison. In Equatorial Guinea the root scrapings are mixed with cassava meal and put in bait as a rat poison. In West Africa the root is considered aphrodisiac when taken in palm wine.

Rauvolfia vomitoria is widely planted as an ornamental in West Africa, as a shade tree for cacao and coffee and as a support for vanilla. It is also grown as a live fence. The young twigs with a whorl of branches at the end are used as mixers for drinks. Larger branches are similarly used to stir the indigo mixture in dyeing pits. The wood is of little economic importance, although the heartwood is fairly hard; small kitchen utensils are made from it, and it is used as a substitute for boxwood. It is also used as firewood. A yellow dye is produced from the bark.

Production and international trade In the 1970s the stem bark and root bark of *Rauvolfia vomitoria* were collected from West and Central Africa, and nearly 200 t of reserpine were sold in total, mainly in tablet form for use in human medicines. Reserpine was also widely added as a sedative to animal feed. Nowadays, reserpine is still widely sold through the internet, mainly in India and the United States.

Properties *Rauvolfia vomitoria* contains a large number of indole alkaloids, between 40 and 80. Most occur in very small amounts and several are disputed. Most alkaloids occur in an unstable complex, and seasonal variation is present as well. Leaves contain 0.03–0.8% total alkaloids, stem bark about 0.6%, roots 0.15–0.2% and root bark 1.5–2%.

The alkaloids of *Rauvolfia vomitoria* can be grouped into 5 main types: (1) yohimbine and derivatives, including reserpine and deserpidine (11-demethoxyreserpine); (2) the heteroyohimbine type, including ajmalicine (raubasine), reserpinine (rescinnamine) and reserpiline; (3) sarpagane derivatives, including sarpagine (raupine); (4) the dihydro-indole type, including ajmaline; (5) the anhydronium bases, including alstonine, serpentine and ser-

penticine. Other groups include the oxindoles and pseudoindoxyls. Serpentinine is the only dimeric yohimbin-related alkaloid isolated so far.

In the root bark reserpiline is the major component, followed by reserpine, reserpinine and ajmaline. In the stem bark reserpiline is also the major component, with small amounts of isoreserpiline and yohimbine. The leaves were found to contain mainly geissoschizol, but no reserpine, reserpinine or ajmaline. The alkaloids in the leaves comprised about 41% heteroyohimbines and 52% oxindoles. The unripe fruit contains several alkaloids, but they are absent in the ripe fruits.

Of the *Rauvolfia* alkaloids, 5 are used in medicine: reserpine, reserpinine, deserpidine, ajmalicine and ajmaline. There are several patented methods for the extraction of the main component reserpine. Furthermore, several simple and accurate methods have been developed to identify *Rauvolfia* alkaloids, e.g. reserpine, serpentine and ajmaline.

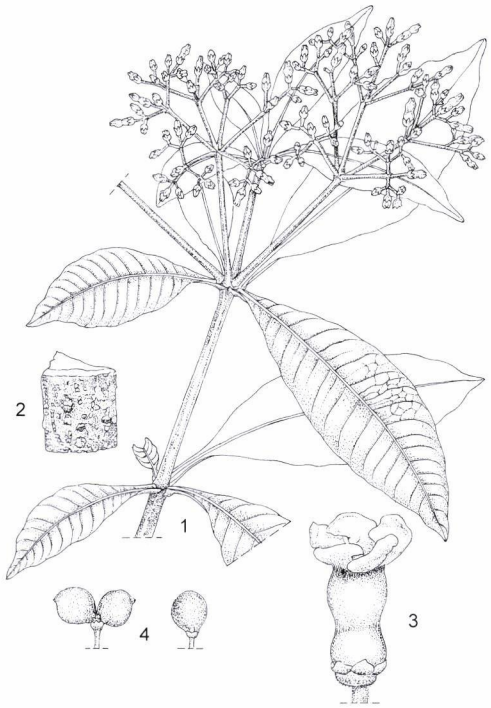
Reserpine is a well-known antihypertensive, antipsychotic and sedative. It is a sympatholytic agent acting indirectly on the peripheral and central nerve terminals. It impairs the storage of biogenic amines resulting in depletion of norepinephrine, dopamine, and serotonin. Depletion of norepinephrine induces a lasting drop in blood pressure. Contraindications for using reserpine are depression, peptic ulcer, and hypersensitivity to the alkaloid. Side effects of the medication include drowsiness, nasal congestion, salivary and gastric hypersecretion, paradoxical anxiety, depression and retention of water and Na^+. Overdose may cause respiratory depression, slowed heartbeat, hypotension, confusion, tremors, convulsions and gastro-intestinal distress. Reserpine has been shown to enhance the hypoglycaemic effect of insulin and the hyperglycaemic effect of adrenalin, and has inhibited the physiological hyperglycaemic response in diabetic patients. Because of the necessary high doses and the resulting dangerous side effects, reserpine lost its importance as a medicine. It is only used in low doses for mild to moderately severe high blood pressure, often together with ajmalicine. Reserpinine and deserpidine are reserpine analogues. Both alkaloids have the same effects as reserpine, and can be used to treat the same conditions, while their side effects are reported to be less pronounced. Reserpiline is marked sympatholytic and hypotensive with no noticeable depressant effects on the central nervous system and no sedative properties. It also lacks most of the side effects of reserpine and its analogues. Ajmalicine is an α-adrenergic blocking spasmolytic which, at high doses, moderates the activity of the vasomotor centres, especially in the brain stem causing an increase of the blood flow to the brain. It is mainly used in products that treat the psychological and behavioural problems associated with senility, stroke and head injuries. Ajmaline is an anti-arrhythmic, which substantially decreases the rate of depolarization of atrial and ventricular cells. Its toxicity has limited its uses and it is mainly prescribed against rapid irregular cardiac beat. Because of its toxicity it is no longer marketed in several countries. Several other *Rauvolfia* alkaloids have hypotensive or sedative activities, but most are less effective.

An ethanolic leaf extract of *Rauvolfia vomitoria* showed a reduction in blood sugar levels of normal and alloxan-induced diabetic rabbits, comparable to that of tolbutamide. A root decoction did not have any adverse effect on the oestrous cycle, fertilization or implantation, and did not show foetotoxicity or hormone-induced infertility in a laboratory test with rats. A root bark extract showed antibacterial activity in vitro against several human pathogens.

The wood is white, reddening with age; the heartwood is fairly hard.

Adulterations and substitutes The Indian *Rauvolfia serpentina* (L.) Benth. ex Kurz was formerly the main source of reserpine, but has been replaced to a large extent by *Rauvolfia vomitoria*. The roots of *Catharanthus roseus* (L.) G.Don are the main source of ajmalicine for the pharmaceutical industry.

Description Shrub or medium-sized tree up to 20(–40) m tall; bole up to 80 cm in diameter; bark pale to dark grey-brown or dark brown, smooth or fissured. Leaves in whorls of 3–5, crowded at the top of branches, simple and entire; stipules absent; petiole 0.5–3.5 cm long; blade elliptical to narrowly elliptical, 2.5–27 cm × 2–9 cm, base cuneate, apex acuminate, glabrous. Inflorescence a lax to congested cyme in terminal whorls of 1–4, 15–450-flowered; peduncle 1.5–8.5 cm long, shortly hairy. Flowers bisexual, regular, 5-merous, fragrant; pedicel 1–4.5 mm long; sepals fused at base, unequal, ovate, 1–2 mm long; corolla tube cylindrical, 6–10(–12) mm long, constricted below the insertion of the stamens, slightly narrowed at the mouth, glabrous outside with 3 hairy belts in-



Rauvolfia vomitoria – 1, flowering branch; 2, part of stem bark; 3, flower; 4, fruits.
Redrawn and adapted by Achmad Satiri Nurhaman

side, greenish, lobes axe-shaped, 1–2 mm long, white, yellow or creamy; stamens inserted at 4.5–7 mm above the corolla base, included; ovary superior, globose to oblong or ovoid, composed of 2 partly fused carpels, usually only 1 developing into fruit, style 2.5–5 mm long, pistil head cylindrical with a basal collar and a stigmoid apex. Fruit a globose to ovoid or ellipsoid drupe 8–14 mm long, orange or red, 1-seeded. Seed ellipsoid, 6–8 mm long, laterally compressed.

Other botanical information *Rauvolfia* is a pantropical genus of about 60 species, of which 7 occur in continental Africa, 2 in Madagascar, and 1 in Madagascar and Comoros. *Rauvolfia vomitoria* has flowers of 2 different shapes: slender, small flowers and robust flowers. The slender flowers occur, as far as verified, on diploid plants, while the robust flowers occur on hexaploid plants. Both flower types occur throughout the area of distribution, although the large-flowered type is not known from East Africa. The root bark of diploid plants contains less reserpine than that of hexaploids.

Rauvolfia serpentina was introduced from India into West Africa. In Nigeria a root infusion is taken to treat snakebites. The root has been used in Ayurvedic medicine in India since ancient times to treat snakebites, mental diseases and epilepsy, and is still important in local medicine and in alkaloid production.

Growth and development *Rauvolfia vomitoria* can be found flowering and fruiting almost throughout the year, but sometimes not and usually less abundantly during the rainy season.

Ramification in *Rauvolfia* is determined by the leaves in whorls; branches terminate in 2–5 branchlets or inflorescences developing in the axils of the leaves. This results in an umbellate ramification and a candelabra-shaped habit. The flowers are pollinated by insects such as small bees and flies, and the fruits are dispersed by birds.

Ecology *Rauvolfia vomitoria* occurs in bush vegetation, gallery forest, secondary vegetation where fallow periods are long, and along roadsides, from sea-level up to 1600 m altitude.

Propagation and planting *Rauvolfia vomitoria* is usually propagated by seed, although stem and root cuttings can also be used. Wild seedlings can be successfully transplanted and cultivated. For sowing, fruits are collected when ripe and dried. The seeds lose their viability quickly, and need to be sown within 6 months after ripening. In Ghana tests with vegetative propagation of root and shoot cuttings in vitro have been moderately successful.

Management *Rauvolfia vomitoria* can be coppiced or pollarded.

Diseases and pests *Rauvolfia vomitoria* is a host of the pathogen causing collar crack of cacao.

Harvesting Roots may be harvested annually in a non-destructive way by cutting them 10 cm from the taproot. All plant parts are harvested whenever the need arises. In Ghana dry season samples were found to contain a higher content of alkaloids than wet season samples.

Handling after harvest The stem bark or roots of *Rauvolfia vomitoria* can be used fresh or dried and powdered for later use.

Genetic resources *Rauvolfia vomitoria* is widely distributed throughout its distribution area, but it is possibly endangered in several countries, e.g. in Ghana, due to overharvesting.

Prospects The use of reserpine has declined

significantly in recent decades in Western countries because of its strong side effects and the availability of more effective alternatives. In developing countries, products based on *Rauvolfia* are still in demand owing to their easy availability and comparatively low prices, but it is expected that they will gradually be replaced by safer alternatives. Continued research might reveal new possibilities for reserpine and related compounds.

Major references Burkill, 1985; Iwu, 1993; Neuwinger, 1996; Neuwinger, 2000; Oduro, 2000; van Dilst & Leeuwenberg, 1991.

Other references Adjanohoun et al. (Editors), 1988; Aké Assi et al., 1985; Bedu-Addo, 1993; Bruneton, 1999; Burkill, 2000; Dasi, 2004; Duez et al., 1986; Duez et al., 1987; Kalanda, Ataholo & Ilumbe, 1995; Latham, 2004; Muanza, Dangala & Mpay, 1993; Nkongmeneck et al., 2000; Nwodo et al., 2003; Terashima & Ichikawa, 2003; World Agroforestry Centre (ICRAF), undated.

Sources of illustration van Dilst & Leeuwenberg, 1991.

Authors G.H. Schmelzer

RHIGIOCARYA RACEMIFERA Miers

Protologue Ann. Mag. Nat. Hist., ser. 3, 14: 101 (1864).

Family Menispermaceae

Chromosome number $2n = 24$

Origin and geographic distribution *Rhigiocarya racemifera* occurs from Sierra Leone east to DR Congo and south to Cabinda (Angola).

Uses In Côte d'Ivoire and southern Burkina Faso *Rhigiocarya racemifera* is well known for its antineuralgic and aphrodisiac properties: leaf sap is applied as eye drops or nose drops, or powdered leaves are instilled into the nose against neuralgia and headache. A decoction of finely ground seeds, leafy twigs or roots is drunk or used as a wash or enema as an aphrodisiac. For sexual vigour, men eat a few seeds or ingest the powder directly or mixed with palm wine. Pulped leaves are topically applied to wounds as a haemostatic. In Côte d'Ivoire vapours of a leaf decoction are inhaled to treat dizziness. In Sierra Leone the root is scraped and put in palm wine obtained from *Raphia* spp. In southern Sierra Leone, Liberia and Nigeria a leaf infusion is drunk against mild stomach-ache and to treat diarrhoea, acute gastrointestinal pain, bloody diarrhoea and spasmodic dysmenorrhoea. The plant is also used against sleeplessness. The Mendes people of Sierra Leone prepare a snake repellent from the pulped stem, with clay and water; the mixture is rubbed onto the body.



Rhigiocarya racemifera – *wild*

Toothpicks are made from stems. Glue from the fruit pulp is used in crafting and as birdlime.

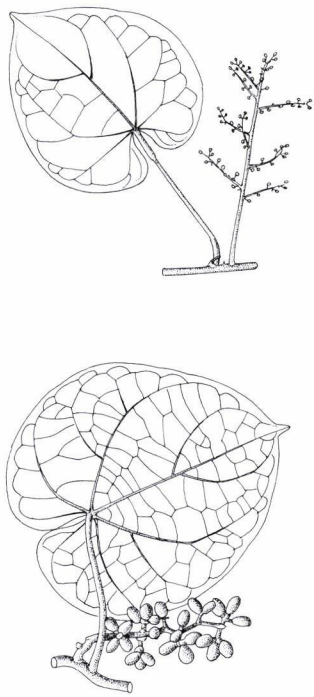
Properties The roots of *Rhigiocarya racemifera* contain the morphinandienone alkaloid O-methylflavinantine (sebiferine), as well as the oxoaporphine alkaloid liriodenine (spermatheridine), the protoberberine alkaloid palmatine and the aporphine alkaloids menisperine (N-methylisocorydine) and magnoflorine. O-methylflavinantine exhibits a morphine-like antinociceptive activity. Liriodenine showed cytotoxicity against human nasopharyngeal carcinoma cells in vitro and against several plant viruses. Menisperine iodide caused hypotension in anaesthetized dogs, blocked neural transmission and, at high doses, blocked neuromuscular transmission in dogs and rabbits. Menisperine chloride caused apnea, cardiac failure and increased excitability in rabbits.

Aqueous leaf extracts contain saponins, tannins and glycosides. They showed significant anti-ulcer activities in experiments with mice and rats with stomach ulcers induced by several drugs. The extracts also reduced gastrointestinal motility. Antispasmodic effects of the leaf extract were studied on isolated guinea-pig ileum, rabbit jejunum and rat uterus; the extract markedly reduced the contractions induced by acetylcholine, histamine and nicotine. The aqueous leaf extract did not show significant antimicrobial activity against several hu-

man pathogens. An ethanolic leaf extract did not show cytotoxicity against mammalian cells in vitro. The LD_{50} of the aqueous leaf extract intraperitoneally in mice was 142 mg/kg body weight, and death was caused by massive cerebral haemorrhage.

Rhigiocarya racemifera is listed in patent applications relating to materials and methods for modulating expression of nucleic acid sequences such as those encoding polypeptides involved in the biosynthesis of alkaloids.

Description Large, dioecious liana, glabrous; stems longitudinally ribbed, green, turning grey then brown, at base 3–5 cm in diameter with suberous comb-like projections about 1 cm long. Leaves arranged spirally, simple and entire; stipules absent; petiole 7–16 cm long, base sharply bent, twisted; blade broadly ovate to nearly orbicular, 7–30 cm × 6–25 cm, base deeply cordate, apex abruptly acuminate, membranous or papery, palmately veined with 5–7 basal veins, with blackish glandular spots at the vein junctions. Inflorescence borne just above the leaf axil; male inflorescence a false raceme or panicle 10–25 cm long, with 1–3-flowered cymes; female inflorescence a false raceme 10–20 cm long, with 1(–3)-flowered cymes. Flowers unisexual, regular, small, greenish white or yellowish green; sepals 6, the outer ones almost triangular c. 1 mm long, inner ones broadly elliptical, 2–2.5mm long; petals 6, lanceolate, 1–1.5 mm long, somewhat fleshy, apex notched; male flowers with pedicel 1–2.5 mm long, stamens 6, outer ones free near apex, inner ones completely fused, c. 1.5 mm long; female flowers with pedicel 1–2 mm long, up to 1 cm in fruit, staminodes 6, ovary superior, composed of 3 free carpels c. 1.5 mm long. Fruit composed of 3 drupes, each drupe ovoid-ellipsoid, up to 2 cm × 1.5 cm, green to purple-black, with very sticky latex, stone 1–1.5 cm × c. 1 cm, one face covered with spines, 1-seeded. Seed compressed ellipsoid, c. 12 mm × 8 mm × 6 mm. Seedling with epigeal germination; hypocotyl 5–7 cm long, smooth, epicotyl very short, glandular; cotyledons leaf-like, ovate-triangular, 28–32 mm × 12–16 mm.



Rhigiocarya racemifera – *1, part of stem with male inflorescence; 2, part of stem with infructescence.*
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Rhigiocarya* comprises 2 species both occurring in tropical Africa. It is related to *Kolobopetalum*, *Limacia* and *Tinospora*. *Rhigiocarya peltata* J.Miège is endemic to Liberia and Côte d'Ivoire, where it is medicinally used.

Growth and development Flowering of *Rhigiocarya racemifera* occurs from November–March and sometimes in June–July; fruit matures in the dry season, in Cameroon in March–April and October.

Ecology *Rhigiocarya racemifera* occurs in humid dense, evergreen or semi-deciduous forest, also in forest edges and in secondary forest, up to 800 m altitude.

Genetic resources *Rhigiocarya racemifera* has a wide distribution and grows often abundantly in its native habitat, e.g. on Mount Cameroon. There are no indications that it is under threat of genetic erosion, except where its habitat is in strong decline.

Prospects In view of its medicinal uses and chemical and pharmacological analyses, more research is warranted on *Rhigiocarya racemifera* to evaluate its importance.

Major references Aguwa, 1985; Aguwa, 1986; Dwuma-Badu et al., 1980b; Keay & Troupin, 1954; Neuwinger, 2000; Troupin, 1962.

Other references Apuya, Bobzin & Park, 2007; Bongers, Parren & Traoré (Editors), 2005; Cable & Cheek, 1998; de Koning, 1983;

de Wet, 2005; Hawthorne & Jongkind, 2006; Lauridsen, 2003; Noamesi & Gyang, 1980; Oliver-Bever, 1983a; Ortiz, Kellogg & Van Der Werff, 2007; Tackie et al., 1974; Zirihi et al., 2005.

Sources of illustration Miège, J., 1955.

Authors E. Thompson

SACOGLOTTIS GABONENSIS (Baill.) Urb.

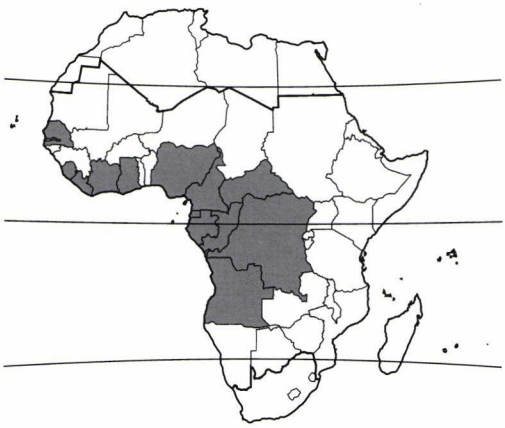
Protologue Mart., Fl. bras. 12(2): 449 (1877).

Family Humiriaceae

Vernacular names Bitterbark tree, cherry mahogony (En). Bidou (Fr).

Origin and geographic distribution *Sacoglottis gabonensis* occurs from Senegal and Gambia east to the Central African Republic and south to Angola.

Uses Infusions of the stem bark of *Sacoglottis gabonensis* are commonly taken to treat fever, diarrhoea, gonorrhoea and abdominal pain, and sometimes they are used to treat hypertension and diabetes. In coastal Cameroon the Kola pygmies and Mvae people use a decoction of the crushed bark mixed with leaves of *Dioscorea minutiflora* Engl. as a rectal enema to treat acute abdominal pain. In Congo a decoction of the stem bark is used to cure difficult cases of dermatitis. In Sierra Leone a bark decoction is used to treat stomach-ache and it also used as a spice in food to induce heat in nursing and pregnant mothers. In coastal Côte d'Ivoire the diluted stem sap is used in hipbaths to promote muscle tone in women after childbirth. In Gabon an extract of the stem bark is drunk as an emetic. In Senegal and Congo a stem bark decoction is mixed with other plants and added to bath water to treat ovarian troubles, vaginal infections and children with fever.



Sacoglottis gabonensis – *wild*

Stem bark is used as a palm wine additive, as it is claimed to prolong the shelf life of the wine, add potency, reduce foaming and impart a bitter taste. It is reported to have aphrodisiac properties. The bark is used as a fish poison.

The wood of *Sacoglottis gabonensis* is widely, though locally, used for house and bridge construction, flooring, interior trim, joinery, mine props, electricity poles, shipbuilding, vehicle bodies, furniture, cabinet work, railway sleepers, toys, novelties, turnery and pattern making. In Liberia and Nigeria, it is used to make canoes and in Gabon for the ribs of boats. The wood is a good firewood and produces a valuable charcoal.

The fruit is edible, sweet and tastes like banana bread. It is mainly eaten by children and can be used to make an alcoholic drink. In coastal Cameroon the seeds are grilled and eaten by pygmies. The sweetness of the resin stored in the cavities of the stone is much sought by bees.

Production and international trade Stem bark is sold for medicinal purposes in local markets. Quantities traded are unknown. Timber of *Sacoglottis gabonensis* is known in the international trade as 'ozouga', but volumes traded are small.

Properties Bergenin, an isocoumarin, was identified as the main active compound of the stem bark extract of *Sacoglottis gabonensis*. The stem bark extract is reported to have hepatoprotective properties. Both the extract and bergenin reduced the rate of formation of intermediates of the lipid peroxidation pathway (lipid hydroperoxide aldehydes, carbonyls) as well as complementing the primary antioxidant enzymes catalase and superoxide dismutase during 2,4-DNPH-induced membrane lipid peroxidation in rat liver and red blood cells. In vivo in rats, bergenin protects against 2,4-DNPH-induced hepatotoxicity and toxicity to red blood cells. However, in another experiment, a stem bark extract given orally to rats showed hepatotoxicity even at low doses. Bergenin also protects stored vegetable oils against peroxidative deterioration over a period of time. A stem bark extract added to drinking water of rats increased prothrombin and thrombin levels of blood plasma.

Further analyses of stem bark extract have shown tannins in appreciable amounts with a

trace of saponins. They have also revealed the presence of 2 cis/trans isomers of lignans (calopiptine and galgravine) which may play a role in cancer prevention.

The alcohol content of palm wine from *Raphia hookeri* G.Mann & H.Wendl. with stem bark added became almost twice as high as that of untreated palm wine. It was found that the ethanol tolerance and osmotolerance of the yeast *Saccharomyces cerevisiae* were enhanced by the bark extract, whereas flocculation and invertase activity were reduced.

The endocarp contains 54% oil of unknown composition.

The heartwood is brown to purplish red and rather indistinctly demarcated from the narrow sapwood. The grain is straight or wavy, texture fine and even.

The wood is heavy, with a density of 870–920 kg/m^3 at 12% moisture content. It should be air dried slowly and with care to avoid serious checking and warping. The rates of shrinkage are high, from green to oven dry 5.8% radial and 10.0% tangential. Once dry, the wood is fairly stable in service.

At 12% moisture content, the modulus of rupture is 114–233 N/mm^2, modulus of elasticity 13,330–18,520 N/mm^2, compression parallel to grain 72–104 N/mm^2, shear 10–13 N/mm^2, cleavage 22–22.5 N/mm, Janka side hardness 9065–11,005 N and Janka end hardness 12,495 N.

Considering its high density and hardness, the wood is not difficult to saw and work. It is difficult to nail and screw, but the holding power is good. The finishing and gluing properties are satisfactory, but the wood is not suited for veneer and plywood production. It is durable, being resistant to fungal and insect attacks.

Adulterations and substitutes Bergenin is commercially extracted from *Ardisia* and *Bergenia* spp. (Siberian tea and marlberry bush) and is used as a weight-loss product, e.g. in body building, and in Chinese medicine to increase body heat.

Description Large, evergreen tree up to 40 m tall; bole branchless for up to 20 m but often branching low, often crooked, knotty and deeply fluted, up to 180(–450) cm in diameter, with buttresses up to 2.5 m high; bark in young trees fairly smooth with horizontal lenticels, in old trees brown to dark brown, very scaly; crown very large, wide-spreading, heavily branched, rounded and fairly open. Leaves alternate, simple; stipules c. 1 mm long, early falling; petiole 6–10 mm long; blade ovate to elliptical or oblong, 6–15 cm × 2.5–6 cm, base cuneate, apex acuminate, margin crenate, pinnately veined with 6–12 pairs of lateral veins. Inflorescence a short axillary cyme up to 5 cm long. Flowers bisexual, regular, 5-merous; pedicel 0.5–1.5 mm long, jointed at base; sepals c. 1.5 mm long, hairy outside; petals free, linear, c. 7 mm long, hairy outside, white; stamens 10, fused at base, 5 longer stamens c. 5 mm long, 5 shorter ones c. 3.5 mm long; ovary superior, ovoid, 5-celled, glabrous, style grooved, c. 4 mm long. Fruit an ellipsoid to globose drupe 3–4 cm × 2.5–3.5 cm, smooth, green to yellow; stone with 10 grooves and many resinous cavities, 1–3-seeded. Seeds oblong, c. 15 mm × 3 mm. Seedling with epigeal germination; hypocotyl 6–9 cm long, epicotyl c. 2 cm long; cotyledons leafy, ovate, c. 1.5 cm × 0.5 cm; first 2 leaves opposite.



Sacoglottis gabonensis – 1, flowering branch; 2, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Sacoglottis* comprises 9 species, which all occur in South America except *Sacoglottis gabonensis*, which is considered to be closely related to *Sacoglottis amazonica* Mart. from South America and the Caribbean. The fruits of *Sacoglottis amazonica* are eaten in Venezuela to cure diarrhoea. The

timber is valued for heavy construction in Venezuela and Brazil.

Sacoglottis gabonensis may have evolved from seeds, which arrived on the West African coast from South America, being one of the most illustrative cases of dispersal by water from South America to Africa. The resin-filled chambers of the stone make it float in water and seeds remain viable for up to 4 years.

Anatomy Wood-anatomical description (IAWA hardwood codes):

Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; 9: vessels exclusively solitary (90% or more); 14: scalariform perforation plates; 16: scalariform perforation plates with 10–20 bars; 22: intervessel pits alternate; (23: shape of alternate pits polygonal); 25: intervessel pits small (4–7 μm); 26: intervessel pits medium (7–10 μm); 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 42: mean tangential diameter of vessel lumina 100–200 μm; 47: 5–20 vessels per square millimetre; 56: tyloses common. Tracheids and fibres: (60: vascular/vasicentric tracheids present); 62: fibres with distinctly bordered pits; 63: fibre pits common in both radial and tangential walls; 66: non-septate fibres present; 70: fibres very thick-walled. Axial parenchyma: 77: axial parenchyma diffuse-in-aggregates; 78: axial parenchyma scanty paratracheal; (84: axial parenchyma unilateral paratracheal); (92: four (3–4) cells per parenchyma strand); 93: eight (5–8) cells per parenchyma strand; (94: over eight cells per parenchyma strand). Rays: 97: ray width 1–3 cells; (100: rays with multiseriate portion(s) as wide as uniseriate portions); (107: body ray cells procumbent with mostly 2–4 rows of upright and/or square marginal cells); 108: body ray cells procumbent with over 4 rows of upright and/or square marginal cells; (109: rays with procumbent, square and upright cells mixed throughout the ray); 115: 4–12 rays per mm. Mineral inclusions: 136: prismatic crystals present; 142: prismatic crystals in chambered axial parenchyma cells.

(L.N. Banak, H. Beeckman & P.E. Gasson)

Growth and development In Liberia flowering of *Sacoglottis gabonensis* occurs from December–March. The fruits are a favourite food of elephants and mandrills, and are adapted for dispersal by elephants. The fruits develop slowly over the dry season, ripening in September–December in Liberia and remaining dull green. They fall to the ground when ripe and develop a strong yeasty smell. Like *Lophira alata* Banks ex P.Gaertn. and *Aucoumea klaineana* Pierre, *Sacoglottis gabonensis* is able to establish in the edges of moist savanna and it is common in younger forest types. It can dominate this habitat, since its branches form huge arches, suppressing vegetation under them, hence cooling annual savanna fires, which might otherwise scorch their trunk. Early colonizers have low, round canopies and branch low down, but later generations grow taller and branch higher to escape from the shadow. Young trees close to the savanna edge often have multiple trunks because they have coppiced after being broken by elephants which feed on their leaves and bark.

Ecology *Sacoglottis gabonensis* occurs in evergreen forest, on river banks, along lagoons, on forest and savanna edges and in secondary forest. It is one of the dominant trees in the coastal rainforests of West and Central Africa and is particularly abundant in Cameroon (associated with *Lophira alata*) and in Gabon (associated with *Aucoumea klaineana*). It is usually found in small pockets, but occasionally in quite large and almost pure stands.

Propagation and planting Natural propagation of *Sacoglottis gabonensis* is only by seed. Natural regeneration is not very abundant as many seeds are damaged by insects. The weight of 100 stones is 560–1000 g. Seeds may take 4 months to germinate.

Management *Sacoglottis gabonensis* is less desirable for commercial forestry as the large crown suppresses regeneration of more valuable timber species. After cutting the tree, the stump coppices vigorously. Poisoning the tree is difficult because of the fluted and ingrown bark, which hinders the application of the toxic substance.

Harvesting The stem bark and wood of *Sacoglottis gabonensis* is harvested from the wild.

Handling after harvest The bark of *Sacoglottis gabonensis* is generally sold in markets in sheets or rolls for use as an additive to palm wine or as a medicine, less frequently as a powder for emetic use.

Genetic resources *Sacoglottis gabonensis* is widespread and locally common, and therefore not threatened by genetic erosion.

Prospects The stem bark extracts of *Sacoglottis gabonensis* and its main isolated compound bergenin have interesting hepatoprotective and anti-oxidant properties, but more research is needed to evaluate its potential as a lead drug. Its use to increase alcohol content in

palm wine deserves more research attention, as does information concerning health risks.

Sacoglottis gabonensis plays an important role in the succession in and regeneration of natural forests. As a widespread and often common species it is important in the local economy as a timber and for firewood and charcoal production. Because of the poor shape of the bole, commercial exploitation of the timber for international trade is limited. Selection for bole shape and research into proper management practices could lead to better shaped boles with higher commercial value in the timber trade.

Major references Badré, 1972; Burkill, 1994; Irvine, 1961; Maduka, Okoye & Mahmood, 2004; Siepel, Poorter & Hawthorne, 2004; Takahashi, 1978; Voorhoeve, 1965; White & Abernathy, 1997.

Other references Cuatrecasas, J., 1961; Ekouya & Itoua, 2005; Ezeronye, Elijah & Ojimelukwe, 2005; Gassita et al. (Editors), 1982; Hawthorne, 1995; Hoshino, 1985; InsideWood, undated; Liben, 1970; Maduka, 2005; Maduka, Okoye & Eje, 2002; Maduka, Uhwache & Okoye, 2003; Madusolumuo & Okoye, 1993; Ojimelukwe, 2001; Okoye & Ohaeri, 1995; Raponda-Walker & Sillans, 1961; Renner, 2004; Udosen & Ojong, 1998.

Sources of illustration Voorhoeve, 1965.

Authors E. Dounias

SAMBUCUS NIGRA L.

Protologue Sp. pl. 1: 269 (1753).

Family Caprifoliaceae (APG: Adoxaceae)

Chromosome number $2n = 36$

Vernacular names Elderberry, black elder, elder, bore tree (En). Sureau, grand sureau, sureau noir (Fr). Sabugueiro-negro (Po).

Origin and geographic distribution *Sambucus nigra* occurs in temperate to tropical regions in Europe, Western Asia, northern Africa, North America and Central America. It is introduced in tropical Africa as a medicinal and ornamental plant, and is cultivated and naturalized in and around towns and villages in e.g. Ghana, Gabon, DR Congo, Rwanda, Burundi, Eritrea, Ethiopia, Kenya, Tanzania and Angola.

Uses *Sambucus nigra* is used throughout its distribution area as a medicinal plant and ornamental. In Gabon the flowers are used in preparations as an emollient and calming skin ointment, and to stimulate sweating.

Outside Africa, various parts of *Sambucus nigra* have long been used in traditional medicine as a diaphoretic, diuretic, astringent, laxative and emetic. Currently, extracts of the fruits are used primarily as antiviral agents in cases of colds, influenza and Herpes virus infection.

The inner bark is diuretic, a strong purgative and in large doses emetic. It is used in the treatment of constipation and arthritic conditions. An emollient ointment is made from the green inner bark. The fresh or dry leaves are purgative, but cause nausea more easily than the bark. They are also diaphoretic, diuretic, expectorant and haemostatic. An ointment made from the leaves is emollient and is used in the treatment of bruises, sprains and wounds. An infusion of the fresh flowers is mildly astringent and a gentle stimulant. It is mainly used as a basis for eye and skin lotions. The dried flowers are diaphoretic, diuretic, expectorant, galactagogue and pectoral. An infusion is very effective in the treatment of chest complaints, as a tonic and blood cleanser, and is also used to bathe inflamed eyes and to poultice burns and wounds. The fruit is depurative, weakly diaphoretic and gently laxative. A tea made from the dried fruits is taken to treat colic and diarrhoea. The pith of young stems is used in treating burns and scalds. The leaves rubbed on the skin are used as an insect repellent. They can be made into insecticidal and fungicidal sprays.

The fruits are widely used for making wine, brandy, jams or pies. They are best not eaten raw as they are mildly poisonous, causing vomiting, particularly if eaten unripe. The mild cyanide toxicity is destroyed by cooking. The flowers are crisp and somewhat juicy, they have an aromatic smell and flavour and are delicious raw as a refreshing snack. The flowers are used to add a muscatel flavour to stewed fruits, jellies and jams, and are an ingredient of fritters. They are often used to make a sparkling wine. A sweet tea is made from the dried flowers.

Sambucus nigra is an excellent pioneer species for re-establishing woodlands in temperate regions. The bark of older branches and the root have been used as an ingredient in dyeing black. A green dye is obtained from the leaves when alum is used as a mordant. The fruits yield various shades of blue and purple dyes. They have also been used as a black hair dye. The blue colouring matter from the fruit can be used as a litmus. It turns green in an alkaline solution and red in an acid solution. The pith of

young branches pushes out easily and the hollow stems thus made have been used as pipes for blowing air into a fire. They can also be made into flutes. The pith of the stems is used in the slicing of samples for viewing under a microscope. The wood is white and fine-textured. It is easily cut and polishes well. It is used for making skewers, mathematical instruments and toys. *Sambucus nigra* is widely planted as an ornamental; in Africa it is mainly cultivated in hedges.

Production and international trade *Sambucus nigra* is planted only occasionally in tropical Africa and is not traded there.

Properties The fruit contains several constituents responsible for its pharmacological activity. Among these are the flavonoids quercetin, kaempferol and rutin, the anthocyanins cyanidin-3-glucoside and cyanidin-3-sambubioside, the haemagglutinin protein *Sambucus nigra* agglutinin III (SNA-III), cyanogenic glycosides including sambunigrin, and viburnic acid, ellagic acid and ursolic acid. The flowers contain flavonoids (up to 3%) composed mainly of flavonol glycosides (astragalin, hyperoside, isoquercitrin, and rutin up to 1.9%) and free aglycones (quercetin and kaempferol), phenolic compounds (about 3% chlorogenic acid), triterpenes (about 1%) including α- and β-amyrin, triterpene acids (mainly ursolic and oleanolic acid), sterols and volatile oils.

In several clinical and in vitro studies, Sambucol®, a syrup containing 38% standardized fruit extract, was shown to neutralize and reduce the infectivity of influenza viruses A and B, HIV strains and clinical isolates, and Herpes simplex virus type 1 (HSV-1) strains and clinical isolates. This syrup also shows immune-modulating activity, by increasing significantly the production of several cytokines, e.g. tumour necrosis factor-α (TNF-α), and interleukins.

The anthocyanins from the fruits possess antioxidant properties. A water extract of the flowers increased glucose uptake, glucose oxidation, and glycogenesis in rat abdominal muscle. The flower extract incubated with rat pancreatic cells also had a dose-dependent stimulatory effect on insulin secretion.

Botany Deciduous shrub up to 4(–6) m tall, with unpleasant smell; main root vertical, spreading horizontally by stolons; stems up to 15 cm in diameter. Leaves opposite, imparipinnately compound, petiolate; leaflets 5–11(–15), narrowly elliptical, 5–9(–11) cm × 2–3(–4) cm, base cuneate to obtuse, apex acuminate, margin toothed. Inflorescence a large terminal umbel-like panicle, up to 20 cm in diameter. Flowers bisexual, 5-merous, regular, white, sweet-scented; pedicel 0–10 mm long, shortly hairy; calyx fused to the ovary, lobes minute; corolla lobes almost free, oblong-ovate, 3–4 mm long, radiate; stamens alternating with the corolla lobes; ovary half-inferior, 5-celled, stigma sessile, 5-lobed. Fruit a globose, fleshy, berry-like drupe 4–7 mm long, green, purple to black when ripe, with 3–5 1-seeded pyrenes.

Sambucus comprises 9 species. Most species occur in the temperate and subtropical regions of the northern hemisphere, 2 occur in South America, 1 in the mountain region of East Africa (*Sambucus ebulus* L. (synonym: *Sambucus africana* Standl.)) and 2 in eastern Australia. In *Sambucus nigra* 6 subspecies are recognized, and notably the variable subspecies *canadensis* (L.) R.Bolli (synonyms: *Sambucus canadensis* L., *Sambucus mexicana* Presl ex DC.) invades tropical regions, and is naturalized here and there. It is most probably this subspecies which is naturalized in tropical Africa. It hardly fruits here, probably due to a lack of stratification of the seeds. In most recent taxonomic publications, subspecies *canadensis* is treated at species level, as *Sambucus canadensis*. The flowers of *Sambucus nigra* are pollinated by flies and the seeds are dispersed by the defecation of birds and mammals.

Ecology *Sambucus nigra* occurs in hedgerows, shrubland, open forest, roadsides, waste places and on disturbed soils.

Management *Sambucus nigra* is propagated by seed or stolons. Seed is best sown as soon as it is ripe at the start of the cold season, so it can germinate at the start of the warm season. Stored seed can be sown at the start of the warm season but will probably germinate better if it is given 2 months cold stratification first. The seedlings can be transplanted into individual pots when they are large enough to handle. If good growth is made, the young plants can be placed in their permanent positions during the warm season.

Sambucus species are notably resistant to honey fungus, *Armillaria* sp.

Genetic resources and breeding *Sambucus nigra* mainly reproduces through stolons in tropical Africa. The genetic diversity in each introduction site is probably low, as the species does not produce much seed in tropical climates. As *Sambucus nigra* is a widely dispersed species in the northern hemisphere, it is not threatened by genetic erosion. There are no

large germplasm collections. In Europe there exist some fruit cultivars with big fruits, and some ornamental cultivars with dissected or variegated leaves.

Prospects *Sambucus nigra* has been introduced in tropical Africa as a medicinal and ornamental plant. As it not really adapted to the tropical climate, it probably will remain of little importance.

Major references Bolli, 1994; Ensermu Kelbessa, 2003; Lawalrée, 1982; Raponda-Walker & Sillans, 1961; Zakay-Rones et al., 2004.

Other references Barak et al., 2002; Bitsch et al., 2004; Burkill, 2000; Gray, Abdel-Wahab & Flatt, 2000; Launert, 1981; Thorne Research, 2005; Verdcourt, 1968; Yamada, 1999; Youdim, Martin & Joseph, 2000.

Authors F.S. Mairura

SCHIZOZYGIA COFFAEOIDES Baill.

Protologue Bull. Mens. Soc. Linn. Paris 1: 752 (1888).

Family Apocynaceae

Chromosome number $2n = 22$

Vernacular names Mpelepele, mwango, mtonga mwitu (Sw).

Origin and geographic distribution *Schizozygia coffaeoides* occurs from DR Congo east to Somalia, Kenya and Tanzania, and south to Malawi, Angola and Mozambique and also in Comoros.

Uses In Kenya the pounded or grated root of *Schizozygia coffaeoides* mixed with coconut oil is applied to sores. A root infusion is taken against dizziness. Inflamed eyes are treated by exposing them to steam from boiled leaves, while ringworm-infected skin is washed with an aqueous leaf extract.

Properties Five schizozyganes have been isolated from the root bark and leaves of *Schizozygia coffaeoides*; these are hexacyclic N-acyl indole alkaloids, with schizozygine and isoschizogaline as main compounds. Schizozyganes have so far not been found elsewhere in the *Apocynaceae*, but they are related to certain alkaloids which occur in *Hunteria* and *Aspidosperma*. Leaf extracts show significant fungistatic activity against the dermatophytic fungi *Trichophyton mentagrophytes* and *Microsporum gypseum*, and also against *Candida albicans* and a phytopathogenic fungus, *Cladosporium cucumerinum*, indicating a broad spectrum of antifungal activity. In further tests with fungi and bacteria, it was shown that 7,8-dehydro-19β-hydroxyschizozygine was the most active antifungal compound, and isoschizogaline the only active antibacterial compound. The fruits of *Schizozygia coffaeoides* are reported to be poisonous.

Botany Shrub or small tree up to 4(–8) m tall, with white latex, repeatedly dichotomously branched; bark rough, brown, lenticels pale. Leaves opposite, simple and entire; stipules absent; petiole 0.5–10 mm long; blade obovate, up to 25 cm × 11 cm, base cuneate, apex acuminate, glabrous, pinnately veined with lateral veins conspicuous. Inflorescence a congested cyme, 2 together in forks of branches, 7–15 mm long; peduncle up to 3 mm long; bracts narrowly oblong, 3–5 mm long. Flowers bisexual, 5-merous, regular, fragrant; pedicel 2–3 mm long; sepals free, elliptical, imbricate, 3–6 mm long, apex acute or acuminate; corolla creamy-yellow, tube cylindrical or urn-shaped, 4–5 mm long, shortly hairy around the stamens, lobes obliquely obovate to nearly hook-shaped, curved to the right, 2–4 mm long, in bud overlapping to right; stamens inserted in the upper part of the corolla tube, anthers sessile, triangular, introrse; ovary superior, composed of 2 free rounded carpels, style slender, pistil head with basal cylindrical part and a 2-lobed stigma. Fruit composed of 2 ellipsoid almost free follicles, 7–15 mm × 3–5 mm, laterally compressed, irregularly striate, glabrous, yellow to orange, dehiscent, each follicle 1-seeded. Seeds obliquely ellipsoid, 5–6 mm long, with a deep groove in the middle and shallowly grooved at the other side, with minute warts, surrounded by a thin pulpy red to orange aril. Seedling with epigeal germination; cotyledons ovate, rounded at base and apex.

Schizozygia comprises a single species and belongs to the tribe *Tabernaemontanae*. *Schizozygia coffaeoides* can be found flowering and fruiting throughout the year.

Ecology *Schizozygia coffaeoides* occurs in moist forest and riverine forest. It grows on sandy or loamy soils, up to 1500 m altitude.

Genetic resources and breeding *Schizozygia coffaeoides* is fairly widespread and it does not appear to be threatened.

Prospects Work is progressing on the purification of active antifungal and antibacterial compounds in *Schizozygia coffaeoides*.

Major references Barink, 1983; Kariba, Houghton & Yenesew, 2002; Kariba, Siboe & Dossaji, 2001; Omino, 2002; Omino & Kokwaro, 1993.

Other references Beentje, 1994; Hajicek, Taimr & Budesinsky, 1998; Kokwaro, 1993; Timberlake, Golding & Clarke, 2004.

Authors M.J. Boone

SCHLECHTERINA MITOSTEMMATOIDES Harms

Protologue Bot. Jahrb. Syst. 33: 148 (1902).

Family Passifloraceae

Origin and geographic distribution *Schlechterina mitostemmatoides* occurs in south-eastern Kenya, Tanzania, Mozambique and north-eastern South Africa.

Uses In Tanzania a root decoction and leaf sap are taken to treat malaria, and the root decoction also as an aphrodisiac. In Mozambique a decoction of the leaves mixed with those of *Hymenocardia ulmoides* Oliv. is taken before meals to treat heavy menstruation. In Kenya and Mozambique the stem is used as a tying material.

Properties Leaves and leaf callus cultures of *Schlechterina mitostemmatoides* contain cyanogenic glycosides.

Botany Small liana or scandent shrub up to 3 m tall, with axillary, up to 14 cm long tendrils; old stems corky, shoots often with lenticels. Leaves alternate, simple to pinnately lobed; stipules triangular to linear, c. 0.5 mm long, soon falling; petiole 4–12 mm long; blade elliptical to lanceolate or linear-lanceolate, 3–13 cm × 1–5 cm, base cuneate, apex acute to acuminate, margin entire or toothed; leaves on saplings or juvenile shoots often linear and pinnately lobed, those of flowering branches often elliptical and entire to toothed. Inflorescence an axillary fascicle, 1–3-flowered; bracts almost triangular, 0.5–1 mm long. Flowers bisexual, regular, whitish, glabrous; pedicel up to 2.5 cm long, jointed; sepals 3–4, free, elliptical to oblong, 6–11 mm × 3–6 mm, obtuse; petals 2–4, free, elliptical to oblong, 5–10 mm long, obtuse; corona composed of threads fused at the base into a tube 0.5–2 mm long, free parts of threads 4–6 mm long; stamens 6–8, with filaments 6–10 mm long, fused at base; ovary superior, ellipsoid-oblong, 2–2.5 mm long, apex narrowed into style 1.5–2 mm long, stigma 3–4-lobed, flattened. Fruit a stalked oblong-ellipsoid capsule c. 5 cm long, 3–4 valved, leathery, many-seeded. Seeds ellipsoid, flattened, c. 7 mm long, enveloped by an aril.

Schlechterina comprises a single species and is characterized by its leaves of different shapes. In Mozambique *Schlechterina mitostemmatoides* flowers from October to February.

Ecology *Schlechterina mitostemmatoides* occurs in lowland dry, evergreen and riverine forest and coastal bushland from sea-level up to 700 m altitude. It occurs on sandy and on black soils.

Genetic resources and breeding Although *Schlechterina mitostemmatoides* is locally common in Kenya, Tanzania and Mozambique, it has a rather limited area of distribution and is considered an endangered species in northern KwaZulu-Natal. Some caution would be needed in case of increased use of this species.

Prospects The use of *Schlechterina mitostemmatoides* appears to be limited and it will probably remain this way. Because of the wide medicinal use of other *Passifloraceae* species containing cyanogenic compounds, more research into the chemical composition and pharmacological activities of *Schlechterina mitostemmatoides* seems warranted.

Major references Fernandes & Fernandes, 1978; Jäger, McAlister & van Staden, 1995; Maite, 1994.

Other references Beentje, 1994; de Wilde, 1975; Pakia & Cooke, 2003a.

Authors A. de Ruijter

SCHWENCKIA AMERICANA L.

Protologue Gen. pl. ed. 6: 577 (1764).

Family Solanaceae

Origin and geographic distribution *Schwenckia americana* is native to Central and South America, but it has spread to tropical Africa and India as a weed. In tropical Africa it was restricted to West and Central Africa, but in recent decades it has also reached East and southern Africa.

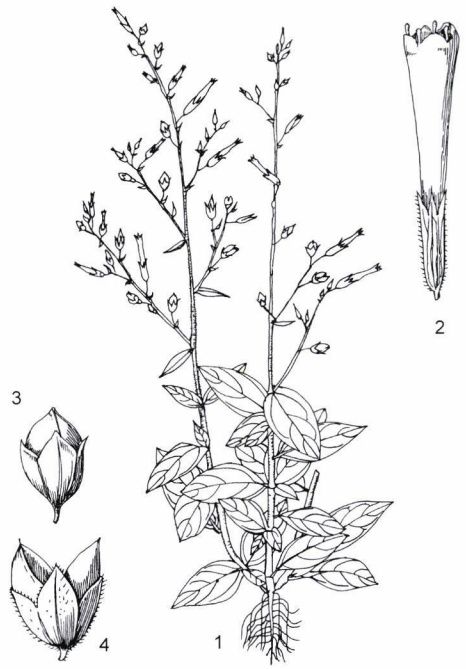
Uses The aerial parts are widely valued in West Africa to treat diseases of babies and small children. A leaf decoction is given to pregnant women when the foetus develops too slowly and is taken by breast-feeding women to prevent diarrhoea of the baby. The roots are chewed to cure respiratory diseases in children. A root decoction is given to babies as a purgative.

An infusion of the aerial parts is used as a mouth wash to cure infections such as aphthae. The plant sap or a decoction of the whole plant is applied as eye drops and nose drops to treat headache, sinusitis and conjunctivitis. In dif-

ferent preparations the crushed whole plant, alone or combined with other plants, is externally applied to relieve intercostal pain or pain caused by swellings, rheumatism, arthritis, stomach problems, hernia and gonorrhoea; it is also applied as an anthelmintic. The crushed leafy stems are applied to the skin against measles and chickenpox. A poultice made of the leaves is applied to whitlow and athlete's foot. Powder from leafy twigs is inhaled to cure convulsions with fever. A decoction of the whole plant is drunk to cure cough, asthma and weak lungs, and as a purgative in cases of poisoning. A leaf decoction is drunk and applied externally to bring fever down and to cure oedema. In Ghana and DR Congo a leaf infusion is taken to treat female sterility. A root decoction is taken as a laxative. In India both fresh and dried leaves are used as an anthelmintic. The whole plant is pounded to pulp for use as an effective fish poison. Roots and stems are used as chewing sticks for cleaning the teeth.

Properties Preliminary research in the 1960s resulted in the detection of a glycoside, schwenckioside, traces of alkaloids and sapogenins, the latter with cardiotonic activity. A water extract of the leaves showed low antimicrobial activity against *Proteus mirabilis* and *Staphylococcus aureus*, but no inhibition of *Pseudomonas aeruginosa* and *Escherichia coli*.

Botany Annual or short-living perennial herb, erect or ascending and spreading, up to 70(–100) cm tall; stem grooved, glabrous but young parts sometimes with curved hairs. Leaves arranged spirally, simple and entire; stipules absent; petiole up to 8 mm long; blade ovate to obovate, up to 4 cm × 2 cm, base cuneate to rounded, apex acute to rounded, almost glabrous to densely short-hairy. Inflorescence a lax, terminal panicle, many-flowered; peduncle 2–12 cm long, slightly longer in fruit. Flowers bisexual, slightly zygomorphic; pedicel 2–4 mm long, erect or curved; calyx tubular, 2–4 mm long, 4–5-lobed, lobes acute to acuminate; corolla narrowly tubular, 6–8 mm long, white, greenish yellow, pale blue to purplish, lobes unequal, up to 0.5 mm long; stamens 2, attached to corolla tube, filaments 0.5–3 mm long, staminodes 3, resembling filaments; ovary superior, ellipsoid, 1–2 mm long, style 3–6 mm long, stigma small, exserted. Fruit a globose or ovoid capsule 3.5–4.5 mm × 2.5–4.5 mm, pale brown, dehiscent, many-seeded. Seeds prismatic, 0.5–1 mm long, black or reddish. Seedling with epigeal germination.



Schwenckia americana – 1, plant habit; 2, flower; 3, fruit; 4, dehisced fruit.
Source: Flore analytique du Bénin

Schwenckia comprises about 22 species, all native to tropical America. *Schwenckia americana* is the only species that has spread to other continents. The orthographic variation '*Schwenkia*' is very common in the literature.

Ecology *Schwenckia americana* is a weed in fields, woodland and disturbed localities, up to 1100 m altitude.

Management *Schwenckia americana* can by propagated by seed or cuttings; it is only harvested from the wild.

Genetic resources and breeding *Schwenckia americana* is widespread and common in anthropogenic habitats and not in danger of genetic erosion. There are a few samples in gene banks.

Prospects Better knowledge of the pharmacological properties of *Schwenckia americana* is needed for a proper assessment of its medicinal value in the future.

Major references Aké-Assi, Guinko & Aya-Lazare, 1991; Burkill, 2000; Goncalves, 2005; Neuwinger, 2000; Nkounkou-Loumpangou et al., 2005.

Other references Adamu et al., 2005; Adjanohoun et al., 1989; Adjanohoun et al., 1985;

Audu, 1995; CAB International, 2004; Hermans, Akoègninou & van der Maesen, 2004; Hodouto, 1990; Iwu, 1993; Kibungo Kembelo, 2004; Latham, 2004.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors C.H. Bosch

SCLEROCROTON CORNUTUS (Pax) Kruijt & Roebers

Protologue Biblioth. Bot. 146: 20 (1996).

Family Euphorbiaceae

Synonyms *Sapium cornutum* Pax (1894).

Origin and geographic distribution *Sclerocroton cornutus* occurs from Cameroon and the Central African Republic south to Angola and Zambia.

Uses In the Central African Republic a bark decoction is drunk to treat hernia. In DR Congo the root bark, crushed in water, is taken to facilitate childbirth, as it contracts the uterine muscles. A leaf decoction is taken to treat female sterility, cough and river blindness. Crushed leaves are applied to insect bites and snakebites. A bark decoction is used as a mouthwash to treat toothache, scurvy and stomatitis. It is externally applied to sore feet, skin diseases and drunk as a purgative and anthelminthic. Leaf sap is used as eye drops to treat filariasis.

In DR Congo the wood is made into charcoal. Edible caterpillars (*Lobobunaea phaedusa*) feed on the leaves.

Properties Extracts from the root bark contain toxic tetracyclic triterpenic cucurbitacins.

Botany Monoecious, glabrous shrub up to 4 m tall. Leaves alternate, simple; stipules linear, 3–5 mm long, soon falling; petiole 2–10 mm long, channeled above; blade elliptical, elliptical-oblong to elliptical-ovate, 2.5–10(–15) cm × 1–4(–5) cm, base cuneate to rounded or truncate, with 1–2 glands, apex acute to acuminate, margin shallowly toothed. Inflorescence an erect, terminal or leaf-opposed, spike-like raceme up to 10(–16) cm long, with all flowers male or with 1–2 female flowers at base; bracts of male flowers with 2 basal glands. Flowers unisexual, regular, petals absent, disk absent; male flowers with pedicel c. 1.5 mm long, sepals 3, broadly ovate, c. 1 mm long, irregularly toothed, greenish yellow, stamens 2–3, free, very short; female flowers with pedicel 3–5 mm long, extending in fruit to 1.5–2 cm, sepals 3, triangular, c. 1 mm long, alternating with deltoid glands, greenish yellow, ovary superior, c. 2 mm long, 3-lobed, each lobe with 2 prickle-shaped appendages 2 mm long, 3-celled, styles 3, 7–8 mm long, fused at base, coiled. Fruit a 3-lobed capsule 1–1.5 cm × 1.5–2 cm, each lobe with 2 prickle-shaped appendages 4–5 mm long, green, hard, turning reddish or blackish, 3-seeded. Seeds ovoid-ellipsoid, 6–7 mm long, smooth, shiny, pale grey mottled blackish.

Sclerocroton comprises 6 species, 5 of which occur in continental Africa and 1 in Madagascar. It was formerly included in *Sapium*. In southern Africa a root decoction of *Sclerocroton integerrimus* Hochst. (synonym: *Sapium integerrimum* (Hochst.) J.Léonard) is used as a mouthwash to treat toothache. The fruits were formerly used to make a black ink and are used for tanning. The wood is heavy, hard and durable and is used to make attractive furniture.

Ecology *Sclerocroton cornutus* occurs in rainforest, secondary forest and open woodland, especially on sandy soils, but also on rocky hill slopes. It prefers well-drained soils.

Management *Sclerocroton cornutus* coppices well.

Genetic resources and breeding *Sclerocroton cornutus* is common in the forest zone of Central Africa and does not seem to be threatened by genetic erosion.

Prospects *Sclerocroton cornutus* has a range of medicinal uses in local medicine in Central Africa, but very little is known about its properties. More research is therefore warranted. In DR Congo it is considered an interesting species for reforestation purposes.

Major references Adjanohoun et al. (Editors), 1988; Kruijt, 1996; Neuwinger, 2000; Radcliffe-Smith, 1996a; Tessier & Paris, 1978.

Other references Coates Palgrave, 1983; Latham, 2005; Léonard, 1962; Nkounkou-Loumpangou et al., 2005; Palmer & Pitman, 1972–1974; Paris & Tessier, 1972.

Authors G.H. Schmelzer

SECURINEGA CAPURONII Leandri

Protologue Mém. Inst. Sci. Madagascar, sér. B, Biol. Vég. 8: 235 (1957).

Family Euphorbiaceae (APG: Phyllanthaceae)

Origin and geographic distribution *Securinega capuronii* is endemic to south-western Madagascar.

Uses A stem bark decoction is taken to treat

chronic bronchitis and cough, and a leaf decoction is taken to treat malaria. A decoction of the twig bark is taken to treat diarrhoea.
The pinkish wood is soft and elastic and is used to make railway sleepers.

Botany Dioecious shrub or small tree up to 4 m tall; bark reddish to grey; young branches shortly hairy. Leaves alternate, simple and entire; stipules oblong to obovate, c. 2 mm long, deciduous; petiole up to 2 mm long; blade obovate, c. 15 mm × 7 mm, base cuneate to rounded, apex rounded, papery, glabrous. Inflorescence an axillary fascicle, 6–10-flowered in male plants, few-flowered in female plants; bracts 1–3 mm long, brown. Flowers unisexual, regular, 5-merous, small; sepals c. 1.5 mm long, slightly unequal, ciliate; petals absent; male flowers sessile, stamens 7–8, free, exserted, filaments 1.5–2 mm long, rudimentary ovary ending in ciliate style; female flowers with pedicel 1–3 mm long, ovary superior, ovoid, 3-celled, style c. 1 mm long, branching into 3 stigmas, each 2-lobed, spread horizontally. Fruit a slightly 3-lobed capsule, reddish brown to yellowish brown, up to 6-seeded.
Securinega capuronii flowers in September.
Securinega comprises 5 species in Madagascar and the Mascarene islands. Several other *Securinega* species have similar medicinal uses to those of *Securinega capuronii*. A stem bark decoction of *Securinega antsingyensis* Leandri or *Securinega seyrigii* Leandri is taken to treat severe diarrhoea with fever. The wood of *Securinega seyrigii* is hard and heavy but easily workable, and used for boat and house construction.

Ecology *Securinega capuronii* is common in bushland at low to medium altitudes.

Genetic resources and breeding As *Securinega capuronii* is relatively common in its distribution area, it is probably not threatened.

Prospects The bark of *Securinega capuronii* and related species is used to treat severe diarrhoea. As no chemical or pharmacological research has been done, it is strongly recommended that the pharmacology of this species be investigated.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Debray, Jacquemin & Razafindrambao, 1971; Leandri, 1958.

Other references Neuwinger, 2000; Rakotovao, 1984a; Rakotovao, 1984b; Ralantonirina, 1993; Wurdack et al., 2004.

Authors G.H. Schmelzer

SENNA ALATA (L.) Roxb.

Protologue Fl. ind. ed. 1832, 2: 349 (1832).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

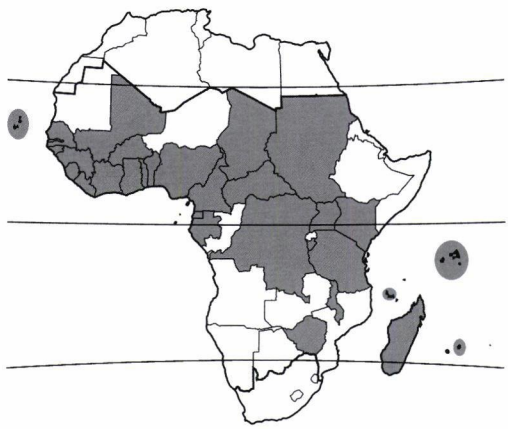
Chromosome number $2n = 28$

Synonyms *Cassia alata* L. (1753).

Vernacular names Ringworm bush, crawcraw plant, seven golden candlesticks, christmas candle, king of the forest (En). Dartrier, casse ailée, plante des cros-cros, buisson de la gale, quatre épingles (Fr). Dartial, cortalinde, café beirão, fedegoso, fedegosão (Po). Upupu wa mwitu (Sw).

Origin and geographic distribution *Senna alata* is native to South America, but has been planted widely for medicinal and ornamental purposes and is now pantropical. In many countries, including most countries of tropical Africa, it has become naturalized and is often considered a weed.

Uses The main medicinal uses of *Senna alata* are as a laxative or purgative and in the treatment of skin problems. For laxative purposes usually a decoction of the leaves is drunk, and less often the flowers, roots or the stem are used. Skin problems treated with *Senna alata* include ringworm, favus and other mycoses, impetigo, syphilis sores, psoriasis, herpes, chronic lichen planus, scabies, rash and itching. Skin problems are most often treated by applying leaf sap or by rubbing fresh leaves on the skin. Other ailments treated in tropical Africa with *Senna alata* include stomach pain during pregnancy, dysentery, haemorrhoids, blood in the urine (schistosomiasis, gonorrhoea), convulsions, heart failure, oedema, jaundice, headache, hernia, one-sided weak-



Senna alata – planted

ness or paralysis. A strong decoction made of dried leaves is used as an abortifacient. In veterinary medicine too, a range of skin problems in livestock is treated with leaf decoctions. Such decoctions are also used against external parasites such as mites and ticks.

In India leaf decoctions are used as an expectorant in bronchitis and dyspnoea, as an astringent, a mouthwash and a wash in cases of eczema. Decoctions of the wood are used to treat liver problems, urticaria, rhinitis and loss of appetite caused by gastro-intestinal problems.

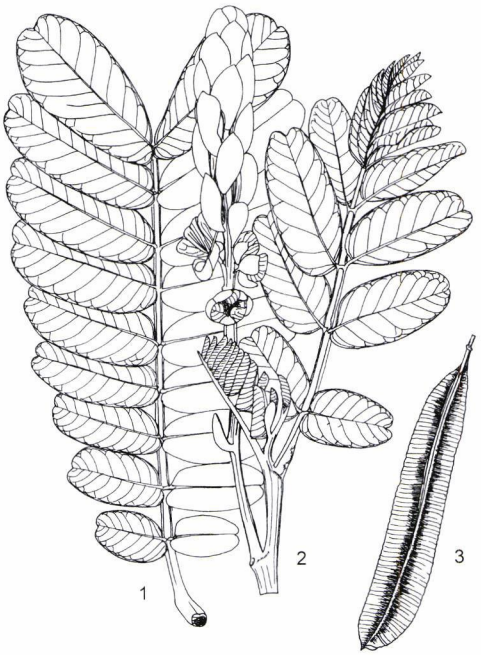
The seeds are a source of gum. The young pods are eaten as a vegetable, but only in small quantities. Toasted leaves are sometimes used as a coffee substitute. *Senna alata* can become a weed in pastures; it is not eaten by livestock and is reported to be poisonous, especially for goats. The bark is used as fish poison and for tanning leather. The roots and the bark are reported to be used for tattooing. *Senna alata* is widely appreciated as a garden ornamental and bee forage.

Production and international trade In India *Senna alata* is cultivated for export purposes, e.g. to Japan, but no trade statistics are available.

Properties From the leaves of *Senna alata* a number of anthraquinone derivatives have been isolated, such as aloe-emodin, chrysophanol, isochrysophanol and rhein, as well as the alkaloid tyramine and the common steroid β-sitosterol. Crude leaf extracts have shown antibacterial activity against a range of bacteria, e.g. against *Dermatophilus congolensis*, which causes a serious skin condition in cattle. Antifungal properties (e.g. against *Pityriasis versicolor* in humans) and antitumour activity have been confirmed by tests. The bark of *Senna alata* contains tannins. The petals contain anthraquinones, glycosides, steroids, tannins and volatile oil. Extracts of the petals have bactericidal activity against gram-positive bacteria but not against gram-negative bacteria. Emodin and chrysophanol can be produced in vitro by using root cultures of *Senna alata*.

Adulterations and substitutes Anthraquinone glycosides are also found in other species of *Senna*, *Cassia* and *Aloe* and are used for their laxative and purgative properties as well.

Description Shrub up to 2(–5) m tall. Leaves arranged spirally, paripinnately compound with 8–20 pairs of leaflets; stipules triangular, 7–10 mm long; petiole 2–3 cm long; leaflets oblong-elliptical, 5–15 cm × 3–7 cm, base and apex obtuse, mucronate, hairy on midrib, veins and margin. Inflorescence an erect, terminal raceme 20–50 cm long, many-flowered; bracts elliptical, orange, enclosing flower buds. Flowers bisexual, zygomorphic, 5-merous; sepals oblong, 10–20 mm × 6–7 mm, orange-yellow; petals ovate-orbicular, 16–24 mm × 10–15 mm, bright yellow; stamens 10, the 2 lower ones largest with filaments 4 mm long and anthers 12–13 mm long, 5 medium-sized, 3 short and rudimentary; ovary superior, woolly, recurved, style slender, short. Fruit a winged pod 10–15 cm × 1.5–8 cm, wings 4–8 mm large, black, glabrous, dehiscent, up to 50-seeded. Seeds quadrangular, flattened, 7–8 mm × 5–8 mm, shiny.



Senna alata – 1, leaf; 2, inflorescence; 3, fruit. Source: Flore analytique du Bénin

Other botanical information Until the early 1980s, *Cassia* was considered a very large genus of about 550 species, but was then split into 3 genera: *Cassia* s.s. with about 30 species, *Chamaecrista* with about 250 species and *Senna* with about 270 species. *Senna* is very similar to *Cassia*, but is distinguished from it by the possession of 3 adaxial stamens which are short and straight, and the pedicels which have no bracteoles.

Senna leandrii (Ghesq.) Du Puy is an endemic shrub or small tree of Madagascar, where the

bark is chewed to relieve dental pain.

Growth and development *Senna alata* has Scarrone's architectural model: an indeterminate trunk with tiers of orthotropic branches, which branch sympodially because they have terminal inflorescences. *Senna alata* is fast growing, short-lived and produces flowers and fruits throughout the year. Ants often live in association with *Senna alata*.

Ecology Although *Senna alata* has a wide ecological amplitude, preferred habitats are disturbed, rather open vegetations such as roadsides, river banks, rain forest edges, lake shores, margins of ponds and ditches, in open forest, orchards and around villages. *Senna alata* is found up to 1400(–2100) m altitude, but is most abundant at lower elevations. It is reported to tolerate an annual rainfall of 600–4300 mm and average yearly temperatures of 15–30°C. It is very tender to frost. It grows well on both heavy and sandy, acid to slightly alkaline, well-drained soils.

Propagation and planting *Senna alata* is propagated by seed or cuttings. Soaking the seeds overnight before sowing improves germination.

Management When *Senna alata* is grown as an ornamental, cutting back hard after flowering is recommended. It produces the nicest flower display in the year after it is pruned.

Diseases and pests *Senna alata* is a host of the common spiral nematode (*Helicotylenchus dihystera*) and the root lesion nematode (*Pratylenchus loosi*).

Harvesting The leaves of *Senna alata* are harvested when needed. The active constituents are probably most abundant prior to flowering, at which time the leaves are preferably collected.

Handling after harvest After harvesting *Senna alata* leaves may be dried and stored in containers until needed. More often, however, leaves are used fresh.

Genetic resources *Senna alata* is widely found wild and cultivated throughout the tropics and is neither endangered nor liable to genetic erosion. There are some accessions in genebanks.

Breeding Even within populations, there is a large variation in anthraquinone content in the leaves of *Senna alata*, which allows for selection. No selection or breeding for medicinal use has been documented.

Prospects As *Senna alata* has various medicinal properties, ornamental value and is a true multipurpose plant, it will continue to be widely planted and used. The antibacterial, antifungal and antitumour properties seem to justify more research. Leaf extracts might be useful in the treatment of opportunistic skin infections in AIDS patients.

Major references Arbonnier, 2004; ILDIS, 2005; Neuwinger, 2000; Owoyale, Olatunji & Oguntoye, 2005; Ross, 2003; Toruan-Purba, 1999b.

Other references Adedayo et al., 2001; Akoègninou, van der Burg & van der Maesen, 2006; Ali-Emmanuel et al., 2003; Berhaut, 1975b; Boampong, 1992; Burkill, 1995; Chatsiriwej, Wungsintaweekul & Panichayupakaranant, 2006; Irwin & Barneby, 1982b; Lock, 1990; Luckow, 1996; Nacro & Millogo-Rasolodimbi, 1993; Pieme et al., 2006; Yagi, El Tigani & Adam, 1998.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors C.H. Bosch

Based on PROSEA 12(1): Medicinal and poisonous plants 1.

SENNA ALEXANDRINA Mill.

Protologue Gard. dict. ed. 8: Senna No 1 (1768).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

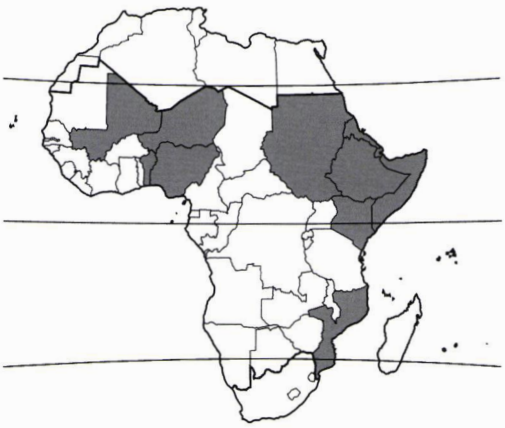
Chromosome number $2n = 28, 56$

Synonyms *Cassia senna* L. (1753), *Cassia angustifolia* Vahl (1790), *Cassia acutifolia* Delile (1813).

Vernacular names Senna, Aden senna, Alexandrian senna, Indian senna, narrow-leaved senna, Nubian senna, Khartoum senna, true senna (En). Séné, séné vrai, séné d'Egypte, cassier, séné grandes feuilles (Fr). Sene, cássia, senna, cene (Po). Msahala (Sw).

Origin and geographic distribution *Senna alexandrina* occurs naturally from Mali eastwards to Somalia and Kenya. It is also native in Asia from the Arabian Peninsula to India and Sri Lanka. In Mozambique it was probably introduced a long time ago and it has also been introduced in a number of Central Asian and Mediterranean countries, the Caribbean and Mexico. Commercial cultivation takes place in India, Sudan, Egypt, Pakistan, China and Korea.

Uses Leaves and pods of *Senna alexandrina* have been used as a laxative and purgative since ancient times and the trade dates back to at least the 9th century A.D. In the Western



Senna alexandrina – wild and planted

world *Senna alexandrina* was included in most pharmacopoeias under the names 'Senna folium' and 'Senna fructus'. The plant is also important in traditional Indian and Chinese medicine. In Sudan, Ethiopia, Somalia and Kenya both leaves and pods are used as a purgative. In Sudan a decoction of the pods is drunk to get rid of intestinal worms and to cure difficulties in breathing. The infusion of the pods is recommended as a purgative for pregnant women and also to suppress fever. An infusion of the leaves is drunk to overcome flatulence and convulsions and to stop nosebleeds.

In Ethiopia the wood is used to make farm tools. The shrubs are grazed by camels and goats in Somalia. However, in Sudan *Senna alexandrina* tends to dominate vegetation in heavily grazed areas, which indicates that it is not readily eaten by livestock. In Ethiopia the species is recommended for soil conservation.

Production and international trade India is the world's largest producer and exporter of leaves and pods of *Senna alexandrina*. It exported 5000–7000 t of leaves and pods annually around 1990, mainly to Germany, the United Sates, Japan, the Netherlands, France, Switzerland and the United Kingdom. In 2003 an amount of 9700 t of leaves alone was exported. Annual figures for exports from Sudan vary from 700–7740 t of leaves and pods. In 1992 the price at the port of import was US$ 1600 per t for pods from India and US$ 1200 per t for pods from Sudan. The price of leaves was about 50% lower than that of pods.

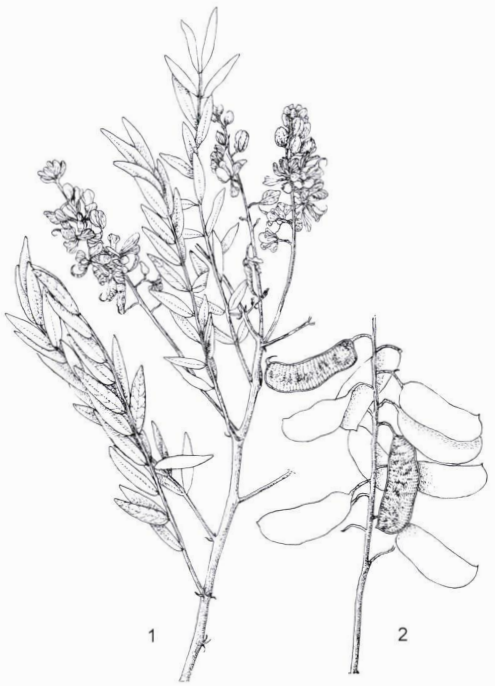
Properties The active constituents of the leaves and the wall of the pods are essentially the same and consist of 2–5% anthraquinone derivatives and related dianthrone glycosides on dry weight basis. The dried drug contains mainly sennosides A and B, together with small quantities of related compounds. The sennosides are little resorbed in the small intestine but once in the colon, they are hydrolyzed by the bacterial flora and the anthraquinones formed are reduced to form the active anthrones, which are responsible for the laxative activity as they stimulate peristalsis. Pharmaceutical grade leaves must contain 5.5–8.0% sennoside B, whereas pods must contain at least 2.2% ('Tinnevelly senna') to 3.4% ('Alexandrian senna') sennoside B.

Much medical research has been published, especially on the use of *Senna alexandrina* as a laxative and on its possible health risks. No carcinogenic effects of prolonged use have been found in tests with rats, but even so it should only be used for occasional constipation, as prolonged use can lead to chronic ulcerative colitis. Use of the drug is contraindicated in case of intestinal obstruction and acute intestinal inflammation. Use for children under 12 years of age and pregnant or lactating women must be discouraged. The use of preparations for weight reduction is dangerous.

Ethanol extracts of leaves of *Senna alexandrina* show inhibitory activity against *Bacillus cereus*, *Staphylococcus aureus* and *Staphylococcus epidermidis*, but not against gram-negative bacteria.

Adulterations and substitutes As a purgative *Senna alexandrina* is often substituted for other *Senna* species and by *Cassia* and *Aloe* species. Adulteration of commercial products used to be common and profitable, but importing countries nowadays have tight rules and controls. Up to 90% adulteration with *Senna auriculata* (L.) Roxb. ('avaram') has been recorded, and *Senna italica* Mill. ('Senegal senna') was also commonly used. In many African countries commercial preparations are imported.

Description Deciduous shrub up to 3 m tall. Leaves arranged spirally, paripinnately compound with 4–10 pairs of leaflets; stipules linear to narrowly triangular, 1.5–5 cm long, acute, persistent; petiole 1–8 cm long; leaflets lanceolate or narrowly elliptical to elliptical, 2–6.5 cm × 0.5–1.5 cm, base cuneate, unequal, apex rounded to obtuse, mucronate, shortly hairy on both sides. Inflorescence an erect, axillary raceme 5–30 cm long, 20–30-flowered; bracts elliptical to obovate, c. 1 cm long. Flow-



Senna alexandrina – 1, flowering branch; 2, infructescence.
Redrawn and adapted by Iskak Syamsudin

ers bisexual, zygomorphic, 5-merous; sepals c. 1 cm long, rounded at apex; petals unequal, (oblong-)obovate, 1.5–3 cm long, yellow or orange-yellow; stamens 10, the 2 lower ones largest, 5 medium-sized, 3 short and sterile; ovary superior, woolly, recurved, style short. Fruit a flattened, slightly curved to almost straight, oblong pod 4–7 cm × 1.5–2.5 cm, transversely partitioned, tardily dehiscent by 2 valves, 9–16-seeded. Seeds oblong or oblong-ovate, compressed, 8–9 mm × 4–5 mm, with a small areole on each face.

Other botanical information Until the early 1980s, *Cassia* was considered a very large genus of about 550 species, but was then split into 3 genera: *Cassia* s.s. with about 30 species, *Chamaecrista* with about 250 species and *Senna* with about 270 species. *Senna* is very similar to *Cassia*, but is distinguished from it by the possession of 3 adaxial stamens which are short and straight, and the pedicels which have no bracteoles.

Two varieties are distinguished in *Senna alexandrina*: var. *obtusata* (Brenan) Lock, restricted to Eritrea, Ethiopia, Somalia and northern Kenya, and var. *alexandrina*, which is the more widespread variety. The distinction made in trade between Indian or Tinnevelly senna from India and Nubian or Alexandrian senna from Sudan has no taxonomic basis.

Several other East African *Senna* species have medicinal uses similar to those of *Senna alexandrina*, but are of local importance only. In Somalia many share the same vernacular name 'jalelo'. *Senna holosericea* (Fresen.) Greuter occurs in Sudan, Eritrea, Ethiopia, Djibouti and Somalia and extends eastwards to India. The pods and leaves are used in Ethiopia as a laxative. The pods and leaves of *Senna hookeriana* Batka (synonyms: *Cassia adenensis* Benth., *Cassia somalensis* Serrato) from Somalia and Socotra are used as a laxative in Somalia. *Senna baccarinii* (Chiov.) Lock of southern and eastern Ethiopia, Somalia and northern Kenya is similarly used as the previous species, and twigs are used as toothbrush. It is also grown as an ornamental. *Senna longiracemosa* (Vatke) Lock is native to Ethiopia, Somalia, Kenya, Uganda and Tanzania and the roots are used by Somali people and the Samburu people of Kenya as a remedy for malaria. Roots are pounded and boiled and the filtrate is drunk with milk.

Growth and development *Senna alexandrina* can be found flowering and fruiting throughout the year. It does not form root nodules and does not fix nitrogen.

Ecology In tropical Africa *Senna alexandrina* occurs in semi-desert scrub and grassland particularly in valley bottoms, flood plains and on river banks, and is often associated with *Acacia* spp. It occurs from sea-level up to 1300 m altitude. Germination is hampered by salinity but older plants are salt-tolerant. *Senna alexandrina* does not tolerate continuous waterlogging or heavy irrigation.

Propagation and planting *Senna alexandrina* is usually established by broadcasting treated seed at rates of 15–25 kg/ha. Untreated seed has a poor germination rate. Treatment of the seed with sulphuric acid is more effective in breaking dormancy than methanol, boiling water, or incision of the testa. The weight of 1000 seeds is about 30 g.

Management In India *Senna alexandrina* is mostly grown as a rainfed crop or as a second crop after rice. In rice fields it germinates on residual moisture and can be irrigated. Before the canopy closes one or two weedings are necessary. The first flower stalks that appear are cut, which induces branching and increases the sennoside content of the leaves. *Senna alexan-*

drina is mostly grown as an annual crop, but can be left standing to produce for another 2–3 years.

Harvesting Two crops per year are harvested in Sudan, the more abundant one after the rains in September, the other one in April. In India leaves are stripped or picked about 3 months after sowing. The second and third harvest follow after 4–6 weeks. At the third harvest the pods are harvested as well.

Yield Yields of *Senna alexandrina* vary considerably depending on the soil and water conditions. In India the average annual yield is about 700 kg of leaves and 100 kg of pods per ha under rainfed conditions. Under irrigation the yield of leaves and pods is about 1400 kg/ha and 150 kg/ha, respectively. Although the sennoside content is higher when plants are under stress, moderate irrigation and fertilization pay off through increased leaf and total sennoside yields.

Handling after harvest In Sudan the harvested plants are placed on rocks until thoroughly dry and are subsequently stripped of the leaves. The leaves curl when drying and are loosely packed. In India the leaves are dried on a clean floor indoors or under shade. The leaves are spread thinly and stirred regularly to promote uniform drying. The leaves are packed into bales after drying, using a hydraulic press. Good leaves are fresh and bright yellowish green, with a faint and peculiar odour like green tea and a mucilaginous, sweetish, slightly bitter taste. The pods are tied in bunches and hung in well-ventilated sheds to dry for 10–12 days. After threshing the seeds are separated from the pods. The pod material is usually packed in boxes. The leaves and pods retain their medicinal value for years if stored at low temperature and humidity, but should be powdered only as needed, because the powder tends to absorb moisture, become mouldy and lose value.

Genetic resources Although *Senna alexandrina* is harvested in Sudan from the wild in considerable quantities, this is not considered a threat to its genetic diversity in the country. The Central Institute of Medicinal and Aromatic Plants in Lucknow, India, holds a considerable number of Indian genotypes. The regional variation within the species is poorly captured in collections.

Breeding Selection in *Senna alexandrina* for a high number of branches offers opportunities to improve the dry leaf yield per plant.

Prospects The multitude of trade names of *Senna alexandrina* and a poor understanding of taxonomic classification and changing nomenclature lead to confusion. The opportunities for expansion of commercial cultivation in tropical Africa deserve to be looked into.

Major references ABC, 2000; Bekele-Tesemma, Birnie & Tengnäs, 1993; Hostettmann et al., 2000; Iqbal, 1993; Kapur & Atal, 1982; Luckow, 1996; Marshall, 1998; Serrato Valenti, 1971.

Other references Akoègninou, van der Burg & van der Maesen, 2006; Al Helal et al., 1989; Alemayehu et al., 1993; Ali, 1973; Al-Yahya et al., 1987; Brenan, 1958; El-Kamali & Khalid, 1998; Elojuba, Abere & Adelusi, 1999; Hussain & Tobji, 1997; Irwin & Barneby, 1982b; Kokwaro, 1993; Neuwinger, 2000; Singh, Tiwari & Dubey, 2003.

Sources of illustration Serrato Valenti, 1971.

Authors C.H. Bosch

SENNA DIDYMOBOTRYA (Fresen.) H.S.Irwin & Barneby

Protologue Mem. New York Bot. Garden 35: 467 (1982).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Chromosome number $2n = 28$

Synonyms *Cassia didymobotrya* Fresen. (1839), *Cassia nairobensis* L.H.Bailey (1941).

Vernacular names Candle bush, peanut-butter cassia, popcorn senna, wild senna, candelabra tree (En). Séné africain (Fr). Mwinu (Sw).

Origin and geographic distribution *Senna didymobotrya* is native to tropical Africa where it is found from Congo east to Ethiopia and south to Namibia, Zimbabwe and Mozambique. It has been introduced as an ornamental plant into many tropical countries including the Comoros, Madagascar, Mauritius and South Africa. It was originally introduced into tropical Asia and America as a fodder, green manure and cover crop, but is now mainly cultivated as an ornamental.

Uses *Senna didymobotrya* is widely used as a medicinal plant, especially in East Africa, where a decoction or infusion from the leaves, stems and roots is drunk as a laxative and purgative for the treatment of abdominal pains, while in large quantities it is taken as an emetic. In Uganda, Rwanda and Burundi it is also taken to expel intestinal worms and to



Senna didymobotrya – wild and planted

treat ringworm. The concoction may make the patient weak and if this happens the patient should drink milk. When treating children, young leaves are cooked in banana leaves and given orally. In Kenya and Uganda an infusion made from the roots is drunk to treat diarrhoea.

In DR Congo, Rwanda, Burundi, Kenya, Uganda and Tanzania a root decoction is drunk for the treatment of malaria, other fevers and jaundice. The powder of the root or leaf mixed in water or a decoction of the fresh parts is taken to treat abscesses of the skeletal muscles and venereal diseases. The plant is also indicated for the treatment of fungal and bacterial infections, hypertension, haemorrhoids, sickle cell anaemia, and a range of women's diseases, such as inflammation of the fallopian tubes, fibroids and backache, to stimulate lactation, and to induce uterine contractions and abortion.

Senna didymobotrya, like other *Senna* species, is poisonous. Decoctions from all plant parts can cause violent vomiting and diarrhoea and may be fatal. It is recommended that pregnant women and children take a small dose. The leaves and roots are also used as fish poison.

Senna didymobotrya is also widely used for the treatment of livestock diseases. A decoction made from the leaves, either alone or in mixtures, is used to treat external parasites, e.g. ticks. In Kenya the leaves and young stems are pounded to a pulp and applied to the skin to treat skin diseases. The leaf sap in water is given to drink to treat diarrhoea, dysentery, and taken as a diuretic, laxative, and emetic. A decoction made from the roots is used as an antidote for poisoning, to expel a retained placenta, and to treat East Coast fever and blackleg.

The ash of burnt twigs is used to coat the inside of gourds that are to be used for storing milk, as it is said to improve digestibility and palatability. The milk can be kept in them for over a year.

The wood is used for making handicrafts, and is also used as firewood. The leaves are used as mulch or green manure. *Senna didymobotrya* is sometimes planted as a shade tree in tea plantations. Flowers, bark, leaves and pods can be used as a colorant for fibres and give a wide range of colours (yellow, orange, red). The bark is used in leather making for dehairing and tanning. The leaves are used to ripen bananas by wrapping them around the bunch. The hot ashes are used to clean beer vessels. *Senna didymobotrya* is widely grown as an ornamental plant.

Properties A number of anthraquinone derivatives have been isolated from the leaves and pods, e.g. emodin, chrysophanol, physcion and knipholone. Other compounds isolated from the leaves are aloe-emodin, rhein and small quantities of dianthrone emodin, dianthrone aloe-emodin, sennoside B, C and D, catechinic tannins, flavonoids and aloe-emodin B-glucoside. The seed contains 4% oil, 24% protein and 6% ash.

The anthraquinone derivatives are little resorbed in the small intestine but once in the colon, they are hydrolyzed by the bacterial flora and the anthraquinones formed are reduced to form the active anthrones, which are responsible for the laxative activity as they stimulate peristalsis. Anthraquinones such as emodin also inhibit ion transport across colon cells, contributing to the laxative effect. Anthraquinones exhibit other biological effects including diuresis, vasorelaxation, and induction of muscular contractions, antioxidant properties as well as antibacterial and antifungal activities. Emodin is known to be a feeding deterrent against a wide range of organisms.

Methanolic plant extracts reduced contractions induced by acetylcholine in isolated guinea pig trachea rings. This decrease was more than half of the relaxation induced by theophylline, a standard drug used in therapy for respiratory diseases. This property may be important for bronchodilatation in asthma treatment. The root and stem bark extracts inhibited growth of *Giardia lamblia* in in-vitro tests but were not lethal to this protozoan parasite that causes

infection of the gastrointestinal tract.
The bioactivity of the plant against malaria is low, although it is fever-suppressing.
The smell of *Senna didymobotrya*, especially when in flower or when bruised, has been described as 'mice', 'wet dogs', 'peanut butter' or 'burnt popcorn', and bees are repelled by the smell.

Adulterations and substitutes As a purgative *Senna didymobotrya* is often substituted for other *Senna* species and by *Cassia* and *Aloe* species.

Description Deciduous shrub or small tree up to 4.5(–9) m tall. Leaves arranged spirally, paripinnately compound with 8–18 pairs of leaflets; stipules broadly ovate-cordate, 1–2.5 cm × c. 1 cm, acuminate, persistent; petiole 1–8 cm long; leaflets oblong-elliptical, 2–6 cm × 0.5–2.5 cm, mostly rounded to obtuse at apex, mucronate, shortly hairy on both sides. Inflorescence an erect, axillary raceme 10–50 cm long, 20–30-flowered; bracts 1–2.5 cm long. Flowers bisexual, zygomorphic, 5-merous; sepals oblong-obovate, up to 1.5 cm long; petals unequal, oblong to obovate, 1.5–3 cm long, yellow; stamens 10, the 2 lower ones largest and fertile, 8 sterile; ovary superior, woolly, recurved, style slender, bent. Fruit a flattened, oblong pod 8–12 cm × 1.5–2.5 cm, transversely partitioned, dehiscent by 2 valves, 9–16-seeded. Seeds oblong, compressed, c. 8 mm × 4–5 mm, with a distinct areole on each face.



Senna didymobotrya – 1, flowering and fruiting branch; 2, stipule; 3, side view of flower; 4, flower in longitudinal section; 5, seed.
Source: PROSEA

Other botanical information Until the early 1980s, *Cassia* was considered a very large genus of about 550 species, but was then split into 3 genera: *Cassia* s.s. with about 30 species, *Chamaecrista* with about 250 species and *Senna* with about 270 species. *Senna* is very similar to *Cassia*, but is distinguished from it by the possession of 3 adaxial stamens which are short and straight, and the pedicels which have no bracteoles. The hairiness of *Senna didymobotrya* varies a good deal in length and density, and the bracts and stipules are variable in size. However, there seems no reason for recognizing subspecific taxa.

Growth and development *Senna didymobotrya* flowers profusely twice a year in the tropics. It is a cross-fertilizer, but also self-compatible. Reports on nodulation are contradictory. When grown as a fallow crop, it appeared to enrich the topsoil with considerable amounts of nitrogen, but it was not clear where this came from. *Senna didymobotrya* stimulates the germination of witchweed (*Striga*) seeds although it is not a host. When incorporated in the rotation it can effectively decrease the infestation.

Ecology *Senna didymobotrya* is common in deciduous bushland, along lake shores, streams, rivers and other damp localities, in grassland and woodland, from sea-level up to 2500 m altitude. Sometimes it is found in old plantations and in hedges near buildings. In South Africa it has become invasive in grassland, coastal scrub, woodland, roadsides, wasteland and on river banks. It tolerates light frost.

Propagation and planting *Senna didymobotrya* is propagated by seed and by cuttings. Seed germinates easily, but requires soaking in water for 24 hours because it exhibits some dormancy due to its hard seed coat. Dormancy can also be overcome by mechanical scarification and immersion in concentrated sulphuric acid or boiling water. Experiments with treated seed gave 75–85% germination, but the germination rate of untreated seeds is 15–20%. The seeds can germinate both in light and dark conditions and over a wide range of

temperatures; however, the optimum germination temperature is 20–25°C and the germination rate is very low at 10°C.
Seeds can be dried without damage to moisture contents that are much lower than normally achieved in nature. Over a wide range of storage environments, their longevity increases with reductions in both moisture content and temperature. The weight of 1000 air-dry seeds is 36–75 g.

Management *Senna didymobotrya* is a good shade tree in tea in areas where *Erythrina* spp. are unsuitable. As such it is spaced at about 5 m × 5 m. Young stems are tender and should be staked.

Diseases and pests *Senna didymobotrya* is hardly attacked by pests and diseases. It is a host of coffee mealy bug (*Planococcus kenyae*) that affects a wide range of crops.

Harvesting *Senna didymobotrya* can be lopped for green manure several times per year, preferably when flowering, as at this stage nutrient contents of the leaves is highest.

Yield The fresh leafy branches of *Senna didymobotrya* contain about 0.7% of N. A typical cut of 5 t/ha thus yields about 35 kg N.

Genetic resources There is a small number of accessions of *Senna didymobotrya* in germplasm collections. As it is widespread, the species is not threatened by genetic erosion.

Prospects The pharmacological benefits of using *Senna didymobotrya* as a crude herbal medicine are outweighed by its potential toxicity. However, herbal extracts prepared under carefully controlled manufacturing settings have potential. The use as a green manure, cover crop and shade tree has never been important in Africa, but could increase. Its ability to induce germination of *Striga* seeds makes it a potential trap crop for inclusion in rotation with grain crops.

Major references Alemayehu, Hailu & Abegaz, 1996; Brenan, 1967; Gacheru & Rao, 2005; Izhaki, 2002; Kamatenesi-Mugisha, 2004; Katende, Birnie & Tengnäs, 1995; Neuwinger, 2000; Okello-Onen et al., 2004; Sunarno, 1997; World Agroforestry Centre, undated.

Other references den Biggelaar & Mureithi, 2000; Geissler et al., 2002; Gessler et al., 1995; Hedberg et al., 1982; Hindmarsh, 1982; Johns et al., 1995; Kasonia, 1995; Kokwaro, 1993; Lindsay & Hepper, 1978; Masinde, 1996; Minja, 1994a; Muregi et al., 2004; Murengezi, 1993; Rambuda & Johnson, 2004; Schlage et al., 2000; Tabuti, Lye & Dhillion, 2003; Teketay, 1996; Thulin, 1989; Van Puyvelde, 1988.

Sources of illustration Sunarno, 1997.

Authors J.R.S. Tabuti

SENNA ITALICA Mill.

Protologue Garden dict. ed. 8: Senna n. 2 (1768).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

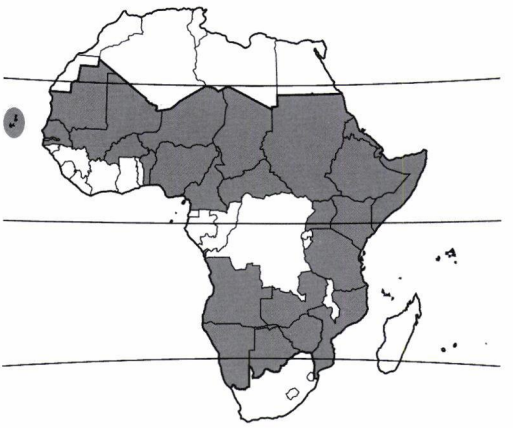
Chromosome number $n = 7, 14$

Synonyms *Cassia italica* (Mill.) Spreng. (1800), *Cassia obovata* Collad. (1816).

Vernacular names Senegal senna, Italian senna, Tripoli senna, Port Royal senna, Jamaica senna, Aleppo senna, eland's pea, wild senna, dog senna (En). Séné du Sénégal (Fr). Sene (Po).

Origin and geographic distribution *Senna italica* is a native of many African countries from Cape Verde east to Somalia and south to South Africa. In Benin it is only recorded as a cultivated plant. It is also native in Asia, from the Middle East through Iraq, Iran, Pakistan and India to Sri Lanka, and has been introduced and is naturalized in the Caribbean and Venezuela.

Uses Throughout its range the leaves, pods and mature seeds of *Senna italica* are used as a purgative. They are taken, usually as a decoction or maceration, to cure stomach complaints, fever, jaundice, venereal diseases and biliousness, as an abortifacient and against intestinal worms. The leaves, either fresh or dried and pulverized, are used as a dressing for skin problems such as burns and ulcers. A tea



Senna italica – wild and planted

made from the flowers is used as a purgative and to induce labour. A maceration of the roots is taken to cure colic and influenza, and boiled roots are used as a wound dressing. A root infusion is used as eye drops for sore eyes. The roots also enter in treatments of indigestion, liver complaints, gall bladder disorders, nausea, vomiting and dysmenorrhoea. In Malawi a root infusion is given to infants to cure diarrhoea.

Reports on the value of *Senna italica* as a browse are contradictory. In East Africa it seems to be eaten by most livestock, whereas in West Africa livestock seems to avoid it. Although mature seeds have a purging activity, young seeds are eaten as a snack or as a vegetable in the Sahel region. The seeds are smoked in Mauritania. The leaves, traded as 'neutral henna' or 'blonde henna', are used as a hair conditioner to make the hair glossy. It may impart a yellowish colour rather than a reddish one.

Production and international trade Both dried leaves and pods of *Senna italica* are traded locally as a purgative. Dried, powdered leaves for use as a hair conditioner are nowadays traded internationally. The origin of this product is Sudan, Egypt or India.

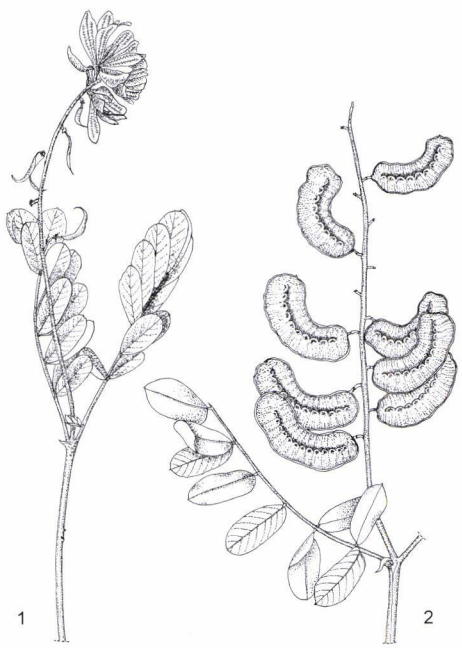
Properties From leaves and pods of *Senna italica* a number of anthraquinones have been isolated, which are responsible for the purgative effect: aloe emodin, chrysophanol, rhein, sennosides and their aglucons sennidins. Chrysophanol is also the active ingredient of 'neutral henna'. The anthraquinone content of the leaves ranges from 1.1–3.8% on a dry weight basis. The pods have a lower anthraquinone content than the leaves. Leaves further contain flavonoids (quercetin, kaempferol and apigenin) and steroids (stigmasterol, α-amyrin and β-sitosterol).

An ethanol extract of the whole plant has anti-inflammatory and antipyretic properties. 1,5-dihydroxy-3-methoxy-7-methylanthraquinone, isolated from *Senna italica*, showed activity against several gram-positive and gram-negative bacteria, as well as anticarcinogenic activity in vitro.

Toxicity tests on goats and rabbits fed with foliage proved negative. Rats and chicks fed with seeds at 10% of their intake showed symptoms of toxicity, but did not die during the 6-week test period. Feeding chicks with seeds at 2% of their intake promoted growth. The seeds yield a water soluble gum (about 20% of dry matter), mainly composed of D-galactose and D-mannose.

Adulterations and substitutes Anthraquinone glycosides, including sennosides, are also found in other species of *Senna*, *Cassia* and *Aloe* and are used for their laxative and purgative properties as well. *Senna italica* is popular as a substitute for *Senna alexandrina* Mill., but is considered inferior.

Description Deciduous, perennial herb or small shrub up to 60 cm tall, often with prostrate stems. Leaves arranged spirally, paripinnately compound with 4–6 pairs of leaflets; stipules narrowly triangular to ovate-triangular, 3–9 mm long, early deflexed, somewhat persistent; petiole 1.5–2.5 cm long; leaflets oblong-obovate or narrowly elliptical to elliptical, 1–6.5 cm × 0.5–1.5 cm, base cuneate, unequal, apex rounded to obtuse, shortly hairy on both sides. Inflorescence an erect, axillary raceme 2–25 cm long, up to 20-flowered; bracts rhombic to ovate, shortly pointed, up to 5 mm long. Flowers bisexual, zygomorphic, 5-merous; sepals unequal, oblong-elliptical, up to 1 cm long, obtuse at apex; petals obovate, up to 13 mm long, yellow; stamens 10, the 2 lower ones largest, 5 medium-sized, 3 short and sterile; ovary superior, with short, stiff hairs, style up to 6 mm long. Fruit a flattened, oblong pod 2.5–



Senna italica – 1, flowering branch; 2, fruiting branch.
Redrawn and adapted by Iskak Syamsudin

6 cm × 1.5–2 cm, with a ridge running along the middle of each valve, tip upcurved, dehiscent by 2 valves, many-seeded. Seeds oblong-ovate, compressed, 6–7.5 mm × 1.5–2.5 mm, with a small areole on each face.

Other botanical information Until the early 1980s, *Cassia* was considered a very large genus of about 550 species, but was then split into 3 genera: *Cassia* s.s. with about 30 species, *Chamaecrista* with about 250 species and *Senna* with about 270 species. *Senna* is very similar to *Cassia*, but is distinguished from it by the possession of 3 adaxial stamens which are short and straight, and the pedicels which have no bracteoles.

In *Senna italica* 3 subspecies are distinguished based on the size of the inflorescence and the length of the petiole. Subsp. *italica* is found in West Africa, North Africa, Sudan, the Horn of Africa and from Yemen to north-western India. This subspecies is naturalized in parts of South America. Subsp. *micrantha* (Brenan) Lock is found from southern Ethiopia and Somalia southwards to Namibia, Botswana, Zimbabwe and Mozambique. This subspecies is also found in most of India. Subsp. *arachoides* (Burch.) Lock is restricted to Namibia, Botswana and South Africa.

Senna truncata (Brenan) Lock, restricted to Ethiopia and Somalia, is used as a purgative. Either seeds are eaten or an infusion of the leaves is drunk. Like *Senna italica*, the pods have a ridge, but the pods are curved and the leaves have spreading, not appressed, hairs. Confusion of *Senna italica* with *Senna alexandrina* Mill. is widespread, but both leaves and pods are readily distinguishable as the former species has wider leaflets and the pods are without ridge.

Growth and development In experiments, the growth of *Senna italica* was enhanced by inoculation with a mixture of vesicular arbuscular mycorrhizal (VAM) inoculum. It does not produce root nodules. Flowering usually takes place during the rainy season, but in moist conditions flowers appear throughout the year.

Ecology *Senna italica* is found in grassland of the drier regions of tropical Africa, from sea-level up to 1850 m altitude. It is often found close to streams and in disturbed habitats such as roadsides and waste places.

Propagation and planting *Senna italica* is easily propagated by seed. Seed treatment by soaking overnight or abrasion with sand improves germination. Sowing in pockets at 5 seeds per pocket at 75 cm distance within and between rows and thinning to 3 plants per pocket is recommended.

Management Husbandry practices for *Senna italica* aim at high leaf yields combined with a high sennoside content. Production of fruits is avoided as their sennoside content is low. Weeding is necessary once or twice in the early stage of the crop. Twenty days after sowing pruning of the main stem to 20 cm will promote the formation of branches. Application of mineral fertilizer was found to be uneconomical in Burkina Faso. Topdressing with farmyard manure after each harvest gave considerable increases in leaf and sennoside yield. In the second year a single weeding should be done early in the growing season. The economic life of the crop is 3 years at the most. The crop can be rejuvenated by natural regeneration.

Diseases and pests *Senna italica* is a host of the root lesion nematode (*Pratylenchus penetrans*). In perennial cultivation serious attacks by termites have been observed.

Harvesting *Senna italica* should be harvested early in the morning as the sennoside content drops in the course of the day. Harvesting by cutting branches is recommended for the first harvest, but leaves may also be stripped from the branches. Stripping the leaflets requires more labour than cutting, but this is outweighed by labour saving during processing. Cutting should be at a height of about 20 cm to allow for adequate regrowth. Cutting higher results in a lower leaf yield, but better regrowth and higher yields in consecutive harvests. The first harvest can be done in the year of establishment towards the end of the rainy season. In consecutive years 2–3 harvests per year can be realized.

Yield The highest yields of *Senna italica* leaflets in Burkina Faso were obtained in the year after establishment with 1300 and 940 kg/ha for the first and second cut, respectively.

Handling after harvest If whole branches of *Senna italica* are harvested they are dried as such when it is the first crop, so that the highest possible sennoside content is obtained. In consecutive crops leaflets are stripped before drying. Leaflets should be dried in the shade at temperatures of 20–40°C. When dry, they are packed in compressed bales of about 200 kg.

Genetic resources A few collections of *Senna italica* are held in gene banks in Israel, the United Kingdom and Namibia. As the species is widespread and common, there is no threat of genetic erosion. It would be worthwhile, however, collecting local selections

whenever encountered.

Breeding Selection and breeding of *Senna italica* have not been attempted, but in view of the wide variation would be worthwhile if commercial production is envisaged.

Prospects *Senna italica* is not likely to regain its position in international trade, as this has been taken over by *Senna alexandrina*. However, for producing a mild laxative for domestic markets in semi-arid regions it does hold promise. The variation of *Senna italica* in medicinal uses, toxicity and contents of active compounds is not understood. Linking the variation to subspecies, growth stage and climatic and edaphic factors may help obtain a better understanding and a more rational use. Extreme caution is required when adopting medicinal uses of *Senna italica* from elsewhere.

Major references Brenan, 1967; Irwin & Barneby, 1982b; Lardinois et al., 1987; Lock, 1990; SEPASAL, 2006c; Southon et al., 1994.

Other references Agwa, 2000; Al-Araidh, Al-Tufail & Al-Jammaz, 2004; Ali et al., 1999b; Bakhiet & Adam, 1996; Dame et al., 1985; El-Molla, 2000; El Sayed et al., 1992; Hifny Saber, Balbaa & Awad, 1962; Inngjerdongen et al., 2004; Jain et al., 1997; Kazmi et al., 1994; Mabberley, 1981; Ross, 1977; Serrato Valenti, 1971; Vidigal, 2002.

Sources of illustration Serrato Valenti, 1971.

Authors J.M. Okeyo & C.H. Bosch

SENNA PETERSIANA (Bolle) Lock

Protologue Kew Bull. 43(2): 340 (1988).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Chromosome number $2n = 28$

Synonyms *Cassia petersiana* Bolle (1861).

Vernacular names Dwarf cassia, eared cassia, monkey pod (En). Mbaraka, mpingawaume (Sw).

Origin and geographic distribution *Senna petersiana* occurs from Cameroon east to Ethiopia and south to South Africa. It has been introduced in several Indian Ocean islands and is widely naturalized in Madagascar.

Uses *Senna petersiana* is widely used as a purgative to treat constipation, stomach-ache and intestinal worms by drinking an infusion or decoction of the roots, or less often, by using fresh leaves. In southern Africa medicinal uses include the treatment of malaria, schistosomiasis, gonorrhoea and syphilis. In southern Africa the sweet fruit pulp is eaten raw by children and in Malawi the pods are soaked, boiled and eaten as a gruel. In Mozambique the seeds and fruits are made into an alcoholic drink. In Zambia and probably elsewhere, the wood is used as firewood.

Properties The active constituents of leaves, bark, roots and pods of *Senna petersiana* are anthraquinone glycosides. These compounds are responsible for the purgative activity. The seeds contain the flavone luteolin. The ethanol extract of the seeds and luteolin were tested for antiviral activity and showed some activity at the highest non-toxic concentrations; luteolin also showed antibacterial activity. The methanol and water extract of the leaves showed some schistosomicidal activity in vitro. Both leaves and roots have shown antimalarial activity in vitro.

Anthraquinone glycosides are also found in other species of *Senna*, *Cassia* and *Aloe* and these are also used for their laxative and purgative properties.

Botany Shrub or small tree up to 12 m tall. Leaves arranged spirally, paripinnately compound, with 4–10(–13) pairs of leaflets; stipules kidney-shaped, 1–2.5 cm long, acuminate, persistent; petiole up to 4 cm long; leaflets lanceolate or ovate-lanceolate, 3–10 cm × 1–4 cm, apex acuminate, variably hairy. Inflorescence an erect, terminal or axillary panicle 15–20 cm long, many-flowered. Flowers bisexual, zygomorphic, 5-merous; sepals unequal, up to 6 mm long, rounded at apex; petals unequal, obovate, 1.5–3 cm long, bright yellow; stamens 10, 3 long, 4 medium-sized and 3 rudimentary; ovary superior. Fruit a somewhat compressed, linear pod 12–25 cm × 1–1.5 cm, indehiscent, sutures transversely cracked, many-seeded. Seeds compressed, ovoid to orbicular, 5–7 mm × 4–6 mm, with an olive-coloured areole.

Until the early 1980s, *Cassia* was considered a very large genus of about 550 species, but was then split into 3 genera: *Cassia* s.s. with about 30 species, *Chamaecrista* with about 250 species and *Senna* with about 270 species. *Senna* is very similar to *Cassia*, but is distinguished from it by the possession of 3 adaxial stamens which are short and straight, and the pedicels which have no bracteoles. *Senna petersiana* is very variable and in East Africa 3 types can be distinguished that are geographically separated and differ by their hairiness. In southern Africa intermediates between the 3 types occur and therefore a formal distinction between them is not justified.

Ecology *Senna petersiana* occurs at the margins of rainforest, in riverine forest, deciduous woodland, coastal evergreen bushland and wooded grassland up to 2500 m altitude.

Genetic resources and breeding In view of its wide distribution *Senna petersiana* is not considered threatened. In areas where the roots and bark are intensively used, monitoring of the populations is recommended. It will be worthwhile to try to link the medicinal uses to the variation in morphology, as there are no recorded medicinal uses in Ethiopia, few in Kenya and Tanzania, but many in southern Africa.

Prospects *Senna petersiana* will remain locally important as a purgative, but has many substitutes. More research into its potential as an anti-malaria and anti-bilharzia medicine is recommended.

Major references Brenan, 1967; Clarkson et al., 2004; Coates Palgrave, 1983; Neuwinger, 2000; Tshikalange, Meyer & Hussein, 2005.

Other references Coetzee et al., 2000; Connelly et al., 1996; Gelfand et al., 1985; Kokwaro, 1993; Sparg, van Staden & Jäger, 2000; Steenkamp, 2003; Storrs, 1979; Thulin, 1989; Williamson, 1955.

Authors C.H. Bosch

SENNA PODOCARPA (Guill. & Perr.) Lock

Protologue Kew Bull. 43(2): 340 (1988).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Chromosome number $2n = 28$

Synonyms *Cassia podocarpa* Guill. & Perr. (1832).

Origin and geographic distribution *Senna podocarpa* is distributed from Senegal and Gambia in the west to Nigeria in the east and is also reported from Bioko (Equatorial Guinea) and São Tomé.

Uses *Senna podocarpa* leaves are extensively used against gonorrhoea, for their purgative properties, as a guinea-worm expellent and as sore-healing remedy. A paste of pounded leaves is applied to the skin to treat problems such as guinea-worm sores. The leaves, reduced to ash, are mixed with shea butter (*Vitellaria paradoxa* C.F.Gaertn.) and applied externally to relieve arthritis and rheumatic pains. Pods are used in the treatment of skin diseases such as eczema, scabies and ringworm. The extract of the pods is taken as a purgative and has been shown to be as good as commercial 'Senna' made from the leaves or pods of *Senna alexandrina* Mill. The root is purgative as well and in decoction it is used as a stomachic and diuretic and is specifically used to cure oedema and gonorrhoea. The root contains a dark dye that is used as a body paint.

Properties The leaves and pods of *Senna podocarpa* contain rhein, chrysophanol, emodin and other combined and free anthraquinones.
In vitro, leaf extracts inhibited the multiplication of herpes simplex virus type HSV-1, whereas they were ineffective against African swine virus.
Toxic effects of extracts of leaves and pods may result from prolonged intake of high doses, but with moderate use the extracts are not considered harmful. Extra caution is needed in case of treatment of children and pregnant women. Repeated administration of different doses of leaf extract of *Senna podocarpa* caused tissue degenerative changes in the liver and kidneys of rats.

Botany Shrub up to 5 m tall. Leaves arranged spirally, paripinnately compound with 3–5 pairs of leaflets; stipules swollen at the base, 7–9 mm long, acute, persistent; petiole 2–4 cm long; leaflets elliptical, 5–12 cm × 3–7 cm, base asymmetrical, apex rounded, mucronate, glabrous on both sides. Inflorescence an erect, terminal raceme 20–30 cm long, 20–30-flowered; bracts elliptical, enclosing flower buds. Flowers bisexual, zygomorphic, 5-merous; sepals greenish yellow; petals 1.5–3 cm long, yellow; stamens 10, the 2 lower ones largest, 5 medium-sized, 3 short and rudimentary; ovary superior, woolly, recurved, style short. Fruit a flattened, oblong pod 4–11 cm × 1–1.5 cm, base and tip acuminate, with transverse ridges, indehiscent, 12–25 seeded.
Until the early 1980s, *Cassia* was considered a very large genus of about 550 species, but was then split into 3 genera: *Cassia* s.s. with about 30 species, *Chamaecrista* with about 250 species and *Senna* with about 270 species. *Senna* is very similar to *Cassia*, but is distinguished from it by the possession of 3 adaxial stamens, which are short and straight, and the pedicels, which have no bracteoles.

Ecology *Senna podocarpa* occurs in humid localities and at the margin of gallery forest. In forest areas it is often common in anthropogenic habitats such as old farmland.

Management Anthraquinone glycosides in *Senna podocarpa* reach their highest level during the dry season and drop during the rainy

season. This can be taken into account when deciding on the time of harvesting.

Genetic resources and breeding *Senna podocarpa* is widespread and occurs in anthropogenic habitats so no threats of genetic erosion are envisaged. It is not present in germplasm collections.

Prospects In the wetter parts of West Africa *Senna podocarpa* is the most important medicinal *Senna* and will probably remain so. Research has been done, notably in Nigeria, to verify whether *Senna podocarpa* could serve as a source of raw material for the local industrial production of laxatives. As results are positive, this may be taken up in the near future.

Major references Berhaut, 1975b; Elojuba, Abere & Adelusi, 1999; Neuwinger, 2000; Silva et al., 1996.

Other references Abo & Adeyemi, 2002; Adjanohoun et al., 1989; Akanmu et al., 2005; Burkill, 1995; Inngjerdongen et al., 2004; Keay, Hoyle & Duvigneaud, 1958; Sequeira, 1994; Rai, 1988; Silva et al., 1997a; Silva et al., 1997b.

Authors C.H. Bosch

SENNA SINGUEANA (Delile) Lock

Protologue Kew Bull. 43(2): 340 (1988).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Synonyms *Cassia singueana* Delile (1826), *Cassia goratensis* Fresen. (1839).

Vernacular names Winter cassia, sticky pod, scrambled egg (En). Pintcheira do mato (Po). Mbaraka, mkundekunde (Sw).

Origin and geographic distribution *Senna singueana* occurs throughout mainland tropical Africa and is probably only absent from Gabon, Djibouti and Somalia. In the Indian Ocean islands it is only on record for the Comoros.

Uses *Senna singueana* has many medicinal uses throughout Africa. A hot water infusion of the leaves is drunk and the warm leaves are applied as a compress to treat fever. The leaf sap is drunk to cure malaria. The leaves in decoction or infusion or as dried powder are applied to wounds caused by leprosy and syphilis. An infusion of the leaves is applied as eye drops to cure conjunctivitis. Extracts of the stem bark are taken to cure stomach complaints. Like the leaves, the stem bark is used to treat skin disorders and malaria. An infusion of the flowers is used as an eye lotion. The fruit pulp soaked in water and cooked with a staple food is eaten by lactating women as it is considered lactogenic. The roots are used to treat venereal diseases, stomach complaints and as a purgative. The roots are also used to cure impotence caused by diabetes. The ash of burnt roots is eaten mixed with porridge to cure abdominal pain. Leaves, stem and root bark are used as an anthelminthic and to treat bilharzia.

As an ornamental *Senna singueana* is spectacular, with flowers appearing before the onset of the rains, but it is only used for this purpose in its native range. The leaves are eaten as a cooked vegetable in Malawi and Tanzania, but elsewhere they are considered poisonous. The stem bark is used as a dye for textile in Ethiopia and Zambia and for tanning hides in large parts of East Africa. The fruits are used in Sudan for tanning skins. Bananas are wrapped in the leaves to speed ripening. The foliage is browsed by livestock. The wood is useful as firewood, and also for hut building, small furniture and carvings. The root fibres are used in hairpieces.

Properties From the roots 4 tetrahydroanthracene derivatives, singueanol-I and -II, torosachrysone and germichrysone, were isolated as well as the pentacyclic triterpene lupeol and steroids (campesterol, β-sitosterol and stigmasterol). The anthracene derivatives showed significant activity against several gram-positive bacteria in vitro and showed antispasmodic activity in isolated guinea pig colon. Extracts of the root bark have also shown significant analgesic, antipyretic, anthelminthic and antiplasmodial activity. The leaves have anthelminthic and antiviral properties, but no significant antibacterial activity. The stem bark contains tannins and is astringent. The leaves contain tannins, but a recent study indicated that digestibility is quite good and not constrained by the presence of tannins. In grazing land with ample *Senna singueana* shrubs the intake by cattle appeared to be very low, so another anti-feedant factor is likely involved. The leaves contain the flavonoid leucopelargonidin, which has dyeing properties. The wood is pale brown.

Botany Deciduous shrub or small tree up to 15 m tall. Leaves arranged spirally, paripinnately compound with 5–12 pairs of leaflets; stipules linear-lanceolate, acuminate, soon falling; leaflets elliptical, oblong-elliptical to obovate-elliptical, 2.5–6.5 cm × 1.5–3 cm, unequal at base, mostly rounded or notched at apex, glabrous to hairy on both sides. Inflorescence a stalked, terminal raceme up to 15 cm

long, 6–many-flowered; bracts 9–27 mm long. Flowers bisexual or female, zygomorphic, 5-merous; sepals oblong-obovate, up to 14 mm long; petals unequal, oblong to obovate, 1.5–3 cm long, yellow; stamens 10, the 3 lower ones largest and fertile, 7 sterile; ovary superior, c. 2 cm long, stipitate, down-curved. Fruit a cylindrical to slightly compressed, straight or slightly twisted, oblong pod 5–25 cm × 0.5–1 cm, slightly constricted between the seeds, indehiscent, apex rounded and shortly pointed, 8–25-seeded. Seeds compressed, round, 5–6 mm in diameter, with a small areole on each face.

Senna singueana often flowers when still leafless. It is susceptible to fire, although the thick bark gives some protection. It is often associated with insects like ants and carpenter bees, and the sticky pods are frequently visited by flies. It does not produce root nodules, hence does not fix nitrogen.

Until the early 1980s, *Cassia* was considered a very large genus of about 550 species, but was then split into 3 genera: *Cassia* s.s. with about 30 species, *Chamaecrista* with about 250 species and *Senna* with about 270 species. *Senna* is very similar to *Cassia*, but is distinguished from it by the possession of 3 adaxial stamens which are short and straight, and the pedicels which have no bracteoles.

Ecology *Senna singueana* occurs in thickets, woodland, savanna and dry evergreen forest, often on termite mounds, from sea-level up to 2250 m altitude. It is found in areas with an annual rainfall of 500–1000 mm.

Management *Senna singueana* is propagated by seedlings, including wildlings, and is quick growing. Dry seed stored in an airtight container remains viable for at least 3 years. Seed germinates in about 9 days with an average germination rate of 78%.

If a tree with a straight stem is required, protection against browsing animals is needed. Trees can be coppiced.

Genetic resources and breeding *Senna singueana* is widespread and common in most of its range. In Namibia, where the roots are harvested for medicinal use, it has become rare and needs conservation.

Prospects Although *Senna singueana* has numerous medicinal uses, research into its pharmacology has been scarce and restricted to the root bark. Because of their many medicinal uses, research into the properties of the leaves is warranted. The leaves are a more sustainable source of medicine than root or stem bark. The morphological variation in the species in connection to its uses and variation in phytochemistry needs further research.

Major references Adzu et al., 2003; Brenan, 1967; Burkill, 1995; Endo & Naoki, 1980; Neuwinger, 2000.

Other references Bein et al., 1996; Coates Palgrave, 1983; Kehlet & Hansen, 2004; Kokwaro, 1993; Kudi & Myint, 1999; Moshi & Mbwambo, 2002; Mutasa, Khan & Jewere, 1990; SEPASAL, 2006d; Williamson, 1955; World Agroforestry Centre (ICRAF), undated.

Authors V. Kawanga & C.H. Bosch

SENNA SOPHERA (L.) Roxb.

Protologue Fl. ind., ed. 1832, 2: 347 (1832).

Family Caesalpiniaceae (Leguminosae - Caesalpinioideae)

Chromosome number $2n = 28$

Synonyms *Cassia sophera* L. (1753).

Vernacular names Pepper-leaved senna, senna, African senna (En). Cassia coromandeliana (Po).

Origin and geographic distribution *Senna sophera* originates from tropical America, but is now pantropical. It occurs throughout tropical Africa, being common in West Africa, but in East Africa and Madagascar it is probably rare.

Uses In West Africa a leaf infusion is drunk to treat fever and malaria. In the Comoros a decoction of the leaves is used as an eye-bath to cure conjunctivitis. A decoction of the roots is drunk to relieve painful menstruation and is given to children to stimulate their nervous system. In Indonesia extracts of all plant parts are used to treat epilepsy. In the Philippines the seeds are used to treat fever. In India the juice of the leaves is applied against ringworm, while it is also employed as an expectorant, anthelminthic and as a remedy for rheumatic and inflammatory fevers. In addition to these applications, in Thailand the leaves are used for wound healing and as an antipyretic.

Powdered dry leaves are traditionally used in Ghana to control insect pests of stored grain and pulses. Planting *Senna sophera* in guard rows in vegetable crops has been shown to reduce the damage caused by the giant African land snail (*Achatina fulica*). The young leaves are eaten as a vegetable in Madagascar. The seeds and roasted leaves serve as a coffee substitute. *Senna sophera* is widely grown as an ornamental.

Properties *Senna sophera* has been re-

ported to contain anthraquinones, including chrysophanol and emodin.
Dried leaves have insect repellent and insecticidal properties and give some control of storage pests, especially of cowpea weevil (*Callosobruchus maculatus*) and the lesser grain weevil (*Sitophilus oryzae*). *Senna sophera*, *Senna occidentalis* (L.) Link, *Senna tora* (L.) Roxb. and *Chamaecrista mimosoides* (L.) Greene are used medicinally almost without distinction.

Botany Erect shrub up to 2(–3) m tall, almost glabrous. Leaves arranged spirally, paripinnately compound with 4–10 pairs of leaflets; stipules broadly triangular, early caducous; petiole 3–5 cm long, with a gland 5–10 mm above the petiole joint, rachis up to 11 cm long, without glands; leaflets lanceolate, 2–7 cm × 1–2 cm, upper leaflets largest, base rounded, apex acute to acuminate. Inflorescence an axillary corymb up to 2.5 cm long, 1–4-flowered. Flowers bisexual, zygomorphic, 5-merous; sepals ovate, 5–8 mm long, thinly hairy outside; petals obovate, 10–14 mm × 6–8 mm, yellow; stamens 10, 2 longer stamens with filaments 5–7 mm long and anthers 5–6 mm long, 4 shorter stamens with filaments 2 mm long and anthers 5 mm long, 4 staminodes; ovary superior, hairy, style thin, glabrous. Fruit a compressed pod 6–10 cm × 0.5–1 cm, 30–40-seeded. Seeds compressed, ovoid to rounded, 3–4 mm long.
Until the early 1980s, *Cassia* was considered a very large genus of about 550 species, but was then split into 3 genera: *Cassia* s.s. with about 30 species, *Chamaecrista* with about 250 species and *Senna* with about 270 species. *Senna* is very similar to *Cassia*, but is distinguished from it by the possession of 3 adaxial stamens, which are short and straight, and the pedicels, which have no bracteoles. *Senna sophera* is closely related to *Senna occidentalis* (L.)Link. The two are often confused, but the pods of the latter are circular in cross-section, not compressed, and have 2 rows of seeds. Records of *Senna sophera* at higher altitudes, e.g. in Rwanda and Uganda, are doubtful and may refer to *Senna occidentalis*.
Senna sophera flowers throughout the year, most abundantly after rains.

Ecology *Senna sophera* occurs in secondary habitats such as roadsides and waste places at lower elevations.

Management *Senna sophera* is sometimes a weed and is a host of bean common mosaic necrosis virus (BCMNV), Javanese root knot nematode (*Meloidogyne javanica*) and bean flower thrips (*Megalurothrips sjostedti*) and some monitoring is indicated in fields where pulse crops are grown.

Genetic resources and breeding *Senna sophera* is widely found in and outside Africa, and is neither endangered nor liable to genetic erosion.

Prospects *Senna sophera* is a truely multipurpose plant, with its various medicinal properties and ornamental value.

Major references Burkill, 1995; ILDIS, 2005; Irwin & Barneby, 1982a; Neuwinger, 2000; Toruan-Purba, 1999b.

Other references Adjanohoun et al. (Editors), 1982; Alemayehu, Abegaz & Kraus, 1998; Belmain et al., 2001; Decary, 1946; Kestenholz, 2001; Luckow, 1996; Raut & Barker, 2002; Sengooba et al., 1997.

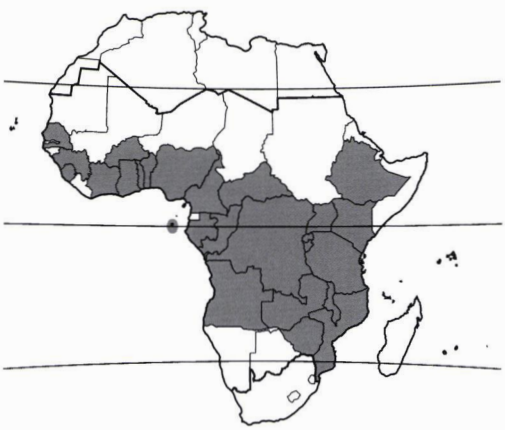
Authors C.H. Bosch
Based on PROSEA 12(1): Medicinal and poisonous plants 1.

SHIRAKIOPSIS ELLIPTICA (Hochst.) Esser

Protologue Kew Bull. 56: 1018 (2001).
Family Euphorbiaceae
Synonyms *Sapium ellipticum* (Hochst.) Pax & K.Hoffm. (1912), *Shirakia elliptica* (Hochst.) Kruijt (1996).

Origin and geographic distribution *Shirakiopsis elliptica* occurs from Senegal east to Ethiopia and Kenya, and south to South Africa.

Uses In Côte d'Ivoire and Congo *Shirakiopsis elliptica* is considered very poisonous and a very drastic purgative. A decoction of the leafy twigs is only occasionally taken orally to treat leprosy and ascites, in a similar way as extracts of *Excoecaria grahamii* Stapf. Exter-



Shirakiopsis elliptica – wild

nally, the extract is applied against Guinea worm sores. A leaf decoction is taken to treat elephantiasis. A leaf extract is applied to abdominal swellings and used as eye drops to treat eye diseases. In Tanzania the Shambaa people apply a paste made from powdered dried twigs with water to wounds infested with maggots. Leaf preparations are applied to treat pain in the chest, shoulders, back and head. In the Central African Republic the Lissongo people use a bark decoction as a mouthwash to treat stomatitis and scurvy. In DR Congo a bark decoction is used as a strong enema to treat abdominal pain. A stem bark infusion is taken to treat scabies and eczema. In Burundi a leaf or stem bark decoction is taken to treat anaemia and persistent headache, and also as an emetic. The bark latex is added to arrow poison based on *Acokanthera schimperi* (A.DC.) Schweinf. A root decoction is drunk to mature abscesses. The pulped roots in water are taken as a cure for stammering. The leaf or root juice is taken to treat fever, cough and colds; a leaf or root bark decoction or infusion is taken to treat colic. A decoction of leaves or roots, or the ash is applied to rheumatic parts of the body. In Kenya a root decoction is taken to treat cough. In Uganda crushed leaves and roots are applied to mumps. A root decoction is laxative and drunk to cure malaria and intestinal worms. In Zambia the grated roots are boiled and applied as a hot poultice on enlarged spleen in small children.

The sweet fruits are eaten in Nigeria and Tanzania. As the latex of the plant is considered poisonous, the consumption of the fruits merits caution. The white wood is tough. It is used for construction purposes, but not for roofs as it is not durable and easily damaged by borers and fungi. It is also used to make tool handles, farm implements, maize storage huts, mortars, spoons, bowls, cups and drums, and as firewood and to make charcoal. The leaves are rich in protein and are used as fodder for livestock, especially in East Africa. *Shirakiopsis elliptica* is occasionally used as shade tree and ornamental. In DR Congo an edible mushroom grows from the rotting trunk. The latex from the young twigs is sticky and caustic. It is used as bird lime and to create body markings.

Properties Almost nothing is known concerning the chemistry and pharmacology of *Shirakiopsis elliptica*. Preliminary tests on whole plants showed the presence of tannins and alkaloids. Crude bark extracts showed moderate bactericidal activity in vitro against *Campylobacter jejuni*.

The fruits contain carotenes and ascorbic acid.

Description Monoecious, much-branched shrub or small tree up to 15(–40) m tall; bole up to 100 cm in diameter, branchless for up to 12 m, often fluted; bark surface pale brown, reddish to almost black, smooth to rough, inner bark dirty yellow to orange or brown; young twigs sparsely hairy, soon glabrous, with milky latex. Leaves alternate, simple; stipules triangular-ovate, c. 2.5 mm long, soon falling; petiole up to 1.5 cm long, channeled above; blade elliptical, elliptical-oblong to oblanceolate, 4–17 cm × 1.5–7.5 cm, base cuneate to rounded with 2–4 glands, apex rounded to acute or acuminate, margin shallowly toothed, glossy and dark green above, reddish brown when young, turning red on falling, glabrous or sparsely hairy on veins beneath. Inflorescence an axillary or terminal spike-like raceme on lateral shoots, up to 12 cm long, with numerous male flowers and 1–3 female flowers at base. Flowers unisexual, regular, petals absent, disk absent; male flowers with pedicel 1–1.5 mm long, sepals 2–3, broadly ovate, c. 0.5 mm long, pale green, stamens 2(–3), free, shortly exserted; female flowers with pedicel 1.5–4 mm long, extending in fruit to 1–2 cm, sepals 2–3, triangular-ovate, 1–1.5 mm long, yellowish, ovary superior, 2-lobed, c. 1.5 mm long, smooth, 2-celled, styles 2(–4), 2–3 mm long, fused at base, coiled, green, persistent. Fruit a 2-lobed and laterally compressed drupe 8–15 mm × 6–8 mm, topped by the styles, smooth, green, turning yellowish then purple or black, slightly fleshy, 2-seeded. Seeds ellipsoid to almost globose, 5–5.5 mm in diameter, smooth, yellowish brown.

Other botanical information *Shirakiopsis* belongs to the tribe *Hippomaneae* and comprises 6 species, 3 in South-East Asia and 3 in tropical Africa. It is based on species formerly included in *Sapium* and later transferred to *Shirakia*. A few African *Shirakia* spp. were found to be congeneric with the Asian *Shirakiopsis* species. The African species mainly differ from the Asian ones in usually having much smaller and 2-celled fruits. *Shirakiopsis aubrevillei* (Leandri) Esser (synonyms: *Sapium aubrevillei* Leandri, *Shirakia aubrevillei* (Leandri) Kruijt) occurs from Sierra Leone to Ghana. It is listed as vulnerable in the IUCN Red List of threatened species, because of habitat loss. A root decoction is taken in Côte d'Ivoire as an aphrodisiac. The third African species, *Shirakiopsis trilocularis* (Pax

& K.Hoffm.) Esser is endemic to Kenya and also listed as vulnerable in the IUCN Red List of threatened species.

Anatomy Wood-anatomical description (IAWA hardwood codes):
Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; 13: simple perforation plates; 22: intervessel pits alternate; (23: shape of alternate pits polygonal); 27: intervessel pits large (≥ 10 µm); 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 31: vessel-ray pits with much reduced borders to apparently simple: pits rounded or angular; 41: mean tangential diameter of vessel lumina 50–100 µm; 42: mean tangential diameter of vessel lumina 100–200 µm; 46: ≤ 5 vessels per square millimetre; (56: tyloses common). Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; (68: fibres very thin-walled); 69: fibres thin- to thick-walled. Axial parenchyma: 76: axial parenchyma diffuse; 77: axial parenchyma diffuse-in-aggregates; 78: axial parenchyma scanty paratracheal; 93: eight (5–8) cells per parenchyma strand. Rays: 96: rays exclusively uniseriate; 105: all ray cells upright and/or square; 109: rays with procumbent, square and upright cells mixed throughout the ray; 115: 4–12 rays per mm; 116: ≥ 12 rays per mm. Mineral inclusions: 159: silica bodies present; 160: silica bodies in ray cells.
(D. Louppe, P. Détienne & E.A. Wheeler)

Growth and development In the Sahel region *Shirakiopsis elliptica* flowers at the beginning of the dry season; in East Africa it flowers in April and May and fruits from July to September.

Ecology *Shirakiopsis elliptica* occurs in savanna and secondary open forest, evergreen forest, fringing forest and swamp forest, from sea-level up to 2200 m altitude.

Propagation and planting *Shirakiopsis elliptica* can be multiplied by wildlings and seed. The ripe fruits are collected and cracked to release the seeds. The seed is sown directly in the field as transplanting is difficult; pretreatment is not necessary. The seeds can be stored for a long period in a container in a cool and dry room without loss of viability.

Management *Shirakiopsis elliptica* can be managed by coppicing, pollarding and lopping.

Diseases and pests The seeds in the fruits of *Shirakiopsis elliptica* are often damaged by insects. The fruits are sometimes galled.

Genetic resources *Shirakiopsis elliptica* has a scattered, irregular distribution in tropical Africa, and has become rare in some areas as a result of habitat degradation, but there are no indications that it is threatened by genetic erosion.

Prospects Despite its toxicity, *Shirakiopsis elliptica* has numerous local medicinal uses throughout its distribution area. As virtually nothing is known concerning its chemistry and pharmacology, research seems warranted to evaluate its potential. More research needs to be effected as well concerning the toxicity or palatability of the fruits, as its consumption by humans could be hazardous.

Major references Adjanohoun & Aké Assi, 1979; Burkill, 1994; Esser, 2001; Katende, Birnie & Tengnäs, 1995; Lovett et al., 2006; Maundu & Tengnäs, 2005; Neuwinger, 1998; Neuwinger, 2000; Radcliffe-Smith, 1987; Udoessien & Ifon, 1992.

Other references Arbonnier, 2002; InsideWood, undated; Léonard, 1962; Roothaert, 2000; Sekatuba et al., 2004; Tan et al., 2006; Yamada, 1999.

Authors G.H. Schmelzer

SMEATHMANNIA PUBESCENS Sol. ex R.Br.

Protologue Trans. Linn. Soc. 13: 221 (1821).
Family Passifloraceae

Origin and geographic distribution *Smeathmannia pubescens* occurs in the forest zone from Guinea-Bissau east to Nigeria.

Uses In Sierra Leone a bark decoction is taken to treat dysentery. In Liberia the inner bark is used as a poultice to treat toothache. In Côte d'Ivoire the Guéré people take the sap from crushed leaves to treat acute enteritis.
The hard and reddish wood of *Smeathmannia pubescens* is used as firewood and to produce chew-sticks by splitting. The pulp of the fruits is edible, but astringent.

Properties A mixture of the cyanogenic glycosides epitetraphyllin B (volkenin) and tetraphyllin B (barterioside) has been isolated from a leaf extract.

Botany Much-branched shrub or small tree up to 10 m tall; branches shallowly grooved, hairy, purplish. Leaves alternate, simple; stipules minute, soon falling; petiole short, glandular, with 2 stalked glands on either side; blade oblong, 5–8 cm long, base rounded, apex obtuse, margin toothed, leathery, glabrous or hairy on both sides. Flowers solitary in leaf

axils, bisexual, regular, 5-merous, glabrous, 5–7 cm in diameter; pedicel up to 3 cm long, reddish hairy; sepals oblong, c. 2.5 cm long, apex acute, imbricate, the exposed portions with golden-brown or reddish brown silky hairs, the covered edges white; petals ovate to oblong, c. 2.5 cm long, apex obtuse to emarginate, white; corona annular; stamens c. 20, fused at base; ovary superior, globose to ovoid, 1-celled, densely hairy at apex, styles 3–5, filiform, stigma large, head-shaped. Fruit an ovoid capsule, leathery, 3-valved. Seeds obovoid, compressed, with hard, pitted testa.

Smeathmannia comprises 6 species, which all occur in West Africa. *Smeathmannia laevigata* Sol. ex R.Br. occurs from Senegal to Sierra Leone and is similar to *Smeathmannia pubescens*. In Sierra Leone a bark decoction of *Smeathmannia laevigata* is taken to treat dysentery. In Senegal macerated leaves or a decoction of leafy stems are used in baths or taken orally to treat fever, back pain and headache. A decoction of twigs is used externally to treat sores and eye troubles.

Ecology *Smeathmannia pubescens* occurs in fringing and open forest.

Genetic resources and breeding *Smeathmannia pubescens* is fairly widespread and therefore not in danger of genetic erosion.

Prospects It seems likely that *Smeathmannia pubescens* will remain of limited use only.

Major references Burkill, 1997; Keay, 1954a; Masters, 1871; Neuwinger, 2000.

Other references Kerharo, 1971; MacFoy & Sama, 1983; Olafsdottir, Andersen & Jaroszewski, 1989.

Authors A. de Ruijter

SOLANUM ACULEATISSIMUM Jacq.

Protologue Icon. pl. rar. 1: 5, pl. 41 (1781).

Family Solanaceae

Chromosome number $2n = 24$

Synonyms *Solanum khasianum* C.B.Clarke (1883), *Solanum angustispinosum* De Wild. (1914).

Vernacular names Cockroach berry, love apple, devil's apple, soda-apple nightshade (En). Pomme d'amour (Fr). Unisca, jurubeba, gogoia (Po).

Origin and geographic distribution *Solanum aculeatissimum* is native of Brazil. It was introduced in Africa centuries ago and is now found throughout tropical Africa, but not yet in the Indian Ocean Islands. In Asia it is widely spread as well.



Solanum aculeatissimum – naturalized

Uses In Liberia and Nigeria a fruit decoction of *Solanum aculeatissimum* is administered as an enema to cure constipation. In DR Congo warm leaves are ground in water and the extract is administered as an enema as an abortifacient or purgative. In Uganda the fruit sap is used as eye drops to treat trachoma and the sap of roasted fruits is taken to induce labour. The fruits are considered toxic and the plants are used in witchcraft. In Kenya the sap from the leaves and fruit is applied to warts. In South Africa a root decoction is drunk to cure back pain and male impotence, a root maceration is drunk to treat snakebites, smoke from burning fruits is inhaled to cure toothache and the fruit is pressed to the forehead to remedy headache and to the skin to cure skin infections. The root extract is taken as a purgative and also to stop flatulence. Roots and fruits enter in preparations to treat coughs and dysmenorrhoea. In China the plant is used to treat bronchitis and rheumatism. No cases of poisoning of free ranging cattle are reported but force-feeding of either ripe or unripe fruits leads to death. In Puerto Rico the sliced fruit is used as bait for cockroaches.

In Asia *Solanum aculeatissimum* is used as rootstock for tomato and eggplant.

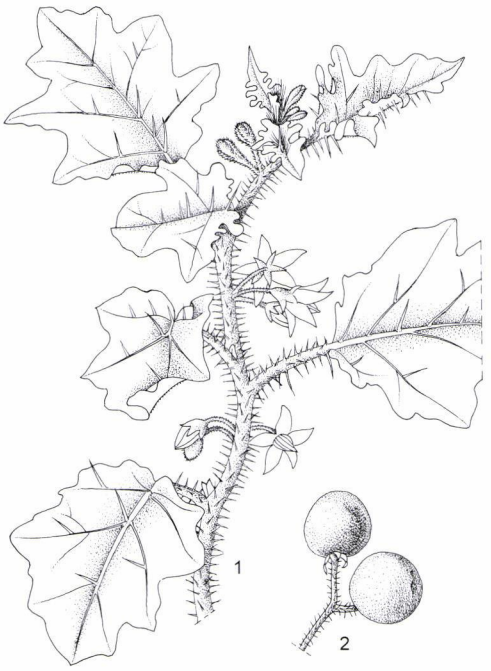
Properties Solasonine is the major glycoalkaloid in leaves, stems, fruits and seeds of *Solanum aculeatissimum*, and minor alkaloids isolated are solamargine, solanine and solasodine. The highest concentration of alkaloids is found in the seed (4.4%). Ripe fruits have a solasodine content of 2.8–3.8%. Mature fruits contain the steroids diosgenin, β-sitosterol and

lanosterol. Roots contain the steroidal saponins aculeatiside A and B, which are precursors of steroid hormones. The roots contain high amounts of solasodine and aculeatiside B (3.8% and 3.0% respectively).

An ethanol extract of the leaves inhibits spore germination of the fungal cabbage disease black spot (*Alternaria brassicicola*). Extracts of leaves and fruits were shown to have a repellent, but not an insecticidal effect on the cabbage aphid (*Brevicoryne brassicae*).

In-vitro production of the steroidal saponins is of economic interest; it has been extensively investigated and protocols have been developed.

Description Perennial herb or small shrub up to 120(–200) m tall; stems densely covered with yellowish, slender prickles up to 18 mm long, hairs mostly simple, some hairs stellate. Leaves alternate, simple; stipules absent; petiole 1–9.5 cm long; blade broadly ovate, 2.5–16 cm × 2.5–19 cm, base unequal, cuneate to cordate, apex usually acute, margin coarsely toothed or more or less deeply lobed, prickles present on main veins. Inflorescence a cyme, inserted above the leaf axil, 2–3.5 cm long, 2–7-flowered. Flowers bisexual or functionally male, regular, 5(–6)-merous; calyx bell- or cup-shaped, 4–10 mm in diameter, lobes unequal, triangular, acuminate, reflexed; corolla stellate, up to 22 mm in diameter, white to mauve or purple; stamens alternate with corolla lobes, filaments 1–2 mm long, anthers lanceolate, c. 6 mm long, opening with apical pores; ovary superior, with stalked glands and short hairs near base, style glabrous, 6–10 mm long. Fruit a globose berry 2–3 cm in diameter, glabrous, green marbled white or cream, yellowish when ripe, many-seeded. Seeds ovoid, compressed, 2.5–4.5 mm in diameter, margin thickened. Seedling with epigeal germination; cotyledons thin, leafy.



Solanum aculeatissimum – 1, flowering shoot; 2, fruits.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Solanum* comprises about 1000 species and has a cosmopolitan distribution, except in boreal, alpine and aquatic habitats. About 110 species are found in tropical Africa. The principal centre of diversity is located in Central and South America, with secondary centres in Africa and Australia. *Solanum* has been subdivided into 7 subgenera and numerous sections and series. The section *Acanthophora* of the subgenus *Leptostemonum*, to which *Solanum aculeatissimum* belongs, comprises about 20 species, all native to tropical America. The name *Solanum aculeatissimum* is sometimes wrongly applied to *Solanum capsicoides* All., a species native of coastal Brazil. *Solanum capsicoides* is fairly widespread in the Caribbean and the fruits are used to make juice. It is also introduced in tropical Africa as an ornamental. The synonym *Solanum khasianum* is still often used in scientific publications in India, and as such it is often misapplied to *Solanum viarum* Dunal, another species of the section *Acanthophora*. Based on their morphology it has been concluded that *Solanum aculeatissimum*, *Solanum viarum* and *Solanum myriacanthum* Dunal are very closely related and molecular research indicates that they belong to a hybrid complex. Misidentification of *Solanum macrocarpon* L. (synonym: *Solanum dasyphyllum* Schumach. & Thonn.) is a further source of confusion, probably in West Africa in particular.

Growth and development In East Africa *Solanum aculeatissimum* flowers from October to February, in DR Congo throughout the year and in South Africa from November to March.

Ecology *Solanum aculeatissimum* occurs in disturbed open vegetation, e.g. in roadsides, forest clearings and as a weed in pastures, agricultural land and forest plantations, from

sea-level up to 2400 m altitude.

Propagation and planting *Solanum aculeatissimum* is easily propagated from seed or stem cuttings. Shoots can be produced from leaf and stem-node explants on Murashige & Skoog medium supplemented with cytokinins.

Management Commercial cultivation of *Solanum aculeatissimum* has not been attempted in tropical Africa. In Asia it is used as rootstock for tomato and eggplant, both in traditional systems and in hydroponics.

Diseases and pests *Solanum aculeatissimum* is a host of the potato leaf rolling virus (PLRV). It is very susceptible to root knot nematodes (*Meloidogyne* spp.).

Harvesting When grown in Japan as an arable crop the dry weight of the roots reached a maximum in November and contained more than 10% steroid saponins.

Genetic resources In Brazil the genetic diversity of *Solanum aculeatissimum* should be looked into, with regard to the alkaloid content. Plants grown in botanic gardens in Europe are very uniform and probably descend from a single introduction from South Africa.

Breeding *Solanum aculeatissimum* is highly resistant to Verticillium wilt (*Verticillium dahliae*), a characteristic that is useful to introduce in eggplant (*Solanum melongena* L.) and gboma eggplant (*Solanum macrocarpon* L.); crosses of *Solanum aculeatissimum* with these 2 species are sometimes successful, but sometimes result in sterile seed.

Prospects The prospects of cultivating *Solanum aculeatissimum* for the extraction of steroidal saponins need further research. A major problem in evaluating the potential of *Solanum aculeatissimum* is the enormous confusion in the literature with several other *Solanum* species.

Major references Burkill, 2000; Gbile & Adesina, 1988; Goncalves, 2005; Hulstaert, 1966; Levin, Watson & Bohs, 2005; Nabeta, 1993; Nee, 1991; Watt & Breyer-Brandwijk, 1962; Welman, 2003.

Other references Alconero et al., 1988; Bukenya-Ziraba & Carasco, 1999; Hamill et al., 2000; Heine, 1963; Hsieh et al., 2005; Hutchings et al., 1996; Ikenaga et al., 1988; Kadkade, 1984; Kadkade, Recinos & Madrid, 1979; Kamatenesi-Mugisha & Oryem-Origa, 2007; Lovatto, Goetze & Thomé, 2004; Rathore & Kamal, 1979; Shale, Stirk & van Staden, 1999; De Souza-Dias, Costa-Alvaro & Nardin-Antonio, 1993; Tokarnia, Canella & Dobereiner, 1973; Asano et al., 1997; Yamada, 1999.

Sources of illustration Agnew & Agnew, 1994; Welman, 2003.

Authors M.J. Nicholson

SOLANUM CATOMBELENSE Peyr.

Protologue Sitzungsber. Akad. Wiss. Math.-Naturwiss. Wien 38: 576 (1860).

Family Solanaceae

Origin and geographic distribution *Solanum catombelense* occurs in southern Africa, except Malawi and Zambia.

Uses In Namibia tea made of the roots of *Solanum catombelense* is drunk or the roots are chewed to treat gastro-intestinal disorders. The sap of fresh unripe fruits is applied as arrow poison.

Mature fruits are considered edible. Leaves and stems are eaten as a vegetable.

Botany Perennial herb, erect or spreading up to 120 cm tall; stems stellate-hairy, sparsely covered with prickles. Leaves alternate, simple; stipules absent; petiole 1–3 cm long; blade oblong, 1.5–8.5 cm × 1–4.5 cm, base rounded or cuneate, apex obtuse or rounded, margin entire or more or less wavy to few-lobed, prickles often present on main veins, densely soft-hairy on both sides. Inflorescence a cyme, inserted above the leaf axil, 2–3.5 cm long, 2–7(–10)-flowered. Flowers bisexual, regular, (4–)5(–6)-merous; calyx bell- or cup-shaped, densely soft hairy, lobes unequal, ovate to linear-lanceolate, up to 3.5(–5) mm long, obtuse, recurved; corolla rotate to stellate, up to 10 mm in diameter, white to purple or violet; stamens alternating with corolla lobes, filaments c. 0.5 mm long, anthers up to 4.5 mm long, opening with apical pores; ovary superior, hairy on upper half, style hairy, 4.5–7.5 mm long. Fruit a globose berry 5–12 mm in diameter, glabrous, yellow, orange, red or blackish when ripe, many-seeded. Seeds ovoid, 2.5–3.5 mm in diameter, pale yellow to brown. Seedling with epigeal germination; cotyledons thin, leafy.

Solanum comprises over 1000 species and has a cosmopolitan distribution, except in boreal, alpine and aquatic habitats. At least 100 species are found in tropical Africa. The principal centre of diversity is located in Central and South America, with secondary centres in Africa and Australia. *Solanum* has been subdivided into 7 subgenera and numerous sections and series. *Solanum catombelense* has been placed in the '*Solanum tomentosum* and rela-

tives' group of the section *Oliganthes* of subgenus *Leptostemonum*. This group comprises 3 species and occurs in southern Africa. The other species in this group, *Solanum burchellii* Dunal and *Solanum tomentosum* L., are also used medicinally. A root infusion of *Solanum burchellii* is drunk to cure venereal diseases in Namibia. *Solanum tomentosum* is restricted to South Africa and a decoction of the roots is drunk to cure syphilis.

The closely related '*Solanum capense* and relatives' group comprises about 7 species, all but one restricted to southern Africa. *Solanum glabratum* Dunal (synonym: *Solanum sepicula* Dunal) occurs in Ethiopia, Somalia and Saudi Arabia. In Ethiopia the roots of *Solanum glabratum* are crushed, mixed with water and given as a drink to cattle suffering from anthrax. Of the species restricted to southern Africa, 3 have documented medicinal uses in Namibia: *Solanum capense* L., *Solanum dinteri* Bitter and *Solanum namaquense* Dammer. In South Africa the pulverized roots of *Solanum capense* are applied for toothache and milk boiled with pounded roots is drunk to cure urinary tract problems. Leaf pulp is applied to ulcers and leaf sap to inflamed eyes. Squashed fruits are applied to warts and skin affected by ringworm. The roots of *Solanum dinteri* are taken for stomach complaints, a root decoction is drunk to cure venereal diseases and crushed roots are applied externally to relieve pain. A root decoction of *Solanum namaquense* is used as a purgative and for liver, gall bladder and stomach complaints. The roots enter in preparations to treat venereal diseases, urinary tract problems and dysmenorrhoea. Fruits are squashed on lips and tongue to treat fever blisters.

Ecology *Solanum catombelense* occurs in many vegetation types: coastal forest, woodland, wooded grassland, along rivers, on rocky outcrops and in overgrazed and disturbed localities, from sea-level up to 1300 m altitude.

Genetic resources and breeding There is no indication that *Solanum catombelense* is in danger of genetic erosion.

Prospects *Solanum catombelense* will probably remain of local importance as a medicinal plant.

Major references Goncalves, 2005; von Koenen, 2001; Wondimu, Asfaw & Kelbessa, 2007.

Other references Edmonds, Friis & Thulin, 2006; Leffers, 2003; Peters, O'Brien & Drummond, 1992; Sarg et al., 1995; SEPASAL, 2008m; Watt & Breyer-Brandwijk, 1962; Whalen, 1984.

Authors C.H. Bosch

SOLANUM COAGULANS Forssk.

Protologue Fl. aegypt.-arab.: 47 (1775).
Family Solanaceae
Chromosome number $2n = 24$
Synonyms *Solanum dubium* Fresen. (1833), *Solanum thruppii* C.H.Wright (1894).

Origin and geographic distribution *Solanum coagulans* occurs in Sudan, Eritrea, Ethiopia, Somalia, Kenya, Uganda and Tanzania. It is also found in Egypt, Yemen and Saudi Arabia. Records for other countries, e.g. China, probably refer to other species of *Solanum*.

Uses In Kenya the boiled roots of *Solanum coagulans* are taken to avoid a miscarriage. Roots are chewed by expectant mothers who experience abnormal pain. The dry seeds are powdered and applied to wounds as an antiseptic. In Sudan the whole plant and fruits are pulped and applied to wounds and skin tumours as a dressing. The seeds are taken in Ethiopia as a purgative. The fruits are used for tanning and for coagulating milk. The plants are browsed by cattle, goats, sheep, donkeys and camels.

Botany Erect or spreading perennial herb up to 70 cm tall, young parts covered with stellate hairs; stems with many straight yellow prickles, rarely without. Leaves alternate, variable, simple; stipules absent; petiole 1–6 cm long, with many prickles; blade ovate-lanceolate, 1–10 cm × 1–5 cm, base unequally truncate or slightly cordate, apex rounded, entire or lobed, with rounded lobes. Inflorescence an axillary 6–10-flowered raceme-like cyme. Flowers bisexual, regular, 5-merous; pedicel 1–1.5 cm long; calyx persistent, lobes lanceolate, c. 5 mm long, with many prickles; corolla stellate, 1–2 cm in diameter, pale blue-violet, lobes spreading or reflexed; stamens inserted on corolla throat, unequal, 4 anthers c. 5 mm long, 1 up to 8 mm long, opening by terminal pores; ovary superior, globose, style slightly longer than stamens. Fruit a globose berry c. 1 cm in diameter, yellow, enclosed in enlarged, prickly calyx, many-seeded. Seeds ovoid, compressed, shiny black. Seedling with epigeal germination.

Solanum comprises about 1000 species and has a cosmopolitan distribution, except in boreal, alpine and aquatic habitats. About 110 species

are found in tropical Africa. The principal centre of diversity is located in Central and South America, with secondary centres in Africa and Australia. *Solanum* has been subdivided into 7 subgenera and numerous sections and series; *Solanum coagulans* belongs to subgenus *Leptostemonum*. Two other East African species from this subgenus are used medicinally.

Solanum mauense Bitter is only known from Kenya west of the Rift Valley. The Maasai people drink a decoction of the roots as a cure for malaria and chest pain. It is also applied as a cure for anthrax in both humans and livestock. Boiled berries are eaten to cure pneumonia.

Solanum richardii Dunal is a very variable species distributed from DR Congo to East and southern Africa and the Indian Ocean Islands. In Tanzania a root decoction is drunk as a cure for gonorrhoea and as an anti-emetic.

Ecology *Solanum coagulans* occurs in roadsides, waste places and in *Acacia-Commiphora* bushland up to of 1800 m altitude.

Management In Sudan *Solanum coagulans* is an important reservoir of the tomato yellow leaf curl virus (TYLCV), an important viral disease in tomato and *Capsicum* peppers.

Genetic resources and breeding *Solanum coagulans* is widely distributed in ruderal habitats and not threatened by genetic erosion.

Prospects As no chemical and pharmacological analyses of *Solanum coagulans* have been done, meaningful predictions about its prospects cannot be made. The different local medicinal uses are interesting though and warrant research.

Major references Edmonds, Friis & Thulin, 2006; El Kheir & Salih, 1980; Graham et al., 2000; Jaeger & Hepper, 1986.

Other references Beentje, 1994; Daffalla & Ahmed, 2005; Glover, Stewart & Gwynne, 1966; Haerdi, 1964; Heine & Heine, 1988b; Kokwaro, 1993; Morgan, 1981; Whalen, 1984.

Authors C.H. Bosch

SOLANUM ERIANTHUM D.Don

Protologue Prodr. fl. nepal.: 96 (1825).

Family Solanaceae

Chromosome number $2n = 24$

Synonyms *Solanum verbascifolium* auct. non L.

Vernacular names Potato tree, tobacco tree, tropillo (En). Amourette marron (Fr). Maria mole amarga (Po).

Origin and geographic distribution *Solanum erianthum* originates from the West Indies, Central America and Mexico, but is now a widespread weed in the tropics, although hardly penetrating South America. It was probably introduced from the Caribbean into West Africa at the time of the slave trade and it is believed to have been introduced into the Philippines by the Spanish in the 16th century, from where it has spread throughout the South-East Asian archipelago and to mainland Asia and Australia as a weed.



Solanum erianthum – naturalized

Uses In West Africa a leaf decoction of *Solanum erianthum* is taken for its diuretic and purgative properties to cure malaria, leprosy and venereal diseases and it is also taken to stimulate the liver functions.

In tropical Asia the leaves are considered a potent medicine for expelling all impurities through the urine, in particular to treat leucorrhoea, and also as an abortifacient. Pounded leaves are applied as a poultice to treat haemorrhoids and scrofula. Heated leaves are applied to the forehead against headache. A decoction of the leaves is drunk to treat vertigo. A decoction of the roots is applied to treat violent body pains or to relieve digestive troubles; it is also given to treat dysentery, diarrhoea and fever. The root bark is used as an antiphlogistic and to treat arthritis. The fruits are an ingredient of arrow poison.

Although the fruits are considered poisonous, causing nausea, headache and cramps, in South-East Asia they are sometimes eaten when cooked. In southern India the fruits are prepared as a curry. In the Philippines the velvety leaves are used to remove grease from dishes. *Solanum erianthum* is considered suit-

able as a shade plant for coffee, but in Ghana it is considered an undesirable shade plant. In the Caribbean *Solanum erianthum* is planted as an ornamental.

Properties *Solanum erianthum* contains steroidal saponins and free genins as well as steroidal alkaloids of the spirosolane group. The spirosolanes are structurally similar to saponins of the diosgenin type. Important spirosolane alkaloids include solasodine and tomatidine, which are both found in *Solanum erianthum*. The total alkaloid content of air dry leaves and fruits is about 0.4%. The solasodine content in fruits from Indian samples was 0.01–0.70%. Leaf samples from Vietnam contained 0.26% solasodine and 0.05% tomatidine. Steroidal alkaloids such as tomatine, solanine and chaconine inhibit growth and development of a large number of fungi. A flavonoid-rich extract of the leaves of *Solanum erianthum* possesses antibacterial and antifungal activity against gram-positive bacteria and the fungi *Aspergillus flavus* and *Candida albicans*. Steroidal alkaloids from *Solanum erianthum* are useful in industry as steroid precursors. Solasodine is a nitrogen-containing analogue of diosgenin, a compound often used as raw material for the production of medicinal steroids. The synthetic steroids have three main applications in medicine: as anti-inflammatory corticosteroids, as contraceptive steroids and as anabolic steroids. An aqueous extract of the leaves given orally to mice was effective as a prophylactic against malaria, but when administered 5 days after infection, it failed to suppress the malaria parasites.

Active compounds can be produced in vitro, although only in low amounts. Both diosgenin and solasodine have been isolated from 6-month-old callus, established from sterilized seeds on Murashige and Skoog's revised medium. Blue light stimulated solasodine synthesis and green light stimulated diosgenin synthesis.

Adulterations and substitutes Steroidal alkaloids (e.g. diosgenin and tigogenin) are also found in *Dioscorea* and *Smilax* species; these are also used as starting material for steroid hormone semisynthesis.

Description Shrub up to 4(–10) m tall; stem up to 20 cm in diameter, unarmed, densely woolly hairy with soft stellate hairs. Leaves alternate, simple; stipules absent; petiole 2–3(–4) cm long; blade elliptical-ovate, 10–20(–30) cm × 3.5–15 cm, base rounded to cuneate, apex acute to acuminate, margin entire or slightly wavy, densely woolly hairy. Inflorescence a terminal or axillary compound cyme, 15–25-flowered. Flowers bisexual, regular, 5-merous; calyx campanulate, c. 5 mm long, lobes ovate; corolla stellate, c. 1.5 cm in diameter, white; stamens alternate with corolla lobes, filaments 1.5 mm long, glabrous, anthers oblong, c. 4 mm long, opening with apical pores; ovary superior, almost glabrous, style glabrous. Fruit a globose berry 8–12 mm in diameter, short-hairy, dull yellow to orange when ripe, many-seeded. Seeds ovoid, compressed, 1–2 mm in diameter. Seedling with epigeal germination; cotyledons thin, leafy.



Solanum erianthum – 1, flowering branch; 2, flower; 3, infructescence.
Source: PROSEA

Other botanical information *Solanum* comprises about 1000 species and has a cosmopolitan distribution, except in boreal, alpine and aquatic habitats. About 110 species are found in tropical Africa. The principal centre of diversity is located in Central and South America, with secondary centres in Africa and Australia. *Solanum* has been subdivided into 7 subgenera and numerous sections and series. *Solanum erianthum* belongs to subgenus *Brevantherum*, which has another introduced spe-

cies present as a weed and ornamental in tropical Africa: *Solanum mauritianum* Scop.

Ecology *Solanum erianthum* occurs in sunny localities, in brushwood and roadsides, on waste ground and in edges of fields and forests. It is also a weed of gardens and fields at low to medium altitudes and prefers a well-drained soil. In Ghana it is frequently encountered as one of the pioneer species of degraded mining sites.

Propagation and planting *Solanum erianthum* is easily raised from seed and can also be propagated from shoot cuttings and by division of rooted shoots.

Diseases and pests Many *Solanum* spp., including *Solanum erianthum*, are hosts of diseases and pests that attack economically important *Solanaceae*.

Yield In many *Solanum* species the steroidal alkaloid content and sapogenin content decline as the fruit ripens. Leaf alkaloid and sapogenin contents also decline with age. In India a method has been developed to estimate solasodine content in the leaves 3 months after sowing by estimating their N content. At that stage a top dressing or foliar sprays may be applied to increase the solasodine yield. In related species a yield of 45–50 kg of solasodine per ha is considered reasonable.

Handling after harvest The leaves and roots can be used fresh or dried and stored in airtight containers for later use.

Genetic resources In its native range in Central America *Solanum erianthum* is locally under serious pressure. In view of its weedy nature and wide distribution throughout the tropics however, the risk of genetic erosion seems to be rather limited.

Breeding The large variation in alkaloid content within *Solanum erianthum* offers possibilities for selection. However, the alkaloid content also varies substantially as a result of ecological conditions, drying and storage.

Prospects *Solanum erianthum* has potential for use in reclamation of degraded sites, and has medicinal and ornamental value. The possibility of its cultivation for extraction of steroidal saponins needs further research. However, introduction in areas where it does not yet occur, should be discouraged as it may become a noxious weed.

Major references Blomqvist, 1997; Blomqvist & Nguyen Tien Ban, 1999; Burkill, 2000; Makinde, Obih & Jimoh, 1987; Roe, 1972.

Other references Abbiw, 1990; Adam, Huong & Khoi, 1979; Ajasa et al., 2004; Barnabas & Nagarajan, 1988; Everitt, 1977; Garland & Barr (Editors), 1998; Jain, Sahoo & Vijvergia, 1995; Karikari, 2006; Kaul & Zutshi, 1982; Nasir, 1985; Neser et al., 1990; Roe, 1967; Roe, 1968.

Sources of illustration Blomqvist & Nguyen Tien Ban, 1999.

Authors D.M. Modise & K.K. Mogotsi

Based on PROSEA 12(1): Medicinal and poisonous plants 1.

SOLANUM ERYTHRACANTHUM Dunal

Protologue A.DC., Prodr. 13(1): 201 (1852).

Family Solanaceae

Origin and geographic distribution *Solanum erythracanthum* occurs in Madagascar and Mayotte.

Uses The dried leaves of *Solanum erythracanthum* are smoked as a cigarette to treat asthma. A leaf decoction is taken as an antidiuretic. A root infusion is taken as a sedative. The fruit is eaten as an appetizer.

Solanum erythracanthum is planted as a live fence in southern Madagascar.

Botany Spreading shrub up to 1 m tall, covered with stellate hairs; stems with many recurved prickles 2–5 mm long. Leaves alternate, simple; stipules absent; petiole c. 5 mm long; blade ovate, 2–5 cm long, base cuneate, apex acute to obtuse, entire or lobed with rounded lobes. Inflorescence a (1–)few-flowered fascicle, at first terminal, later becoming lateral. Flowers bisexual, regular, (3–)4(–5)-merous; pedicel 1–3 cm long; calyx c. 4 mm long, persistent, lobes c. 1 mm long; corolla stellate, c. 1 cm long, violet or purple, lobes lanceolate, c. 3 mm long; stamens inserted on corolla throat, filaments very short, anthers 4.5–6 mm long, opening by terminal pores; ovary superior, globose, short-hairy. Fruit a globose berry 4–6 mm in diameter, red, many-seeded. Seeds ovoid, compressed, 1.5–2 mm long, black. Seedling with epigeal germination.

Solanum comprises about 1000 species and has a cosmopolitan distribution, except in boreal, alpine and aquatic habitats. About 110 species are found in tropical Africa. The principal centre of diversity is located in Central and South America, with secondary centres in Africa and Australia. *Solanum* has been subdivided into 7 subgenera and numerous sections and series. *Solanum erythracanthum* has been placed in the '*Solanum zanzibarense* and relatives' group of the section *Oliganthes* of subgenus *Lepto-*

stemonum. This group numbers about 12 species and occurs from Sudan to South Africa and on Madagascar. There are some other medicinally used species in this group.
Solanum hastifolium Hochst. ex Dunal occurs from Sudan south to Tanzania. In Kenya a root decoction was used to treat children with smallpox and a root infusion is drunk against abdominal pain, diarrhoea and as a laxative or emetic. The Maasai people administer a root decoction to cattle as a remedy for anthrax. Goats and sheep sometimes browse on it in the dry season.
Solanum taitense Vatke occurs in Kenya, Uganda and Tanzania and *Solanum zanzibarense* Vatke is a coastal species occurring from Kenya to South Africa. Of both species, the roots are chewed and the sap is used as a mouthwash against toothache. The Maasai people boil the roots of *Solanum taitense* and the resulting liquid is sieved and drunk as a cure for arthritis, malaria, typhoid and stomach-ache.

Ecology *Solanum erythracanthum* grows in disturbed localities, forest margins and roadsides.

Genetic resources and breeding *Solanum erythracanthum* occurs throughout Madagascar in ruderal habitats and is not threatened by genetic erosion.

Prospects As no chemical and pharmacological analyses of *Solanum erythracanthum* have been done, meaningful predictions about its prospects cannot be made. The different local medicinal uses are interesting though and more research seems to be warranted.

Major references Boiteau & Allorge-Boiteau, 1993; Boiteau, Boiteau & Allorge-Boiteau, 1999; D'Arcy & Rakotozafy, 1994; Ranaivoson, 1996.

Other references Beentje, 1994; Decary, 1946; Heine & Heine, 1988b; Kiringe, 2006; Kokwaro, 1993; Levin, Myers & Bohs, 2006; Ole-Miaron, 2003; Whalen, 1984.

Authors C.H. Bosch

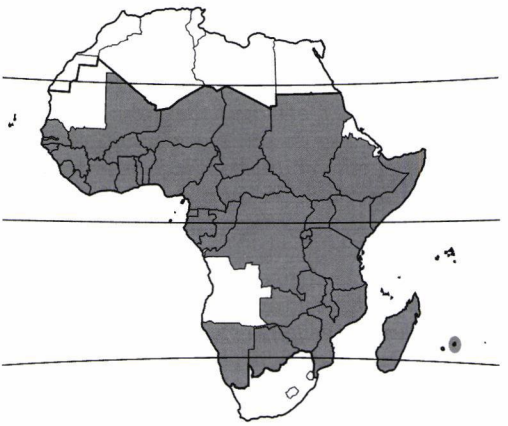
SOLANUM INCANUM L.

Protologue Sp. pl. 1: 188 (1753).
Family Solanaceae
Chromosome number $2n = 24, 48$
Synonyms *Solanum campylacanthum* Hochst. ex A.Rich. (1851), *Solanum bojeri* Dunal (1852), *Solanum delagoense* Dunal (1852), *Solanum panduriforme* E.Mey. ex Dunal (1852).

Vernacular names Thorn apple, grey bitter apple, bitter tomato, Sodom's apple (En). Aubergine sauvage, pomme de Sodome (Fr). Mtunguja, mtunguja-mwitu, mnyanya-mwitu, mnyanya-porini, mtua, mtula (Sw).

Origin and geographic distribution *Solanum incanum* is distributed throughout continental Africa, including South Africa. It is also found growing wild in Madagascar and Mauritius but is probably a recent introduction, as the fruits are considered edible there. It furthermore occurs from the Middle East east to India.

Uses Many of the medicinal uses of *Solanum incanum* are based on its analgesic properties. Throughout tropical Africa a sore throat, angina, stomach-ache, colic, headache, painful menstruation, liver pain and pain caused by onchocerciasis, pleurisy, pneumonia and rheumatism are treated with *Solanum incanum*. For these purposes, leaf, root and fruit decoctions are gargled or drunk, roots are chewed and sap swallowed, leaf paste, root infusions and pounded fruits are applied externally or rubbed into scarifications, leaf sap is used for washing painful areas, and ash of burnt plants is mixed with fat and applied externally. For relief of toothache a root infusion is used as mouth wash, fruit or root is rubbed on the gums or smoke of burning seeds is inhaled. Hiccups are suppressed by licking a mixture of the ash of burned leaves and salt.
Another widespread use of *Solanum incanum* is in the treatment of venereal diseases. Root powder is mixed with food or rubbed into scarifications, root infusions or decoctions are drunk, roasted pulverized roots are taken in water, leaf decoctions and fruit sap are drunk,



Solanum incanum – wild and naturalized

and fruit sap is applied externally. Different plant parts are also widely used in the treatment of skin problems, including skin infections, whitlow, ringworm, burns, sores, rashes, wounds, warts, carbuncles, ulcers and benign tumours. In Senegal a maceration of the leaves is used as an eye bath to cure ophthalmia; in Malawi fruit sap is rubbed into scarifications around the eye to treat conjunctivitis. In Senegal pounded seeds are mixed with pulped fruits to massage aching ears. In Uganda, Tanzania and South Africa extracts of leaves or flowers are used as ear drops to cure inflammations.

In Senegal, Kenya, Uganda and Zimbabwe different plant parts are used to treat snakebites: a decoction of the roots is drunk, roots are chewed and sap is swallowed, and young chewed leaves or pulped fresh roots are applied to the bite wound.

In Niger, Sudan, Rwanda and Namibia the fruits are used as an ingredient of arrow poison and in Mozambique of fish poison. In Ethiopia fruit sap is mixed with butter and applied to cattle to control ticks.

Selection for larger, less toxic fruits and leaves has taken place over time and whereas the wild types produce small, bitter and toxic fruits, cultivated types are available, especially in West Africa, of which the fruits and leaves can be safely eaten in soup and as a vegetable. Leaves are added to soup to improve the flavour. The large variation in toxicity makes it dangerous to transfer specific uses from one region to another.

The fruit and the seed are used in Africa and Asia to curdle milk and to make cheese. In Ethiopia the boiled fruits are used as soap and in tanning leather.

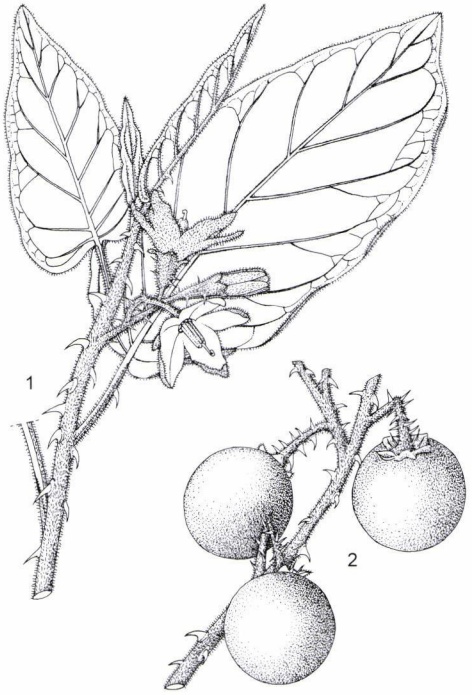
Properties *Solanum incanum* contains saponin steroids, in particular glycoalkaloids, which are found in all parts of the plant, but in highest concentrations in the fruit. The main glycoalkaloid is solasonine. Other compounds isolated from the fruits include the alkaloids solasodine and solamargine, and the steroidal sapogenins diosgenin and yamogenin. The fruits also contain dimethylnitrosamine, a potent carcinogen that is thought to cause the high incidence of oesophageal cancer in areas of Africa where the fruit sap is used to curdle milk. Alkaloids such as solasodine are used commercially as precursors for the production of steroidal compounds for medicinal use, mainly as contraceptives. Flavonoids and chlorogenic acid, a phenolic derivative, have also been isolated. Solamargine has shown promise for treatment of liver, lung and breast cancer.

In in-vitro efficacy tests on ticks (*Boophilus decoloratus*), solamargine resulted in 30–100% mortality. An extract of the fruits has caused skin cancer in animals.

A methanol extract of the fruits showed broad-spectrum antifungal activities. A strong effect was observed against the fungus that causes athlete's foot, *Trichophyton mentogrophytes*. The water extract of the fruit showed antibacterial activity against *Bacillus subtilis*, *Micrococcus flavus* and *Pseudomonas aeruginosa* and the methanol extract against *Staphylococcus aureus* and *Micrococcus flavus*. The cytotoxicity of the methanol extract against human foetal liver cells was IC_{50} = 35 µg/ml. Extracts of the fruit and of the roots, administered daily to diabetic rats, lowered blood glucose levels, but the fruit extract also reduced food intake, whereas the root extract increased food intake and caused diarrhoea. Chlorogenic acid has antioxidant and insect repellent properties and when ingested by insects decreased growth and development.

Adulterations and substitutes The alkaloids found in *Solanum incanum* occur in many species of subgenus *Leptostemonum*. Diosgenin is mainly obtained from *Dioscorea* spp., but it is also present in most *Costus* spp. and in the seeds of fenugreek (*Trigonella foenum-graecum* L.).

Description Erect or spreading shrub up to 3 m tall, occasionally a small tree; stems and leaves with stellate hairs and pale yellow to brown prickles, up to 1 cm long. Leaves alternate, simple; stipules absent; petiole 0.5–8.5 cm long; blade almost round to lanceolate, 1–30 cm × 1–17 cm, base rounded, truncate or cordate, often unequal, apex acute or obtuse, margin entire to pinnately lobed, densely hairy. Inflorescence a 2–15(–26)-flowered cyme, inserted above the leaf axil. Flowers bisexual or functionally male, nodding or pendent, regular, (4–)5–7(–9)-merous; pedicel 0.5–4 cm long; calyx campanulate, lobes up to 1.5 cm long, enlarging and splitting in fruit; corolla campanulate to rotate, 1–4.5 cm in diameter, with ovate or broadly triangular lobes, blue, pink, purple or violet, rarely white; stamens inserted near the base of the corolla tube and alternating with corolla lobes, filaments short, anthers slender; ovary superior, 2(–4)-celled, style up to 15 mm long, densely hairy. Fruit a globose or depressed globose, occasionally ovoid-ellipsoid berry 2.5–3.5 cm × 2–3 cm, yellow, orange or



Solanum incanum – 1, flowering shoot; 2, fruits. Redrawn and adapted by Achmad Satiri Nurhaman

brown when ripe, many-seeded. Seeds lentil-shaped to almost kidney-shaped, up to 3.5 mm × 3 mm, pale yellow to brown. Seedling with epigeal germination.

Other botanical information *Solanum* comprises over 1000 species and has a cosmopolitan distribution, except in boreal, alpine and aquatic habitats. At least 100 species are found in tropical Africa. The principal centre of diversity is located in Central and South America, with secondary centres in Africa and Australia. *Solanum* has been subdivided into 7 subgenera and numerous sections and series. *Solanum incanum* belongs to subgenus *Leptostemonum* section *Melongena*. *Solanum incanum* is considered here as a single polymorphic species, whereas some authors distinguish 4 groups within the species and others consider each of these groups a different species. *Solanum incanum* is considered the ancestor of eggplant (*Solanum melongena* L.) and the 2 species are therefore considered by some as a single species. In the ethnobotanical literature the distinction of the 4 groups or species is not made and therefore can not be used here.

From Taiwan research findings have been published on *Solanum incanum*, but a misapplication of the name is apparent. Results refer to the indigenous species *Solanum undatum* Lam. (synonym: *Solanum cumingii* Dunal), a species that also is placed in section *Melongena*, hybridizes freely with the eggplant, and also contains solamargine.

Several other tropical African species of section *Melongena* have medicinal uses. *Solanum arundo* Mattei (synonym: *Solanum diplacanthum* Dammer) occurs in the coastal lowlands of Somalia, Kenya and Tanzania. In Somalia, the filtrate of the crushed fruits is massaged into the skin to treat itch and scabies. Seeds are soaked in hot oil, which after cooling is applied to aching teeth as an analgesic. In Kenya the roots are pounded and soaked in water or chewed as a cure for fever. The Rendille people of northern Kenya apply fruit juice to wounds on the feet of camels. Sheep and goats browse the plants. *Solanum linnaeanum* Hepper & P.M.L.Jaeger, the true 'Sodom apple', is a weed that originates from the Mediterranean region and is now widespread throughout tropical Africa. It is used in South Africa for its analgesic properties, to treat wound infections and to counteract bloating. In Ethiopia the pounded roots of *Solanum marginatum* L.f. are applied to wounds. The roots are chewed and the sap swallowed to cure syphilis. Roots and leaves are steeped in water and the water is applied to scabies; root pulp is given to dogs as a cure for rabies. In Kenya the root of *Solanum sessilistellatum* Bitter is baked and chewed as a cure for whitlow.

Growth and development All parts of *Solanum incanum* contain solasodine, but the levels vary widely. The smallest leaves have the highest alkaloid concentration. The amount of alkaloids in the leaves increases during leaf development. Both leaves and roots showed alkaloid accumulation with time, although in experiments alkaloid levels in the root fell after 20 weeks.

Ecology *Solanum incanum* is common as a weed, around houses, in overgrazed grassland and in roadsides. It is also found at forest edges and in bushland and grassland, from sea-level up to 2500 m altitude. It is considered an indicator for low-fertility soils.

Propagation and planting A cultivation method commonly used for eggplant can be adopted for *Solanum incanum* as well: seeds

are sown in trays or seedbeds, and seedlings are transplanted to small pots or bags (8–10 cm diameter) 2–3 weeks later when the first leaf appears. The seedlings are kept in the nursery till they have developed 5–7 leaves and are then planted in the open or in a greenhouse at a spacing of 50 cm between plants and 1 m between rows, preferably in light and well-prepared soil.

Management No details on cultivation of *Solanum incanum* have been published but husbandry as practised for eggplant, African eggplant (*Solanum aethiopicum* L.) and gboma eggplant (*Solanum macrocarpon* L.) can be applied selectively.

Diseases and pests As a crop *Solanum incanum* is unimportant and observations on its diseases and pests are lacking. It is a potential host for a wide range of pests and diseases of Solanaceous crops (especially eggplant, tomato and *Capsicum* pepper). It is a major host of the papaya fruit fly (*Bactrocera papayae*).

Harvesting For medicinal use, harvesting of *Solanum incanum* is done from the wild whenever the need arises and fruits are available.

Genetic resources The genetic variation of *Solanum incanum*, which is of interest for breeding and selection, is not well covered in germplasm collections; the number of accessions in genebanks is modest. National research institutes in Kenya (e.g. National Genebank of Kenya, KARI, Kikuyu) maintain some germplasm as do the University of Nijmegen (Netherlands) and the Millennium Seedbank (Ardingly, United Kingdom). As *Solanum incanum* is widespread in tropical Africa, there is no danger of genetic erosion.

Breeding For breeding purposes of the closely related *Solanum melongena*, *Solanum incanum* is an important source of genes that can be introduced through breeding. Wild species of section *Melongena* offer an extensive genepool, especially for resistance to pests and diseases. On the other hand the productivity and the fruit size of the eggplant offer opportunities for breeding for commercial production of steroidal alkaloids of *Solanum incanum*.

Prospects An unambiguous taxonomic classification of the polymorphic *Solanum incanum* and closely related species is needed to be able to start detailed ethnobotanical and pharmacological studies. Although there seems to be potential for commercial production of steroidal alkaloids with *Solanum incanum*, more research is needed.

Major references Bukenya-Ziraba & Carasco, 1999; Burkill, 2000; Lester & Daunay, 2003; Musabayane, Bwititi & Ojewole, 2006; Neuwinger, 2000; Shiu et al., 2007.

Other references Al Fatimi et al., 2007; Behera et al., 2006; D'Arcy & Rakotozafy, 1994; Dharani, 2002; du Plessis, Nunn & Roach, 1969; Eltayeb, Al-Ansari & Roddick, 1997; Fukuhara & Kubo, 1991; Hegnauer, 1973; Johns et al., 1995; Kambizi & Afolayan, 2001; Kirtsova & Korneva, 1999; Neuwinger, 1996; Regassa, 2000; Stamp & Osier, 1998; TICAH, 2006; Welman & Condy, 2003; Whalen, 1984.

Sources of illustration Heine, 1963.

Authors E.N. Matu

SOLANUM NIGRUM L.

Protologue Sp. pl. 1: 186 (1753).

Family name Solanaceae

Chromosome number $2n = 72$

Vernacular names Black nightshade, common nightshade, garden nightshade (En). Morelle noire, brède martin, herbe à calalou (Fr). Erva moura (Po). Suga, mnavu (Sw).

Origin and geographic distribution The exact origin of *Solanum nigrum* is unknown, but it is generally considered to be native to Europe and Asia and possibly also Africa. *Solanum nigrum* (hexaploid) is thought to have been derived from the tetraploid *Solanum villosum* Mill. and the diploid *Solanum americanum* Mill., but possibly more taxa have been involved. It is very well adapted to the Mediterranean climate and possibly originated there. It has certainly been introduced in North America, New Zealand and Australia and has not yet been found in South and Central America or on the islands of the Pacific Ocean. In Africa it is probably widely distributed, but accurate taxonomic work has yet to be carried out in many countries.

Uses *Solanum nigrum* has many uses, but determination of the true identity of the plants called *Solanum nigrum* in the literature is mostly impossible and some of the uses listed here may apply to closely related species.

The medicinal use of *Solanum nigrum* probably goes back more than 2000 years. The plants are used as an emollient and analgesic to treat itch, burns and neuralgic pains, and are also considered to be expectorant and laxative. The leaves are said to have sedative and healing properties and are applied to cuts, ulcers, wounds, inflammations and skin diseases. A decoction of the leaves is used to treat yaws.

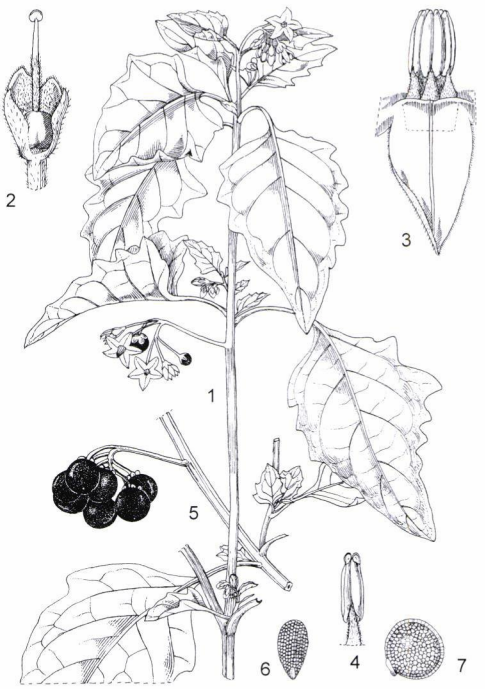
The fruit is considered to be a cure for diabetes. Diuretic properties are also attributed to the plant. An extract of the leaves and stem is used for treating dropsy, heart diseases, piles, gonorrhoea, fevers, eye diseases and chronic enlargement of liver and spleen. In Tanzania the roots are eaten to treat stomach-ache.

The leaves and young shoots of *Solanum nigrum* are probably collected from the wild like other *Solanum* spp. and eaten boiled as a vegetable. It is recommended that the cooking water is refreshed a number of times. However, it has been recorded, e.g. in Ethiopia, that the leaves taste bitter and are only eaten when more tasty vegetables are not available. Fruits are said to be poisonous, but there are records of fruits being eaten when ripe. Most reports state that unripe fruits are particularly poisonous.

Properties When the leaves of *Solanum nigrum* are eaten regularly (several times a week) they are said to cause stomach-ache because of the presence of toxic glyco-alkaloids such as solanine (with aglycon solasodine). Total alkaloid content of air-dried leaves is 0.1%. Solanine poisoning can cause vomiting, dizziness, mental confusion, loss of speech and sometimes blindness. *Solanum nigrum* also contains the sapogenins diosgenin and tigogenin. Unripe berries contain 0.7% solasodine, 0.2% diosgenin and 0.15% tigogenin; leaves contain 1.3% tigogenin.

The powdered aerial parts of *Solanum nigrum* and their methanolic extract significantly reduced gastric ulcer formation in rats, and an alcoholic fruit extract showed significant inhibition of carrageenin-induced oedema. An alcoholic leaf extract was active against *Staphylococcus aureus* and *Escherichia coli*. Some other pharmacological activities include antispasmodic, hypotensive, hypocholesterolaemic and anti-HIV-1 activities, as well as insecticidal and molluscicidal activities.

Botany Annual herb up to 70 cm tall, with decumbent or erect stem, glabrous to long-hairy with simple multicellular hairs, glandular or not. Leaves arranged spirally, simple; stipules absent; petiole 0.5–6.5 cm long, slightly winged towards apex; blade ovate to lanceolate-rhombic, 2.5–10 cm × 2–7 cm, base cuneate, apex obtuse, margin entire to wavy-toothed. Inflorescence an extra-axillary raceme-like cyme, 3–12-flowered; peduncle 1–3 cm long. Flowers bisexual, regular, 5-merous; pedicel recurved in fruit; calyx campanulate, up to 2.5 mm long with ovate lobes, deflexed or



Solanum nigrum – 1, flowering stem; 2, opened calyx showing pistil; 3, petal and stamens; 4, stamen; 5, part of fruiting stem; 6, seed, back view; 7, seed, side view.
Source: PROSEA

adhering to the base of the mature fruit; corolla stellate, 0.5–1 cm in diameter, white with yellow-green basal star, lobes 1.5–4 mm long; stamens inserted on corolla throat, filaments up to 1.5 mm long, anthers up to 2.5 mm long; ovary superior, globose to ellipsoid, c. 1 mm in diameter. Fruit a globose to ovoid berry 6–10 mm in diameter, dull purple to blackish or sometimes yellow-green, many-seeded. Seeds flattened, obovoid, c. 2 mm long, creamy, minutely pitted.

Solanum nigrum belongs to the subgenus *Solanum* and section *Solanum*, together with species such as *Solanum americanum* Mill., *Solanum florulentum* Bitter, *Solanum grossedentatum* A.Rich., *Solanum scabrum* Mill., *Solanum tarderemotum* Bitter and *Solanum villosum* Mill. Many of the species in section *Solanum* have been named *Solanum nigrum* in the past and thus references to *Solanum nigrum* in the literature must be interpreted with great caution. Research is still needed to better understand the species within section

Solanum and their diversity. *Solanum nigrum* can be divided into 2 subspecies: subsp. *nigrum* (glabrous to slightly hairy with appressed, non-glandular hairs) and subsp. *schultesii* (Opiz) Wessely (densely hairy with patent, glandular hairs). However, the distinction is not everywhere clear.

Ecology *Solanum nigrum* often occurs as a weed in fields, but also in wasteland, roadsides and disturbed localities, in full sunshine or in slight shade, from sea-level up to 3000 m altitude.

Genetic resources and breeding *Solanum nigrum* is variable and widespread and not in danger of genetic erosion. A germplasm collection is available at the Botanical and Experimental Garden of Nijmegen University, Netherlands.

Prospects *Solanum nigrum* will remain a minor leafy vegetable, particularly of importance in times of food scarcity. Its toxic components do not allow large-scale consumption and may make use as a medicinal plant hazardous.

Major references Blomqvist & Nguyen Tien Ban, 1999; Bukenya-Ziraba & Carasco, 1995; Edmonds & Chweya, 1997; Goncalves, 2005; Katambo, 2007.

Other references Bukenya-Ziraba, 1996; Bukenya-Ziraba & Carasco, 1999; Bukenya-Ziraba & Hall, 1988; Debray, Jacquemin & Razafindrambao, 1971; Decary, 1946; Edmonds, 1977; Edmonds, 1979; Gurib-Fakim, Guého & Bissoondoyal, 1997; Nacro & Millogo-Rasolodimbi, 1993; van Wyk & Gericke, 2000.

Sources of illustration Blomqvist & Nguyen Tien Ban, 1999.

Authors P.C.M. Jansen

SOLANUM TERMINALE Forssk.

Protologue Fl. aegypt.-arab. 45 (1775).

Family Solanaceae

Synonyms *Solanum welwitschii* C.H.Wright (1894).

Origin and geographic distribution *Solanum terminale* occurs from Guinea east to Ethiopia and south to Angola and South Africa. There is a single record from the Comoros.

Uses In Rwanda a leaf extract is drunk as an abortion-inducing drug and in Rwanda and Uganda it is drunk to induce labour in childbirth. In DR Congo a root decoction is filtered and applied as an enema as a mild purgative for children. In Tanzania a root extract is drunk as a stimulant and to induce sweating. The fruits are poisonous and have been used in the Central African Republic as a criminal poison.

In eastern DR Congo the stems are used for tying in construction of houses and fences.

Botany Liana up to 15 m long, or straggling shrub; young stems hairy, hairs simple or branched. Leaves alternate, simple; stipules absent; petiole 0.5–4 cm long; blade ovate to lanceolate or elliptical, 2–13.5 cm × 1–7 cm, base rounded or cuneate, apex acuminate, margin entire to wavy, almost glabrous. Inflorescence a terminal cyme, becoming displaced laterally, lax to congested, many-flowered. Flowers bisexual, regular, 5-merous; calyx bell- or cup-shaped, 1–3 mm long, soft-hairy, lobes triangular to ovate, obtuse, reflexed; corolla deeply stellate, 1–2 cm in diameter, blue to mauve or purple; stamens alternate with corolla lobes, filaments up to 1.5 mm long, anthers elliptical, up to 5 mm long, opening with apical pores; ovary superior, c. 1 mm in diameter. Fruit a globose to ellipsoid berry 5–10 mm in diameter, glabrous, orange or red to dark blue, many-seeded. Seeds obovoid, 2.5–3 mm in diameter, pale brown. Seedling with epigeal germination; cotyledons thin, leafy.

Solanum comprises over 1000 species and has a cosmopolitan distribution, except in boreal, alpine and aquatic habitats. At least 100 species are found in tropical Africa. The principal centre of diversity is located in Central and South America, with secondary centres in Africa and Australia. *Solanum* has been subdivided into 7 subgenera and numerous sections and series. *Solanum terminale* has been placed in the subgenus *Solanum*, and 4 subspecies have been recognized, but in southern Africa intermediates between subspecies have been found and there is considerable overlap of the areas of distribution. In Ethiopia subsp. *welwitschii* (C.H.Wright) Heine is considered sufficiently different from the other subspecies to reinstate it as a separate species.

Two endemic species of Madagascar, belonging to subgenus *Solanum*, are also used medicinally. Grated bark of *Solanum madagascariense* Dunal is applied as a plaster to wounds and bark sap is applied to bruises. A bark decoction of *Solanum heinianum* D'Arcy & Keating is drunk to cure syphilis.

Ecology *Solanum terminale* occurs in forests, especially at edges, along streams and in rocky localities, at 900–1300 m altitude. It is less frequent in high-rainfall woodland.

Genetic resources and breeding There is

no indication that *Solanum terminale* is in danger of genetic erosion.

Prospects *Solanum terminale* will probably only remain of local importance as a medicinal plant.

Major references Burkill, 2000; Goncalves, 2005; Jaeger & Hepper, 1986.

Other references D'Arcy & Rakotozafy, 1994; Hulstaert, 1966; Kamatenesi-Mugisha & Oryem-Origa, 2007; Kokwaro, 1993; Ralantonirina, 1993; Ranaivoson, 1996; Rwangabo, 1993; Vergiat, 1970; Yamada, 1999.

Authors C.H. Bosch

SOLANUM TETTENSE Klotzsch

Protologue Peters, Naturw. Reise Mossambique, Vol. 6, Botanik 1: 237 (1861).

Family Solanaceae

Synonyms *Solanum renschii* Vatke (1882), *Solanum kwebense* N.E.Br. ex C.H.Wright (1906).

Origin and geographic distribution *Solanum tettense* occurs from Ethiopia and Somalia south throughout East Africa and southern Africa.

Uses In Kenya a root extract is drunk to cure typhus and abdominal pain. In Zimbabwe a root extract is drunk or pulverized root is mixed with food to cure diarrhoea. The preparation and use of arrow poison made from the roots is practised by bushmen in Namibia. Samburu warriors of Kenya used to take the plant as a drug.

Properties The fruit of *Solanum tettense* contains calystegines, which are nortropane alkaloids with glycosidase inhibitory activity. Calystegine A3 selectively inhibits the rat liver β-glucosidase activity. Calystegines are found in many species of the families *Convolvulaceae* and *Solanaceae*.

Accidental feeding on *Solanum tettense* causes disorders in cattle (crazy cow syndrome) characterized by epileptic-like attacks. The poison acts on the central nervous system and the functions of the cerebellum, but does not cause fatal poisoning.

Botany Perennial herb or shrub up to 3(–4) m tall; stems with many pale yellow prickles 1–5 mm long and stellate hairs. Leaves alternate, simple; stipules absent; petiole 0.5–4 cm long, rarely with prickles; blade lanceolate to ovate or ovate-elliptical, 1.5–14 cm × 0.5–8 cm, base unequal, rounded to cuneate, apex obtuse to acute, margin entire to wavy. Inflorescence a lateral cyme, few- to many-flowered. Flowers bisexual, regular, 4–5(–7)-merous; calyx bell- or cup-shaped, 2.5–6 mm long, lobes lanceolate to broadly obovate; corolla rotate, up to 2 cm in diameter, blue, violet, purple or rarely white; stamens alternate with corolla lobes, filaments up to 1.5 mm long, anthers lanceolate, 4 –7 mm long, opening with apical pores; ovary superior, up to 1.5 mm in diameter, style 5–11 mm long. Fruit a globose, soft berry 5–10 mm in diameter, glabrous, yellowish brown, deep red when ripe, many-seeded. Seeds ovoid, compressed, 2.5–4 mm in diameter, pale yellow or creamy. Seedling with epigeal germination; cotyledons thin, leafy.

Solanum comprises about 1000 species and has a cosmopolitan distribution, except in boreal, alpine and aquatic habitats. About 110 species are found in tropical Africa. The principal centre of diversity is located in Central and South America, with secondary centres in Africa and Australia. *Solanum* has been subdivided into 7 subgenera and numerous sections and series. *Solanum tettense* is a polymorphic species and 2 varieties are distinguished, based on differences in hairiness. It is placed in the *Solanum giganteum* group of the section *Oliganthes* of subgenus *Leptostemonum*, a group of about 10 species, all of them restricted to sub-Saharan Africa. Two other species of this group have medicinal uses in tropical Africa.

Solanum giganteum Jacq. has a disjunct montane distribution in Africa and is also known from tropical Asia, Australia and South America. In East Africa the woolly hairy underside of the leaves is used to clean wounds and the glabrous upper side is used to dress wounds. The fruits are edible but bitter and are used to treat throat ulcers and to curdle milk. In Uganda powdered dry leaves are added to bath water to overcome sleeplessness. In India *Solanum giganteum* is planted as a shade tree.

Solanum goetzei Dammer occurs from Kenya southwards to Zambia and Mozambique. In Kenya a hot poultice of pounded leaves is used to reduce swellings and to draw out abscesses.

Solanum somalense Franch. occurs in eastern Ethiopia, Somalia and Kenya,. Its classification in subgenus *Leptostemonum* and especially in the section *Oliganthes* is disputed. In Somalia the fruit ash is applied to wounds to promote healing.

Ecology *Solanum tettense* occurs in woodland, wooded grassland and thickets. In miombo woodland it grows on termite mounds and is also found along streams and in rocky

areas. It thrives under both moist and semi-arid conditions, up to 1600 m altitude.

Genetic resources and breeding As *Solanum tettense* is widespread and not heavily exploited, there appears to be no threat of genetic erosion.

Prospects *Solanum tettense* does not have medicinal uses or properties that make it likely that its importance will develop beyond the present local medicinal uses.

Major references Chinemana et al., 1985; Goncalves, 2005; Kokwaro, 1993; Wondimu, Asfaw & Kelbessa, 2007.

Other references Asano et al., 1997; Beentje, 1994; Bukenya-Ziraba & Carasco, 1999; Edmonds, Friis & Thulin, 2006; Gonçalves, 1996; Lehmann & Mihalyi, 1982; Neuwinger, 1998; Samuelsson et al., 1993; Whalen, 1984.

Authors C.H. Bosch

SPHENOCENTRUM JOLLYANUM Pierre

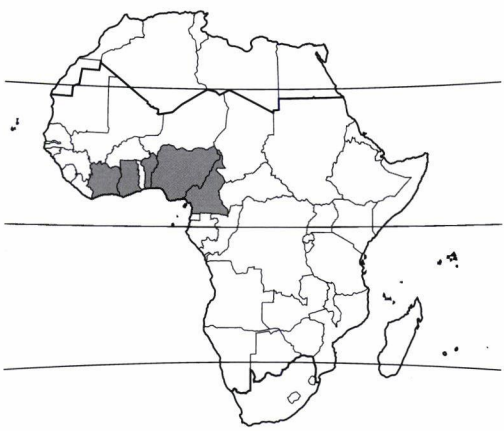
Protologue Bull. Mens. Soc. Linn. Paris, n.s. 1: 77–79 (1898).

Family Menispermaceae

Chromosome number $2n = 26$

Origin and geographic distribution *Sphenocentrum jollyanum* occurs from Côte d'Ivoire east to Cameroon.

Uses *Sphenocentrum jollyanum* is widely used for medicinal purposes. The plant, mainly the bark, is used as an emetic and purgative, especially when poisoning is suspected. The root is used as an aphrodisiac tonic for men. The sap from chewing sticks made from the root is believed to relieve stomach-ache and constipation, and to boost appetite and sexual drive. The roots are used as a sweetener; they taste sour, but make food eaten thereafter taste sweet. In Côte d'Ivoire the root is pulped into a paste, with salt, fruit of maniguette (*Aframomum melegueta* K.Schum.) and palm oil, and the mixture is taken to treat abdominal disorders. Pounded roots are taken to treat high blood pressure. The boiled or pulped roots are given in draught or enema against epileptic fits. In Ghana the pulped roots have been applied to treat breast tumours. In Nigeria a decoction of the root is applied to dress tropical ulcers. A decoction of the leafy twigs is used as a wash to stop bleeding of wounds, sores and cuts; the wounds are also covered with the powdered bark. Ingestion of crushed leaves curbs spitting of blood. The fruit is edible and is taken against fatigue. It is sometimes taken with lemon or the fruits of *Piper guineense* Schumach. & Thonn. to cure coughs.



Sphenocentrum jollyanum – wild

Production and international trade *Sphenocentrum jollyanum* is sold in local markets and through the internet as an aphrodisiac.

Properties The chemical analyses of *Sphenocentrum jollyanum* showed the presence of saponins, tannins, alkaloids, terpenes and flavonoids in the stem bark. The isoquinoline alkaloids palmatine, jatrorrhizine, tetrahydrojatrorrhizine and columbamine, and some bitter tasting diterpenes were also extracted from the plant, as were the inositol-derivative (–)-viburnitol, the sterols sitosterol, campestrol and stigmasterol, and the furanoditerpenes columbin, isocolumbin and fibleucin.

Sphenocentrum jollyanum has shown anti-oxidant, anti-angiogenic, anti-inflammatory, antipyretic, antinociceptive, antitumour, anti-viral, laxative, stomachic, tonic and aphrodisiac activities. Investigations on the anti-oxidant properties of methanol extracts of several parts of the plant revealed that the stem bark has the strongest activity, although it is much lower than that of vitamin C. The chloroform fractions of the extracts had the greatest activity.

To test the anti-angiogenic properties, a methanol extract of the stem bark was tested in hen's eggs. The extract showed a dose-dependent inhibition of blood-vessel formation. The effect of the chloroform fraction was strongest, but still much weaker than that of the control chemical suramin. Several crude extracts from the plant were assessed for anti-inflammatory activity using the carrageenan-induced oedema test in rats. The methanol

extract of the fruit showed a higher anti-inflammatory activity than the root extract. The most active fraction of the fruit extracts contained the furanoditerpenes columbin, isocolumbin and fibleucin. Both columbin and a flavonoid-rich fraction of the fruit extract showed significant anti-inflammatory activities. Methanol and petroleum-ether extracts of the leaves have shown antipyretic and analgesic properties in vitro. The potential of *Sphenocentrum jollyanum* as an aphrodisiac was confirmed in tests with rats. A methanol extract of the root given orally caused increased sexual activity and increased levels of testosterone in male rats. Other sex hormones were much less affected. In another test the extract caused a similar effect on testosterone levels, but also caused decreased sperm counts and lower sperm vitality, accompanied by reversible degeneration of the seminal tubules.

The hexane and methanol extracts of the leaf and root had only slight antiviral activities against cowpea aphid-borne mosaic virus (CABMV) and cowpea mottle virus (CMeV).

Adulterations and substitutes Several *Penianthus* spp. may be used as substitutes for *Sphenocentrum jollyanum* as they grow in the same area. The root and stem bark of these species are sold in local markets and are difficult to differentiate from those of *Sphenocentrum jollyanum* when dried.

Description Small, evergreen, dioecious shrub up to 1.5 m tall, sparingly branched; roots bright yellow; stem thinly short-hairy when young, later glabrous; bark grey. Leaves arranged spirally, but crowded at the end of branches, simple; stipules absent; petiole (3–)4.5–9(–10) cm long, swollen at both ends, flattened or with a shallow groove above and 2 shallow lateral grooves; blade entire or shallowly to deeply pinnately lobed, oblong to elliptical or ovate in outline, 15–26 cm × 6–17(–22) cm, base cuneate or obtuse, apex long-acuminate, lobes acute to acuminate, leathery, pinnately veined with 8–12 pairs of lateral veins. Flowers solitary on older branches or on stem between the leaves, unisexual, regular; tepals more or less arranged spirally, increasing in size towards the centre, cream-coloured; male flowers sessile, tepals 15–21, outer tepals triangular to ovate-oblong, short-hairy, inner tepals obovate, glabrous outside, 0.5–6.5 mm × 0.5–4 mm, stamens (13–)16–31, erect, free, 1.5–2.5 mm long, filaments inflated; female flowers sessile or with pedicel up to 4 mm long, tepals 9–11, early falling, 2–4 outer tepals triangular to circular, c. 1 mm × 1 mm, short-hairy to glabrous outside, 7 inner tepals obovate to oblong, the innermost spoon-shaped, (2.5–)3–7 mm × 2–4.5 mm, glabrous outside, staminodes up to 14(–17), club-shaped, 1–2 mm long, usually falling with the tepals, ovary superior, consisting of (3–)9–12(–15) ovoid carpels c. 3 mm × 1.5 mm, densely short-hairy, stigma large, sessile, horse-shoe shaped, lobed. Fruit composed of 3–12 drupes, each drupe ellipsoid, (11–)18–26 mm × 10–16 mm, yellow to orange at maturity, smooth, fleshy, 1-seeded. Seed with very thin seed coat; endosperm absent; embryo straight, ellipsoid, 15–18 mm × 8–9 mm. Seedling with plano-convex cotyledons remaining inside the stone.



Sphenocentrum jollyanum – 1, branch with male flowers; 2, male flower; 3, female flower, part of perianth removed; 4, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Sphenocentrum* belongs to the tribe *Peniantheae* together with *Penianthus*, but has formerly been classified in *Tinosporeae*. *Sphenocentrum* comprises a single species.

Growth and development On germination the seedling does not develop a hypocotyl and the cotyledons remain enclosed inside the

stone. Young seedlings up to two months old show a more or less short-hairy epicotyl, stem and petiole, and some scale-leaves develop on the epicotyl.

Sphenocentrum jollyanum flowers and bears fruit either irregularly or continuously throughout the year. Pollination of flowers is done by ants or other insects, and dispersal of seeds occurs over short distances only.

Ecology *Sphenocentrum jollyanum* occurs mainly in the undergrowth of rainforest, often in deep shade, also in gallery forest, from sea-level up to 400 m altitude. It occurs in regions with a mean minimum temperature of 20°C and a mean maximum of 29°C. The mean annual rainfall is 1800 mm or more.

Handling after harvest The different plant parts collected may be dried, powdered and kept for later use. Plant material collected, usually leaves, is sometimes charred before use. To char the leaves, they are thoroughly washed, dried and put in a closed earthenware pot or in a large iron saucepan, which is left open, and placed on a fire without adding water. The leaves are stirred occasionally and left until completely charred, but not burned to ash, as ash is believed to be ineffective. When cooled the material is powdered and stored in airtight containers.

Genetic resources *Sphenocentrum jollyanum* is common in its distribution area, but its common use as an aphrodisiac may lead to genetic erosion. In Benin and Nigeria the plant is considered locally vulnerable or even threatened and in need of protection. Small germplasm collections are maintained in Ghana.

Prospects So far, no attempt has been made to cultivate *Sphenocentrum jollyanum* on a larger scale for medicinal purposes. To ensure sustainable production of this widely used medicinal plant, it is recommended that husbandry systems be developed and the plant be grown in home gardens or on a commercial scale. Pharmacological studies have shown the potential of the plant as an anti-oxidant, anti-angiogenic, anti-inflammatory, antinociceptive and antiviral, and more studies are warranted for drug development with respect to these activities.

Major references Burkill, 1997; Dekker, 1983; Moody, Robert & Hughes, 2002; Moody et al., 2005; Muko, Ohiri & Ezugwu, 1998; Nia et al., 2004; Oliver-Bever, 1986; Troupin, 1962.

Other references Abbiw, 1996; Adomou, 2005; Amponsah et al., 2002; de Wet, 2005; Dwuma-Badu et al., 1976b; Egunyomi, Fasola & Oladonjoye, 2005; Iwu, 1993; Neuwinger, 2000; Obio, 2006; Okafor & Ham, 1999; Oke & Hamburger, 2002; Raji et al., 2006; Soladoye et al., 2005.

Sources of illustration Dekker, 1983.

Authors D.M. Mosango

SPIGELIA ANTHELMIA L.

Protologue Sp. pl 1: 149 (1753).

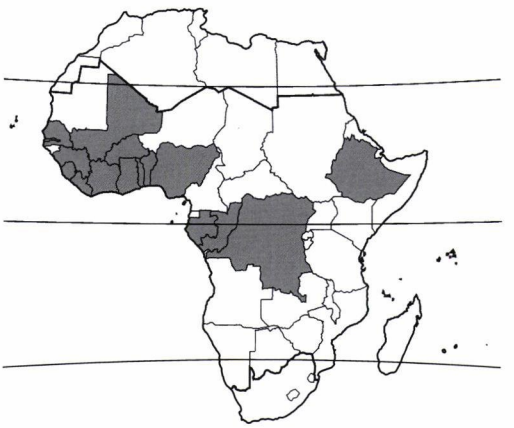
Family Loganiaceae

Chromosome number $2n = 32$

Vernacular names Wormgrass, wormbush, West Indian pinkroot (En). Brinvillière, herbe à vers, herbe à la brinvilliers (Fr). Lombrigueira, pó vermifugo, pimenta d'água, arapabaca (Po).

Origin and geographic distribution *Spigelia anthelmia* originates from tropical and subtropical America, but is widely naturalized in tropical Africa and Indonesia. In Africa it occurs from Senegal east to DR Congo and Ethiopia.

Uses *Spigelia anthelmia* combats intestinal worms. Both roots and leaves are anthelmintic. In the Americas *Spigelia anthelmia* is said to be one of the best vermifuges, and is renowned as a medicine against spasmodic and nervous attacks. It is also used to cause transpiration, while a decoction of the plant is applied against thrush and hypertension. In the German homeopathic pharmacopoeia, an extract of the aerial parts is official as a remedy for neuralgic and cardiac disorders. Despite its relatively recent introduction in Africa, the plant has found a place in traditional medicine. In Benin and Nigeria a decoction of fresh leafy



Spigelia anthelmia – naturalized

twigs is taken as an anthelmintic. Caution is needed not to apply high doses, as these cause convulsions. Because of the toxicity of the plant, it is essential that immediately after a dose is taken to treat worm infections, a strong purge is taken as a chaser. Some fatal cases have been reported, especially in children. In Congo a plant decoction is gargled to treat sore throat and plant sap is rubbed into scarifications to treat chest complaints.

The fresh plant serves as rat poison and fruiting plants eaten in large quantities are poisonous to cattle, causing death 2–3 hours after ingestion. However, the intake of sufficient other forage, may cancel out the toxic effects.

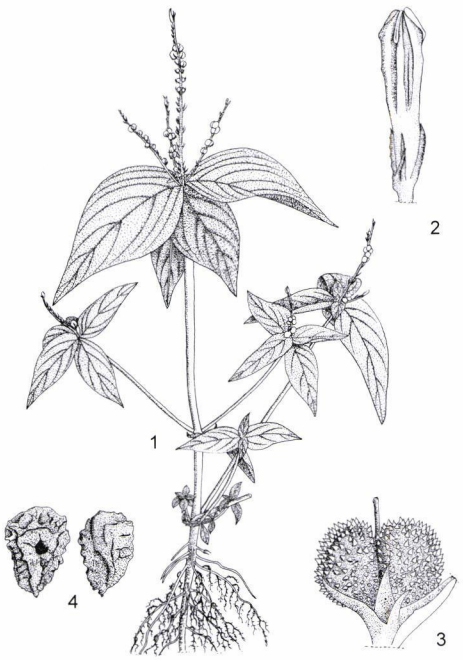
Production and international trade On the internet, dried *Spigelia anthelmia* plants cost US$ 31/kg, dried roots US$ 62/kg, or US$ 44/kg for larger quantities. Seeds are sold at US$ 6 per 100.

Properties *Spigelia anthelmia* contains quaternary alkaloids, the major ones being spiganthine, ryanodine and structurally related compounds. The highest concentrations of alkaloids are present in the roots and in the fruit wall. Spiganthine and ryanodine are the main cardioactive principles. The effect is characterized by a delay in contraction development of the heart muscle.

Several fractions of an ethanol extract of aerial parts were tested in screening tests. Hypotensive and bradycardiac effects in anaesthetized cats and rats were observed, as well as contractions of isolated guinea-pig and rat ileums. An intravenously applied infusion of aerial parts in rats produced a dose-dependent, prompt, more or less short-lasting hypertension or led to acute lethal intoxication with signs of cardiorespiratory depression. An ethyl acetate extract of aerial parts was shown to induce tonic paralysis in vivo; it decreased amplitude of twitches and increased tonus of skeletal muscle in vitro. Effects of an overdose of *Spigelia anthelmia* medicines in humans include excitement, dizziness, delirium, dilation of the pupils, vomiting and convulsions.

Spiganthine, ryanodine and related compounds (e.g. ryanoid diterpenes) demonstrated antifeedant activity against some beetles. In addition, considerable insecticidal activities were observed. An ethyl acetate extract and a methanol extract of the aerial parts had a significant inhibitory effect on egg hatching and larval development of the sheep and goat nematode *Haemonchus contortus*. Anthelmintic trials against *Nippostrongylus braziliensis* in rats using the aqueous fraction showed a progressive decrease in worm count with increasing dose. Crude ethanol extracts of leaves showed significant mortality in the tick *Boophilus microplus*.

Description Annual herb, up to 50(–90) cm tall, few-branched at base; stem erect, hollow, glabrous. Leaves opposite, with an apical pseudo-whorl of 2 decussate pairs, simple and entire; stipules united, broad-triangular; petiole up to 1 cm long; blade ovate-oblong to ovate-lanceolate, 4–18 cm × 1–6 cm, base obtuse to cuneate, apex acuminate. Inflorescence a terminal or axillary spike up to 15 cm long, many-flowered; peduncle very short; bracts sepal-like. Flowers bisexual, regular, 5-merous, sessile; sepals free, slightly unequal, 2–6 mm long, pale green; corolla 8–17 mm long, tube 6–15 mm long, lobes equal, triangular, 2–2.5 mm long, lilac to white, or tube white and lobes pale pink, with or without 5 pairs of reddish lines inside; stamens inserted just below the middle of the corolla tube, included; ovary superior, globose, glabrous, 2-celled, style slightly exserted. Fruit a capsule consisting of 2 ellipsoid parts, 4–5 mm × 5–6 mm, sharp-warty, green, lobes dehiscent with 4 valves, a boat-



Spigelia anthelmia – 1, plant habit; 2, flower bud; 3, fruit; 4, seeds.
Source: PROSEA

shaped base remaining in the persistent calyx, few-seeded. Seeds obliquely ellipsoid or ovoid, 3 mm × 2 mm, dull brown, warty.

Other botanical information *Spigelia* comprises about 50 species, all originating from tropical America. American wormwood or pinkroot (*Spigelia marilandica* (L.) L.) has ornamental value, having showy flowers with scarlet red tubes and lobes yellow inside. It was collected almost to extinction as a cure for roundworms. It is also traditionally used to protect stored food grains from storage pests.

Growth and development *Spigelia anthelmia* can be found flowering and fruiting throughout the year. The flowers open in the afternoon and are self-pollinating.

Ecology *Spigelia anthelmia* occurs mainly along roadsides, in waste places, arable land, gardens, rice fields and on riverbanks, from sea-level up to 600 m altitude.

Propagation and planting Propagation is by seed, which remain fully viable up to 3 years, and up to 57% germination was obtained after storage for 48 months. Fresh seeds and those stored for 6 months show dormancy.

Management As a weed in maize, cowpea, millet and sorghum, *Spigelia anthelmia* can be controlled by hand-weeding; some tests with herbicides (e.g. alachlor) were not successful.

Harvesting Plants are simply pulled up and normally used fresh.

Handling after harvest Dried plant parts should be stored in airtight containers.

Genetic resources *Spigelia anthelmia* is widely distributed and of a weedy nature; it is not threatened by genetic erosion.

Prospects *Spigelia anthelmia* will likely spread into more African countries and in spite of the risk of poisoning, its local use as an anthelmintic will spread as well. Extracts may be useful in the control of gastrointestinal nematodes of sheep and goats. More research on the pharmacological activities of the different compounds in the leaves, fruits and roots is needed, especially on the anthelmintic and cardiac effects. Further potential uses, such as in insecticides and acaricides, also need to be explored.

Major references Burkill, 1995; Dalziel, 1937; Leeuwenberg, 1961c; Leeuwenberg, 1980; Neuwinger, 2000; van Valkenburg, 2003.

Other references Abbiw, 1990; Achenbach et al., 1995; Adegoke, Akinsaya & Naqvi, 1968; Assis et al., 2003; Bouquet, 1969; Bouquet & Debray, 1974; Camurca-Vasconcelos et al., 2004; Esposito-Avella et al., 1985; Gonzalez-Coloma et al., 1999; Hübner et al., 2001; Jegede et al., 2006; Wagner et al., 1986.

Sources of illustration van Valkenburg, 2003.

Authors L.J.G. van der Maesen

SPIROSPERMUM PENDULIFLORUM DC.

Protologue Syst. nat. 1: 515 (1817).

Family Menispermaceae

Origin and geographic distribution *Spirospermum penduliflorum* is endemic to eastern Madagascar where it occurs from Antsiranana in the north to Toliara in the south.

Uses A leaf decoction is widely drunk to treat malaria, sometimes as an adjuvant to chloroquine. The dried and compressed leaves are smoked to stop the progress of pulmonary tuberculosis and vomiting of blood and an infusion of the leaves is taken against colic. A root decoction is taken as a cholagogue, as a cardiac tonic and against liver complaints.

Properties From the root the clerodane type diterpenoid columbin, the protoberberine-type quaternary alkaloid palmatine and the bisbenzylisoquinoline limacine have been isolated. Limacine was tested for its effect against *Plasmodium falciparum* and a multidrug resistant leukaemia cell line; it was found to be less active than the structurally related fangchinoline.

Botany Dioecious liana or small, arching tree up to 10(–12) m tall; stem up to 15 cm in diameter, dark brown to blackish. Leaves alternate, simple and entire; stipules absent; petiole swollen at apex or at both ends, bent at apex; blade peltate, glossy green, leathery, pinnately veined. Inflorescence an axillary or seemingly terminal, much branched, pendulous panicle up to 80 cm long, female inflorescence fewer-flowered than male one. Flowers yellowish green to whitish; pedicel pinkish; male flowers with 5–6 stamens; female flowers with superior ovary, composed of 1–9 free carpels. Fruit a cluster of 1–9 large, globose, fleshy drupes, reddish pink when mature, with bony stone, each drupe 1-seeded. Seeds horseshoe-shaped.

Spirospermum comprises a single species. However, there are specimens with narrow leaves that may represent a second species.

Ecology *Spirospermum penduliflorum* occurs in humid forest, up to 500(–1100) m altitude.

Genetic resources and breeding *Spiro-*

spermum penduliflorum has a wide distribution in Madagascar and although the area under rainforest is diminishing rapidly, there are no signs that it is in danger of genetic erosion.

Prospects Unless new pharmacologically active compounds are found, *Spirospermum penduliflorum* will probably remain of local importance only.

Major references Gurib-Fakim & Brendler, 2004; Neuwinger, 2000; Rasoanaivo, Ratsimamanga-Urverg & Rakoto-Ratsimamanga, 1995; Ratsimamanga-Urverg et al., 1992; Schatz, 2001.

Other references Boissier et al., 1975; Boiteau, Boiteau & Allorge-Boiteau, 1999; Frappier et al., 1996; Missouri Botanical Garden, undated; Rasoanaivo et al., 1992; Schlittler & Weber, 1972b.

Authors L.P.A. Oyen

SPONDIANTHUS PREUSSII Engl.

Protologue Bot. Jahrb. 36: 216 (1905).

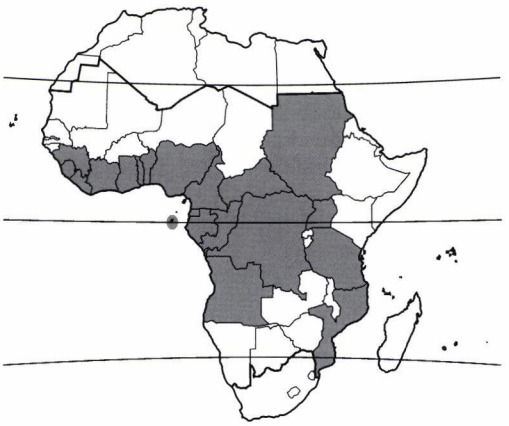
Family Euphorbiaceae

Chromosome number $2n = 26, 52$

Origin and geographic distribution *Spondianthus preussii* occurs from Guinea east to Sudan, and south to Angola and Mozambique.

Uses All parts of *Spondianthus preussii* are extremely poisonous, and medicinal uses are scarce. A strongly diluted leaf decoction is sometimes drunk to treat fever. A bark decoction is used as mouthwash to treat toothache. It is also taken to treat stomach-ache and pains during pregnancy. A bark maceration is applied to snakebites. Rice, meat or fish cooked with the bark, bark sap or pulverized seeds are widely used in baits to kill rodents and stray dogs. The plant is considered too poisonous to use as arrow poison as the poison spreads too easily through the meat; however, in Côte d'Ivoire it has sometimes been used in hunting elephants. Pulverized twig bark and seeds are added to drinks for criminal purposes. The bark sap is also used as fish poison. The poisonous leaves are particularly dangerous to cattle; the animals may die suddenly several hours later without any symptoms. Drying the leaves removes the toxicity. In southern Nigeria the Yoruba people use the fruit in a ceremony to cure certain cough ailments.

The heartwood is brownish, strongly speckled, hard and heavy. The wood is used for construction and implements. In Uganda the trunk is used to make dugout canoes. As the wood is dense and slow burning, the charcoal is popular with blacksmiths in southern Nigeria.



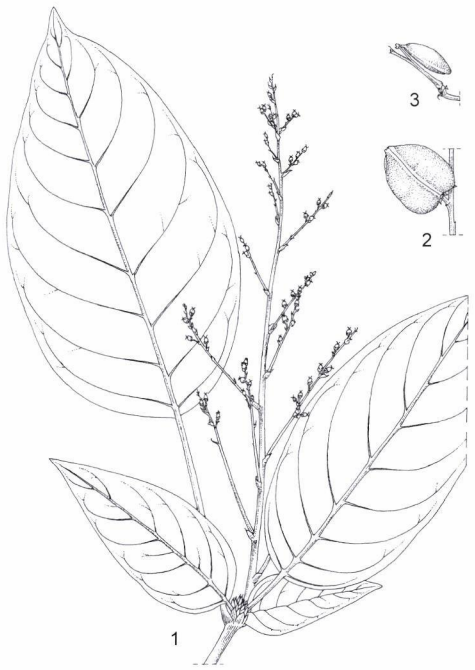
Spondianthus preussii – wild

Production and international trade Stem bark of *Spondianthus preussi* is traded at a local level in Nigeria, Cameroon and Gabon, where it is commonly in stock in local markets. Its main use is as a rodenticide. The price per kg of bark is US$ 1.20–1.50. The quantity traded is not known.

Properties The leaves and stem bark contain the extremely hazardous, very toxic and volatile monofluoroacetic acid, as well as saponins, flavonoids and tannins. From the stem bark several toxic tetracyclic triterpenoid cucurbitacins were isolated, including cucurbitacin L, A2 and E. From an alcoholic extract of the stem bark the lupane-type triterpene betulinic acid (3β-hydroxy-lup-20(29)-en-28-oic acid) and several derivatives, as well as oxalic acid were isolated. An ethyl acetate extract of the stem bark exhibited selective in-vitro antitumour activity against human melanoma. The active compound was found to be betulinic acid. This compound has a range of biological activities including in-vivo and in-vitro antitumour and antiplasmodial activity, it is not toxic and plays an important role in pharmacological research. It is commercially extracted from *Betula pubescens* Ehrh.

Adulterations and substitutes The stem bark of *Erythrophleum suaveolens* (Guill. & Perr.) Brenan is sometimes used as a substitute for the stem bark of *Spondianthus preussii*.

Description Dioecious medium-sized tree up 30(–60) m tall; bole up to 150 cm in diameter, low-branching, with or without stilt-roots; bark surface smooth or slightly scaly, dark



Spondianthus preussii – 1, flowering branch; 2, fruit; 3, seed.
Redrawn and adapted by Achmad Satiri Nurhaman

brown, inner bark reddish, exuding red sap. Leaves alternate, simple and entire; stipules small; petiole 0.5–11.5 cm long; blade elliptical to broadly elliptical-ovate, 3–35 cm × 1.5–18 cm, base cuneate to rounded, apex obtuse to acute, glabrous, reddish when young. Inflorescence an erect, terminal or axillary panicle up to 10 cm long; bracts elliptical-ovate to lanceolate, 2–5 mm long. Flowers unisexual, regular, 5-merous, sepals broadly ovate, c. 1 mm long, whitish, pinkish tinged, petals elliptical-ovate, c. 0.5 mm long, 2–3-toothed; male flowers almost sessile, stamens 1.5 mm long; female flowers with pedicel 1–10 mm long, ovary superior, c. 2 mm long, 3-celled, styles 3, c. 1 mm long. Fruit an ovoid to ellipsoid capsule 1.5–2 cm × 1–1.5 cm, smooth, greenish becoming purplish black, 3-seeded. Seeds compressed ovoid-ellipsoid, c. 1 cm long, smooth, bright red, often remaining attached to the central axis after dehiscence.

Other botanical information *Spondianthus* comprises a single species, in which 2 widely distributed varieties with different ecological preferences are recognized, var. *preussii* with hairy inflorescences, occurring in humid rainforest, swamp forest and lagoon forest at low altitudes from Liberia east to DR Congo, and var. *glaber* (Engl.) Engl. with glabrous inflorescences, mainly occurring in drier areas, often in fringing forest and swamp forest, from Guinea east to Sudan and Uganda and south to Angola and Mozambique.

Ecology *Spondianthus preussii* occurs in humid rainforest, riverine forest, swamp forest and fringing forest, from sea-level up to 1800 m altitude. It prefers sandy-loamy soils and an annual rainfall of 1000–1600 mm.

Propagation and planting *Spondianthus preussii* is propagated by seed. As the number of seeds available for propagation is limited, work is in progress at CENRAD, Nigeria to find good methods of vegetative propagation.

Harvesting For medicinal purposes, bark is harvested in strips or in patches.

Handling after harvest The bark is thoroughly sun-dried before storing in a dry and cool place. The bark needs to be checked regularly because it is liable to fungal attack.

Genetic resources *Spondianthus preussii* is probably liable to genetic erosion in West Africa due to deforestation.

Prospects *Spondianthus preussii* will remain locally important as a source of rodenticide for use in rural and urban environments. Much work is being done on the pharmacological properties of betulinic acid and derivatives from it. Although betulinic acid is not rare in plants, further research into the chemical compounds of *Spondianthus preussii* seems worthwile.

Major references Abo & Kinghorn, 2003; Burkill, 1994; Léonard & Nkounkou, 1989; Neuwinger, 1998; Neuwinger, 2000; Radcliffe-Smith, 1987; Séré et al., 1982.

Other references Adebisi & Ladipo, 2000; Adjanohoun & Aké Assi, 1979; Gassita et al. (Editors), 1982; Irvine, 1961; Kamgue et al., 1979; Lovett et al., 2006; Raponda-Walker & Sillans, 1961; Sandberg et al., 1987; Tessier & Paris, 1978.

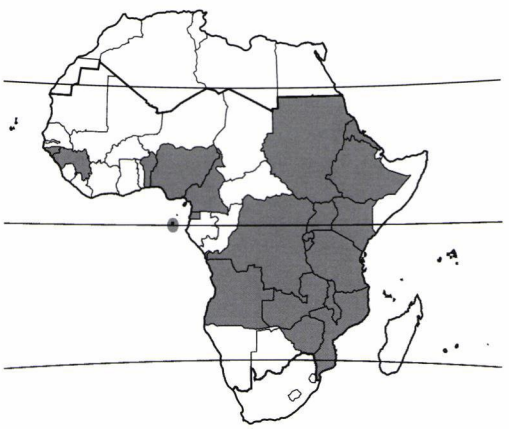
Sources of illustration Radcliffe-Smith, 1987.

Authors M.O. Soladoye & A.A. Adebisi

STEPHANIA ABYSSINICA (Quart.-Dill. & A.Rich.) Walp.

Protologue Repert. Bot. Syst. 1: 96 (1842).
Family Menispermaceae
Origin and geographic distribution *Stephania abyssinica* occurs from Guinea east to Eritrea and south to Angola, Mozambique and eastern South Africa.

Uses The plant sap of *Stephania abyssinica* is taken to treat dysentery, diarrhoea, vomiting, stomach complaints, sexually transmitted diseases, and in remedies for menstrual disorders and sterility in women. In Tanzania the sap is taken with milk as an emetic to relieve chest pain and heart complaints, or administered topically to treat eye problems. Pulped leaves are applied as a dressing to heal fractures and dislocations. The purgative effects of the plant sap are mild and fresh leaves pounded with water are even given to children for this purpose; it is also used to expel intestinal worms and to cure menorrhagia. In Malawi pounded leaves are taken against indigestion. A decoction of the leaves and roots used as a wash is considered invigorating for pregnant women and weak children. Throughout eastern Africa a root extract is used in malaria therapy and against internal parasites, particularly roundworm, threadworm and pinworm. The roots are also taken as an aphrodisiac. The root sap is an antidote to snakebites, whereas crushed leaves are applied to tortoise bites. In South Africa the powdered root is taken with the leaves of *Momordica foetida* Schumach. to treat abscesses on the skin. An extract of the root together with extracts of *Catharanthus roseus* (L.) G.Don and *Indigofera arrecta* Hochst. ex A.Rich. is drunk to treat diabetes. All parts of the plant are applied as a powder to scarifications made in the skin of the painful body part, to relieve pain. In Ethiopia an extract the whole plant is used to cure mastitis in cattle. In Uganda *Stephania abyssinica* is believed to distract hunting dogs if they eat the leaves, and disorientate hunters if they touch the plant.
The stems are used as binding material, e.g. in fence constructions and also in basketry.

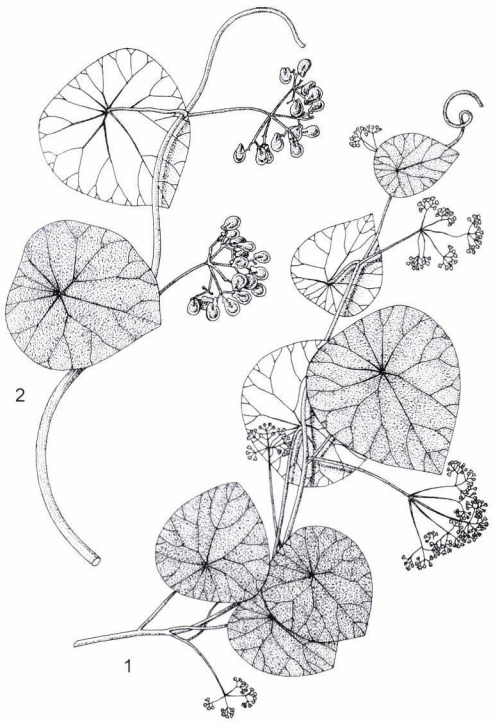


Stephania abyssinica – *wild*

Properties Hasubanan and aporphine-type alkaloids are the principle phytochemical constituents in *Stephania abyssinica*. The aporphine alkaloids include corydine, crebanine, stephanine and stephalagine; also present are the oxoaporphine alkaloids dicentrinone and oxoxylopine, and hasubanan alkaloids such as stephabyssine, stephaboline, stephavanine and derivatives.
Methanol extracts of the leaves and of the roots showed significant activity against HIV-1 and HIV-2 in vitro, but the cytotoxicity of the extracts as well as the isolated alkaloids were higher than their activity against the viruses. An aqueous root decoction was significantly active against both chloroquine-sensitive and chloroquine-resistant strains of *Plasmodium falciparum* in vitro, with an IC_{50} of 22.9 µg/ml. Methanol extracts of the leaves and stems showed antibacterial activity in vitro against *Neissera gonorrhoea* and *Shigella dysenteriae*.

Description Dioecious small liana, woody at the base; bark of stem thin; branchlets glabrous, hairy when young. Leaves arranged spirally, simple, peltate; petiole 4–12 cm long; blade ovate to broadly ovate, rarely almost round, 5–20 cm × 4–13 cm, base rounded, apex obtuse to acute, membranous or papery, glabrous or hairy, palmately veined with 8–10 main veins. Inflorescence an axillary, compound false umbel, solitary or 2–4 together; peduncle 4–10 cm long with 3–6 branches ending in umbel-like cymes; involucre composed of 3–5 bracts, soon falling. Flowers unisexual, small; petals 3–4, broadly ovate or nearly orbicular, c. 1 mm long, cream to reddish; male flowers with 6(–8) obovate sepals 1–2.5 mm long, purplish, stamens fused into a staminal column; female flowers with 3–4 sepals, ovary superior, glabrous, style short. Fruit an obovoid, flattened drupe 5–8 mm in diameter, glabrous, yellowish to pinkish green, 1-seeded; stone with small prickles or thick tubercles arranged in three lines. Seed up to 8 mm long.

Other botanical information *Stephania*



Stephania abyssinica – 1, branch with male inflorescences; 2, fruiting branch.
Redrawn and adapted by Achmad Satiri Nurhaman

comprises about 30 species, 25 of them occurring from southern Asia to New Guinea, and 5 in tropical Africa. Two varieties are recognised in *Stephania abyssinica*: var. *abyssinica* and var. *tomentella* (Oliv.) Diels, both with a wide distribution. Var. *abyssinica* is nearly glabrous whereas various plant parts are hairy in var. *tomentella*.

Ecology *Stephania abyssinica* occurs in grassland, usually in shady, damp localities, but not in rainforest, up to 3500 m altitude. It also occurs in abandoned fields, road sides and where forest has been destructed by fire.

Genetic resources *Stephania abyssinica* is widely distributed and no risks of genetic erosion have been reported.

Prospects *Stephania abyssinica* has many medicinal uses, but little pharmacological research has been done so far. As several other species of *Stephania* are important in pharmacology, further research seems warranted.

Major references Asres et al., 2001; Baerts & Lehmann, 2006f; Burkill, 1997; Geyid et al., 2005; Kokwaro, 1993; Muregi et al., 2004; Troupin, 1956; Troupin, 1960.

Other references Abebe & Hagos, 1991; Adegoke, Akinsaya & Naqvi, 1968; Benvenuto, 1974; Chakraborty et al., 2000; de Wet, 2005; Getahun, 1976; Haerdi, 1964; Harjuli, 1980; Jansen, 1981; Kakudidi, 2004; Kandé, Philipov & Dutschewska, 1994; Kupchan, Liepa & Fujita, 1973; Morris, 1996; van Wyk & Wiechers, 1974; Watt & Breyer-Brandwijk, 1962; Wrangham & Waterman, 1983.

Sources of illustration Benvenuto, 1974.

Authors O.M. Grace & D.G. Fowler

STEPHANIA DINKLAGEI (Engl.) Diels

Protologue Engl., Pflanzenr. IV, 94: 265 (1910).

Family Menispermaceae

Synonyms *Cissampelos dinklagei* Engl. (1899).

Origin and geographic distribution *Stephania dinklagei* is widely distributed from Guinea east to Uganda and south to DR Congo, Tanzania and Cabinda (Angola).

Uses In southern Nigeria fresh plant sap is mixed with water or maize gruel and other ingredients and taken to treat dysentery or diarrhoea. In Sierra Leone a fresh infusion of young leaves is given to children with stomachache; the infusion is given immediately as it thickens on standing. In Ghana a plant extract is taken as a cough remedy. The leaves are used as an aphrodisiac and to treat impotence in men. In Liberia women who wish to become pregnant eat the leaves cooked with rice, and wrap the tender stem around the hips. A decoction of the plant is used to induce menstruation, whereas in Sierra Leone the leaves, stem and roots are used to treat profuse menstruation and complaints following childbirth. The stems are taken as a sedative and analgesic. In the Central African Republic scrapings of the fresh root are applied in a hot poultice to the ribs to relieve pain in the sides. The root is also used against internal parasites. The seeds are used against leprosy. The Temne people of Sierra Leone use the pounded stems in the preparation of a fish poison.
Strong rope made from the stem is known in Sierra Leone as 'Government rope' owing to its official use as such in the past.

Properties A large number of alkaloids have been isolated from *Stephania dinklagei*, including the aporphine alkaloids corydine,

dinklageine, stephalagine, steporphine, roemerine, dicentrine and N-methylglaucine, the oxoaporphine alkaloids liriodenine (spermatheridine), N-methylliriodendronine, atherospermidine and oxodicentrine, and the proaporphine alkaloid stepharine. Of these, corydine is present in the highest concentrations. The anthraquinone aloe-emodin has also been isolated.

An infusion of the roots exhibited antispasmodic activity in vitro. A methanol extract of the leaves and stems demonstrated antiprotozoal and cytotoxic properties in vitro. Liriodenine and N-methylliriodendronine showed significant activity against *Leishmania donavani*, and liriodenine the highest activity against *Plasmodium falciparum*. Aloe-emodin was active against *Trypanosoma brucei*. An ethanol extract of the stems showed cytotoxic and DNA-damaging properties in a bioassay with several strains of yeast. Liriodenine inhibited the growth of all yeast strains tested, but did not show DNA-damaging activity, while corydine did indicate DNA-damaging properties. Corydine also has mild sedative properties and a depressant effect on the cardiac and respiratory systems, and a stimulatory effect on the central nervous system.

Botany Dioecious liana up to 20 m long, twining clockwise, sometimes rambling shrub; bark of branchlets greyish brown, glabrous. Leaves arranged spirally, simple, peltate; petiole 6–12 cm long, glabrous; blade ovate to nearly orbicular, 7–15 cm × 7–15 cm, base rounded, apex acuminate, margin wavy, membranous to papery, dark green above, pale bluish green below, palmately veined with 8–10 main veins. Inflorescence a panicle of small cymes, generally on leafless branches, rarely axillary, solitary or in clusters of 2–4, male inflorescence up to 50 cm long, female inflorescence smaller; peduncle up to 10 cm long; axes glabrous or finely densely hairy; cymes umbellike, 2–5 cm long; bracts asymmetrical, up to 2.5 cm × 1.5 cm. Flowers unisexual, small, green or purple; pedicel c. 1 mm long; male flowers with 6–8 narrowly obovate, incurved, short-hairy sepals, 1–2 mm × 0.5–1 mm, 3 broadly ovate to obtriangular petals, c. 0.5 mm long, stamens fused into a staminal column up to 1 mm long. Fruit a broadly obovoid drupe with somewhat truncate base, 6–12 mm long, green, yellow when ripe, 1-seeded; stone with 4 prickly ribs, 2 median ones broadened at apex. Seed up to 1 cm long, black.

Stephania comprises about 30 species, 25 of them occurring from southern Asia to New Guinea, and 5 in tropical Africa.

Ecology *Stephania dinklagei* occurs in dense humid rainforest and riverine forest, and in old clearings, up to 1500 m altitude.

Genetic resources and breeding *Stephania dinklagei* has a wide distribution and there are no indications that it is in danger of genetic erosion.

Prospects Of the alkaloids isolated from *Stephania dinklagei* only corydine and liriodenine have undergone pharmacological tests, some of them with promising results. Research is necessary to evaluate the pharmacological activities of the other isolated alkaloids.

Major references Burkill, 1997; Keay & Troupin, 1954; Troupin, 1951; Troupin, 1956.

Other references Akubue, Mittal & Aguwa, 1983; Camacho et al., 2003; Dwuma-Badu et al., 1980b; Gören, Zhou & Kingston, 2003; Iwu, 1993; Oliver, 1960; Paris & Le Men, 1955; Vergiat, 1970.

Authors O.M. Grace

STILLINGIA LINEATA (Lam.) Müll.Arg.

Protologue A.DC., Prodr. 15(2.2): 1157 (1866).

Family Euphorbiaceae

Vernacular names Tanguin de pays, bois de lait (Fr).

Origin and geographic distribution *Stillingia lineata* occurs in Réunion and Mauritius, and also in Fiji, the Philippines, the Lesser Sunda Islands and the Moluccas.

Uses In Mauritius bathing in the decoction of the whole plant is recommended as a cure for eczema. The leaves are toxic and stupefying.

Properties The leaves and stems contain phenols, tannins, coumarins, terpenes, saponins and alkaloids. A dichloromethane extract of the leaves showed cytotoxic effects. Extracts from *Stillingia lineata* were among the most active against human tumour cell line Co-115 in in-vitro tests.

Botany Monoecious shrub or small tree up to 12 m tall; bark smooth, covered with leaf-scars. Leaves alternate, simple, crowded at apex of branches; stipules 1–1.5 mm long, deeply split, soon falling; petiole 3–17 mm long, without glands or with a pair of glands on the junction with the blade; blade orbicular to elliptical, (4–)7–24 cm × 2–4 cm, base cuneate to obtuse, apex acute to rounded to retuse, mar-

gin entire or toothed with teeth 2–3(–4) mm apart, membranous or slightly succulent. Inflorescence a terminal spike 2–13 cm long, lower part with up to 12 solitary female flowers, terminal part with male flowers in clusters of up to 15 flowers; bracts minute. Flowers unisexual, nearly sessile; pedicel minute; male flowers with tubular perianth with 2 lobes or horns, 1 mm long, stamens 2, filaments c. 1 mm long; female flowers with 3-lobed perianth, ovary superior, ovoid, 3-celled, styles 3. Fruit a 3-lobed capsule 5–6 mm × 7–8 mm, notched, dehiscing explosively, remaining thickened, 3-lobed stalk up to 8 mm in diameter. Seeds oblong, 4–5 mm × 3–3.5 mm, grey when dry, pitted, with caruncle. Seedling with epigeal germination.

In *Stillingia lineata* 2 subspecies are distinguished. The typical subspecies from Mauritius and Réunion has firm to slightly succulent, entire leaves with scarcely visible venation and no marginal glands, whereas the Asian plants are distinguishable by thin leaves with obvious serration, venation and glands.

Stillingia comprises about 30 species, 27 of which are Neotropical, ranging from Argentina to the United States. Of the 3 species native to the Old World, 2 are endemic to Madagascar.

Ecology *Stillingia lineata* occurs on beaches, but also in forest up to 300 m altitude.

Genetic resources and breeding In Réunion *Stillingia lineata* has a protected status, but in Mauritius it is not considered threatened.

Prospects The cytotoxic properties of *Stillingia lineata* warrant further research.

Major references Coode, 1982; Esser, 1999; Gurib-Fakim & Brendler, 2004.

Other references Govaerts, Frodin & Radcliffe-Smith, 2000; Gurib-Fakim, Guého & Bissoondoyal, 1996; Marston, Décosterd & Hostettmann, 1993.

Authors C.H. Bosch

STROPHANTHUS AMBOENSIS (Schinz) Engl. & Pax

Protologue Bot. Jahrb. Syst. 15: 376 (1892).

Family Apocynaceae

Synonyms *Strophanthus intermedius* Pax (1892).

Origin and geographic distribution *Strophanthus amboensis* occurs from western DR Congo to Angola and Namibia.

Uses In Angola a decoction of the roots or leaves of *Strophanthus amboensis* is taken against rheumatism. The Luvale people use an enema of the root to treat venereal diseases. The Luchazi people mix the pounded root with oil and apply the ointment to treat scabies. In Namibia the seeds are used in the preparation of arrow poison.

Properties From the seeds about 10 cardiac glycosides (cardenolides) have been isolated of which the most important are based on the aglycone sarverogenin: mainly intermedioside and panstroside, and traces of amboside, leptoside, kwangoside and sarveroside. These glycosides are highly toxic. The aglycones sarverogenin and sarmentogenin have also been isolated. Sarverogenin has also been isolated from the root and bark after hydrolysis. Leptoside has a weak cardio-stimulant action.

Cell suspension cultures from the leaves, to which digitoxigenin was added, produced 6 transformation products, e.g. periplogenin.

Botany Deciduous shrub up to 4 m tall or liana up to 20 m long, with clear or white exudate, all parts glabrous to hairy; stem up to 20 cm in diameter; bark pale grey; branches with few to many lenticels, pale brown or purple brown. Leaves decussately opposite, simple and entire; stipules absent; petiole 2–9 mm long; blade ovate to broadly ovate, 2–12.5 cm × 1–6.5 cm, base cuneate, rounded to slightly cordate, apex rounded or acuminate, papery or thinly leathery, with translucent dots. Inflorescence a terminal dichasial cyme, on long or short branches or in the forks, lax or congested, 1–12-flowered; peduncle 0–1 cm long; bracts ovate, narrowly ovate or narrowly triangular, 2–6 mm long, deciduous. Flowers bisexual, regular, 5-merous; pedicel 0.5–2 cm long; sepals free, slightly unequal, ovate or obovate, 3–11 mm long, obtuse or acute; corolla tube 15–27 mm long, widening at 15–35% of its length into a cylindrical upper part, at the mouth 6–13 mm wide, short-hairy, orange-yellow turning purple via dark red, white-streaked inside, corona lobes tongue-shaped, 2.5–7.5 mm long, obtuse, fleshy, minutely hairy, pink or violet, corolla lobes ovate, gradually narrowing into a narrow, spreading tail, lobes including the tail 25–75 mm long, hairy, reddish violet on the right outer side and whitish yellow on the left outer side, yellow on the inner side; stamens inserted at 5–7.5 mm from the base of the corolla tube, included; ovary half-inferior, 2-celled, style 5–7.5 mm long, ending in a ring-like pistil head surrounding the stigma. Fruit consisting of 2 ellipsoid follicles 12–27 cm ×

1.5–2.5 cm, tapering into a broad and obtuse apex, 2-valved, divergent at 180–270°, wall thick and hard, many-seeded. Seeds spindle-shaped, slightly flattened, 8–16 mm × 2–4.5 mm, densely pubescent, at apex with a long beak up to 10 cm long, glabrous in lower half, upper half with long hairs up to 7 cm long.
Strophanthus comprises 38 species, of which 30 occur in continental Africa, 1 in Madagascar and 7 in Asia, from India to South-East Asia. *Strophanthus amboensis* is a variable species. It flowers towards the end of the dry and the beginning of the rainy season; flowers appear before or with the leaves. Fruits mature at the beginning of the dry season.

Ecology *Strophanthus amboensis* occurs in forest margins, woodland and thorn scrub, often in rock fissures, at 450–2000 m altitude.

Genetic resources and breeding *Strophanthus amboensis* is rather widespread and not in danger of genetic erosion.

Prospects Medicinal use of *Strophanthus amboensis* will be limited to local use in its area of distribution, unless further studies on the chemical constituents reveal new possibilities. *Strophanthus amboensis* has unusual and beautiful flowers, which makes it an interesting ornamental plant.

Major references Beentje, 1982; McKenzie, 2002; Watt & Breyer-Brandwijk, 1962.

Other references Hoffmann, 2005; Kawaguchi, Hirotani & Furuya, 1988; Kawaguchi, Hirotani & Furuya, 1989; Omino, 2002; Schindler, 1956; van Euw et al., 1951; Wall, 1955.

Authors A. de Ruijter

STROPHANTHUS BOIVINII Baill.

Protologue Bull. Mens. Soc. Linn. Paris 1: 757 (1888).

Family Apocynaceae

Synonyms *Roupellina boivinii* (Baill.) Pichon (1949).

Vernacular names Wood shaving flower (En). Roupellina (Fr).

Origin and geographic distribution *Strophanthus boivinii* is endemic to Madagascar. It is naturalized in Réunion and Mauritius.

Uses A decoction of the aerial parts is drunk to treat gonorrhoea and fever. It is also used to poison dogs and pest animals. A bark decoction is taken to treat colic and is rubbed in to treat wounds and itch. *Strophanthus boivinii* is sometimes sold as a rare ornamental because of its striking orange-brown flowers.

Properties All parts of *Strophanthus boivinii* are considered toxic when ingested. Several cardiac glycosides (cardenolides) have been isolated from the seeds and leaves. The seeds contain mainly glycosides based on the aglycone corotoxigenin: milloside, paulioside, stroboside, boistroside and christyoside. In addition, the gitogenin glycoside strospeside is found. The leaves also contain glycosides, with paulioside, boistroside, strospeside, madagascoside, zettoside and sadleroside as main components. Only strospeside is also present in other *Strophanthus* species.

Botany Deciduous shrub or small tree up to 5(–12) m tall, sometimes up to 30 m, dichotomously branched with white latex; bole up to 40 cm in diameter; bark pale grey, flaking. Leaves decussately opposite, clustered at the apex of branchlets, simple and entire; stipules absent; petiole 4–15(–20) mm long; blade elliptical or narrowly elliptical to obovate, 2–21 cm × 1–6(–8) cm, base cuneate to decurrent, apex acute to acuminate, papery, glabrous to shortly hairy. Inflorescence a dichasial congested cyme in the forks of lateral branches, shortly hairy, few- to many-flowered; peduncle 2–7 mm long, erect or drooping; bracts ovate, up to 4 mm long, scale-like, whitish. Flowers bisexual, regular, 5–merous; pedicel 1.5–3.5 cm long; sepals free, narrowly ovate, 1.5–8 mm long, acute, shortly hairy; corolla tube 8–22 mm long, widening at 25–45% of its length into a cylindrical or cup-shaped part, at the mouth 3–10 mm wide, short-hairy, yellow or orange fading to reddish brown, corona lobes scale-like or tongue-shaped, 1–3 mm long, obtuse, fleshy, yellow, corolla lobes oblong, 7–32 mm long, apex rounded, margin undulate or crisped, short-hairy, orange turning reddish, with yellow margins; stamens inserted at 3–6 mm from the base of the corolla tube, included; ovary half-inferior, 2-celled, style 3.5–5 mm long, ending in a ringlike pistil head surrounding the stigma. Fruit consisting of 2 ellipsoid follicles 11–24 cm × 1.5–3 cm, tapering into a narrow apex, curved inwards at the tip, 2-valved, divergent at an angle of 160–220°, wall thick and hard, with lenticels, many-seeded. Seeds spindle-shaped, slightly flattened, 11–16 mm long, densely hairy, at apex with a long beak up to 2.5 cm long, with long hairs in upper 1–2 cm 3–4.5 cm long.
Strophanthus comprises 38 species, of which 30 occur in continental Africa, 1 in Madagascar and 7 in Asia, from India to South-East Asia.

Strophanthus boivinii flowers towards the end of the dry and the beginning of the rainy season; flowers appear before or with the leaves. Mature fruits are present in the dry season. The plant is deciduous in dry regions. It is drought tolerant and can be grown both in full sun and in shade. It is a compact shrub when container-grown, and can be trained into a small tree.

Ecology *Strophanthus boivinii* occurs in dry deciduous forest and thickets, sometimes on limestone, from sea-level up to 800 m altitude.

Genetic resources and breeding *Strophanthus boivinii* is rather widespread especially in the western part of Madagascar and is not in danger of genetic erosion. It is cultivated in botanic gardens in several countries and as ornamental.

Prospects *Strophanthus boivinii* will remain of local use only, unless further research of the many cardio-active glycosides reveals properties with medicinal potential.

Major references Beentje, 1982; Boiteau & Allorge-Boiteau, 1993; Debray, Jacquemin & Razafindrambao, 1971; Neuwinger, 2000; Rasoanaivo, Petitjean & Conan, 1993.

Other references Hegnauer, 1964; Markgraf, 1976; Pernet & Meyer, 1957; Russel, Schindler & Reichstein, 1961a; Russel, Schindler & Reichstein, 1961b; Schindler & Reichstein, 1952a; Schindler & Reichstein, 1952b; Schindler & Reichstein, 1952c.

Authors A. de Ruijter

STROPHANTHUS COURMONTII Sacleux ex Franch.

Protologue Journ. Bot. (Morot) 7: 300 (1893).

Family Apocynaceae

Vernacular names Kia ya mamba, mubongwena, mbuba, mtobwe (Sw).

Origin and geographic distribution *Strophanthus courmontii* occurs in east and southeastern Africa, from southern Kenya through Tanzania, Malawi and eastern Zambia to Zimbabwe and Mozambique.

Uses In Tanzania a root decoction is drunk to treat rheumatism and also as an aphrodisiac. The seeds of *Strophanthus courmontii* are used to make ordeal poison and arrow poison. Such poisoned arrows are still used in northeastern Tanzania to kill animals that are damaging crops. In Malawi, Zimbabwe and southern Mozambique *Strophanthus courmontii* is used for making arrow poison as are several other *Strophanthus* species. The wood is used for making walking sticks.

Properties From unripe seeds various cardiac glycosides (cardenolides) have been isolated, i.e. panstroside and sarmentocymarin, based on the aglycone sarmentogenin, and sarveroside, based on the aglycone sarverogenin. From ripe seeds the glycosides intermedioside, panstroside, sarmentocymarin and sarveroside were isolated. These glycosides are all highly toxic.

Botany Deciduous liana up to 22 m long or less often a shrub up to 4 m tall, with white latex; stem up to 10 cm in diameter, with corky ridges to 5 cm × 2 cm; branches dark grey to reddish brown, with compressed corky triangles at the nodes, later growing into ridges. Leaves decussately opposite, simple and entire; stipules absent; petiole 3–11 mm long; blade elliptical to ovate or obovate, 2–14 cm × 2.5–6.5 cm, base rounded to cuneate, apex acute to acuminate, thinly papery, glabrous. Inflorescence a terminal dichasial cyme, on long or short branches or in the forks, almost sessile, 1–3-flowered; bracts ovate or narrowly ovate, 1.5–4 mm long, sometimes deciduous. Flowers bisexual, regular, 5-merous, fragrant; pedicel 1–7.5 mm long; sepals free, almost equal, ovate, 3–10 mm long, acute or apiculate, often with pink margins; corolla tube 22–43 mm long, widening at 15–35% of its length into a cup-shaped upper part, at the mouth 17–35 mm wide, hairy inside, white turning yellow near the base and red turning purple near the apex, inside yellow with purple streaks, corona lobes subulate with a wide base, 2–6 mm long, apex obtuse, fleshy, yellow turning purple via red, corolla lobes ovate, 20–57 mm × 10–27 mm, gradually narrowing into the acute apex, white turning yellow, with a violet band on the right margin; stamens inserted at 6–12 mm from the base of the corolla tube, included, anthers acuminate; ovary half-inferior, 2-celled, style 8.5–16 mm long, ending in a ring-like pistil head surrounding the minute stigma. Fruit consisting of 2 ellipsoid follicles 12–26 cm × 3–4.5 cm, with obtuse apex, 2-valved, divergent at 160–200°, wall thick and hard, glabrous, grey- or purplish black, many-seeded. Seeds spindle-shaped, slightly flattened, 10–15 mm long, densely hairy, at the apex with a long beak up to 8.5 cm long, glabrous in lower half, upper half with long hairs, up to 7 cm long.

Strophanthus comprises 38 species, of which 30 occur in continental Africa, 1 in Madagascar

and 7 in Asia, from India to South-East Asia. *Strophanthus courmontii* flowers towards the end of the dry season while leafless, and to a lesser extent during the rainy season. Mature fruits are present towards the end of the rainy season.

Ecology *Strophanthus courmontii* occurs in gallery forest or riverine thickets, less often in forest away from rivers, from sea-level up to 1400 m altitude.

Genetic resources and breeding *Strophanthus courmontii* is rather widespread in eastern and southern Africa and not in danger of genetic erosion.

Prospects *Strophanthus courmontii* has so far mainly been used for making arrow poison, a use which is declining rapidly. Although it contains glycosides, its medicinal use will be limited and restricted to its area of distribution unless further studies reveal new possibilities.

Major references Beentje, 1982; Neuwinger, 1998; Neuwinger, 2000; Watt & Breyer-Brandwijk, 1962.

Other references Githens, 1948; Haerdi, 1964; McKenzie, 2002; Omino, 2002.

Authors A. de Ruijter

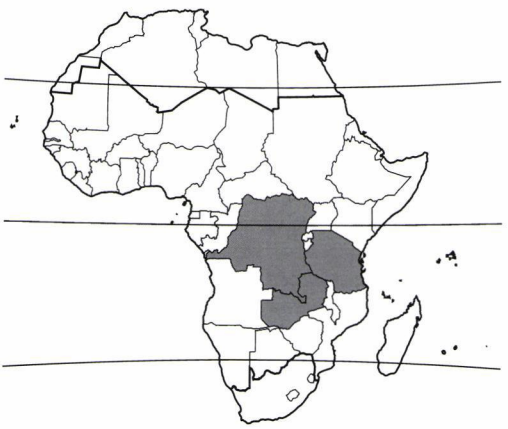
STROPHANTHUS EMINII Asch. & Pax

Protologue Bot. Jahrb. Syst. 15: 366, t. 10, 11 (1892).

Family Apocynaceae

Vernacular names Spider tresses, poison arrow vine (En). Msungululu, mtondo (Sw).

Origin and geographic distribution *Strophanthus eminii* occurs in south-eastern DR Congo, Tanzania and northern Zambia.



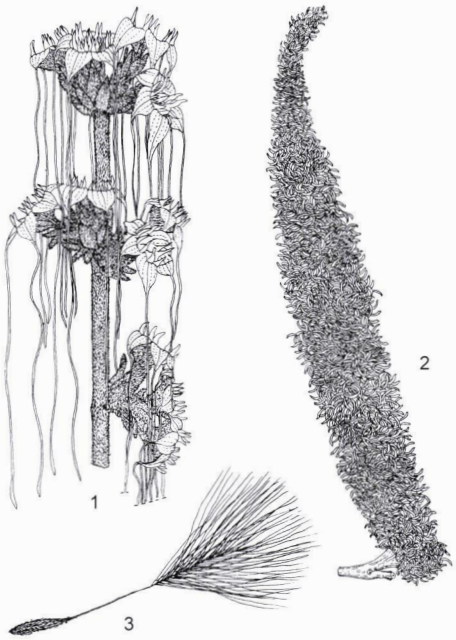
Strophanthus eminii – *wild*

Uses In DR Congo and Tanzania the roots are used as emetic. The seeds are used in arrow poisons. In Tanzania a root infusion is applied to skin diseases and wounds, and it is taken orally, mostly together with other plants, as emetic and anthelmintic, whereas the vapours are inhaled against fever. Children are bathed in a root decoction to combat fever. Young twigs are chewed against the effects of snakebites. The soft leaves are sometimes used as toilet paper for babies.

Properties As in many *Strophanthus* species, a complex mixture of cardiac glycosides (cardenolides) is present in *Strophanthus eminii*, and the seeds contain the highest concentration. The main glycosides isolated from the seeds are emicymarin and periplocymarin, which have periplogenin as aglycone, cymarin with strophanthidin as aglycone, and cymarol with strophanthidol as aglycone. Ledienoside, with periplogenin as aglycone, has been isolated as a minor compound, and was previously found in *Strophanthus ledienii* Stein. When used as an arrow poison, these glycosides cause the heart of the prey animal or victim to arrest in systole.

Adulterations and substitutes If the seeds of *Strophanthus eminii* are supplied within the fruit, there is no chance of adulteration or substitution, as the fruits are unique within the genus, with the characteristic dense and long fruit wall protuberances. The seed on its own, though, can be confused with many other *Strophanthus* species.

Description Shrub or small tree up to 7 m tall or liana up to 10 m long, with clear, white or yellow exudate; stem up to 6 cm in diameter; bark grey or brown; branches sometimes fleshy, sparsely lenticellate, grey or brown. Leaves decussately opposite, simple and entire; stipules absent; petiole 1–10 mm long; blade ovate to elliptical, 6–24 cm × 4–18 cm, base cuneate or rounded, apex acute to acuminate, papery or leathery, densely hairy on both sides. Inflorescence a dichasial cyme, axillary on long or short leafless branches, congested, 1–12-flowered; peduncle 0–4 mm long; bracts ovate to elliptical, 4–15 mm long. Flowers bisexual, regular, 5-merous, fragrant; pedicel 1–8 mm long; sepals free, ovate or narrowly ovate, 11–25 mm long, acute; corolla tube 17–26 mm long, widening between 50–75% of its length into a cup-shaped upper part, pubescent outside, glabrous or short-hairy inside, outside pink with white, turning red, inside white, turning yellow with red spots and streaks, co-



Strophanthus eminii – 1, flowering branch; 2, fruit, one follicle removed; 3, seed.
Redrawn and adapted by Iskak Syamsudin

rona lobes subulate, 2.5–6.5 mm long, acute or obtuse, fleshy, papillose, red or purple, corolla lobes ovate, gradually narrowing into a narrow, spreading tail, lobes including the tail 94–180 mm long, hairy outside, glabrous inside, white and turning yellow, the tails orange, turning red; stamens inserted at 9.5–14 mm from the base of the corolla tube, just exserted or just included; ovary half-inferior, 2-celled, style 11–18 mm long, ending in a ring-like pistil head surrounding the minute stigma. Fruit consisting of 2 narrowly ellipsoid follicles 20–38 cm × 1.5–3 cm, tapering into an obtuse apex or knob, 2-valved, divergent at 180°, wall thick, densely set with 4–18 mm long hairy protuberances, many-seeded. Seeds spindle-shaped, 11–24 mm × 2.5–5 mm, densely pubescent, at apex with a long beak up to 11 cm long, glabrous in lower half, upper half with long hairs up to 11 cm long.

Other botanical information *Strophanthus* comprises 38 species, of which 30 occur in continental Africa, 1 in Madagascar and 7 in Asia, from India to South-East Asia.
Several *Strophanthus* species related to *Strophanthus eminii* have similar uses. *Strophanthus holosericeus* K.Schum. & Gilg is a deciduous liana from south-eastern DR Congo and northern Zambia; its seeds are used as arrow poison and ordeal poison. *Strophanthus mirabilis* Gilg is a small shrub occurring in Somalia and Kenya; the seeds are used as ordeal poison and the roots are considered edible when cooked. *Strophanthus nicholsonii* Holmes is a shrub occurring in Malawi, Zambia, Zimbabwe and Mozambique; the seeds are used as a hunting poison and ordeal poison.

Growth and development *Strophanthus eminii* flowers at the end of the dry season and the beginning of the rainy season, with the flowers appearing before or together with the leaves. Mature fruits are found in the dry season.

Ecology *Strophanthus eminii* occurs in deciduous woodland or *Acacia-Commiphora* bushland, especially in rocky localities, at 600–1650 m altitude.

Genetic resources As *Strophanthus eminii* is distributed over a fairly large area in common habitats, it is not threatened by genetic erosion.

Prospects If pharmacological interest in *Strophanthus* is revived, it might be worth investigating the pharmacological potential of *Strophanthus eminii*, as it is chemically similar to better-known species, e.g. *Strophanthus hispidus* DC. and *Strophanthus kombe* Oliv. Because of its beautiful flowers, *Strophanthus eminii* would make an interesting ornamental.

Major references Beentje, 1982; Neuwinger, 1996; Neuwinger, 2000.

Other references Beentje, 1994; Githens, 1948; Kokwaro, 1993; Lardon, 1950; Von Euw & Reichstein, 1948; Watt & Breyer-Brandwijk, 1962; Zelnik & Reichstein, 1957.

Sources of illustration Beentje, 1982.

Authors H.J. Beentje

STROPHANTHUS GRATUS (Wall. & Hook.) Baill.

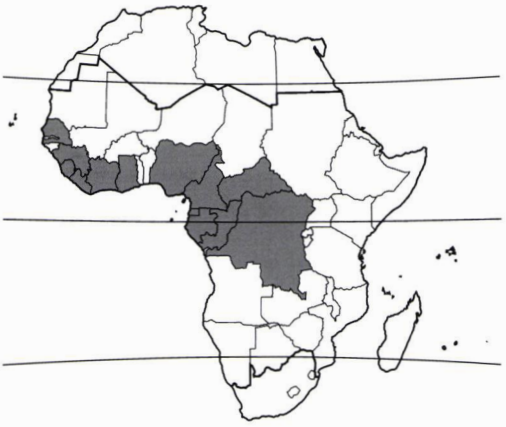
Protologue Hist. pl. 10: 171 (1889).

Family Apocynaceae

Chromosome number $2n = 18$

Vernacular names Spider tresses, poison arrow vine (En). Strophanthus glabre du Gabon (Fr). Estrofanto (Po).

Origin and geographic distribution *Strophanthus gratus* occurs in the forest area of West Africa and western Central Africa, from Senegal east to south-western Central African



Strophanthus gratus – wild

Republic and north-western DR Congo and south to Gabon.

Uses Seeds of *Strophanthus gratus* are very toxic and have been used extensively in the preparation of arrow poison throughout its distribution area. The seeds are mostly ground with the sticky plant juice and the arrow tip is dipped into the mixture. In the rainforest area of Central Africa, the stem bark or roots are used similarly; they are often mixed with other plant products, especially the latex of *Periploca nigrescens* Afzel., but also of *Rauvolfia* spp. Game wounded by a poisoned arrow dies quickly, and the flesh can be eaten without problem, although the flesh immediately surrounding the wound is discarded. The seeds are also used as fish poison. In southern Nigeria *Strophanthus gratus* is cultivated by hunters for the seeds.

A leaf and stem decoction is taken in Sierra Leone and Côte d'Ivoire to treat gonorrhoea. In Ghana a decoction of bark is taken to treat weakness, and a leaf paste is applied to snakebites. In Côte d'Ivoire, Ghana and Nigeria a leaf paste is put onto sores, including guinea worm sores. In Nigeria a leaf infusion is taken to treat constipation, and is rubbed on the body to cure fever. A root decoction is said to be an aphrodisiac.

The glycoside ouabain is extracted from the seed ('Semen strophanthi') and used in a number of pharmaceuticals in several European countries, especially in Germany, as a rapid cardiac and vascular stimulant.

In West Africa the plant has many magic uses, e.g. as a good luck charm. *Strophanthus gratus* is widely planted in gardens in the tropics and in greenhouses in the temperate zones as an ornamental.

Production and international trade *Strophanthus gratus* is locally cultivated in Nigeria, Cameroon and Gabon, mainly for export to Europe. In the early 1990s, 2700 t/year of *Strophanthus* fruit were licensed for export from Cameroon; much of this would be *Strophanthus gratus*.

Properties A large number of cardiac glycosides (cardenolides) have been isolated from *Strophanthus gratus*. The seeds contain the highest concentration of glycosides characterized by highly oxygenated aglycones. They have no smell but are extremely bitter. The seeds contain 4–8% of a glycoside mixture with predominantly ouabagenin as aglycone: 90–95% is ouabain (g-strophanthin), followed by acolongifloroside K, and strogoside, which has strogogenin as aglycone. Minor components with different aglycones are sarnovide and several sarmentosides. The leaves also contain the lignans pinoresinol, 8-hydroxypinoresinol and olivil.

Strophanthus gratus fulfils all conditions for a perfect hunting poison: extremely high toxicity, fast and sure effect, unusually high concentrations of the active principle in the seeds, and very easily water-soluble and thus easily extracted from the seed. Acolongifloroside K is comparable to ouabain in its toxic properties; strogoside is less toxic. The sarmentosides are highly toxic but because of their very low concentration they play only a small role.

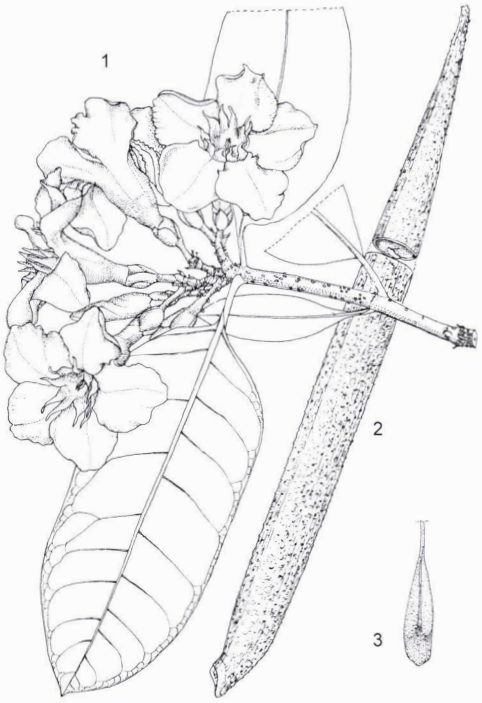
In medicine, ouabain is used as a remedy for congestive heart failure, like digitalis glycosides. Congestive heart failure is a disease characterized by impaired blood circulation, due to a decrease in the force with which the heart muscle contracts. Cardiac glycosides such as ouabain have a direct cardiotonic action on the myocardium, resulting in an increase in the force of contraction. The increased contractility is caused by inhibition of the membrane-bound enzyme Na^+K^+ATPase, leading to an increase in the intracellular stores of calcium. When the cardiac glycoside is given to a patient suffering from congestive heart failure, the stroke volume of the heart is increased, causing a more effective emptying of the ventricles, and a lowering of the diastolic pressure. In higher doses, cardiac glycosides have a direct inhibiting action on atrioventricular conduction together with a decrease of the heart rate, and are especially employed in the treatment of atrial flutter and atrial fibrilla-

tion. The effects of cardiac glycosides are particularly dramatic in patients suffering from a combination of congestive heart failure and atrial fibrillation. When ouabain is applied, its actions are of rapid onset, but of short duration; furthermore, there is little risk of accumulation. It is mainly administered by injection, because it is poorly absorbed orally, contrary to digitalis glycosides. Its major disadvantage is its narrow therapeutic range, which is the margin between the therapeutically effective and toxic doses. Toxic effects include vomiting and convulsions, while larger doses lead to cardiac arrest and death, which explains its success as arrow poison. Ouabain has recently been identified as a steroid hormone in mammals. A remarkable interaction occurs between ouabain and reserpine obtained from *Rauvolfia* spp. Pretreatment with reserpine reduces the toxicity of ouabain, while simultaneous treatment increases it. This may well explain the success of the mixture in hunting poisons.

Leaves of *Strophanthus gratus* are a folk medicine against snakebite in Africa. Aqueous leaf extracts show a dose-related delay of clotting of blood in animals treated with a standardized dose of venom of the saw-scaled viper (*Echis carinatus*). This venom causes rapid intra-arterial clotting of blood, resulting in death in small animals, while death in larger animals and in man occurs as a result of depletion of fibrinogen reserves and internal haemorrhage. Preliminary tests found a novel activity for ouabain that could prove relevant to the treatment of metastatic prostate cancer. The compound induces programmed cell death in androgen-independent human prostate cancer cell lines in vitro.

Adulterations and substitutes The seeds of *Strophanthus gratus* are often mixed with those of *Strophanthus hispidus* DC.; both contain toxic and bio-active glycosides, though in different proportions. Ouabain is also found in the wood and bark of *Acokanthera schimperi* (A.DC.) Schweinf., a famous arrow-poison plant from East Africa. *Digitalis* glycosides are used as a remedy for congestive heart failure, in the same way as ouabain.

Description Liana up to 25 m long or less often a shrub, with clear or white exudate; stem up to 10 cm in diameter, in older plants often with corky ridges; branches with many lenticels, dark brown to purplish brown. Leaves decussately opposite, simple and entire; stipules absent; petiole 5–17 mm long; blade ovate or elliptical to obovate, 5–18 cm × 2–9 cm, base rounded or cuneate, apex acuminate, margins entire, often somewhat revolute, thinly leathery, glabrous. Inflorescence a terminal dichasial cyme, on long or short branches or in the forks, congested, few- to many-flowered; peduncle 0–6(–15) mm long; bracts ovate or triangular, 2–9 mm long. Flowers bisexual, regular, 5-merous, fragrant; pedicel 4–13 mm long; sepals free, unequal, obovate or broadly obovate, 7–18 mm long, emarginate, rounded or apiculate; corolla tube 25–45 mm long, widening at 33–55% of its length into a cylindrical upper part, at the mouth 13–22 mm wide, glabrous outside, papillose or slightly scabrid near the apex, white and turning yellow near the base outside, reddish or purple near the mouth outside, white and red- or purple-streaked inside, corona lobes 10, subulate or narrowly triangular, 5–15 mm long, with acute tip, fleshy, hairy or almost glabrous, pink, turning purple, corolla lobes orbicular, 14–35 mm × 15–32 mm, apex emarginate or rounded and apiculate, glabrous on both sides,



Strophanthus gratus – 1, flowering branch; 2, follicle, with middle section removed; 3, seed, with part of beak and tuft of hairs removed. Redrawn and adapted by Iskak Syamsudin

white often with a stripe of purple on the right side outside, turning reddish or purple all over, white and turning yellow inside; stamens inserted at 14–21 mm from the base of the corolla tube, exserted; ovary half-inferior, 2-celled, style 16–22 mm long, ending in a ring-like pistil head surrounding the minute stigma. Fruit consisting of 2 ellipsoid follicles 23–41 cm × 3–4.5 cm, tapering into a narrow and obtuse apex and ending in a large knob, 2-valved, divergent at 180°, wall thick and hard, slightly grooved, glabrous, with many lenticels, many-seeded. Seeds spindle-shaped, 12–20 mm × 2.5–4.5 mm, glabrous, slightly rough, at apex with a long beak up to 6 cm long, in upper 2.5–4.5 cm with long hairs up to 13 cm long. Seedling with epigeal germination; cotyledons elliptical to obovate, 17–25 mm long, apex rounded.

Other botanical information *Strophanthus* comprises 38 species, of which 30 occur in continental Africa, 1 in Madagascar and 7 in Asia, from India to South-East Asia.

Only 2 other *Strophanthus* spp. contain the important compound ouabain, *Strophanthus thollonii* Franch. and *Strophanthus sarmentosus* DC., but only traces.

Growth and development *Strophanthus gratus* possibly flowers throughout the year in humid parts of West Africa, but with a peak in November–December. In areas with distinct dry and rainy seasons, it flowers towards the end of the dry season and the beginning of the rainy season; fruits are mature in the dry season. *Strophanthus gratus* is an obligate cross pollinator. Fruit maturation takes about 1 year.

Ecology *Strophanthus gratus* occurs in primary and secondary moist forest, often at forest margins or on river banks, from sea-level up to 650 m altitude.

Propagation and planting The 1000-seed weight of *Strophanthus gratus* is 20–30 g. Under glasshouse conditions in temperate climates ripewood cuttings are rooted in early spring in moist sand in a closed case with bottom heat. *Strophanthus gratus* should preferably be grown in full light in a fertile, moist but well-drained loam rich in organic matter and with additional leaf mould.

Management Domestication of *Strophanthus gratus* is being attempted at the Plantecam compound at Mutengene, Cameroon. Plants grow subspontaneously around Pygmy villages in western Cameroon. *Spondias* trees are sometimes used as support.

Handling after harvest Before exportation the tuft of hair is often removed from the seed. However, the preferred method for exporting seed is inside the fruit and with the tuft of hairs attached, to limit adulteration. For arrow-poison use, almost mature fruits are kept in a pot until they open. The seeds are then cleaned by removing the tuft of hair by stirring or burning, and they are roasted to preserve their chemical properties by destroying the enzyme, which can convert the glycosides into biologically inactive compounds when the seeds are stored for a long time or become damp.

Genetic resources Because of its wide distribution, *Strophanthus gratus* is not threatened by genetic erosion. No concerted efforts to conserve genetic resources or breeding programmes are known.

Prospects At present in medicine, cardiac glycosides are only applied in special cases, e.g. the combination of congestive heart failure and atrial fibrillation. In the Western world, the drug of choice is in general digoxin (from *Digitalis lanata* Ehrh.), but in acute situations ouabain is often preferred. At present ouabain is only applied to treat acute congestive heart failure combined with atrial fibrillation. Given its toxicity it is unlikely that it will become of more general use.

Major references Beentje, 1982; Burkill, 1985; Hendrian, 2001a; Neuwinger, 1996.

Other references Burkill, 2000; Cowan et al., 2001; Geiger, Weiss & Reichstein, 1967; Houghton & Skari, 1994; Jäger et al., 1965; McConkey et al., 2000; Neuwinger, 2000; Schoner, 2002.

Sources of illustration Beentje, 1982.

Authors H.J. Beentje

STROPHANTHUS HISPIDUS DC.

Protologue Bull. Sci. Soc. Philom. Paris 3: 123, t. 8 (1802).

Family Apocynaceae

Chromosome number $2n = 18$

Vernacular names Poison arrow vine, brown strophanthus, hairy strophanthus (En).

Origin and geographic distribution *Strophanthus hispidus* occurs from Senegal east to the Central African Republic, DR Congo, Uganda and western Tanzania and south to northern Angola.

Uses In the savanna zone of West Africa the latex and seeds of *Strophanthus hispidus* have been used mostly to make arrow poison; the plant has locally been cultivated for this pur-



Strophanthus hispidus – wild

pose and for trade, and remnants of small plantations still exist. The seeds are usually pounded together with other poisonous plant or animal parts and the liquid evaporated to obtain a sticky mass. Because of their great toxicity, the seeds are not used in traditional medicine. Decoctions of the roots or sometimes of the pulped root bark, stem bark or leaves are used externally to treat skin diseases, leprosy and ulcers, and internally to treat parasites, malaria, dysentery and gonorrhoea. A decoction of the bark or leaf sap is taken against the effects of snakebites. In Guinea the sap from crushed leaves or young shoots is applied to kill head-lice and other parasites. A decoction of the bark is dripped into the eye to treat conjunctivitis. In Nigeria and Ghana a leaf and stem decoction is taken as a laxative or to treat fever, and is externally applied to sores. A root decoction is taken to treat rheumatic afflictions. In Togo beer with root bark macerate and potassium carbonate, sometimes mixed with other plants, is taken to treat oedema.

Nowadays, the glycosides extracted from the seeds ('Semen strophanthi') are used in a number of medicines in several European countries, the United States, Argentina and Chili as a rapid cardiac and vascular stimulant.

In south-western Burkina Faso the young leaves are made into a tasty sauce, which is also restorative. The stems stripped from their bark are used in Nigeria for the end pieces of reed screens, and for cotton-carding bows.

Production and international trade *Strophanthus* seeds are exported to Europe and the United States. In Germany the seeds of *Strophanthus hispidus* are preferred because their purity can be tested easily. The British, French and Swiss officially favour *Strophanthus kombe* Oliv., while the United States Pharmacopoeia recognizes both.

Properties A large number of cardiac glycosides (cardenolides) have been isolated from *Strophanthus hispidus*. These glycosides, collectively called strophanthins, are most abundant in the seed and are responsible for the activity in arrow poison as well as cardiac and vascular stimulant. In comparison with *Digitalis* cardenolides, they are characterized by highly oxygenated aglycones.

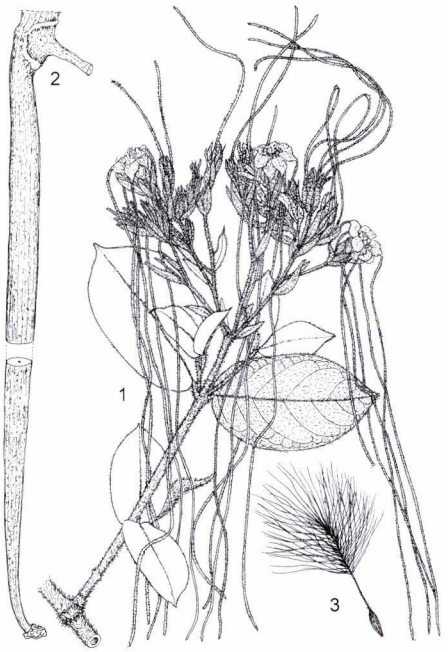
The seeds of *Strophanthus hispidus* contain 4–8% of a glycoside mixture, mainly with strophanthidin as aglycone: cymarin (k-strophanthin-α) and k-strophanthoside (k-strophanthin-γ). Minor components have as aglycones strophanthidol and periplogenin. Used as arrow poison, these glycosides cause the heart to arrest in systole. The sole official use of *Strophanthus* drugs in medicine is for their influence on the circulation, especially in cases of chronic heart weakness. As the action is similar to that of *Digitalis* glycosides, although more likely to cause digestive disturbances and diarrhoea, *Strophanthus* drugs are often useful as an alternative or adjuvant. Some believe that *Strophanthus* glycosides have a direct stimulating effect upon the kidney and are superior to *Digitalis* glycosides as a diuretic, but the evidence in favour of this view is far from convincing. While they possess some local anaesthetic powers, they are so highly irritant that it is not practical to use it for this effect.

An aqueous leaf extract showed a dose-related delay of blood clotting due to the venom of the saw-scaled viper (*Echis carinatus*), thus inhibiting the effect of its bite. This venom causes rapid intra-arterial clotting of blood, resulting in death in small animals, while death in larger animals and in man occurs due to depletion of fibrinogen reserves and internal haemorrhage. Extracts of *Strophanthus hispidus* showed significant anti-inflammatory activity against acute inflammation.

The extracts of both the roots and leaves showed in-vitro inhibition of the bacteria *Escherichia coli*, *Klebsiella pneumoniae*, *Neisseria gonorrhoeae*, *Proteus mirabilis*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Streptococcus pyogenes*. Strains of the pathogens with laboratory induced resistance against certain antibiotics were also sensitive to the aqueous and ethanolic extracts of *Strophanthus hispidus*.

Adulterations and substitutes The seeds of *Strophanthus sarmentosus* DC. are commonly used in the savanna zone of West Africa for arrow poison, but usually in regions where *Strophanthus hispidus* is rare or absent. In the forest regions, *Strophanthus gratus* (Wall. & Hook.) Franch. is preferred over *Strophanthus hispidus*, also because the last species grows very high into the trees, where the fruits are inaccessible. The Mongo people of DR Congo prefer the similarly highly cardiotoxic *Periploca nigrescens* Afzel. over *Strophanthus* spp., or use them together to make poison. The seeds of *Strophanthus hispidus* are sometimes adulterated with those of several other *Strophanthus* spp., e.g. *Strophanthus thollonii* Franch. or *Strophanthus gratus*.

Description Deciduous shrub up to 5 m tall or large liana up to 100 m long, with clear, reddish or white exudate; stem up to 6 cm in diameter; bark dark grey; branches with few to many lenticels, dark brown or blackish. Leaves decussately opposite or rarely in whorls of three, simple and entire; stipules absent; petiole 1–5 mm long; blade ovate or elliptical to obovate, 3–15 cm × 1.5–8 cm, base rounded or slightly cordate, apex acuminate, sparsely to densely stiff-hairy. Inflorescence a terminal dichasial cyme, on long or short branches or in the forks, lax or congested, 1–70-flowered; peduncle 1–55 mm long; bracts narrowly ovate or elliptical, 0.5–3 cm long. Flowers bisexual, regular, 5-merous; pedicel 0.5–3 cm long; sepals free, unequal, ovate to linear, 13–35 mm long, acute; corolla tube 11–22 mm long, widening at 54–66% of its length into a cup-shaped upper part, at the mouth 7.5–17 mm wide, hairy on both sides except for the base, white and turning orange, suffused with red near the base, red- or purple-spotted inside, corona lobes tongue-shaped, 1–3 mm long, with rounded tip, fleshy, minutely hairy or scabrous, yellow, reddish or brown-spotted inside, corolla lobes ovate, rather abruptly narrowing into the 1 mm wide pendulous tails, lobes including tails 15–23 cm long, short hairy on both sides, creamy and turning orange on both sides, red- or brown- spotted inside, tails yellow, greenish yellow or reddish; stamens inserted at 7–13 mm from the base of the corolla tube, included; ovary half-inferior, 2-celled, style 7–12 mm long, ending in a ringlike pistil head surrounding the minute stigma. Fruit consisting of 2 ellipsoid follicles 25–50 cm × 1.5–2 cm, tapering into a narrow apex and ending in a large knob, 2-valved, divergent at 200–260°, wall



Strophanthus hispidus – 1, flowering branch; 2, follicle with middle section removed; 3, seed. Redrawn and adapted by Iskak Syamsudin

thick and hard, grooved, hairy or glabrescent, many-seeded. Seeds spindle-shaped, 10–18 mm × 2–3 mm, densely pubescent, at apex with a long beak up to 8 cm long, in upper 2–4.5 cm with long hairs up to 8.5 cm long.

Other botanical information *Strophanthus* comprises 38 species, of which 30 occur in continental Africa, 1 in Madagascar and 7 in Asia, from India to South-East Asia. *Strophanthus hispidus* is closely related to *Strophanthus kombe* Oliv. *Strophanthus mortehanii* De Wild. is chemically related to *Strophanthus hispidus*; it occurs from Cameroon to Gabon and northern DR Congo. In DR Congo the crushed seeds are mixed with the latex of *Periploca nigrescens* Afzel. and used as an arrow poison. *Strophanthus parviflorus* Franch. occurs in Gabon, Congo and northern DR Congo and the seeds are used in Congo to make arrow poison.

Growth and development If pruned regularly, rooted branches will develop in a few years into a thick shrub or small tree, producing more fruits than wild plants. In Ghana *Strophanthus hispidus* is found flowering from February to April (rarely to July), and fruiting

from January to July. In areas with distinct dry and rainy seasons, *Strophanthus hispidus* flowers towards the end of the dry season and the beginning of the rainy season; fruits are mature in the dry season.

Ecology *Strophanthus hispidus* occurs in primary and secondary moist forest, or in woodland on rocky outcrops or in thickets, from sea-level up to 1600 m altitude.

Propagation and planting *Strophanthus hispidus* can be grown from seed or rooted branches. In northern Togo, 1-m-long branches are stuck in the ground; they root quickly.

Management Young plants of *Strophanthus hispidus* need careful watering. Protection from insects and other animals is necessary.

Harvesting Fruits of *Strophanthus hispidus* remain closed longer than those of *Strophanthus sarmentosus*, and thus can be harvested later, which is an advantage as only ripe seeds have maximum activity.

Handling after harvest For arrow-poison use, almost mature fruits are kept in a pot until they open. The seeds are then cleaned by removing the tuft of hair by stirring or burning, and they are roasted to preserve their chemical properties by destroying the enzyme, which converts the glycosides into biologically inactive compounds when the seeds are stored for a long time or become damp.

Genetic resources Because of its wide distribution and its habitat range *Strophanthus hispidus* is not threatened by genetic erosion. No concerted efforts to conserve genetic resources or breeding programmes are known.

Prospects *Strophanthus hispidus* is a source of compounds that are useful in treating heart failure and blood circulation disorders. The biotransformation abilities of *Strophanthus* plant cell and tissue cultures may provide new, more effective and safer cardiac glycosides useful in the pharmaceutical industry. Because of its easy growth and beautiful flowers, *Strophanthus hispidus* would make an interesting ornamental plant.

Major references Beentje, 1982; Burkill, 1985; Ebana, Madunagu & Etok, 1993; Hendrian, 2001a; Neuwinger, 1996; Neuwinger, 2000.

Other references Akah & Nwambie, 1994; Burkill, 2000; Githens, 1948; Houghton & Skari, 1994.

Sources of illustration Beentje, 1982.

Authors H.J. Beentje

STROPHANTHUS KOMBE Oliv.

Protologue Hook.f., Icon. pl. 11: 79, t. 1098 (1871).

Family Apocynaceae

Synonyms *Strophanthus hispidus* DC. var. *kombe* (Oliv.) Holmes (1890).

Vernacular names Kombi (Po). Mchoki (Sw).

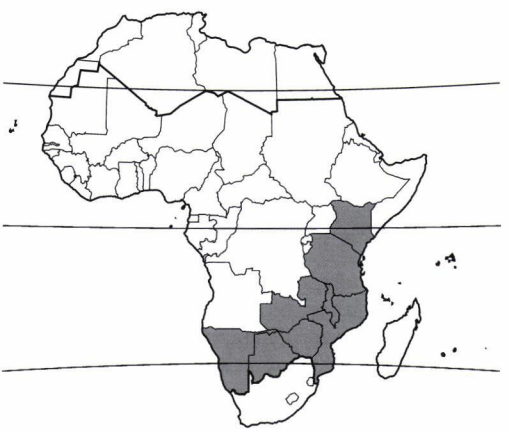
Origin and geographic distribution *Strophanthus kombe* occurs naturally in eastern and southern Africa, from south-eastern Kenya and eastern Tanzania to eastern Namibia (Caprivi Strip), Botswana, Zimbabwe, Mozambique and northern South Africa. It is not planted on a large scale.

Uses The seeds and roots of *Strophanthus kombe* have been used in the preparation of arrow poison since prehistoric times throughout the species' range. Game wounded by a poisoned arrow dies quickly, while the flesh can be eaten without ill effect. However, flesh immediately surrounding the wound is usually discarded.

Nowadays, the glycoside mixture from the seeds ('Semen strophanthi') is used medicinally as a heart stimulant. It is used in a number of medicines in several European countries for its influence on blood circulation, especially in cases of chronic heart weakness. The Giriama people of coastal Kenya use the leaves to make a charm used in a cleansing ritual.

Production and international trade Although seeds of *Strophanthus kombe* are exported from Africa, mainly to Europe, but also to the United States and Japan, there are no data on amounts and value.

Properties More than a dozen cardiac gly-



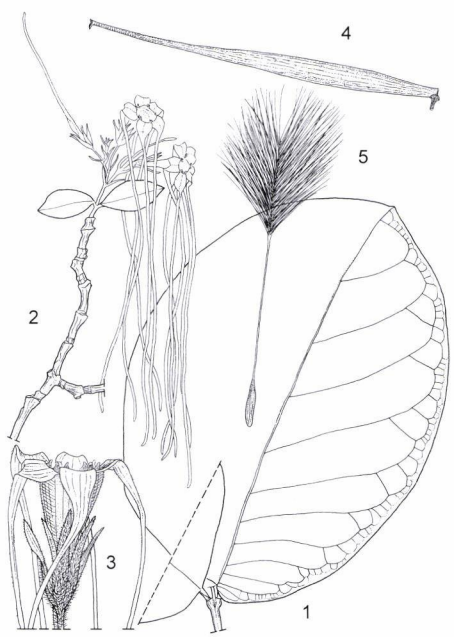
Strophanthus kombe – wild

cosides (cardenolides) have been isolated from *Strophanthus kombe*. Compared to *Digitalis* cardenolides, those of *Strophanthus kombe* are characterized by highly oxygenated aglycones. The glycosides are most abundant in the seed and are responsible for the activity as arrow poison and as cardiac and vascular stimulant. The seeds contain about 4 g/100 g of a mixture of glycosides called strophanthin-K. It is a whitish, crystalline powder which is freely soluble in water, and is readily hydrolyzed into genins and sugars when warmed in acidic conditions. The composition of the mixture varies, but has as major component k-strophanthoside (k-strophanthin-γ). Other glycosides in the mixture, based on the aglycone strophanthidin, are cymarin (k-strophanthin-α), k-strophanthin-β, erysimoside and helveticoside (erysimotoxin). Minor components with periplogenin as aglycone are periplocymarin, periplocin and emicymarin; minor components with strophanthidol as aglycone are cymarol, k-strophanthol-β, k-strophanthol-γ, helveticosol and erysimosol. All compounds are highly toxic. The seeds of *Strophanthus kombe* provide the precursor for the semi-synthetic compound acetylstrophanthidin, which is of clinical interest because of its rapid onset of vascular stimulant action when administered intravenously. The roots and fruits also contain considerable amounts of cardiac glycosides, while the leaves contain mainly resin.

k-Strophanthin-β has a similar effect as ouabain (from *Strophanthus gratus* (Wall. & Hook.) Baill.) or *Digitalis* glycosides and causes a positive inotropic effect and electrophysiological changes in the heart by inhibiting the membrane-bound Na^+-K^+-ATPase pump responsible for Na^+-K^+ exchange. It should be used with great care and under strict medical direction because of its strength and narrow pharmaceutical range. It may cause intense local irritation when administered by hypodermic injection. In urgent cases, the effects upon circulation can be obtained almost immediately by means of intravenous injection. It has stronger diuretic properties than other cardiac glycosides, which is of value in cases complicated by oedema, but is also more likely to cause digestive disturbances

Adulterations and substitutes It is likely that the seeds of several *Strophanthus* species are sometimes mixed before they are exported. *Strophanthus courmontii* Sacleux ex Franch., *Strophanthus eminii* Asch. & Pax and *Strophanthus nicholsonii* Holmes, all from more or less the same region as *Strophanthus kombe*, have seeds which resemble those of the latter and are probably mixed with them in trade.

Description Deciduous shrub up to 3.5 m tall or liana up to 20 m long, with clear, white or yellow exudate, roots thick and fleshy, necklace-shaped; stem up to 10 cm in diameter; bark reddish brown or grey-brown; branches with few to many lenticels, dark brown, dark grey or black. Leaves decussately opposite, simple and entire; stipules absent; petiole 1.5–5 mm long; blade ovate or elliptical, less often obovate or nearly orbicular, 8–23.5 cm × 5–16.5 cm, base cuneate, rounded or slightly cordate, apex obtuse, acute or acuminate, papery, in young leaves densely hairy on both sides, in older leaves glabrescent above. Inflorescence a rather congested terminal dichasial cyme, on short branches or in the forks, 1–12-flowered; peduncle 2–14(–25) mm long; bracts linear or narrowly obovate, 5–23 mm long. Flowers bisexual, regular, 5-merous, fragrant; pedicel 3–14(–20) mm long; sepals free, slightly unequal, narrowly ovate or linear, 9–20(–27) mm long, acute; corolla tube 13–24 mm long, widening at 45–66% of its length into a cup-shaped upper part, at the mouth (6–)8–14 mm wide, densely



Strophanthus kombe – 1, mature leaf; 2, flowering branch; 3, flower; 4, fruit, one follicle removed; 5, seed.
Redrawn and adapted by M.M. Spitteler

hairy outside except for the base, sparsely hairy inside except for the base, white turning yellow on both sides, red-spotted and -streaked inside, corona lobes tongue-shaped, 1–3 mm long, rounded, fleshy, minutely hairy, yellow and pink-spotted, the pink turning purple, corolla lobes ovate, gradually or rather abruptly narrowing into the 1 mm wide pendulous tails, lobes including the tail 10–16(–20) cm long, hairy except for the inner side of the tails, white and turning yellow, tails yellow; stamens inserted at 7–12 mm from the base of the corolla tube, included; ovary half-inferior, 2-celled, style 6.5–13.5 mm long, ending in a ringlike pistil head surrounding the minute stigma. Fruit consisting of 2 ellipsoid follicles 15–47 cm × 1.5–2.5 cm, tapering towards the apex and ending in a small or large knob, 2-valved, divergent at 180°, wall thick and hard, densely hairy in young fruits but glabrescent when maturing, many-seeded. Seeds spindle-shaped, 11–21 mm × 2.5–4.5 mm × 1.5 mm, densely hairy, at apex with a long beak up to 10 cm long, glabrous in lower half, upper half with long hairs, top including the hairs up to 8 cm long. Seedling with epigeal germination; cotyledons elliptical or ovate, obtuse at apex, glabrous; first leaves resembling leaves of mature plants but usually narrower.

Other botanical information *Strophanthus* comprises 38 species, of which 30 occur in continental Africa, 1 in Madagascar and 7 in Asia, from India to South-East Asia. Many of these species are used medicinally. *Strophanthus kombe* is closely related to *Strophanthus hispidus* DC. from West and Central Africa, which differs in more widely divergent follicles and wider outer sepals.

Growth and development Flowering of *Strophanthus kombe* occurs towards the end of the dry season and the beginning of the rainy season. Nothing is known about pollinators, although flower structure and colouring suggest butterflies. Fruits mature in the dry season. Seeds are dispersed by wind.

Ecology *Strophanthus kombe* occurs in coastal forest, gallery forest, riparian thickets and woodland, often on inselbergs, from sea-level up to 1100 m altitude.

Management Seeds intended for trade are usually collected from wild plants. As far as is known, *Strophanthus kombe* is not cultivated on a large scale.

Propagation and planting At the Royal Botanic Gardens, Kew, United Kingdom, semi-ripe cuttings are taken in April. Cuttings are dipped into a rooting hormone and then placed in a mist unit in pots containing a coir and perlite mix, at a temperature of 25°C and relative humidity of 80%. When they have rooted, after about 4 weeks, they are potted up.

Handling after harvest In preparing the arrow poison, the seeds are pounded to a pulp after removal of the tuft of hairs. An adhesive is added (e.g. *Euphorbia* latex or saliva), the mixture is sometimes exposed to strong sunlight for some hours, and subsequently smeared along the point of the arrow.
Strophanthus seeds should be preserved in tightly closed containers, and a few drops of chloroform or carbon tetrachloride should be added from time to time to prevent insect attack. The drug is extracted with absolute alcohol, the oil is removed from the percolate with petroleum ether, and the glycosides are subsequently converted into strophanthidin by boiling with hydrochloric acid.

Genetic resources There are no indications that *Strophanthus kombe* is at risk of genetic erosion. Large germplasm collections of *Strophanthus kombe* do not exist. As the glycoside concentration differs per population, variability studies are needed to evaluate this.

Prospects *Strophanthus kombe* is a source of compounds that are useful in treating heart failure and blood circulation disorders. The use of strophanthin-K, k-strophanthin-β and acetylstrophanthidin is likely to continue, but the use of strophanthins as cardiac medicine had its peak from 1950 to 1970 and has declined since. The biotransformation abilities of *Strophanthus* plant cell and tissue cultures may provide new, more effective and safer cardiac glycosides.

Major references Beentje, 1982; Grosa, Allegrone & Del Grosso, 2005; Kawaguchi, Hirotani & Furuya, 1993; Neuwinger, 1996.

Other references Beentje & Cooke, 2000; Gelfand et al., 1985; Pakia & Cooke, 2003b; van Wyk & Gericke, 2000; Williamson, 1955.

Sources of illustration Beentje, 1982.

Authors H.J. Beentje

STROPHANTHUS PETERSIANUS Klotzsch

Protologue Peters, Naturw. Reise Mossambique 6(1): 276 (1861).

Family Apocynaceae

Vernacular names Mvariso (Sw).

Origin and geographic distribution *Strophanthus petersianus* occurs in East and

southern Africa, from southern Kenya to Zimbabwe, Mozambique and eastern South Africa.

Uses Throughout its distribution area, the seeds of *Strophanthus petersianus* are used to make arrow poison. In general poison makers do not discriminate between the *Strophanthus* species growing in their area. *Strophanthus petersianus* is used by Zulu herbalists in South Africa as a charm against evil.

Properties From the seeds the cardiac glycoside (cardenolide) sarmentocymarin and its aglycone sarmentogenin has been isolated. Panstroside has been found in seeds from Malawi. The whole plant gave a positive test for haemolysis.

Botany Deciduous shrub or liana up to 15 m long, with white or reddish exudate; stem up to 10 cm in diameter; bark pale grey; branches usually glabrous, with corky flattened triangular protuberances up to 2.5 cm high at the nodes. Leaves decussately opposite, simple and entire; stipules absent; petiole 2–13 mm long; blade elliptical to ovate, 3–11 cm × 1.5–5 cm, base cuneate to rounded, apex acuminate, glabrous. Inflorescence a terminal dichasial cyme, on long or short branches or in the forks, 1–4-flowered, usually glabrous; peduncle 0–6 mm long; bracts linear or narrowly elliptical, 2.5–11 mm long, deciduous. Flowers bisexual, regular, 5-merous, fragrant; pedicel 1–7.5 mm long; sepals free, unequal, ovate or narrowly elliptical, 5–21 mm long, acute; corolla tube 15–35 mm long, widening at 20–40% of its length into a cup-shaped upper part, at the mouth 10–30 mm wide, glabrous outside, short-hairy inside, white turning yellow near the base and purplish near the apex of the tube, yellow and purple-streaked inside, corona lobes narrowly triangular, 6–15 mm long, white, with a purple line in the middle, corolla lobes ovate, narrowing into slender pendulous tails, lobes including the tail 90–205 mm long, undulate, maroon-violet outside, yellow inside; stamens inserted at 6–12 mm from the base of the corolla tube, included, acumen on anther 1–4 mm long; ovary half-inferior, 2-celled, style 7.5–14.5 mm long, ending in a ringlike pistil head surrounding the minute stigma. Fruit composed of 2 ellipsoid follicles 20–37 cm × 2–3.5 cm, tapering into an obtuse apex, 2-valved, divergent at an angle of 180°, wall thick and hard, dark brown, glabrous, with lenticels, many-seeded. Seeds almost spindle-shaped, 10–18 mm long, densely pubescent, at apex with a long beak up to 12 cm long, glabrous for (20–)35–65 mm, upper part with long hairs up to 9 cm long.

Strophanthus comprises 38 species, of which 30 occur in continental Africa, 1 in Madagascar and 7 in Asia, from India to South-East Asia. *Strophanthus petersianus* produces flowers and leaves towards the end of the dry and the beginning of the rainy season. Mature fruits can be found in the dry season.

Ecology *Strophanthus petersianus* occurs in coastal forest and woodland, often on rocky localities, from sea-level up to 1100 m altitude.

Genetic resources and breeding *Strophanthus petersianus* is relatively common in East and southern Africa and is not in danger of genetic erosion.

Prospects *Strophanthus petersianus* has so far mainly been used for making arrow poison and this use is declining rapidly. The effects of sarmentocymarin on cell-proliferative diseases are being studied.

Major references Beentje, 1982; Neuwinger, 1998; Watt & Breyer-Brandwijk, 1962.

Other references Chandra Singh, 2004; Githens, 1948; Omino, 2002.

Authors A. de Ruijter

STROPHANTHUS PREUSSII Engl. & Pax

Protologue Bot. Jahrb. Syst. 15: 369 (1892).

Family Apocynaceae

Vernacular names Spider tresses, poison arrow vine (En).

Origin and geographic distribution *Strophanthus preussii* occurs in the forest area of West and Central Africa, from Sierra Leone east to the Central African Republic, and extending to Uganda and northern Tanzania, and south to southern DR Congo and Angola.

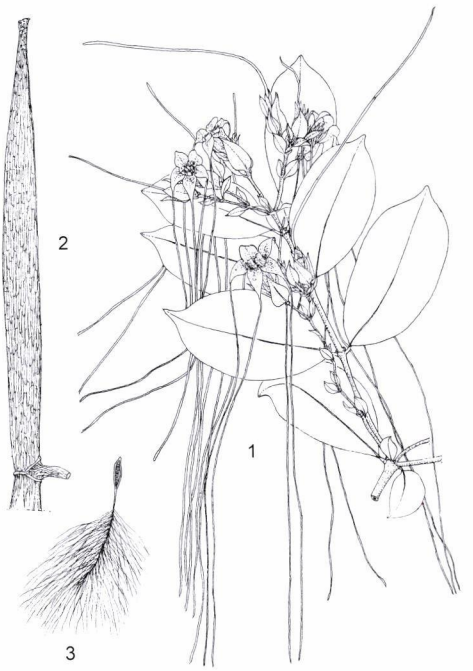


Strophanthus preussii – wild

Uses In Côte d'Ivoire the latex or the young leaves crushed in water are applied to treat gonorrhoea. A leaf decoction is taken to treat post-partum pain in the Central African Republic. In DR Congo the latex is put on sores and wounds to promote healing. The latex or seeds are used in arrow poison mixtures in Liberia and DR Congo, but because they are less toxic than those of *Strophanthus gratus* (Wall. & Hook.) Baill. and *Strophanthus hispidus* DC., they are of second choice. The stems are used to make bows in southern Nigeria. The latex has been used for coagulating *Funtumia* latex in Ghana. In the Central African Republic the fibre is used to make fishing lines, nets and ropes. In Gabon the young leaves are said to be cooked and eaten as a vegetable. *Strophanthus preussii* is sold as an ornamental in the United States, because of its strikingly beautiful flowers with very long corolla tails. The flowering branches are sometimes used as cut-flower.

Properties The seeds of *Strophanthus preussii* are not rich in cardiac glycosides (cardenolides); they contain 0.5–1% glycosides. The glycosides are mainly based on the aglycone periplogenin, with periplocin, periplocymarin and emicymarin as main components. Small amounts of glycosides based on the aglycone strophanthidin are also present. The toxicity of the strongly cardio-active periplocin, periplocymarin and emicymarin is only slightly less than that of ouabain, a well-known compound found in other *Strophanthus* spp., especially *Strophanthus gratus*.

Description Evergreen liana up to 12 m long or less often a shrub up to 5 m tall, with clear or white exudate, stem up to 2.5 cm in diameter; branches with few to many lenticels, reddish to purple-brown. Leaves decussately opposite, simple and entire; stipules absent; petiole 2–9(–14) mm long; blade ovate or elliptical to slightly obovate, 2–18.5 cm × 1.5–7.5 cm, base cuneate, rounded to rarely slightly cordate, apex acuminate, papery or thinly leathery, glabrous. Inflorescence a terminal dichasial cyme, on long or short branches or in the forks, lax, few- to many-flowered; peduncle 0–24 (–35) mm long; bracts ovate or orbicular to obovate, 4–20 mm long, sometimes deciduous. Flowers bisexual, regular, 5-merous, fragrant; pedicel 4–25 mm long; sepals free, unequal, ovate to narrowly ovate or linear, 4–25 mm long, acute or obtuse; corolla tube 12–26 mm long, widening at 40–66% of its length into a cup-shaped upper part, at the mouth 7–17 mm wide, minutely hairy except outside near the base, white turning reddish orange via yellow, outside suffused with pink at the base and with red near the apex, inside red-spotted and -streaked, corona lobes tongue-shaped, 1–2.5 mm long, rounded, fleshy, minutely hairy, yellow turning orange, pink- or purple-streaked, corolla lobes ovate, gradually narrowing into a narrow, spreading tail, lobes including the tail 25–75 mm long, minutely hairy except for the apex, white and with 3 pink lines, the white turning yellow; stamens inserted at 8–14.5 mm from the base of the corolla tube, exserted or included; ovary half-inferior, 2-celled, style 7.5–13.5 mm long, ending in a ringlike pistil head surrounding the stigma. Fruit consisting of 2 ellipsoid follicles (13–)15–29 cm × 1–3 cm, tapering into a narrow obtuse apex, or with a small or large knob, 2-valved, divergent at 160–190°, wall rather thick and hard, slightly or conspicuously grooved, glabrous, with many elongated lenticels, many-seeded. Seeds spindle-shaped, 12–20 mm × 2–3.5 mm, densely hairy, at apex with a long beak up to 6 cm long, glabrous for 3–8 mm in basal part and in upper part with long



Strophanthus preussii – 1, flowering branch; 2, fruit, one follicle removed; 3, seed.
Redrawn and adapted by Iskak Syamsudin

hairs up to 10 cm long.

Other botanical information *Strophanthus* comprises 38 species, of which 30 occur in continental Africa, 1 in Madagascar and 7 in Asia, from India to South-East Asia. *Strophanthus preussii* is related to *Strophanthus barteri* Franch. and *Strophanthus gracilis* K.Schum. & Pax. *Strophanthus barteri* is a slender liana from the forest area of West Africa and western Central Africa. In Ghana the stem bark in decoction is taken to treat diarrhoea, a use supported by pharmacological tests. In Côte d'Ivoire it is becoming rare because of overharvesting. *Strophanthus gracilis* occurs from Nigeria to Gabon, in coastal and riverine forest. The seeds and latex are used in arrow and fish poisons. It has a high content of cardiac glycosides.

Growth and development *Strophanthus preussii* flowers in the dry season and the first part of the long rainy season; fruit ripens in the dry season.

Ecology *Strophanthus preussii* occurs in primary and secondary moist forest, gallery forest, forest margins and clearings, from sea-level up to 1400 m altitude.

Propagation and planting *Strophanthus preussii* can be propagated by seed or by soft wood cuttings.

Management *Strophanthus preussii* grows to a shrub 1–2 m tall when potted. It needs to be kept at a minimum temperature of 25°C, in half-shade. It should be planted in fertile, humus-rich, well-drained soil, and regularly watered. A slightly alkaline soil is preferred. *Strophanthus preussii* may drop its leaves in the cool, dry season.

Harvesting The pods need to dry on the plant before they are harvested and opened to get the seeds.

Genetic resources Because of its wide distribution and its habitat range *Strophanthus preussii* is not threatened by genetic erosion.

Prospects *Strophanthus preussii* will remain of local importance only, as it contains only low levels of glycosides. As an ornamental it is promising.

Major references Beentje, 1982; Burkill, 1985; Neuwinger, 1996.

Other references Burkill, 2000; Neuwinger, 2000; Quarm, 1989; Rosselet & Reichstein, 1953.

Sources of illustration Beentje, 1982.

Authors H.J. Beentje

STROPHANTHUS SARMENTOSUS DC.

Protologue Bull. Sci. Soc. Philom. Paris 3: 123, t. 8, fig. 1 (1802).

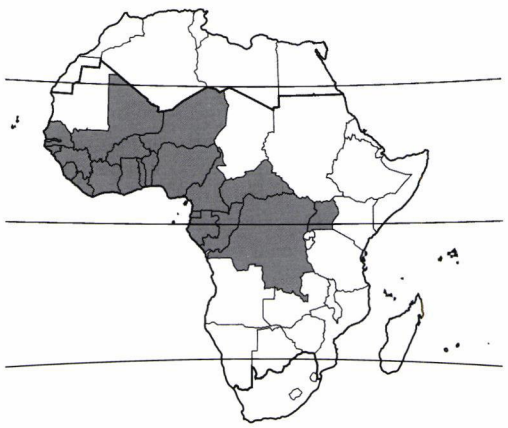
Family Apocynaceae

Chromosome number $2n = 18$

Vernacular names Spider tresses, poison arrow vine (En).

Origin and geographic distribution *Strophanthus sarmentosus* occurs from Senegal east to the Central African Republic, northern DR Congo and southern Uganda, and south to Angola (Cabinda).

Uses In West Africa the seed is used to make arrow poison, especially in the drier parts where *Strophanthus hispidus* DC. is scarce or absent. *Strophanthus sarmentosus* seeds are usually mixed with parts of other plants and boiled in water, after which the decoction is concentrated into a poisonous syrup in which the arrow tips are dipped. The plant enters into local medicine throughout West Africa. In Senegal a root decoction is taken to treat gonorrhoea and leprosy. A macerate of pounded roots is taken on an empty stomach to treat painful joints and hernia. The powdered roots cooked together with the grains of *Digitaria exilis* (Kippist) Stapf are taken to treat flatulence with constipation, without causing painful purging. In Guinea the crushed seeds are applied to the head to kill lice, and in Liberia they are applied to scabies. In Côte d'Ivoire a leaf decoction is used as an eye drop to treat conjunctivitis and trachoma. A decoction of the twigs is taken to treat rheumatoid arthritis, while the leaf sap is drunk and the bark macerate used as an enema to treat venereal diseases. They are considered diuretic and sooth-



Strophanthus sarmentosus – wild

ing. A leaf decoction is taken as emetic and to treat diarrhoea, whereas a root decoction is taken as vermifuge or to restore strength. In Senegal and Côte d'Ivoire the latex is applied to wounds and sores as a cicatrisant. In Senegal the plant is therefore used in circumcision ceremonies. In Benin a leaf decoction mixed with other plants is taken as a remedy against snakebites. In Congo the stems and leaves are used to make steam baths and infusions against rheumatism. In the 1950s a seed extract was used to combat rheumatoid arthritis in the United States and Europe. In Nigeria the stems are used to make bows and the bark to make ropes, hats and mats.

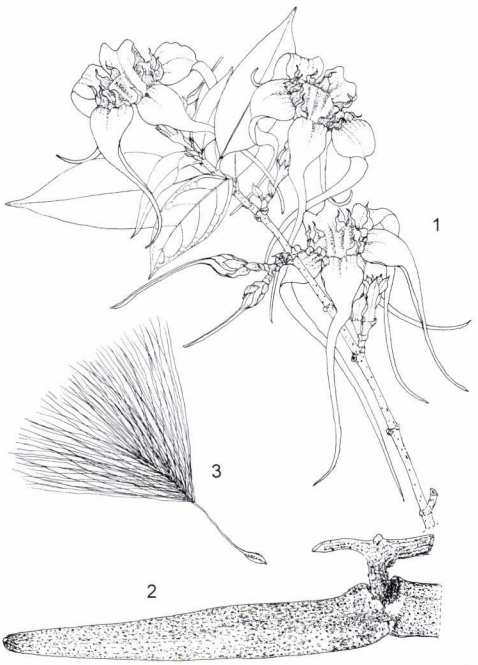
Production and international trade In the early 1950s the fruits of *Strophanthus sarmentosus*, mixed with those of other *Strophanthus* spp., were collected and exported on a large scale from West Africa as raw material for the production of cortisone. Since then, easier methods of making this compound have been found, and collection stopped as quickly as it had started.

Properties The composition of cardiac glycosides (cardenolides) in *Strophanthus sarmentosus* seeds is very variable. Four chemical types are distinguished, based on the weakly polar chloroform-soluble glycosides, of which 2 are widespread. The first type occurs throughout the distribution area of *Strophanthus sarmentosus*, and its main constituents are the sarverogenin glycosides panstroside and sarveroside. The second type occurs only in West Africa, with main constituents the sarmentogenin glycosides sarnovide and sarmentocymarin. The third type is rare and occurs only in southern Mali. Its main constituents are musaroside and sarmutoside, which yield the aglycone sarmutogenin. The fourth type occurs from west Côte d'Ivoire to Sierra Leone and is characterized by a very low level of glycosides, mainly of the aglycone sarverogenin, with sarveroside sometimes replaced by intermedioside. The water-soluble glycosides of the 4 types are strongly polar and so far 18 have been identified. These polar glycosides are mainly derivatives of 7 aglycones of different oxidation states, with as main compounds sarmentoside A, tholloside, sarhamnoloside, locundioside and bipindoside. The seed also contains traces of ouabain. All other plant parts also contain glycosides but except for the latex, only in traces. Most of the isolated glycosides are highly toxic.

Sarmentoside A increased the force and rate of rabbit heart contractions in vitro; this cardioactive property was similar to digoxin, a *Digitalis* glycoside. The aglycone sarmentogenin was used in the 1950s to manufacture cortisone, as it contains a 11-ketocorticosteroid. Cortisone was at that time a new medicine for arthritis and cardiac rheumatism, and it was thought that large amounts were needed to treat patients, but it was later found that doses needed were much lower. Due to the fame of *Strophanthus* for cortisone production, more research into the botany and chemistry was done, especially on other corticosteroids and sex-hormones. As the concentration of sarmentogenin for cortisone production was found to be very variable in the seeds of *Strophanthus sarmentosus*, other methods were developed to obtain 11-ketocorticosteroids more easily from other plant species, e.g. from the sapogenin diosgenin from *Dioscorea* spp., and from hecogenin from *Agave* spp. The demand for the seed of *Strophanthus sarmentosus* then collapsed.

Adulterations and substitutes The seeds of *Strophanthus hispidus* are more commonly used in West Africa for arrow poison than those of *Strophanthus sarmentosus*, except in the dry regions, where the former is rare or absent. In the forest regions, especially east of Cameroon, *Strophanthus gratus* (Wall. & Hook.) Franch. is preferred over *Strophanthus sarmentosus*.

Description Deciduous shrub with long trailing stems or liana up to 40 m long, with clear or white exudate, stem up to 15 cm in diameter; bark pale brown, corky and deeply fissured; branches with many lenticels, dark brown or reddish brown, with many up to 1 cm high corky protuberances. Leaves decussately opposite or in whorls of 3, simple and entire; stipules absent; petiole 2–17(–20) mm long; blade elliptical to ovate, 2–15 cm × 1.5–7 cm, base rounded to cuneate, apex acuminate, margin often undulate or slightly revolute, glabrous. Inflorescence a congested terminal dichasial cyme, on short branches or less often on long branches or in the forks, 1–5(–11)-flowered; peduncle 0–6(–10) mm long; bracts ovate, 4.5–13.5 mm long, sepal-like. Flowers bisexual, regular, 5-merous, fragrant; pedicel 2–12 mm long; sepals free, slightly unequal, ovate to elliptical, 5–20 mm long, acute; corolla tube 15–40 mm long, widening at 22–35% of its length into a cup-shaped upper part, at the mouth 15–30 mm wide, white and turning yellow in the lower part outside, pink and turning purple in the upper part outside, white and



Strophanthus sarmentosus – 1, flowering branch; 2, fruit, one follicle removed; 3, seed. Redrawn and adapted by Iskak Syamsudin

red- or purple-streaked inside, the white turning yellow, corona lobes narrowly triangular and often undulate, 5–22 mm long, tip acute, white, pink-or purple-streaked, the white turning yellow, corolla lobes ovate, 7–20 mm × 6–18 mm, gradually or rather abruptly narrowing into the 1–2.5 mm wide pendulous tail, lobes including the tail 4–14 cm long, white and turning yellow on both sides, outside near the base pink or purple, tails pale yellow; stamens inserted at 7–13.5 mm from the base of the corolla tube, included; ovary half-inferior, 2-celled, style 9–17.5 mm long, ending in a pistil head surrounding the minute stigma. Fruit consisting of 2 ellipsoid follicles 10–28 cm × 1.5–4.5 cm, tapering into a broad and obtuse apex, 2-valved, divergent at 180°, wall thick and hard, glabrous, slightly grooved, with many lenticels, many-seeded. Seeds spindle-shaped, 8–20 mm × 2–4 mm, densely hairy, at apex with a long beak up to 8 cm long, glabrous in lower half, upper half with long hairs up to 10 cm long.

Other botanical information *Strophanthus* comprises 38 species, of which 30 occur in continental Africa, 1 in Madagascar and 7 in Asia, from India to South-East Asia. Two varieties of *Strophanthus sarmentosus* are distinguished, the very common var. *sarmentosus* with shortly hairy flowers and the rare var. *glabriflorus* Monach., restricted to Guinea, with glabrous flowers.

Growth and development *Strophanthus sarmentosus* flowers in the dry season, just before the leaves expand. Fruits mature in the dry season. Cultivated plants have reached ages of over 55 years.

Ecology *Strophanthus sarmentosus* occurs in rain forest, gallery forest and thickets, from sea-level up to 1400 m altitude.

Management Though *Strophanthus sarmentosus* is not cultivated, it is sometimes spared when clearing woodland and tended. Compared to *Strophanthus hispidus*, *Strophanthus sarmentosus* does not grow easily from rooted stems, and produces less fruit in cultivation than in the wild.

Harvesting Fruits are harvested before maturity, as otherwise they open and the seeds disperse.

Handling after harvest For arrow-poison use, the almost mature fruits are kept in a pot until they open. The seeds are then cleaned by removing the tuft of hair by stirring or burning, and they are roasted to preserve their chemical properties by destroying the enzyme, which converts the glycosides into biologically inactive compounds when the seeds are stored for a long time or become damp.

Genetic resources *Strophanthus sarmentosus* has a wide distribution, but is not common. Although it is represented in botanic gardens in both tropical and temperate regions, no concerted efforts to conserve genetic resources or breeding programmes are known.

Prospects The medicinal of use of *Strophanthus sarmentosus* will remain limited unless further studies on the chemical constituents reveal new possibilities. *Strophanthus sarmentosus* can be grown as an ornamental, as it has beautiful flowers, but as propagation is not easy, it will probably remain of minor importance.

Major references Beentje, 1982; Burkill, 1985; Hegnauer, 1964; Neuwinger, 2000.

Other references Arbonnier, 2004; Beentje & Cooke, 2000; Burkill, 2000; Neuwinger, 1996; Owonubi & Iwalewa, 1997.

Sources of illustration Beentje, 1982.

Authors H.J. Beentje

STROPHANTHUS SPECIOSUS (N.B.Ward & Harv.) Reber

Protologue Fortschr. (Genf) 3: 299 (1887).
Family Apocynaceae
Chromosome number $2n = 18$
Vernacular names Common poison rope, forest poison rope (En).
Origin and geographic distribution *Strophanthus speciosus* occurs in Zimbabwe, South Africa and Swaziland.
Uses *Strophanthus speciosus* is used to treat snakebites in humans and cattle. For humans the powdered root is sniffed or the root is chewed and the sap is swallowed, while spoonfuls of roasted pulverized root are given to cattle. It is possibly also used as an arrow poison and for criminal purposes.
Properties From seeds of *Strophanthus speciosus* the cardiac glycosides (cardenolides) strospeside and christyoside have been isolated. Strospeside also occurs in *Adenium* spp.
Botany Shrub up to 4 m tall or liana up to 16 m long, with clear or white exudate; stem up to 3 cm in diameter, branching trichotomously; branches with rather many lenticels, branchlets glabrous. Leaves in whorls of 3, simple and entire; stipules absent; petiole 2–12 mm long; blade narrowly elliptical to slightly obovate, 2–11.5 cm × 1–3.5 cm, base decurrent into the petiole, apex acute or acuminate, margin often slightly revolute, papery, glabrous. Inflorescence a congested terminal dichasial cyme, on long branches or in the trichotomous forks, usually glabrous, few- to many-flowered; peduncle 3–16(–23) mm long; bracts narrowly ovate, 1.5–10.5 mm long, deciduous. Flowers bisexual, regular, 5-merous; pedicel 6–21 mm long; sepals slightly unequal, narrowly ovate, 3–14.5 mm long, acute, with some hairs near the apex or hairy all over; corolla tube 9–14 mm long, widening at 30–50% of its length into a cup-shaped upper part, at the mouth 5.5–11 mm wide, yellow turning orange, outside white near the base, inside red streaked, corona lobes subulate, 2–5 mm × 1–2 mm, acute or obtuse, fleshy, white, corolla lobes ovate, gradually narrowing into the 1–1.5 mm wide spreading tails, lobes including the tail 19–50 mm long, yellow on both sides, with a red spot near the base, tails yellow; stamens inserted at 4–6.5 mm from the base of the corolla tube, included; ovary half-inferior, 2-celled, hairy, style 4–5.5 mm long, ending in a ringlike pistil head surrounding the minute stigma. Fruit consisting of 2 ellipsoid follicles (7–)10–22 cm × 1–1.5 cm, tapering into a narrow apex, 2-valved, divergent at (60–)100–230°, wall thick and hard, glabrous or densely short-hairy, many-seeded. Seeds almost spindle-shaped, slightly flattened, 13–22 mm × 2–4.5 mm, densely hairy, at apex with a beak up to 1.5 cm long, glabrous for 0–2 mm in basal part, in upper part with long hairs up to 4.5 cm long.
Strophanthus speciosus flowers towards the end of the dry and the beginning of the rainy season. Mature fruits occur throughout the year, with a peak in the dry season.
Strophanthus comprises 38 species, of which 30 occur in continental Africa, 1 in Madagascar and 7 in Asia, from India to South-East Asia. Some other species are used in southern Africa for similar purposes as *Strophanthus speciosus*. The latex of *Strophanthus gerrardii* Stapf from southern Mozambique, north-eastern South Africa and Swaziland is used as a spear poison, whereas a fruit in decoction is taken to treat hysteria. *Strophanthus luteolus* Codd from southern Mozambique and north-eastern South Africa has the same uses.
Ecology *Strophanthus speciosus* occurs in forest, often at margins, at (300–)900–1500(–1800) m altitude.
Genetic resources and breeding Like most *Strophanthus* species from the forest, *Strophanthus speciosus* is not common in its distribution area, although not in danger of genetic erosion.
Prospects In traditional medicine *Strophanthus speciosus* is only used to treat snakebites. It will remain of minor importance, unless the effectivity against snake poison is confirmed by research.
Major references Beentje, 1982; Neuwinger, 2000; van Wyk, van Heerden & van Oudtshoorn, 2002; Watt & Breyer-Brandwijk, 1962.
Other references Arnold et al., 2002; Schindler & Reichstein, 1952b.
Authors A. de Ruijter

STROPHANTHUS THOLLONII Franch.

Protologue Journ. Bot. (Morot) 7: 299 (1893).
Family Apocynaceae
Origin and geographic distribution *Strophanthus thollonii* occurs in south-eastern Nigeria, southern Cameroon, the Central African Republic and Gabon.
Uses The Fang people and Bagielli pygmies

in Gabon and Cameroon use the crushed or boiled seeds to prepare hunting poison. The seeds are used alone or together with those of *Strophanthus gratus* (Wall. & Hook.) Baill., or as part of a complex recipe of several plants, snake heads and mushrooms.

Properties A large number of cardiac glycosides (cardenolides) have been isolated from *Strophanthus thollonii*. The seeds contain the highest concentration. Chemically, the water-soluble seed glycosides of *Strophanthus thollonii* are very similar to those of *Strophanthus sarmentosus* DC. The main glycosides isolated are based on 3 aglycones and include sarmentoside A, tholloside, bipindoside, locundioside and sarhamnoloside. They are all highly poisonous. The seeds also contain traces of ouabain.

Botany Evergreen liana up to 20 m long, with clear or white exudate in all parts; stem up to 5 cm in diameter; bark grey; branches with many lenticels, dark maroon-brown or blackish. Leaves decussately opposite, simple and entire; stipules absent; petiole 2–13 mm long; blade narrowly elliptical to obovate, 3–17.5 cm × 1–7.5 cm, base cuneate to decurrent, apex acute to acuminate, margin slightly revolute, leathery, glabrous. Inflorescence a congested terminal dichasial cyme, on long or short branches or in the forks, glabrous, 1–5-flowered; peduncle 0–4 mm long; bracts ovate to narrowly triangular, 1.5–12 mm long, acute, early deciduous. Flowers bisexual, regular, 5-merous, fragrant; pedicel 2–10 mm long; sepals free, unequal, elliptical to narrowly elliptical, 10–26 mm long, acute; corolla tube 24–38 mm long, widening at c. 50% of its length into a cylindrical or cup-shaped upper part, at the mouth 11–22 mm wide, white turning yellow at the base outside, pink and turning purple in the upper part outside, white and red- or purple-streaked inside, the white turning yellow, corona lobes narrowly triangular, 10–27 mm × 2–4 mm, acute, slightly fleshy, sparsely pubescent, pink, turning purple in the centre, with white margins and apex, the white turning yellow, corolla lobes ovate, 18–41 mm × 10–19 mm, acute to slightly acuminate, white and turning yellow inside, dark pink or purple outside; stamens inserted at 15–20 mm from the base of the corolla tube, exserted; ovary half-inferior, 2-celled, style 17–23 mm long, ending in a pistil head surrounding the stigma. Fruit consisting of 2 ellipsoid follicles 18–47 cm × 1.5–2.5 cm, tapering into a narrow apex, 2-valved, divergent at 140–180°, wall rather thin and hard, smooth or slightly grooved, glabrous, with lenticels, dark maroon-brown or blackish purple, many-seeded. Seeds spindle-shaped, 15–24 mm × 2–3 mm, densely short-hairy, at apex with a beak up to 3.5 cm long, glabrous for 1.5–15 mm in basal part, upper part with long hairs up to 4 cm long.

Strophanthus comprises 38 species, of which 30 occur in continental Africa, 1 in Madagascar and 7 in Asia, from India to South-East Asia. *Strophanthus thollonii* resembles *Strophanthus gratus* (Wall. & Hook.) Baill., but chemically they are not related at all. They both lack the long petal tails, which are characteristic for the genus. *Strophanthus thollonii* flowers all year round, with a peak from November to January. Mature fruits can be found from December to January. Seeds are sometimes used to adulterate seed of *Strophanthus hispidus* DC.

Strophanthus gardeniiflorus Gilg is closely related to *Strophanthus thollonii* and is chemically similar. It is restricted to gallery forest in southern DR Congo, northern Zambia and eastern Angola at 1000–1500 m altitude. The seeds are used for arrow poison.

Ecology *Strophanthus thollonii* occurs on river banks in moist forest from sea-level up to 300 m altitude.

Genetic resources and breeding *Strophanthus thollonii* occurs rather dispersed in its comparatively small distribution area, and is uncommon. Because of overharvesting, it has become locally threatened.

Prospects *Strophanthus thollonii* has so far mainly been used for making arrow poison, but this use is declining rapidly. Although it contains several glycosides, its medicinal use will remain limited unless further studies reveal new possibilities.

Major references Beentje, 1982; Neuwinger, 1996.

Other references Bisset, 1989a; Brandt, Kaufmann & Reichstein, 1966; McKenzie, 2002; Weiss, Schindler & Reichstein, 1957.

Authors H.J. Beentje

STROPHANTHUS WELWITSCHII (Baill.) K.Schum.

Protologue Engl. & Prantl, Nat. Pflanzenfam. Nachtr. 2: 59 (1900).

Family Apocynaceae

Origin and geographic distribution *Strophanthus welwitschii* occurs throughout Cen-

tral Africa and in the western part of southern Africa, in DR Congo, eastern Tanzania, Zambia and Angola.

Uses In DR Congo a seed decoction is administered orally to treat respiratory diseases in children. In Angola a root infusion is drunk to treat gonorrhoea, but excessive usage is dangerous and can even be fatal. Root powder mixed with oil is rubbed in to treat scabies. The seeds are used to produce arrow poison.

Properties The amount of cardiac glycosides (cardenolides) in the seeds varies throughout the area of distribution; seeds from Zambia are less bitter than those from Angola and contain hardly any glycosides. Seeds from Angola contain intermedioside, panstroside, inertoside and leptoside. All glycosides except inertoside are highly toxic.

Botany Deciduous shrub or small tree up to 5 m tall or liana up to 8 m long, with clear or white exudate; stem up to 10(–40) cm in diameter; bark dark brown or grey; branches with many lenticels, branchlets minutely hairy. Leaves decussately opposite or rarely in whorls of 3 or 4, simple and entire; stipules absent; petiole 1–5 mm long; blade ovate to narrowly elliptical, up to 8.5 cm × 4 cm, base cuneate to rounded, apex rounded to acute or acuminate, margins undulate or slightly revolute, thinly leathery, with a line of translucent dots near the midrib. Inflorescence a terminal dichasial cyme, on long or short branches or in the forks, glabrous or hairy, 1–2(–5) flowered; peduncle 0–6(–17) mm long; bracts linear or narrowly ovate, 2–8 mm long, sometimes deciduous. Flowers bisexual, regular, 5-merous, fragrant; pedicel 3–9(–17) mm long; sepals free, slightly unequal, ovate or narrowly ovate, 5–19 mm long, acute; corolla tube (13.5–)17–38 mm long, widening gradually at 20–40% of its length into a cup-shaped upper part, at the mouth (11–) 15–25(–35) mm wide, white, sometimes suffused with pink near the base, pale or reddish purple in the upper part outside, creamy and red- or purple-streaked inside, corona lobes narrowly triangular, 5–23 mm long, acute, not fleshy, red or purple-red, corolla lobes ovate, (10–)14–38(–48) mm × (7.5–)10–24(–29) mm, acute, spreading or recurved, minutely hairy inside, inside white, turning dark pink, outside white turning pale pink on left side, pale purple turning purple-red on the right side; stamens inserted at 5.5–10.5 mm from the base of the corolla tube, included; ovary half-inferior, 2-celled, style 8–15 mm long, ending in a ring-like pistil head surrounding the minute stigma. Fruit consisting of 2 ellipsoid follicles 11–35 cm × 1–2.5 cm, long-tapering towards a narrow apex and ending in an obtuse tip, 2-valved, divergent at an angle of 160–240°, wall thick and hard, glabrous, with many lenticels, dark brown or purple-brown, many-seeded. Seeds spindle-shaped, flattened, 8.5–19.5 mm × 2.5–4 mm, densely hairy, at apex with a long beak up to 11 cm long, glabrous in lower half, upper half with long hairs up to 9.5 cm long.

Strophanthus comprises 38 species, of which 30 occur in continental Africa, 1 in Madagascar and 7 in Asia, from India to South-East Asia. *Strophanthus welwitschii* flowers towards the end of the dry and the beginning of the rainy season when forming new leaves. Mature fruits are present in the dry season.

Ecology *Strophanthus welwitschii* occurs in woodland, often in rocky localities and gallery forest, at 300–1800 m altitude.

Genetic resources and breeding *Strophanthus welwitschii* is not uncommon in its distribution area and not in danger of genetic erosion.

Prospects Medicinal use of *Strophanthus welwitschii* will remain limited in its area of distribution, unless further studies reveal new possibilities.

Major references Beentje, 1982; Neuwinger, 1998; Neuwinger, 2000; Watt & Breyer-Brandwijk, 1962.

Other references Disengomoka & Delaveau, 1983; McKenzie, 2002; Von Euw et al., 1952.

Authors A. de Ruijter

STRYCHNOPSIS THOUARSII Baill.

Protologue Bull. Mens. Soc. Linn. Paris 1: 456 (1885).

Family Menispermaceae

Origin and geographic distribution *Strychnopsis thouarsii* is endemic to Madagascar where it occurs from Antsiranana in the north to Toamasina in the centre and also in Toliara in the south.

Uses A decoction of the leaves or root bark is drunk to treat liver problems, enlarged spleen, fever and malaria, sometimes as an adjuvant of chloroquine.

The root yields a bright yellow dye. The branches are used to make temporary huts in the forest.

Properties From the leaves the bisbenzylisoquinoline alkaloid fangchinoline, the apor-

phine alkaloids isocorydine, liriotulipiferine, N-methylindcarpine and predicentrine, and the morphinan alkaloid sinoacutine were isolated. The roots have been shown to contain fangchinoline and the related tetrandrine. The stem bark yielded the morphinan alkaloid tazopsine. In a test with several bisbenzylisoquinoline alkaloids, fangchinoline was the most active compound tested against chloroquine-resistant *Plasmodium falciparum* and against a multidrug-resistant lymphoblastic acute leukaemia cell line. Fangchinoline also has an antagonistic effect on the antinociceptive properties of morphine.

Tazopsine has shown strong activity against *Plasmodium falciparum* and *Plasmodium yoelli*. The semi-synthetic derivative N-cyclopentyltazopsine combines strong antiplasmodial activity with a lower toxicity. Because of its specific action against the liver form of the parasite, the risk of resistance developing is considered small.

Botany Dioecious, small tree up to 15 m tall; bark dark brown and green mottled. Leaves simple and entire; petiole distinctly swollen and bent at apex; blade lanceolate, base cuneate, apex acute, with 3 prominent main veins from the base. Inflorescence an erect raceme, axillary or on older, leafless branches, often many together. Flowers unisexual, 3–4-merous; sepals greenish yellow to pink; petals translucent whitish to pink; male flowers with 5–6 stamens; female flowers with superior ovary, composed of free carpels. Fruit a cluster of 1–4, flattened globose, somewhat fleshy drupes, pale greenish yellow to whitish when ripe, each drupe 1-seeded. Seed horseshoe-shaped.

Strychnopsis comprises a single species.

Ecology *Strychnopsis thouarsii* occurs in humid and evergreen forest up to 1150 m altitude. Black lemurs eat the fruits and probably disperse the seeds.

Genetic resources and breeding *Strychnopsis thouarsii* is widely used as a traditional medicine against malaria. Continued exploitation, combined with the reduction of the areas under rainforest in Madagascar, may become a threat to its genetic diversity. However, it is not yet included in the IUCN Red List.

Prospects If semi-synthetic tazopsine derivatives are admitted as antimalaria drugs, the pressure on natural stands of *Strychnopsis thouarsii* will increase even more. Research aiming at the development of propagation and management techniques is urgently needed.

Major references Carraz et al., 2006; Rasoanaivo & Ratsimamanga-Urverg, 1994; Rasoanaivo, Ratsimamanga-Urverg & Rakoto-Ratsimamanga, 1995; Ratsimamanga-Urverg et al., 1992; Schatz, 2001.

Other references Boiteau, Boiteau & Allorge-Boiteau, 1999; Fang, Zhang, & Ku, 2005; Frappier et al., 1996; Schatz, undated.

Authors L.P.A. Oyen

STRYCHNOS ACULEATA Soler.

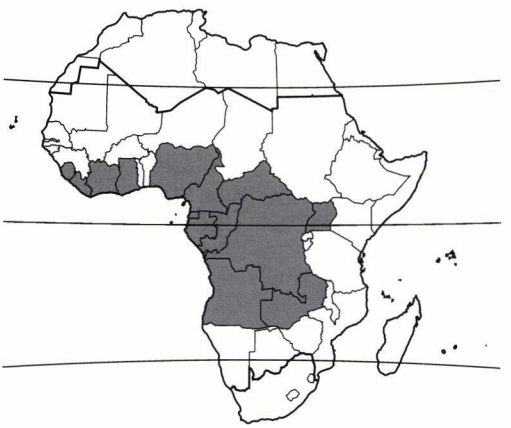
Protologue Engl. & Prantl, Nat. Pflanzenfam. IV, 2: 40 (1892).

Family Loganiaceae

Chromosome number $2n = 36, 44$

Origin and geographic distribution *Strychnos aculeata* occurs from Sierra Leone east to Uganda and south to Angola and Zambia.

Uses *Strychnos aculeata* is widely used for medicinal purposes, mainly as an emetic and to treat urinary, genital and pulmonary infections. In Côte d'Ivoire plant sap is rubbed in to treat guinea worm infections. An infusion of the bark together with the fruit of *Piper guineense* Schumach. & Thonn. is administered as an enema and rubbed in to treat gonorrhoea and swellings in the genital region. A bark decoction is taken and used as an enema to treat oedema and scrotal elephantiasis. Fruit pulp is rubbed on the head to treat insanity. In Ghana ground seeds are used as an enema to treat oedema of the abdomen. In Gabon the maceration of pulped fruit is taken as an abortifacient. Ground seeds are taken in water as an emetic. In Congo a bark decoction is taken to treat pulmonary complaints, food poisoning,



Strychnos aculeata – wild

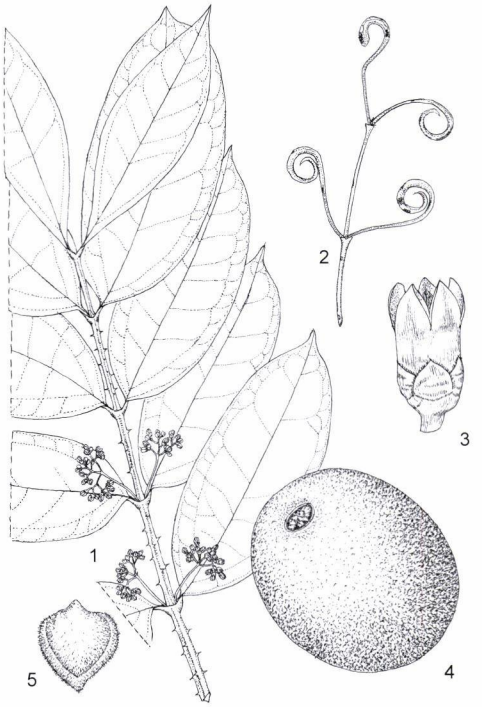
trypanosomiasis and insanity and as an expectorant and emetic. Leaf sap is rubbed in and a bark decoction is used in vapour baths to treat fever fits. The Badala people of DR Congo use the crushed leaves to treat pulmonary tuberculosis. In Zambia a root decoction is taken to treat gonorrhoea and pneumonia.

In Cameroon the seeds of *Strychnos aculeata* are rubbed into a paste and used as arrow poison. The fruit and a paste from the seed are used as fish poison. The fruit is also a common soap substitute. In Côte d'Ivoire the large spherical fruit cut in half is used to make drinking cups and ladles.

Properties The fruits and especially the seeds of *Strychnos aculeata* are highly poisonous. The fruit contains saponins. Indole alkaloids were only found in the fruit wall, not in the seeds. Principal indole alkaloids of the root bark are strychnofendlerine and N-acetylstrychnosplendine. The stem bark contains spermostrychnine, N-acetyl-isostrychnosplendine and N-acetyl-O-methylstrychnosplendine, the latter being also the main indole alkaloid of the fruit.

N-acetyl-O-methylstrychnosplendine is partly responsible for the strong muscle-paralysing activity in vitro and in vivo. Spermostrychnine causes clonic convulsions, but no tonic convulsions in mice.

Description Large liana up to 100 m long, climbing with tendrils in 1–3(–4) pairs; stem up to 20(–22) cm in diameter, with prickles 3–5(–9) mm long; branchlets dark green and shining, with prickles, glabrous. Leaves opposite, simple and entire; stipules absent; petiole 2–12 mm long, glabrous; blade oblong to elliptical, (3–)8–18 cm × (2–)3–8 cm, base cuneate to rounded, apex acuminate, glabrous, 3-veined from the base. Inflorescence an axillary congested thyrse up to 7 cm long, many-flowered. Flowers bisexual, regular, 5-merous; sepals fused at base, almost orbicular, up to 2 mm long; corolla tube almost cylindrical, up to 3 mm long, pale green, slightly widened towards the throat, lobes triangular to ovate, 1–2 mm long, acute, erect, thick, glabrous outside, inside with a flat brush of white hairs on the lobes, white; stamens inserted at the middle of the corolla tube, included; ovary superior, ovoid, 1.5–2 mm long, glabrous, 2-celled, stigma almost sessile, oblong. Fruit a globose berry 10–12 cm in diameter, slightly laterally compressed, very hard, greenish yellow to dark green, many-seeded. Seeds obliquely ovoid to ellipsoid, flattened, 20–35 mm × 16–25 mm × 4–8 mm, hairy, rough, often at one side with a raised line.



Strychnos aculeata – 1, flowering branch; 2, tendrils; 3, flower; 4, fruit; 5, seed.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Strychnos* comprises about 200 species: about 60 species in Asia, 65 in America and 75 in Africa. *Strychnos aculeata* belongs to the section *Aculeatae* and is the only species in this section. The fruits and seeds of *Strychnos elaeocarpa* Gilg ex Leeuwenb. from section *Rouhamon*, *Strychnos ternata* Gilg ex Leeuwenb. from section *Spinosae* and *Strychnos staudtii* Gilg from section *Densiflorae* are all used in Cameroon as arrow poison and fish poison. *Strychnos densiflora* Baill. and *Strychnos lucens* Baker also belong to section *Densiflorae*. *Strychnos densiflora* is used in Cameroon as ordeal poison. In Tanzania the ground roots of *Strychnos lucens* are taken in food to treat hookworm infections.

Ecology *Strychnos aculeata* occurs in rainforest, including secondary forest, from sea-level up to 700 m altitude.

Genetic resources There are no indications that *Strychnos aculeata* is in danger of genetic erosion.

Prospects *Strychnos aculeata* is widely used

for medicinal purposes. In order to promote its sustainable use, research should be done on improved methods of harvesting and possibly its domestication. More research into the pharmacological activities of the compounds of *Strychnos aculeata* seems warranted.

Major references Burkill, 1995; Leeuwenberg, 1969; Leeuwenberg, 1980; Neuwinger, 1996; Neuwinger, 2000; Neuwinger, 2004; Weeratunga et al., 1984.

Other references Bisset & Leeuwenberg, 1968; Bouquet, 1969; Bouquet & Debray, 1974; Irvine, 1961; Kerharo & Bouquet, 1950; Mirand et al., 1979; Noumi, 2004; Ohiri, Verpoorte & Baerheim Svendsen, 1983c; Raponda-Walker & Sillans, 1961; Rolfsen et al., 1979; Téré, 2000; Tra Bi, Kouamé & Traoré, 2005.

Sources of illustration Leeuwenberg, 1969.

Authors A. de Ruijter

STRYCHNOS AFZELII Gilg

Protologue Bot. Jahrb. Syst. 17: 572 (1893).

Family Loganiaceae

Chromosome number $2n = 44$

Origin and geographic distribution *Strychnos afzelii* occurs from Senegal east to Nigeria.

Uses In Senegal the crushed leaves and root of *Strychnos afzelii* together with the crushed leaves of *Hugonia planchonii* Hook.f. are applied to treat abscesses and swellings. In Sierra Leone a decoction of the seeds together with leaves of *Ocimum* sp. or other aromatic herbs is taken to promote sweating in case of fever attacks. Ground seeds are taken in soup to treat stomach-ache.

All parts of the plant smell like cloves, especially the twig bark. In Sierra Leone women of the Mende people rub the sap from crushed leaves, pure or mixed with white clay, on their bodies for the fragrance and as an aphrodisiac. In Sierra Leone and Côte d'Ivoire the twigs are used as chew-sticks. The Temne people of Sierra Leone chew the leaves to treat bad breath. Chewing makes the lips red, and in Ghana the leaves are chewed for this purpose.

Properties The main indole alkaloids of *Strychnos afzelii* are the dimeric tertiary indole alkaloid bisnordihydrotoxiferine and its derivatives bisnordihydrotoxiferine N-oxide and bisnordihydrotoxiferine di-N-oxide, the monomeric caracurine VII (Wieland-Gumlich aldehyde), its acetyl derivative diaboline, the dimeric bisquaternary caracurine V and its derivative caracurine V N-oxide, the dimeric tertiary longicaudatine and its isomer bisnor-C-alkaloid H.

Stem bark extracts showed activity against several micro-organisms, including some species associated with caries. Bisnordihydrotoxiferine, bisnor-C-alkaloid H and caracurine VII showed antimicrobial effects. Bisnordihydrotoxiferine, isolated from the root bark of *Strychnos trinervis* (Vell.) Mart., showed a wide antimicrobial spectrum against gram-positive and gram-negative bacteria, and against filamentous and yeast-like fungi. Preliminary studies of this compound also revealed some cytotoxic activity in vitro against sarcoma 180 tumours. Bisnordihydrotoxiferine also showed a weak activity in vitro against *Plasmodium falciparum*.

Botany Large liana up to 50 m long, climbing with solitary tendrils; branchlets medium green, yellowish hairy; lateral branches transformed into blunt spines 7–25(–35) mm long. Leaves opposite, simple and entire; stipules absent; petiole 1–5 mm long, almost glabrous; blade ovate, orbicular, elliptical, obovate or oblong, 1–11(–14.5) cm × 1–5.5(–6.5) cm, base cordate, rounded or cuneate, apex notched or rounded to acuminate, sparsely appressed hairy when young, later almost glabrous, 3-veined from the base. Inflorescence an axillary congested or lax thyrse 2–5 cm long, few- to many-flowered. Flowers bisexual, regular, 5-merous; sepals fused at base, broadly triangular to almost orbicular, up to 0.5 mm long; corolla tube up to 1 mm long, lobes narrowly triangular, 1–1.5 mm long, acute, erect, sparsely hairy outside, inside with a flat brush of white hairs on the lobes, white, creamy or pale yellowish green with slightly darker lobes; stamens inserted at the mouth of the corolla tube, included; ovary superior, broadly ovoid, 0.5 mm in diameter, glabrous, 2-celled, style very short, stigma white, globose. Fruit an obliquely ellipsoid, laterally compressed berry 11–16 mm × 9–13 mm × 9–11 mm, rather hard, orange, 1(–2)-seeded. Seed ellipsoid, 10–14 mm × 9–11 mm × 4–6.5 mm, slightly flattened, glabrous, knobbed at one side in the middle.

Strychnos comprises about 200 species: about 60 species in Asia, 65 in America and 75 in Africa. *Strychnos afzelii* belongs to the section *Breviflorae*. Another spiny species from West and northern Central Africa is *Strychnos congolana* Gilg which belongs to section *Spinosae*. In Côte d'Ivoire the leaf pulp is applied to treat snakebites. Ground roots of *Strychnos congolana* and seeds of *Aframomum melegueta*

K.Schum. made into a paste are administered as a suppository to treat dysmenorrhoea. The paste is also used as an aphrodisiac.

Ecology *Strychnos afzelii* occurs on river banks or in moist localities in periodically inundated rainforest, including secondary forest and coastal swamp forest, from sea-level up to 700 m altitude.

Genetic resources and breeding *Strychnos afzelii* is widespread and does not seem to be in danger of genetic erosion.

Prospects It seems likely that *Strychnos afzelii* will remain of limited use only, unless more elaborate tests on the antibacterial and antifungal activities of the stem bark reveal potential for developing phytomedicines.

Major references Abbiw, 1990; Bisset, 1970; Leeuwenberg, 1969; Leeuwenberg, 1980; Ohiri, Verpoorte & Baerheim Svendsen, 1983c.

Other references Adjanohoun & Aké Assi, 1979; Bouquet & Debray, 1974; Frédérich, Tits & Angenot, 2003; Melo et al., 1987; Tra Bi et al., 1999; Tra Bi, Kouamé & Traoré, 2005; Verpoorte, Groenink & Baerheim Svendsen, 1980; Verpoorte et al., 1978.

Authors A. de Ruijter

STRYCHNOS ANGOLENSIS Gilg

Protologue Bot. Jahrb. Syst. 17: 571 (1893).

Family Loganiaceae

Chromosome number $2n = 88$

Origin and geographic distribution *Strychnos angolensis* occurs from Nigeria east to Tanzania, and south to Angola and Mozambique.

Uses *Strychnos angolensis* was recorded as being used as ordeal poison in the Equateur province in DR Congo. In Cameroon the branches are used to make arrow shafts.

Properties The root and stem bark of *Strychnos angolensis* contain at least 15 alkaloids: gentianine, aspidospermine, akuammicine, tubifoline, condylocarpine, akuammidine, 16(R)-epi-isositsirikine, 16(S)-epi-isositsirikine, tubifolidine, normavacurine, antirhine (anthirine), strychnofluorine (18-hydroxy-nor-C-fluorocurarine), flavopereirine, caracurine VII-N-oxide (WGA N-oxide) and tubotaiwine; the last two are the major components. The stem bark also contains the tertiary dimeric alkaloid caracurine V. In pharmacological screenings of bark extract, convulsive effects have been shown in the nonpolar part of the tertiary alkaloid fraction, while the polar fraction showed a strong muscle-relaxant activity. *Strychnos angolensis* has a considerable amount of mucilage in the leaves. The fruit pulp contains the polyphenol caffeic acid.
In-vitro tests of leaf and root extracts showed moderate antiplasmodial activity against *Plasmodium falciparum*.

Botany Large liana up to 30 m long, climbing by solitary tendrils or shrub to small tree up to 12 m tall; stem up to 20 cm in diameter; bark pale brown; branches medium to dark brown, branchlets green, ochrous hairy. Leaves opposite, simple and entire; stipules absent; petiole 1–5 mm long, ochrous hairy; blade ovate to elliptical, 2–7(–10) cm × 1–4(–5) cm, base cuneate to rounded, apex obtuse to acute or acuminate, glabrous or hairy on the veins especially at the base, 3-veined from the base. Inflorescence an axillary or sometimes terminal lax thyrse 1–6 cm long, few-flowered; peduncle ochrous hairy. Flowers bisexual, regular, 4–5-merous; sepals broadly ovate, 0.5–1 mm long; corolla tube c. 0.5 mm long, lobes ovate to triangular, 1.5–2 mm long, acute, spreading, outside glabrous or minutely hairy, inside hairy at base, white or yellow; stamens inserted at the mouth of the corolla tube, just exserted; ovary superior, globose or broadly ovoid, c. 1 mm in diameter, 2-celled, gradually narrowing into the style c. 0.5 mm long, stigma head-shaped. Fruit an ellipsoid to globose, glaucous berry c. 12 mm × 12–22 mm × 18 mm, soft, orange or red, 1-seeded. Seed ellipsoid, 8.5–15 mm × 6–11 mm × 5–9 mm, smooth, glabrous, dark brown, shiny.
Strychnos comprises about 200 species: about 60 species in Asia, 65 in America and 75 in Africa. *Strychnos angolensis* belongs to the section *Breviflorae*. Also in this section is *Strychnos malchairii* De Wild., which occurs in DR Congo; the Mbuti and Efe people use the pounded bark to make an arrow poison. The ground roots are applied as a paste to treat large ulcers. The stems are used to make arrow shafts. The flexible stem is also used as rope.

Ecology *Strychnos angolensis* occurs in forest near river banks and in gallery forest, from sea-level up to 1500 m altitude.

Genetic resources and breeding *Strychnos angolensis* is widespread and is not threatened by genetic erosion.

Prospects It is likely that *Strychnos angolensis* will remain of little importance, unless further research shows new pharmacological activities of the alkaloids.

Major references Bisset, 1970; Bisset & Leeuwenberg, 1968; Bohlin et al., 1979; Leeu-

wenberg, 1969; Leeuwenberg, 1980.

Other references Bouquet & Fournet, 1975b; Delaude et al., 1995; Neuwinger, 2000; Ohiri, Verpoorte & Baerheim Svendsen, 1983c; Philippe et al., 2005; Terashima & Ichikawa, 2003; Terashima, Kalala & Malasi, 1992; Verpoorte et al., 1983a.

Authors A. de Ruijter

STRYCHNOS BARTERI Soler.

Protologue Bot. Jahrb. Syst. 17: 556 (1893).

Family Loganiaceae

Chromosome number $2n = 44$

Origin and geographic distribution *Strychnos barteri* occurs from Guinea east to Cameroon.

Uses In Côte d'Ivoire the fruit is used as a fish poison. In Nigeria the stems are used to make bows.

Properties Seven indole alkaloids have been isolated from *Strychnos barteri*. The stem contains nigritanine, the stem bark and the root akagerine, the stem bark and the leaves contain 18-dehydro-nigritanine and the leaves 10-hydroxy-nigritanine, 18-dehydro-10-hydroxy-nigritanine, oxindole alkaloid I and oxindole alkaloid II. Akagerine is a potent convulsant agent, although 100 times less active than strychnine.

Botany Large liana, up to 100 m long, climbing with tendrils in 1–3 pairs; stem up to 16 cm in diameter; branchlets medium to dark green, glabrous. Leaves opposite, simple and entire; stipules absent; petiole 4–10 mm long, glabrous; blade elliptical to narrowly obovate, 3–10(–20) cm × 1.5–6(–8) cm, base cuneate to rounded or cordate, apex rounded to shortly acuminate, leathery, glabrous, 5-veined from somewhat above the base. Inflorescence an axillary, usually congested thyrse 1–3 cm long, several together, few-flowered. Flowers bisexual, regular, 4-merous; sepals fused at base, ovate to orbicular, 1–1.5 mm long; corolla tube up to 4.5 mm long, slightly widened at the throat, lobes oblong, 2.5–3 mm long, acute, recurved, outside glabrous, inside hairy on the base of the lobes and on upper part of the tube, white; stamens inserted at the mouth of the corolla tube, exserted; ovary superior, ovoid, 4–6 mm long, glabrous, 2-celled, style 3–5 mm long, stigma obscurely 2-lobed. Fruit an obliquely ellipsoid or obovoid berry 20–32 mm × 16–22 mm × 15–22 mm, wall thin, rather hard, orange, 1–several-seeded. Seeds obliquely ellipsoid, 13–20 mm × 10–14 mm × 4–10 mm, white, at one side with a deep pit, at the other with a bulge surrounded by a shallow groove. *Strychnos* comprises about 200 species: about 60 species in Asia, 65 in America and 75 in Africa. *Strychnos barteri* belongs to the section *Dolichanthae*. Several other *Strychnos* spp. from this section are used medicinally. Plant extracts of *Strychnos gossweileri* Excell, a small fire resistant savanna shrub, which occurs from Cameroon south to Zambia, are used in African folk medicine to treat malaria. The plant contains several indole alkaloids, of which matadine shows interesting toxic activities against human cancer cells. An ethyl acetate extract of the root showed significant antimalarial activity in vitro. The Mende people of Sierra Leone grind the young leaves of *Strychnos melastomatoides* Gilg, a liana from Guinea and Sierra Leone, to a paste to treat wounds and use the stems as chew-sticks.

Ecology *Strychnos barteri* occurs mostly on river banks in rainforest, also montane rainforest and periodically inundated secondary forest, from sea-level up to 1300 m altitude.

Genetic resources and breeding *Strychnos barteri* does not seem to be in danger of genetic erosion.

Prospects In view of the pharmacologically interesting compounds found in other *Strychnos* species, more research into the chemical composition and pharmacological activities of the indole alkaloids of *Strychnos barteri* and the other species mentioned seems warranted.

Major references Burkill, 1995; Leeuwenberg, 1969; Leeuwenberg, 1980; Ohiri, Verpoorte & Baerheim Svendsen, 1983c.

Other references Dassonneville et al., 1999; Nicoletti, Oguakwa & Messana, 1980; Philippe et al., 2005.

Authors A. de Ruijter

STRYCHNOS CAMPTONEURA Gilg & Busse

Protologue Bot. Jahrb. Syst. 36: 93 (1905).

Family Loganiaceae

Chromosome number $2n = 44$

Origin and geographic distribution *Strychnos camptoneura* occurs from Liberia east to the Central African Republic and south to DR Congo.

Uses In Cameroon the bark is eaten or a bark maceration in water or palm wine is taken to treat lack of sexual strength. In Cameroon and Congo *Strychnos camptoneura* is

used to treat malaria. In Congo tea made from the stem bark and sweetened with honey is taken to treat stomach-ache, kidney pain and hernia. A warm decoction of leaves or bark or dry powdered bark is applied to wounds and ulcers. In the Central African Republic and in Congo the root bark of *Strychnos camptoneura* mixed with plant sap of *Periploca nigrescens* Afzel. and sometimes other plant species, is used as an arrow poison. In Liberia and Cameroon the fruit is used as a fish poison and the root is used for the same purpose in the Central African Republic.

Properties *Strychnos camptoneura* is rich in alkaloids. Total alkaloid content of the leaves is over 2%. At least 10 monomeric indole alkaloids have been isolated; the leaves contain the vallesiachotamine class tertiary alkaloid antirhine, its quaternary base antirhine methobromide and the trinitrogenated angustine, which is also present in the stem bark. The stem bark also contains the tetracyclic akagerine class alkaloid akagerine, its isomer kribine, the trinitrogenated camptoneurine, the retuline type alkaloid retuline, its derivative retuline-N-oxide and the ajmalicine type alkaloids alstonine and serpentine. Retuline, alstonine and serpentine are also present in the root bark.

Stem bark and root bark extracts have strong muscle relaxant activity. A crude ethanol root extract did not have a significant toxic effect on a chloroquine-sensitive strain of *Plasmodium falciparum*. Serpentine, present in large amounts in *Rauvolfia serpentina* (L.) Benth. ex Kurz, is known to inhibit topoisomerase II and has shown cytotoxic activity against some tumour cell lines, for instance B16 melanoma and HeLa carcinoma. Retuline has a significant anti-oedematogenic activity in anti-inflammatory tests in rats. Akagerine is a potent convulsant agent, but 100 times less active than strychnine. Kribine causes clonic and tonic convulsions.

Botany Large liana up to 120 m long, climbing with tendrils in 1–3 pairs; stem up to 25 cm in diameter; branchlets shining and dark green, glabrous. Leaves opposite, simple and entire; stipules absent; petiole 7–17 mm long, glabrous; blade elliptical to ovate, 6–22(–31) cm × 3–10(–12) cm, base cuneate to rounded, apex acute to shortly acuminate, glabrous, 3-veined from the base. Inflorescence an axillary or occasionally terminal solitary lax or congested thyrse 4.5–6.5 cm long, few-flowered. Flowers bisexual, regular, 5-merous; sepals fused at base, orbicular, up to 3.5 mm long; corolla tube campanulate or cylindrical, up to 6 mm long, corolla lobes triangular to ovate, 4–6 mm long, acute, spreading or recurved, thick, glabrous outside, white or yellow, inside with a minutely hairy, wavy or 5-lobed corona; stamens inserted at the mouth of the corolla tube, included; ovary superior, ovoid, 3–4 mm long, glabrous, 2-celled, style up to 5.5 mm long, stigma head-shaped. Fruit a globose to ellipsoid or slightly pear-shaped berry 6–20 cm in diameter, pale glaucous to yellow, wall thick, hard, pulp orange, containing very strong fibres, with 10–many seeds. Seeds obliquely orbicular to ovoid, flattened, 25–50 mm × 20–40 mm × 3–6 mm, glabrous, smooth, with a narrow irregular wing 1–6 mm wide.

Strychnos comprises about 200 species: about 60 species in Asia, 65 in America and 75 in Africa. *Strychnos camptoneura* is the only species in section *Scyphostrychnos*.

Ecology *Strychnos camptoneura* occurs in rainforest, including secondary forest, up to 700 m altitude.

Genetic resources and breeding *Strychnos camptoneura* is rather widespread and does not seem to be threatened by genetic erosion.

Prospects *Strychnos camptoneura* will remain of limited use only, unless additional pharmacological research on the alkaloids reveals interesting possibilities for medicine development.

Major references Burkill, 1995; Leeuwenberg, 1969; Leeuwenberg, 1980; Neuwinger, 2000; Ohiri, Verpoorte & Baerheim Svendsen, 1983c.

Other references Betti, 2003; Bouquet, 1969; Dassonneville et al., 1999; Frédérich et al., 1999; Neuwinger, 1996; Noumi, Amvan Zollo & Lontsi, 1998.

Authors A. de Ruijter

STRYCHNOS DINKLAGEI Gilg

Protologue Bot. Jahrb. Syst. 28: 121 (1899).

Family Loganiaceae

Chromosome number $2n = 44$

Origin and geographic distribution *Strychnos dinklagei* occurs naturally from Guinea east to Ghana.

Uses In Côte d'Ivoire a decoction of the wood of the roots is used as a mouth wash or for inhalation in case of mouth infections. A decoction of stem and root bark is taken to treat

kidney diseases and it is used as a wash to treat palpitations. A decoction of the bark in palm oil is applied in small amounts to the tongue to treat palpitations, tachycardia and other symptoms of heart problems.

Properties Twelve alkaloids were isolated from the stem bark: 2 monoterpene alkaloids (gentianine and venoterpine), 8 pyrido-4,3β-carbazoles (ellipticine and several derivatives) and 2 apparicine derivatives (brafouedine and isobrafouedine). The stem bark also contains methyl syringate, lirioresinol A and lirioresinol B. The leaves contain the monoterpene alkaloids dinklageine, strychnovoline, gentianine and cantleyine. Leaf and bark extracts have muscle relaxant and convulsant activities. A stem bark extract has strong antimicrobial activity against *Bacillus subtilis* and *Staphylococcus aureus*.

Botany Large liana up to 40 m long, climbing with paired tendrils; stem 5–13 cm in diameter; bark pale grey or dark brown and grey-brown spotted, with large lenticels; branches dark brown with lenticels, branchlets medium green, often with lenticels. Leaves opposite, simple and entire; stipules absent; petiole 2–7 mm long, minutely hairy or glabrous; blade elliptical to narrowly elliptical, usually narrower toward the top of the branchlets, 3–10(–13) cm × 2–5(–7) cm, base cuneate or rounded, apex acuminate, glabrous, 3-veined from the base. Inflorescence a terminal or sometimes axillary lax thyrse 1–2 cm long, many-flowered; peduncle 6–15 cm long. Flowers bisexual, regular, usually 5-merous; sepals broadly ovate, 0.5–1 mm long; corolla bell-shaped, tube 0.5–1 mm long, lobes triangular to ovate, 1–2 mm long, acute, thick, spreading, outside minutely hairy, inside hairy at the base, white or greenish white; stamens inserted at the mouth of the corolla tube, exserted, anthers orbicular, with white hairs; ovary superior, broadly ovoid or globose, 0.5–1 mm in diameter, 2-celled, rather abruptly narrowed into the style c. 0.5 mm long, stigma head-shaped. Fruit an obliquely ovoid berry 18–24 mm × 13–16 mm × 10–14 mm, soft, orange, 1-seeded. Seed elliptical, 15–18 mm × 10–12 mm × 5–5.5 mm, rough, with thick, short erect hairs.

Strychnos comprises about 200 species: about 60 species in Asia, 65 in America and 75 in Africa. *Strychnos dinklagei* belongs to the section *Lanigerae*.

Ecology *Strychnos dinklagei* occurs in rainforest, also in secondary forest, often on river banks, from sea-level up to 250 m altitude.

Genetic resources and breeding Although the natural distribution of *Strychnos dinklagei* is restricted, it seems not to be in danger of genetic erosion.

Prospects It seems likely that *Strychnos dinklagei* will remain of limited use only, unless the antibacterial activity of the stem bark shows potential in additional tests.

Major references Bisset, 1970; Bisset & Leeuwenberg, 1968; Leeuwenberg, 1969.

Other references Leeuwenberg, 1980; Michel et al., 1985; Michel, Tillequin & Koch, 1986; Michel et al., 1982; Verpoorte et al., 1983b.

Authors A. de Ruijter

STRYCHNOS FLORIBUNDA Gilg

Protologue Bot. Jahrb. Syst. 17: 566 (1893).

Family Loganiaceae

Chromosome number $2n = 44$

Origin and geographic distribution *Strychnos floribunda* occurs from Sierra Leone east to the Central African Republic and south to Angola.

Uses In Côte d'Ivoire a decoction of stem and root bark is taken to treat kidney diseases. It is also used as a wash to treat palpitations, while a decoction of the stem bark in palm oil is applied in small amounts to the tongue to treat palpitations, tachycardia and other symptoms of heart disease. A maceration of the root wood is taken to treat oedema.

Properties *Strychnos floribunda* stem bark contains the indole alkaloids bisnordihydrotoxiferine, akagerine, decussine, rouhamine, strychnocarpine, desacetylisoretuline and isorosibiline and the common sterols β-sitosterol, stigmasterol and campesterol. Bisnordihydrotoxiferine is known to exhibit antimicrobial activity in vivo and has shown in-vivo antidiarrhoeal activity in mice. Decussine and rouhamine have a pronounced muscle-relaxant activity. Stem bark extracts of *Strychnos floribunda* have muscle-relaxant and convulsive effects and showed antimicrobial activity against *Bacillus subtilis* and *Staphylococcus aureus*.

Botany Climbing shrub or liana up to 30 m long, climbing with solitary tendrils; stem up to 13 cm in diameter, branchlets green, glabrous or minutely hairy. Leaves opposite, simple and entire; stipules absent; petiole 2–9 mm long, glabrous; blade elliptical to ovate, 4–10(–12) cm × 1.5–5(–6) cm, base cuneate to rounded, apex

acuminate, glabrous, 3– or 5-veined from the base. Inflorescence an axillary or occasionally terminal lax or congested thyrse up to 4.5 cm long, few-flowered. Flowers bisexual, regular, (4–)5-merous; sepals fused at base, triangular to ovate, often unequal, up to 1.5 mm long; corolla tube cylindrical, up to 1.5 mm long, lobes oblong to ovate or triangular, 1.5–3 mm long, acute, spreading or recurved, glabrous or minutely hairy outside, inside often densely hairy, white or greenish white; stamens inserted at the mouth of the corolla tube, exserted; ovary superior, globose or ovoid to nearly conical, 1–2 mm long, glabrous, 2-celled, style up to 4.5 mm long, stigma small, obscurely 2-lobed or head-shaped. Fruit an ellipsoid berry 14–17 mm in diameter, soft, orange, with smooth skin, 1-seeded. Seed slightly flattened, 8–13 mm × 7–10 mm × 5–7 mm, yellowish, densely hairy, smooth.

Strychnos comprises about 200 species: about 60 species in Asia, 65 in America and 75 in Africa. *Strychnos floribunda* belongs to the section *Rouhamon*.

Ecology *Strychnos floribunda* occurs in rainforest, including secondary forest, often on river banks, from sea-level up to 800 m altitude.

Genetic resources and breeding *Strychnos floribunda* is widespread and does not seem to be in danger of genetic erosion.

Prospects It seems likely that *Strychnos floribunda* will remain of limited use only, unless the antibacterial activity of the stem bark shows potential in additional tests.

Major references Bisset, 1970; Bouquet & Debray, 1974; Kerharo & Bouquet, 1950; Leeuwenberg, 1969.

Other references Leeuwenberg, 1980; Ohiri, Verpoorte & Baerheim Svendsen, 1983c; Verpoorte et al., 1981; Verpoorte et al., 1983b.

Authors A. de Ruijter

STRYCHNOS HENNINGSII Gilg

Protologue Bot. Jahrb. Syst. 17: 569 (1893).

Family Loganiaceae

Vernacular names Red bitterberry (En).

Origin and geographic distribution *Strychnos henningsii* occurs from DR Congo east to Ethiopia and south to Angola and South Africa. It also occurs in Madagascar.

Uses The Maasai and Batemi peoples in Tanzania add the plant to milk and meat-based soups as a general tonic. In Kenya a decoction of the branches in soup is taken to treat rheumatism and gynaecological complaints; a root decoction is taken to treat chest pain and internal injuries. A stem decoction is taken to treat malaria. In Kenya and Tanzania fresh roots are chewed to treat snakebites. In Tanzania pounded roots are taken in food to treat hookworm infections. In South Africa a bark extract is taken in small doses to treat colic, stomach-ache, dizziness and as a purgative and anthelminthic. The powdered bark in water is taken to treat nausea. A bark decoction is given to children to treat internal worms and it is given to cattle to treat diarrhoea and heartwater caused by the rickettsial parasite, *Cowdria ruminantium*. In Madagascar the stem bark and roots are used to poison rats and mice, and sometimes also for criminal purposes.

In Kenya the wood is used to make arrow shafts and poles for building huts and cattle enclosures.

Properties *Strychnos henningsii* is rich in monomeric indole alkaloids of the tsilanine, spermostrychnine, diaboline and retuline classes. The stem bark contains alkaloids of the tsilanine class (holstiine, holstiline and rindline), spermostrychnine class, diaboline class and retuline class. The leaves and root bark contain alkaloids of the tsilanine class, retuline class and spermostrychnine class. The twigs contain alkaloids of the retuline class.

Stem bark alkaloids of *Strychnos henningsii* have shown convulsive, hypotensive and cardiac depressant activities, due to their effect on the central nervous system (CNS), and have anti-cancer potential. Holstiine and holstiline showed weak to moderate antimalarial activity against chloroquine-resistant *Plasmodium falciparum* but did not show antiamoebic activity. Extracts of a mixture of stem and root bark showed no muscle-relaxant or convulsive activity. Some alkaloids isolated from *Strychnos henningsii* demonstrated additional pharmacological activities. In-vivo tests showed an anti-inflammatory action for retuline on rat paw oedema, an analgesic action for isoretuline, acetylisoretuline and desacetylisoretuline in mice and an antispasmodic action for isoretuline and O-acetylisoretuline in guinea-pigs.

Botany Shrub or small tree up to 10(–20) m tall, with spreading rounded crown; bole up to 50 cm in diameter; bark pale grey to pale brown, rough; branchlets pale to medium brown or yellowish, conspicuously grooved,

glabrous. Leaves opposite, simple and entire; stipules absent; petiole 1–3 mm long, glabrous; blade elliptical to oblong or ovate, 2–6(–10) cm × 1–3(–6) cm, base cuneate to rounded, apex rounded to acuminate, glabrous, 3-veined from the base. Inflorescence an axillary and sometimes terminal congested thyrse 1–2 cm long, few- to many-flowered. Flowers bisexual, regular, 5-merous, fragrant, sessile; sepals fused at base, almost orbicular, up to 1.5 mm long; corolla tube up to 1.5 mm long, lobes triangular to ovate, 2–2.5 mm long, acute, spreading, glabrous outside, inside usually hairy at the base, greenish yellow, creamy or white; stamens inserted at the mouth of the corolla tube, just exserted; ovary superior, globose or depressed globose, 1–1.5 mm long, glabrous, 2-celled, style c. 1 mm long, stigma head-shaped. Fruit an ellipsoid berry c. 2 cm × 1 cm, yellow, orange or red, 1-seeded. Seed ellipsoid, 8–12 mm × 5–7 mm × 5–7 mm, glabrous, minutely pitted, with a deep closed groove at one side.

Strychnos comprises about 200 species: about 60 species in Asia, 65 in America and 75 in Africa. *Strychnos henningsii* belongs to the section *Breviflorae*.

Ecology *Strychnos henningsii* occurs in woodland and open forest, from sea-level up to 2000 m altitude.

Genetic resources and breeding *Strychnos henningsii* is widely distributed in a large part of Africa and is not in danger of genetic erosion, although local overexploitation has caused *Strychnos henningsii* to become rare in some regions, e.g. the Machakos District, Kenya.

Prospects *Strychnos henningsii* contains many indole alkaloids and several of them show pharmacological activity. Further study of the cardiac and anti-cancer potential of the alkaloids and the analgesic and anti-inflammatory properties of the retuline class alkaloids seems warranted.

Major references Kareru et al., 2007; Leeuwenberg, 1969; Neuwinger, 2000; Ohiri, Verpoorte & Baerheim Svendsen, 1983c; Tits et al., 1991.

Other references Bisset, 1970; Boiteau, Boiteau & Allorge-Boiteau, 1999; Dold & Cocks, 2001; Dold & Cocks, 2002; Hutchings et al., 1996; Leeuwenberg, 1980; Massiot et al., 1991; Njoroge & Bussmann, 2006; Tyiso & Bhat, 1998; van Wyk, van Oudtshoorn & Gericke, 1997.

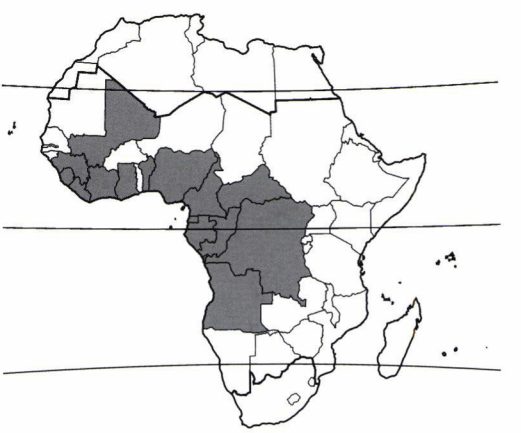
Authors A. de Ruijter

STRYCHNOS ICAJA Baill.

Protologue Adansonia 12: 368 (1879).
Family Loganiaceae
Chromosome number $2n = 44$
Vernacular names Curare, strychnos, icaja (En).

Origin and geographic distribution *Strychnos icaja* occurs from Guinea east to the Central African Republic and south to Angola.

Uses Because of its toxicity *Strychnos icaja* is usually administered under the supervision of a traditional medicine man, mainly in the treatment of skin diseases and chronic and persistent malaria. In Ghana an alcoholic extract of stem bark is taken to treat haemorrhoids. In the Central African Republic the body is rubbed with a root bark maceration as a snake repellent. A very small dose of root bark maceration is taken as an abortifacient and as an anthelmintic. In Gabon a root decoction is taken as a diuretic or as an intoxicating drink. In Congo a cold infusion of the root in palm wine is taken to treat gastrointestinal complaints and hernia. In DR Congo ground root bark mixed with palm oil is applied to treat skin diseases and itch. The ash of burnt twigs or roots is rubbed into scarifications of the forehead to treat insanity and malaria. A maceration of ground roots is used as a rectal wash to treat sterility. Throughout Central Africa a root or root bark infusion, or more rarely a stem bark extract, has been used as ordeal poison. Often roots of young plants were used, which seem to have a lower toxicity than those of mature plants. The root bark is an ingredient in arrow poison. In Côte d'Ivoire, Nigeria and DR Congo whole plants, root bark



Strychnos icaja – wild

and fruits are used as a fish poison.

Properties The root, stem and leaves contain a mixture of tertiary indole alkaloids of which strychnine and pseudostrychnine (12-hydroxystrychnine) are the principal active substances. The roots contain dimeric tertiary alkaloids such as bisnordihydrotoxiferine and sungucine. They also contain quaternary alkaloids, such as N-strychninium. Strychnine is also the main alkaloid component of the fruits and seeds. Strychnine activity enhances epinephrine levels and increases blood pressure. The most direct symptoms caused by strychnine are violent convulsions. It is applied in medicine as a stimulator of the nervous system and as a reliable anaesthetic. It is slightly soluble in water, but more soluble in alcohol. *Strychnos icaja* could be used as a local source either of an extract or of a partially purified mixture of strychnine, 12-hydroxystrychnine, and other tertiary alkaloids. Sungucine and isosungucine exhibit antiplasmodial activities but also show cytotoxic effects against human cancer cells. Pharmacological experiments have shown that the quaternary alkaloid fraction has pronounced muscle-relaxant activity. Moreover, this fraction has a powerful cardiotoxic action ending in irreversible cardiac arrest.

Other alkaloids of the leaves are the monomers protostrychnine, genostrychnine and pseudostrychnine, the bisindolic alkaloid strychnogucine, and the trimeric indolomonoterpenic alkaloid strychnohexamine, which has antiplasmodial activity against *Plasmodium falciparum*.

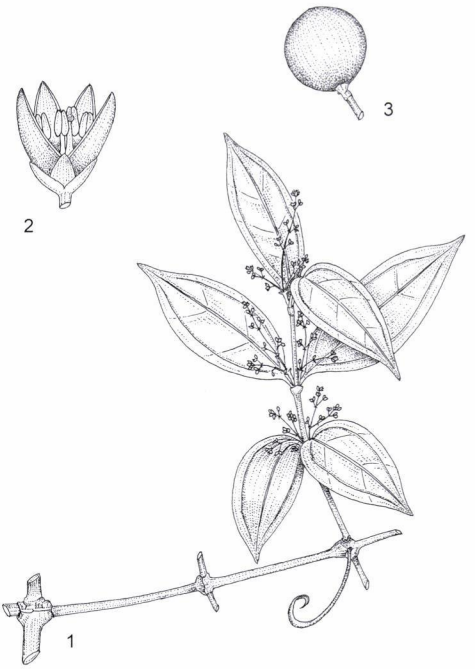
Strychnogucine and strychnohexamine were also isolated from the root bark.

Saponins, iridoids and phenolic compounds are also present in *Strychnos icaja*, but they probably have little activity compared to the alkaloids.

In-vitro production of strychnine and some other *Strychnos* alkaloids is possible.

Adulterations and substitutes Several other tropical African plant species such as *Strophanthus* spp. are used as substitutes for *Strychnos icaja* to produce arrow poison.

Description Large liana up to 100 m long, climbing with solitary tendrils; stem up to 15 cm in diameter; branchlets dark green, glabrous. Leaves opposite, simple and entire; stipules absent; petiole 4–12 mm long, glabrous; blade ovate to elliptical, 5–15(–21) cm × 2–7(–10) cm, base cuneate to rounded, apex acuminate, glabrous, 3-veined from the base.



Strychnos icaja – 1, flowering branch; 2, flower; 3, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

Inflorescence an axillary lax thyrse 3–7 cm long, few- to many-flowered. Flowers bisexual, regular, 4-merous; sepals fused at base, broadly ovate to almost orbicular, up to 1 mm long; corolla tube up to 1.5 mm long, lobes oblong to ovate or triangular, 1.5–2 mm long, acute, spreading, glabrous or hairy inside at base, greenish yellow or yellowish white; stamens inserted at the mouth of the corolla tube, exserted; ovary superior, globose, c. 0.5 mm in diameter, glabrous, 2-celled, style 0.5–1 mm long, stigma small, head-shaped. Fruit an ellipsoid or globose berry c. 2.5 cm × 3 cm, soft, dark yellow when ripe, 1-seeded. Seed ellipsoid, 16–21 mm × 15–20 mm × 9–15 mm, woolly hairy.

Other botanical information *Strychnos* comprises about 200 species: about 60 species in Asia, 65 in America and 75 in Africa. *Strychnos icaja* belongs to the section *Breviflorae*.

Ecology *Strychnos icaja* occurs in rainforest and secondary forest on lateritic sandy clay soils, from sea-level up to 800 m altitude.

Propagation and planting *Strychnos icaja*

regenerates from seed and suckers.

Harvesting The roots are dug up and the bark is removed before the root dries out. Harvesting the stem bark or the leaves is a more sustainable activity.

Handling after harvest After drying and grinding, the material can be subjected to a conventional alkaloid extraction procedure.

Genetic resources There are no indications that *Strychnos icaja* is in danger of genetic erosion.

Prospects Because of its alkaloid content *Strychnos icaja* is widely used for medicinal purposes. In order to promote its sustainable use, research should be done on domestication and improving its productivity for industrial production with respect to local and international trade. Research on the antimalarial properties of some of the alkaloids seems promising.

Major references Bisset, 1970; Bisset & Leeuwenberg, 1968; Bisset & Phillipson, 1971; Bohlin, 1978; FAO, 1986; Iwu, 1993; Leeuwenberg, 1969; Mshana et al., 2000; Neuwinger, 2000; Ohiri, Verpoorte & Baerheim Svendsen, 1983c.

Other references Adjanohoun et al. (Editors), 1988; Bisset & Khalil, 1976; Bisset, Das & Parello, 1973; Caniato & Puricelli, 2003; Frédérich et al., 2003b; Frédérich et al., 2000a; Frédérich et al., 2001; Frédérich, Tits & Angenot, 2003; Gassita et al. (Editors), 1982; Kambu, Coune & Angenot, 1979; Lamotte et al., 1979; Philippe et al., 2004; Philippe et al., 2003; Philippe et al., 2006; Raponda-Walker & Sillans, 1961.

Sources of illustration Leeuwenberg, 1969.

Authors D.M. Mosango

STRYCHNOS LONGICAUDATA Gilg

Protologue Bot. Jahrb. Syst. 17: 570 (1893).

Family Loganiaceae

Chromosome number $2n = 44$

Origin and geographic distribution *Strychnos longicaudata* occurs from Côte d'Ivoire east to the Central African Republic and south to DR Congo.

Uses In Côte d'Ivoire unspecified plant parts of *Strychnos longicaudata* are used to treat chest-complaints, while in Cameroon they are used to treat malaria. The Aka people of the Central African Republic take a palm wine maceration of twig bark as an aphrodisiac. In the Central African Republic *Strychnos longicaudata* is used as an ingredient of arrow poison.

In DR Congo the Andiri and Teturi people use the wood to make arrow-shafts, machete handles and other small implements.

Properties Preliminary tests of leafy twigs from Côte d'Ivoire and leaves and seeds from Cameroon showed the presence of the monomeric strychnine class indole alkaloids icajine and vomicine. The root bark contains the dimeric tertiary longicaudatine and its isomer bisnor-C-alkaloid H.

The chloroform fraction of a bark extract showed a weak muscle-relaxant effect in mice. Although icajine does not have an intrinsic antiplasmodial activity, it did reverse chloroquine resistance in in-vitro tests and proved to be synergistic with mefloquine. In in-vivo tests longicaudatine, isolated from *Strychnos trinervis* (Vell.) Mart., was shown to have an antispasmodic effect on artificially induced contractions of guinea-pig ileum and rat uterus.

Botany Climbing shrub or liana up to 60 m long, climbing with solitary tendrils; stem up to 15 cm in diameter; branchlets medium to dark green, glabrous or less often short-hairy. Leaves opposite, simple and entire; stipules absent; petiole 2–7 mm long, short-hairy or glabrous; blade elliptical, narrowly elliptical to ovate, 5.5–14(–17.5) cm × 2–6(–8) cm, base cuneate to rounded, apex acuminate, glabrous or with some stiff brown hairs beneath, 3-veined from the base. Inflorescence an axillary or occasionally terminal, solitary, more or less congested thyrse up to 4 cm long, many-flowered. Flowers bisexual, regular, 5-merous; sepals fused at base, orbicular to broadly obovate, up to 1.5 mm long; corolla tube cylindrical, up to 2.5 mm long, lobes triangular, 1.5–2 mm long, acute, almost erect, thick, glabrous or sometimes sparsely hairy outside, greenish white, white or outside pale green and inside white; stamens inserted about halfway in the corolla tube, included; ovary superior, globose, up to c. 1 mm long, glabrous, 2-celled, style up to 1.5 mm long, stigma head-shaped. Fruit an ellipsoid berry 14–17 mm in diameter, wall thin, soft, smooth, orange or yellow-green, 1-seeded. Seed ellipsoid to nearly ovoid, flattened, 11–15 mm × 8–12 mm × 3–5 mm, very short-hairy.

Strychnos comprises about 200 species: about 60 species in Asia, 65 in America and 75 in Africa. *Strychnos longicaudata* belongs to section *Penicillatae*. *Strychnos tchibangensis* Pellegr. occurs in Cameroon, the Central Afri-

can Republic, Gabon and DR Congo and also belongs to section *Penicillatae*. In the Central African Republic a bark decoction is taken as an anthelmintic; pulverized bark is used for cicatrisation of wounds.

Ecology *Strychnos longicaudata* occurs in moist localities and on river banks in rainforest, including secondary forest, from sea-level up to 700 m altitude.

Genetic resources and breeding *Strychnos longicaudata* is rather widespread and does not seem to be threatened by genetic erosion.

Prospects *Strychnos longicaudata* will remain of limited use only. The alkaloids which have been identified so far are more abundant in other *Strychnos* species.

Major references Bisset, 1970; Burkill, 1995; Leeuwenberg, 1969; Leeuwenberg, 1980; Neuwinger, 2000.

Other references Betti, 2003; Bisset & Leeuwenberg, 1968; Bisset & Phillipson, 1971; Bouquet & Debray, 1974; de Medeiros, Thomas & Mukherjee, 1991; Frédérich et al., 2000b; Ohiri, Verpoorte & Baerheim Svendsen, 1983c; Terashima & Ichikawa, 2003; Thepenier et al., 1990; Verpoorte & Bohlin, 1976.

Authors A. de Ruijter

STRYCHNOS MOSTUEOIDES Leeuwenb.

Protologue Meded. Landbouwhogeschool 69(1): 194 (1969).

Family Loganiaceae

Origin and geographic distribution *Strychnos mostueoides* is endemic to Madagascar, but a somewhat different, more hairy specimen that may belong to this species was found in DR Congo.

Uses In Madagascar a decoction of the aerial parts is taken to treat malaria.

Properties From the root bark 8 indole alkaloids have been identified: normacusine B, caracusine VII, strychnofendlerine, spermostrychnine, strychnobrasiline, deacetylstrychnobrasiline, malagashine and malagashanine. Chemically normacusine B belongs to the corynanthean class of alkaloids, the other compounds belong to the strychnine class. Normacusine B is also found in *Rauvolfia*, *Tabernaemontana* and *Vinca* spp. It is sympatholytic and its hypotensive activity is stronger than that of reserpine, which is commonly used against high blood pressure. Malagashanine was shown to have promising chemosensitizing activity against chloroquine-resistant strains of the malaria parasite *Plasmodium falciparum*.

Botany Shrub up to 3 m tall, often dichotomously branched; branchlets sparsely hairy or glabrous. Leaves opposite, simple and entire; stipules absent; petiole 0.5–2 mm long, hairy or glabrous; blade ovate, narrowly ovate or elliptical, 20–70 cm × 9–30 cm, base rounded or cuneate, apex long-acuminate, glabrous or sparingly hairy on the veins on both sides or only beneath, 3-veined from the base. Inflorescence a terminal, lax thyrse 1–2 cm long, few-flowered; peduncle 1–2 cm long. Flowers bisexual, regular, 5-merous; sepals fused at base, nearly triangular, c. 1 mm long; corolla tube cylindrical, c. 2.5 mm long, lobes oblong, c. 2.5 mm long, acute, outside glabrous, inside hairy at base, white; stamens inserted at the middle of the corolla tube, included, anthers oblong, with a single hair at the deeply cordate base; ovary superior, ovoid, c. 1 mm × 0.5 mm, 2-celled, stigma sessile, head-shaped. Fruit a globose berry 6–8 mm in diameter, 1–2-seeded. Seeds elliptical, disk-like, 6–8 mm × 5–7 mm × 2 mm, rough, testa rather thick.

Strychnos comprises about 200 species: about 60 species in Asia, 65 in America and 75 in Africa.

Ecology *Strychnos mostueoides* occurs in forest near river banks, from sea-level up to 500(–1000) m altitude.

Genetic resources and breeding *Strychnos mostueoides* is endemic to Madagascar and may easily become endangered by habitat destruction.

Prospects *Strychnos mostueoides* will remain of minor importance in traditional medicine. More research into the chemical composition and pharmacological activities of the indole alkaloids is needed to evaluate the use in traditional medicine.

Major references Leeuwenberg, 1969; Neuwinger, 2000; Ramanitrahasimbola et al., 2006; Rasoanaivo et al., 2001b; Rasoanaivo et al., 1992; Saxton, 1993.

Other references Leeuwenberg, 1980; Leeuwenberg, 1984; Rasoanaivo et al., 1991a; Rasoanaivo, Ratsimamanga-Urverg & Frappier, 1996.

Authors A. de Ruijter

STRYCHNOS MYRTOIDES Gilg & Busse

Protologue Bot. Jahrb. Syst. 32: 178 (1902).
Family Loganiaceae
Origin and geographic distribution *Strychnos myrtoides* occurs in south-eastern Tanzania, Mozambique and Madagascar.

Uses In Madagascar an infusion or decoction of *Strychnos myrtoides* together with chloroquine is taken to treat malaria.

Properties Two major indole alkaloids, strychnobrasiline and malagashanine, were isolated from the stem bark, as well as 4 minor alkaloids: malagashanol, 12-hydroxy-19-epi-malagashanine, myrtoidine and 11-demethoxy-myrtoidine. These compounds showed no intrinsic antimalarial effect against a chloroquine-resistant strain of *Plasmodium falciparum* in vitro and in vivo, but significantly enhanced the effect of chloroquine. No cytotoxicity was observed. A crude stem-bark extract also showed no intrinsic antimalarial effects, but significantly enhanced the action of chloroquine both in vitro and in vivo against a chloroquine-resistant *Plasmodium yoelii* strain in mice.

Botany Much-branched shrub or small tree up to 5 m tall, often dichotomously branched; branchlets hairy. Leaves opposite, simple and entire; stipules absent; petiole up to 2 mm long, hairy; blade ovate, narrowly ovate to narrowly elliptical, obovate or sometimes nearly orbicular, (0.5–)1–3.5 cm × 0.5–2 cm, base cuneate to rounded, apex rounded to acute or acuminate, glabrous or sparingly hairy on the veins on both sides or only beneath, 3-veined from the base. Inflorescence a terminal, lax thyrse 0.5–1.5(–2) cm long, few-flowered; peduncle short, brown hairy. Flowers bisexual, regular, (4–)5-merous; sepals fused at base, broadly ovate to orbicular, c. 1 cm long; corolla tube bell-shaped to nearly cylindrical, 1–2.5 mm long, lobes narrowly triangular, 1–2 cm long, acute, outside glabrous or minutely hairy, inside hairy at the base, white; stamens inserted at the middle of the corolla tube, included, anthers orbicular or oblong, hairy at the deeply cordate base; ovary superior, ovoid, c. 1 mm × 0.5 mm, 2-celled, style up to 0.5 mm long, stigma head-shaped. Fruit a globose or flattened berry 8–9 mm in diameter, soft, red or orange, 1-seeded. Seed elliptical, flattened, disk-like, 8 mm × 7 mm × 1.5 mm, rough, with thick, short hairs.

Strychnos comprises about 200 species: about 60 species in Asia, 65 in America and 75 in Africa. *Strychnos myrtoides* belongs to the section *Penicillatae*. *Strychnos diplotricha* Leeuwenb., which is endemic to Madagascar, also belongs to this section. It is used as an antimalarial in north-eastern Madagascar. The root bark of *Strychnos diplotricha* contains indole alkaloids that have also been isolated from the leaves or stem bark of *Strychnos myrtoides*.

Ecology *Strychnos myrtoides* occurs in *Brachystegia*-woodlands and open forest, from sea-level up to 600 m altitude.

Genetic resources and breeding *Strychnos myrtoides* does not seem to be in danger of genetic erosion.

Prospects The importance of *Strychnos myrtoides* as traditional antimalarial medicine will probably increase because of its proven effect of enhancing the action of chloroquine in case of chloroquine-resistance. In view of the pharmacologically interesting compounds found in other *Strychnos* species, more research into the chemical composition and pharmacological activities of the indole alkaloids of *Strychnos myrtoides* seems warranted.

Major references Leeuwenberg, 1969; Rasoanaivo et al., 1994b; Schwikkard & van Heerden, 2002.

Other references Neuwinger, 2000; Ramanitrahasimbola et al., 2006; Rasoanaivo et al., 2001b.

Authors A. de Ruijter

STRYCHNOS NUX-VOMICA L.

Protologue Sp. pl. 1: 189 (1753).
Family Loganiaceae
Chromosome number $2n = 24, 44$
Vernacular names Crow fig, nux-vomica tree, poison nut, snake-wood, strychnine plant (En). Vomiquier, noix vomique, vomique officinale, pomme de voutac (Fr). Noz vômica, carimão (Po).

Origin and geographic distribution *Strychnos nux-vomica* originates from India and South-East Asia and is introduced and locally naturalized in tropical Africa. It is cultivated in Ghana and Sudan.

Uses The medicinal use of *Strychnos nux-vomica* in Africa is limited. In Ghana the seeds are eaten to treat anaemia. The seed, bark, wood and roots have numerous applications in traditional medicine in Asia, Europe and the United States. In India the fruit is used in both the Ayurvedic and Unani systems of medicine and is considered acrid, pungent, bitter, poisonous and heating. It is used as an appetizer,

tonic, astringent, aphrodisiac and antipyretic, and it is claimed to cure leucoderma, blood diseases, itching, ringworm, piles, ulcers, anaemia, jaundice, urinary discharges, joint pain, lumbago and weakness of limbs. In Europe a description of medicinal use of *Strychnos nux-vomica* dates back as early as 1540 A.D. It was especially used to treat nervous disorders and problems of the digestive organs and the respiratory system. Nowadays it is mainly used in phytotherapy to treat upset stomach, abdominal pain, constipation, hangover, heartburn, insomnia, circulatory problems, depression, migraine, nervous conditions, problems related to menopause and respiratory diseases.

In India the seeds are used for dying cloth pale brown. The seeds are an ingredient of liquors. The wood is hard and termite proof and is used in manufacturing furniture, cart wheels and agricultural implements. The leaves are used as a green manure.

Production and international trade The annual production of *Strychnos nux-vomica* seed in India was estimated at 2000 t at the beginning of the 1970s. In the period 1965–1971 the average production of strychnine and brucine from *Strychnos nux-vomica* seeds in India was 18,000 kg/year. Most of the alkaloids are exported to the United States and Europe.

Properties All plant parts of *Strychnos nux-vomica* contain indole alkaloids, but the seeds have the highest concentration. They contain 1–3% alkaloids, mainly strychnine and its dimethoxylated derivative brucine. The other plant parts contain several other strychnine derivatives with a total concentration of up to 1%: 12-hydroxy-strychnine, 15-hydroxy-strychnine, α-colubrine, β-colubrine, icajine, 11-methoxy-icajine, novacine, vomicine, pseudostrychnine, pseudobrucine, pseudo-α-colubrine, pseudo-β-colubrine, N-methyl-sec-pseudo-β-colubrine, and isostrychnine. The bisindole alkaloid longicaudatine has also been isolated; it has reserpine-like activity.

Strychnine is very toxic, and the lethal dose in humans may start at about 0.4 mg/kg. It may cause anxiety, restlessness, painful convulsions of the body, breathing difficulties and even death resulting from suffocation or exhaustion. In addition, long-term intake of even small amounts of strychnine can cause liver damage. Strychnine increases blood pressure, and it is applied in medicine as a stimulator of the nervous system and as a reliable anaesthetic. Brucine is about 50–100 times less toxic than strychnine. The seed extract exhibits significant analgesic, anti-inflammatory, anti-ulcer, cytotoxic, antioxidant and uterine stimulant activity. The analgesic and anti-inflammatory activities are caused by brucine and brucine N-oxide.

The analysis of cytotoxic effects of brucine, brucine N-oxide, strychnine and isostrychnine on human hepatoma cells showed that brucine exhibited the strongest toxic effect.

Galactomannans and galactans are also present in the seeds. The seed extract is efficient in the coagulation–flocculation of hydrophobic colloids (such as a clay suspension), but it is a poor flocculent in the case of hydrophilic colloids (such as bacteria). The leaves have strong allelopathic properties.

Botany Medium-sized tree up to 25 m tall; bole up to 100 cm in diameter; branchlets slightly short-hairy. Leaves opposite, simple and entire; stipules absent; petiole 5–15 mm long; blade orbicular to broadly elliptical or ovate, 5–18 cm × 4–13 cm, base rounded to cordate, apex shortly acuminate or acute, glabrous and shiny above, minutely hairy especially on veins beneath, 3–5-veined from the base. Inflorescence an axillary thyrse 3–7 cm long, many-flowered. Flowers bisexual, regular, 5-merous; calyx lobes ovate, outside densely hairy; corolla with a slender tube c. 1 cm long, abruptly widening at the throat, outside glabrous, inside sparsely woolly hairy in lower part, lobes narrowly ovate, c. 3 mm long, margin thickened and minutely hairy, greenish white to white; stamens inserted at the mouth of the corolla tube, exserted; ovary superior, ovoid, glabrous, style up to 1 cm long, stigma head-shaped. Fruit a globose berry 2–4(–6) cm in diameter, orange, glabrous, 1–4-seeded. Seeds lens-shaped to orbicular or ellipsoid, 20–23 mm × 18–20 mm × c. 4 mm, silky hairs.

Strychnos comprises about 200 species: about 60 species in Asia, 65 in America and 75 in Africa. *Strychnos nux-vomica* belongs to section *Strychnos*.

Ecology In its natural habitat *Strychnos nux-vomica* occurs at the edge of dense forest, on river banks and along the shore, mainly on loamy or loamy-sandy soil, although it also occurs on lateritic and clayey loam soils. The annual rainfall varies from 1200–3500 mm.

Management *Strychnos nux-vomica* regenerates from seeds and suckers. Seeds take 70–120 days to germinate. In India seeds are sown in nurseries and seedlings are transplanted to the field. *Strychnos nux-vomica* plants have

been successfully regenerated from tissue culture.

Fruiting starts 10–15 years after planting. Fruits are usually gathered from the trees. Fallen fruits are considered to be of inferior quality. After collecting, seeds are cleaned and dried in the sun. Dried seeds can be stored in jute bags for a long period without loss of alkaloid content, but they should be kept in dry conditions to prevent deterioration by fungi. Seeds are further processed in factories to obtain strychnine and brucine. In traditional Chinese medicine, seeds are usually heated in oil to reduce their toxicity. This significantly reduces the contents of strychnine and brucine and increases the amounts of isostrychnine, isobrucine, strychnine N–oxide and brucine N–oxide.

Genetic resources and breeding *Strychnos nux-vomica* is widespread in its original area of distribution in India, Indo-China and Thailand and is not in danger of genetic erosion. In Africa virtually nothing is known about its distribution or genetic variability.

Prospects The use of *Strychnos nux-vomica* for medicinal purposes has diminished over the years. The use of strychnine has been superseded because of its high toxicity. Some of the other alkaloids may play a role in the development of new anti-cancer or anti-malarial drugs. More research into the chemical composition and pharmacological activities of these compounds seems warranted. In India the seeds are still widely used in traditional medicine and there is a need to develop high yielding, alkaloid-rich cultivars.

Major references Cai et al., 1998; Iwu, 1993; Leeuwenberg, 1980; Mshana et al., 2000; Purwaningsih, 1999.

Other references Yin et al., 2003; Bisset, 1989a; Bisset & Leeuwenberg, 1968; Cai et al., 1996; Corsaro et al., 1995; Deng et al., 2006; Yin et al., 2003.

Authors P. Oudhia

STRYCHNOS PHAEOTRICHA Gilg

Protologue Bot. Jahrb. Syst. 36: 105 (1905).

Family Loganiaceae

Origin and geographic distribution *Strychnos phaeotricha* occurs from Ghana east to DR Congo.

Uses In DR Congo the seeds are put into a calabash containing embers and the smoke is inhaled to treat tuberculosis in children.

Properties Preliminary chemical analysis shows that *Strychnos phaeotricha* has a low alkaloid content. The tertiary indole alkaloids of the bark have weak muscle-relaxant and convulsant activities.

Botany Large liana up to 50 m long, climbing with paired tendrils; stem 2–7 cm in diameter; branchlets brown, without lenticels. Leaves opposite, simple and entire; stipules absent; petiole 2–4 mm long, with some large colleters at the base; blade narrowly obovate to narrowly elliptical, (2.5–)5–16.5(–22) cm × (1.5–)2.5–8 cm, base cordate, apex acuminate, brown hairy, 3-veined from the base. Inflorescence a terminal lax thyrse, 5–8 cm long, many-flowered. Flowers bisexual, regular, 5-merous; sepals fused at base, linear, 0.5–1 mm long; corolla tube 0.5–1 mm long, widening at the throat, lobes narrowly oblong, 2.5–4 mm long, acute, spreading to reflexed, outside brown hairy or sometimes glabrous, inside with a hairy gland just above the base, white, cream or yellow; stamens inserted at the mouth of the corolla tube, exserted, filaments near the base with a 2-lobed hairy gland; ovary superior, ovoid, 1–1.5 mm × 0.5–1 mm, 2-celled, style 1.5–2 mm long, stigma head-shaped. Fruit an ellipsoid berry 25–30 mm × 18–27 mm × 18–25 mm, soft, orange, 3–7-seeded. Seeds obliquely ovoid to ellipsoid, flattened, 15–23 mm × 10–15 mm × 3–6 mm, yellowish brown, smooth.

Strychnos comprises about 200 species: about 60 species in Asia, 65 in America and 75 in Africa. *Strychnos phaeotricha* is the only species in the section *Phaeotrichae*.

Ecology *Strychnos phaeotricha* occurs in rainforest, including secondary forest, or gallery forest from sea-level up to 700 m altitude.

Genetic resources and breeding *Strychnos phaeotricha* does not seem to be in danger of genetic erosion.

Prospects *Strychnos phaeotricha* will probably remain of local importance as a medicinal plant.

Major references Bohlin, Ali & Sandberg, 1974; Disengomoka, Delaveau & Sengele, 1983; Leeuwenberg, 1969; Leeuwenberg, 1980.

Other references Bouquet & Fournet, 1975a; Neuwinger, 2000.

Authors A. de Ruijter

STRYCHNOS POTATORUM L.f.

Protologue Suppl. pl.: 148 (1781).

Family Loganiaceae

Vernacular names Grape strychnos (En).

Origin and geographic distribution *Strychnos potatorum* occurs from DR Congo and Tanzania south to northern South Africa. *Strychnos potatorum* was probably introduced in Asia by Arabic traders; it occurs in India, Sri Lanka and Myanmar.

Uses In Tanzania pounded leaves are used to treat watering and aching eyes and the vapour of a root decoction is inhaled to treat venereal diseases. In Malawi a leaf decoction is taken to treat epilepsy. In Zambia the vapour of a root decoction is inhaled to treat colds. In Tanzania and Zambia the roots are used as an aphrodisiac. In Zimbabwe a decoction of roots and leaves is taken to treat cough. In Indian traditional medicine *Strychnos potatorum* seeds are used for the treatment of complaints of the liver, kidneys and stomach and gonorrhoea, leucorrhoea, bronchitis, chronic diarrhoea, strangury, kidney and bladder stones, diabetes and eye diseases.

In Zimbabwe, Mozambique and South Africa the pounded fruits are used as fish poison, and in Zimbabwe crushed bark is also used for this purpose.

In Tanzania and Zambia the wood is used to make tool handles. In Asia the seeds are used to clear muddy water.

Properties *Strychnos potatorum* contains many monomeric and dimeric indole alkaloids, the root bark being especially rich.

The monoterpene alkaloid cantleyine, isolated from the root bark, showed a relaxing effect on isolated tracheal smooth muscles of guinea-pig and may be the active ingredients responsible for the anticough and anti-asthmatic activity. Normacusine B, a monomeric alkaloid of the corynanthe class, also found in *Rauvolfia*, *Tabernaemontana* and *Vinca* spp., is sympatholytic and its hypotensive activity is stronger than that of reserpine, which is commonly used against high blood pressure. In-vitro tested ochrolifuanine A, a dimeric alkaloid of the β-carboline class, showed significant activity against chloroquine sensitive and chloroquine resistant *Plasmodium falciparum* strains.

The total alkaloidal extracts of the seeds, bark and leaves showed strychnine-like activity in vivo, had marked hypotensive effect and exhibited a depressant action on isolated heart. In in-vivo tests the seed powder and an aqueous extract of the seeds prevented ulcer formation by decreasing acid secretory activity and increasing the mucin activity in rats. An aqueous extract of the seeds also showed significant hepatoprotective activity in rats. A methanol extract of the seeds had a diuretic effect and an antidiarrhoeal activity on castor oil-induced diarrhoea in rats. The seeds contain polyelectrolytes which can be used as coagulants to clarify turbid waters. In laboratory tests, direct filtration of turbid surface water with the seeds as a coagulant, produced a substantial improvement in its aesthetic and microbiological quality. The aerial parts also contain β-sitosterol, stigmasterol, oleanolic acid and its 3β-acetate, triterpenes and the polysaccharide mannogalactan.

The wood is very hard and termite resistant, but splits easily and is therefore not suitable for carving.

Botany Deciduous much-branched shrub or small or medium-sized tree up to 18 m tall; bole up to 100 cm in diameter; branchlets pale to dark brown, glabrous, apex modified into a spine-like tip 1–3 mm long. Leaves opposite, simple and entire; stipules absent; petiole 1–7 mm long, glabrous; blade elliptical to ovate, 6–15 cm × 3–9 cm, base cuneate to rounded, apex acute to acuminate, glabrous, 5-veined from the base. Inflorescence an axillary lax or congested thyrse 1.5–2.5 cm long. Flowers bisexual, regular, (4–)5-merous, appearing before or with the young leaves; sepals fused at base, ovate to oblong, up to 2.5 mm long; corolla tube up to 3.5 mm long, lobes oblong, c. 4.5 mm long, acute, spreading, glabrous outside, inside with hairs on the base of the lobes, white, creamy or yellow; stamens inserted at the mouth of the corolla tube, exserted; ovary superior, ovoid or conical, 1–2 mm long, glabrous, 2-celled, style up to 4.5 mm long, stigma small, head-shaped or sometimes obscurely 2-lobed. Fruit a globose berry (10–)15–25 mm in diameter, soft, blue-black, pulp purplish, smooth, shining, 1-seeded. Seed depressed-globose or ellipsoid, 10–13 mm × 9–13 mm × 6–9 mm, slightly glossy, with an obscure angular line all around, densely silky hairy, smooth.

Strychnos comprises about 200 species: about 60 species in Asia, 65 in America and 75 in Africa. *Strychnos potatorum* belongs to the section *Rouhamon*.

Ecology *Strychnos potatorum* occurs in gallery forest, in *Brachystegia*-woodland and in semi-evergreen bushland, often on river banks or on termite hills, from sea-level up to 1600 m altitude.

Genetic resources and breeding *Strychnos potatorum* is widespread and not in danger of genetic erosion.

Prospects Several alkaloids of *Strychnos potatorum* show promising medicinal activities, and more research into the pharmacological activities of the compounds seems warranted.

Major references Bisset, 1970; Leeuwenberg, 1969; Leeuwenberg, 1980; Massiot et al., 1992; Neuwinger, 2000.

Other references Babu & Chaudhuri, 2005; Biswas et al., 2001; Cavendish, 1999; Clarkson et al., 2004; Coates Palgrave, 1983; Gelfand et al., 1985; Sanmugapriya & Venkataraman, 2006; Sanmugapriya & Venkataraman, 2007; Zhu et al., 2005.

Authors A. de Ruijter

STRYCHNOS SAMBA P.A.Duvign.

Protologue Bull. Séanc. Inst. Roy. Col. Belg. 19: 216 (1948).

Family Loganiaceae

Chromosome number $2n = 44$

Origin and geographic distribution *Strychnos samba* occurs from Nigeria east to the Central African Republic and DR Congo.

Uses In the Central African Republic the root bark of *Strychnos samba* mixed with other plants, including root bark of *Penianthus longifolius* Miers, is used to make arrow poison. In Gabon, Congo and DR Congo the root bark has been used as ordeal poison. In DR Congo the pounded fruit is used as a fish poison.

Properties The leaves of *Strychnos samba* contain the indolopyridine alkaloid angustine and its derivatives angustidine and angustoline. Crude leaf and stem bark extracts showed a muscle relaxant effect in mice; root bark extract showed tonic convulsion as well.

Botany Liana up to 20 m long, climbing with paired tendrils; stem up to 5 cm in diameter; branchlets quadrangular, green, glabrous. Leaves opposite, simple and entire; stipules absent; petiole 5–12 mm long, glabrous; blade elliptical, 5–10(–17) cm × 2.5–7(–8.5) cm, base cuneate to rounded, apex acuminate, leathery, glabrous, 3-veined from the base. Inflorescence an axillary or terminal lax or congested thyrse 3–10 cm long, few- to many-flowered. Flowers bisexual, regular, 5-merous; sepals fused at base, ovate, up to 1 mm long; corolla tube c. 1 mm long, lobes narrowly triangular, 1–1.5 mm long, acute, almost erect or spreading, glabrous outside, inside hairy on the lobes, greenish; stamens inserted at the mouth of the corolla tube, exserted; ovary superior, ovoid, c. 1 mm long, glabrous, 2-celled, style up to 0.5 mm long, stigma head-shaped. Fruit a globose berry 17–20 mm in diameter, soft, pale green, smooth, 1-seeded. Seed obliquely ovoid, flattened, c. 14 mm × 13 mm × 7 mm, irregularly curved, pale brown, short-hairy.

Strychnos comprises about 200 species: about 60 species in Asia, 65 in America and 75 in Africa. *Strychnos samba* belongs to the section *Brevitubae*.

Ecology *Strychnos samba* occurs in rainforest, including secondary forest, in moist localities, from sea-level up to 700 m altitude.

Genetic resources and breeding *Strychnos samba* does not seem to be in danger of genetic erosion.

Prospects It seems likely that *Strychnos samba* will remain of limited use only.

Major references Burkill, 1995; Leeuwenberg, 1969; Leeuwenberg, 1980; Neuwinger, 1998; Neuwinger, 2000.

Other references Bisset, 1970; Bisset & Leeuwenberg, 1968; Bisset & Phillipson, 1971; Bohlin, 1978; Phillipson et al., 1974.

Authors A. de Ruijter

STRYCHNOS USAMBARENSIS Gilg ex Engl.

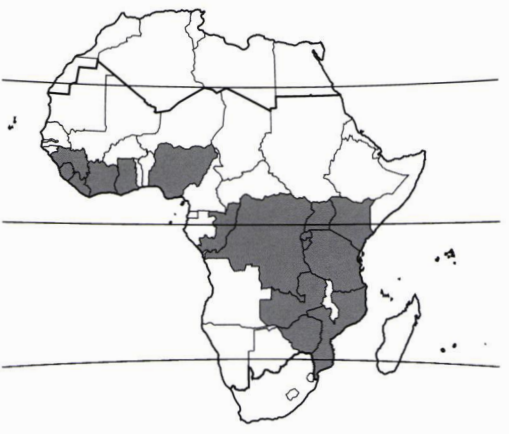
Protologue Abh. Königl. Preuss. Akad. Wiss. Berlin 36 (1894).

Family Loganiaceae

Synonyms *Strychnos cerasifera* Gilg (1895).

Vernacular names Blue bitterberry, stipe-fruited strychnos, stipe-fruited monkey orange (En).

Origin and geographic distribution *Strychnos usambarensis* occurs from Guinea east to Nigeria, and from Congo east to Kenya and



Strychnos usambarensis – wild

south to South Africa.

Uses The Banyambo people of Rwanda and Tanzania use the root bark and leaves of *Strychnos usambarensis* to produce arrow poison, sometimes in combination with other plants. In DR Congo the Nduye people mix the powdered root with water and apply this to the nostrils of hunting dogs to improve their scent. In DR Congo and western Kenya the wood is used for house construction.

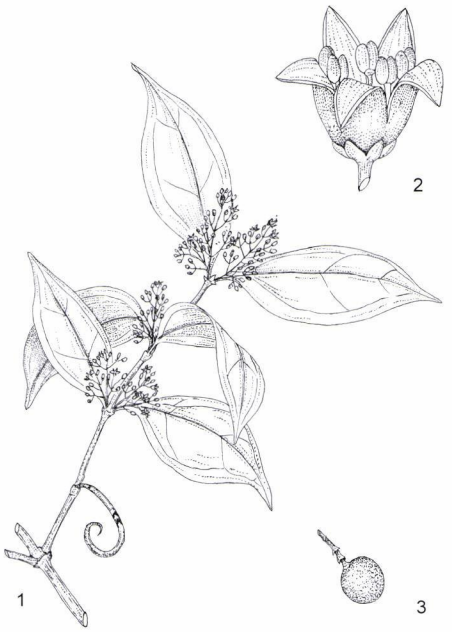
Properties *Strychnos usambarensis* is the best investigated African *Strychnos* species and more than 60 indole alkaloids have been isolated from it. The ones that have been identified so far are predominantly dimeric terpenoid indole alkaloids. In addition, the root bark contains tertiary alkaloids and several important quaternary alkaloids and anhydronium bases. Among these are the retuline class alkaloids C-dihydrotoxiferine, C-curarine and C-calebassine and the monomeric C-fluorocurarine, which are also the active principles of calabash curare obtained from South American *Strychnos* spp. *Strychnos usambarensis* root bark also contains the less active afrocurarine, the monomeric tetracyclic alkaloid akagerine, the non-terpenoid alkaloids harmane and melinonine F and the monoquaternary alkaloids malindine and isomalindine, which belong to the group of trinitrogenated alkaloids. Four root alkaloids, the dimeric usambarensines, are of the corynanthean class.

The leaf alkaloids are all of the corynanthean class, and belong to the usambarine group and the dimeric oxindole group. The main component of the leaves is the oxindole strychnofoline. Apart from alkaloids also known from other plant species, *Strychnos usambarensis* leaves contain some rare alkaloids with 5 nitrogen atoms such as strychnopentamine, its derivatives chrysopentamine, isostrychnopentamine and the oxindole strychnophylline.

The muscle paralyzing, curare-like effect of *Strychnos usambarensis* root bark is caused by the quaternary alkaloids, which block the excitation of the skeletal muscles. The paralyzing effect can be antagonized by acetylcholine. At higher doses the alkaloids cause a series of side-effects: drop in blood pressure, blocking of the vagus nerve, change in cardiac rate and frequency of respiration. Malindine also has a strong muscle relaxant activity, which is not antagonized by acetylcholine and is not of the curare type. Akagerine and its derivatives are potent convulsant agents, but 100 times less active than strychnine. The usambarensines have no paralyzing effect on skeletal muscles, but do have an atropine-like and spasmolytic activity on smooth muscles. Harmane induces enrichment of biogene amines such as serotonine in the brain. In small doses it causes hallucinations, in high doses convulsions and respiratory paralysis. Strychnopentamine and 5',6'-dihydrousambarensine showed strong activity against *Plasmodium falciparum* in vitro, but were inactive against *Plasmodium berghei* in vivo. However, isostrychnopentamine has an interesting antiplasmodial activity both in vitro against various chloroquine-resistant and chloroquine-sensitive strains of *Plasmodium falciparum* and in vivo against chloroquine-sensitive strains of rodent-infecting *Plasmodium berghei* and *Plasmodium vinckei*. Usambarine, usambarensine and 18,19-dihydrousambarine were less active against *Plasmodium falciparum* in vitro, but highly active against *Entamoeba histolytica* in vitro. Akagerine has only little antiprotozoal activity. Usambarensine and 5',6'-dihydrousambarensine are active against the gram-positive bacteria *Staphylococcus aureus*, *Bacillus subtilis* and *Mycobacterium smegmatis*. Harmane showed no antimicrobial activity. Many of the *Strychnos usambarensis* alkaloids were shown to be markedly toxic to a number of tumour lines. A chloroform extract of the leaves of *Strychnos usambarensis* is active against lymphatic leukaemia P-388 in mice in vivo. Especially strychnopentamine, chrysopentamine and isostrychnopentamine are regarded as potential anticancer agents. Curare alkaloids have played an important role in reducing the risk of anaesthesia, since much smaller amounts of anaesthetic are necessary. The drugs have made it possible to achieve adequate muscle relaxation for all clinical requirements. Some of the *Strychnos* alkaloids can be synthesized in vitro in tissue cultures, but most of the syntheses produce a mixture of stereoisomers.

Adulterations and substitutes Several other tropical African plant species such as *Strychnos icaja* Baill., *Acokanthera schimperi* (A.DC.) Schweinf. and *Strophanthus* spp. are used as substitutes for *Strychnos usambarensis* to produce arrow poison.

Description Large liana up to 70 m long, climbing with solitary tendrils, or shrub to small tree up to 10(–15) m tall; stem up to 25 cm in diameter; bark pale or dark grey or grey-brown with darker patches, smooth, inner bark orange; branches with lenticels, usually very



Strychnos usambarensis – 1, flowering branch; 2, flower; 3, fruit.
Redrawn and adapted by Iskak Syamsudin

dark brown, often covered with a pale skin which splits and peels off, branchlets pale brown, glabrous or short-hairy. Leaves opposite, simple and entire; stipules absent; petiole 2–6 mm long, glabrous; blade ovate to elliptical, 3–8(–16) cm × 1–3.5(–7) cm, base cuneate to rounded, apex acuminate, 3–5-veined from the base. Inflorescence an axillary lax or congested thyrse, solitary or several together, 1–2.5 cm long, few-flowered. Flowers bisexual, regular, 4–5-merous; sepals fused at base, ovate to triangular, up to 1 mm long; corolla tube up to 1.5 mm long, lobes oblong to ovate or triangular, c. 1 mm long, acute, recurved from somewhat below the middle, glabrous or minutely hairy outside, inside with a ring of hairs in the throat, white, yellow or sometimes orange; stamens inserted at the mouth of the corolla tube, exserted; ovary superior, ovoid, 0.5–1 mm long, glabrous, 2-celled, style up to 1.5 mm long, stigma small, head-shaped or sometimes obscurely 2-lobed. Fruit a globose berry 1–2 cm in diameter, often laterally compressed, soft, orange or orange-yellow when ripe, often glaucous, 1-seeded. Seed depressed-globose or ellipsoid, 9–12 mm × 7–11 mm × 5–8 mm, short and densely hairy, smooth.

Other botanical information *Strychnos* comprises about 200 species: about 60 species in Asia, 65 in America and 75 in Africa. *Strychnos usambarensis* belongs to the section *Rouhamon*. *Strychnos variabilis* De Wild., which occurs in Congo and DR Congo, also belongs to this section, and contains at least 20 indole alkaloids. An ethyl acetate and a methanolic extract of the root showed significant anti-malarial activity in vitro.

Growth and development *Strychnos usambarensis* is a very adaptable species, varying in habit from shrub to liana or tree.

Ecology *Strychnos usambarensis* occurs in lowland and upland rainforest, also in secondary forest, in gallery forest and semi-evergreen and coastal evergreen bushland from sea-level up to 2000 m altitude.

Harvesting Root bark, stem bark and leaves intended for trade are usually collected from wild plants. The best time for harvesting is after flowering.

Yield The total alkaloid content of the leaves is approximately 1% dry weight. The yield of isostrychnopentamine from the leaves is 0.2% (w/w).

Handling after harvest The root bark, stem bark or leaves are usually dried for later use.

Genetic resources *Strychnos usambarensis* is widespread and occurs in many habitats; it is therefore not likely that it is threatened by genetic erosion.

Prospects *Strychnos usambarensis* is not used for medicinal purposes in Africa because of its toxicity. Several of its alkaloids show promising anticancer or antimalarial activities, and more research into the pharmacological activities of the compounds seems warranted.

Major references Angenot, 1971; Leeuwenberg, 1969; Neuwinger, 1996; Ohiri, Verpoorte & Baerheim Svendsen, 1983c; Philippe et al., 2005; Schwikkard & van Heerden, 2002; Terashima & Ichikawa, 2003.

Other references Bassleer et al., 1982; Bisset & Leeuwenberg, 1968; Bonjean et al., 1996; Bosch, Bonjoch & Amat, 1996; Frédérich et al., 2003a; Frédérich et al., 2004a; Frédérich et al., 1999b; Frédérich, Tits & Angenot, 1998; Frédérich et al., 2004; Lovett et al., 2006; Mitchell, 2004.

Sources of illustration Leeuwenberg, 1969.

Authors N.S. Alvarez Cruz

SUREGADA ZANZIBARIENSIS Baill.

Protologue Adansonia 1: 254 (1861).
Family Euphorbiaceae
Vernacular names Woodland suregada (En). Mdimu msitu (Sw).
Origin and geographic distribution *Suregada zanzibariensis* is distributed in the coastal belt from Somalia south to South Africa and in Madagascar.
Uses In Ulanga, Tanzania, a root and stem bark extract is drunk to cure ankylostomiasis, which is caused by parasitic hookworms. The root extract is also drunk to cure gonorrhoea, stomach-ache, schistosomiasis, chest pain, hernia, pneumonia, chickenpox and as a purgative. The roots are chewed or a root extract is drunk to treat snakebites. Ground leaves mixed with water are applied externally against skin infections and taken in tea or porridge against poliomyelitis. Pulped leaves are taken in porridge to cure dysentery and to expel worms. The roots are used as a medicine by the Mijikenda people of Kenya to treat oedema. The use of extracts for the treatment of diabetes is aimed at symptoms such as bacterial and fungal infections, rather than the diabetes itself.
Properties The leaves contain alkaloids, flavonoids, saponins, steroids and tannins. A leaf extract of *Suregada zanzibariensis* showed significant activity against chloroquine resistant and sensitive strains of the malaria parasite *Plasmodium falciparum* (IC_{50} = 1.5 µg/ml). A leaf extract also showed antifungal activity against *Candida albicans* in vitro.
Botany Dioecious shrub or small tree up to 10 m tall; bark grey, smooth, scaling towards the base of the bole; branches horizontal. Leaves alternate, simple; stipules triangular-ovate, c. 1 mm long, acute, soon falling; petiole 3–7 mm long; blade obovate to elliptical-oblanceolate, 2–13 cm × 1–7 cm, base cuneate or rounded, apex abruptly acuminate, margin entire or finely and irregularly toothed, leathery, pinnately veined with 5–9 pairs of looping lateral veins. Inflorescence an axillary fascicle, rarely flowers solitary; bracts minute. Flowers unisexual, regular, 5-merous; pedicel 1–2 mm long, sepals nearly orbicular, 2.5–3 mm × 2–2.5 mm, with gland outside; petals absent; male flowers with usually 14 stamens, filaments 1–2 mm long; female flowers with 5-angular or shallowly 10-lobed disk, ovary superior, ovoid, 3-celled, c. 1.5 mm in diameter, styles 3 with 2-fid apex. Fruit a 3-lobed to almost globose capsule 7 mm × 8 mm, smooth, black when mature, late dehiscent, 3-seeded. Seeds ovoid, 4 mm × 4 mm, grey when dry and finely pitted. Seedling with epigeal germination.
Suregada comprises about 30 species, all occurring in the Old World tropics; 8 species occur in continental tropical Africa and 14 in Madagascar. *Suregada adenophora* Baill. and *Suregada boiviniana* Baill. (synonym: *Suregada pycnanthera* (Pax & K.Hoffm.) Croizat) occur throughout Madagascar and are used as purgatives; the fresh sap of *Suregada decidua* Radcl.-Sm. from West Madagascar is applied to wounds to promote healing.
Ecology *Suregada zanzibariensis* occurs usually on sandy soils in woodland, riverine forest, coastal forest and in salt marshes, from sea-level up to 1200 m altitude.
Genetic resources and breeding *Suregada zanzibariensis* is fairly widespread and not heavily exploited; hence there are no threats at present.
Prospects The leaves of *Suregada zanzibariensis* show promise as a cure for malaria. Other *Suregada* species have antipyretic properties as well, and more pharmacological research is warranted.
Major references Bhatnagar & Das, 2007; Govaerts, Frodin & Radcliffe-Smith, 2000; Kokwaro, 1993; Neuwinger, 2000; Radcliffe-Smith, 1996a.
Other references Gilbert, Holmes & Thulin, 1993; Hedberg et al., 1983a; Moshi & Mbwambo, 2002; Omulokoli, Khan & Chhabra, 1997; Pakia & Cooke, 2003b; Radcliffe-Smith, 1991b; Runyoro et al., 2006a; Wongsatit Chuakul, Noppamas Soonthornchareonnon & Orawan Ruangsomboon, 2003.
Authors C.H. Bosch

SURIANA MARITIMA L.

Protologue Sp. pl. 1: 284 (1753).
Family Simaroubaceae (APG: Surianaceae)
Vernacular names Tassel plant, bay cedar, Temporana Bay cedar (En). Bois matelot, romarin noir (Fr).
Origin and geographic distribution *Suriana maritima* occurs in Central and South America, Oceania and along the coasts of the Indian Ocean. In tropical Africa it occurs in coastal Kenya, Tanzania, Mozambique and the Indian Ocean Islands.
Uses In Mauritius the aerial parts are used as an astringent and to cure dysentery. It is

also used as a poultice to treat wounds caused by poisonous fish. Elsewhere decoctions of leaves and branches are used as a bath to cure arthritis, applied externally to clean wounds and taken internally to treat rectal bleeding. Powdered flowers are used to cure diarrhoea.
The wood is used in the Virgin Islands to make small articles. In southern Florida the plant is used as an ornamental, especially for hedges and screens. It helps stabilize beaches and coastal dunes.

Properties *Suriana maritima* is devoid of the terpenoid lactones that characterize *Simaroubaceae*. It contains a triterpenoid diol, surianol, as well as β-sitosterol, the flavonoids rutin and rhamnetin and the flavonol glycoside rhamnetin-3-rutinoside. Rutin is used medicinally to decrease capillary fragility. Leaf and stem contain sterols, terpenes and phenols. The flavonoids are thought to be responsible for the anti-infective properties.
The wood is dark red and hard, and polishes well.

Botany Spreading, much-branched, evergreen shrub up to 3(–7) m tall; stems grey-green, densely short-hairy, marked with leaf scars. Leaves arranged spirally, clustered at ends of branches, simple and entire, upright; stipules absent; petiole 1–3 mm long; blade oblanceolate, 1–4.5 cm × 2–6 mm, base cuneate, apex rounded to acute, hairy on both sides, glandular hairs present. Inflorescence an axillary cyme as long as the leaves, few-flowered; bracts up to 1 cm long. Flowers bisexual, regular, 5-merous; pedicel up to 8 mm long; calyx c. 8 mm long, deeply lobed, glandular hairy; petals free, oblong to obovate, c. 7 mm × 5 mm, margins with short hairs, yellow; stamens 10, free, 2.5–4.5 mm long; ovary superior, densely long-hairy, consisting of 5 free carpels, styles c. 4 mm long. Fruit composed of 5 ellipsoid to obovoid drupes, with faces compressed, each c. 3.5 mm × 3 mm, 1-seeded, hairy, black.
Suriana comprises a single species.

Ecology *Suriana maritima* is found on coral reefs and sandy soil. It is confined to seashores above the high-water mark and is often found on the landward side of *Avicennia* mangrove. It is tolerant of moderately saline soil and highly tolerant of beach conditions including high surface heat, drought and wind.

Management Propagation of *Suriana maritima* is done by seeds. It is planted for hedges at distances of c. 1.5 m. Once established it grows well without irrigation, even on well-drained sandy soils. It responds well to trimming.

Genetic resources and breeding *Suriana maritima* is widespread and often common, and is not threatened by genetic erosion. Urban development of coastal areas as in Florida can have destructive effects on populations of *Suriana maritima*.

Prospects *Suriana maritima* can play a role in the protection of seashores and in landscaping in tropical coastal areas. Its pharmacological properties need further investigation to determine its value as a medicinal plant.

Major references Beentje, 1998; Gurib-Fakim & Brendler, 2004.

Other references Coode, 1979; Fernando et al., 1993; Gilman, 1999; Gurib-Fakim, Guého & Bissoondoyal, 1997; Mitchell & Geissman, 1971; Perrier de la Bâthie, 1950; Wild, Phipps & Paiva, 1969.

Authors C.H. Bosch

SYMPHYTUM OFFICINALE L.

Protologue Sp. pl. 1: 136 (1753).
Family Boraginaceae
Chromosome number $2n = 24, 40, 48, 56$
Vernacular names Common comfrey, consound, knitbone (En). Grande consoude, oreille de vache (Fr). Consolda maior, grande consolda, orelhas de asno (Po).

Origin and geographic distribution *Symphytum officinale* originates from Europe, where it is widespread, and has been introduced in North America and Asia. It is cultivated in several Mediterranean, African and Asian countries. In Africa it is cultivated on a small scale only, mainly in Madagascar and South Africa.

Uses All parts of *Symphytum officinale* are medicinally used in its area of natural distribution, and the flowers, leaves and rootstocks are official in several European pharmacopoeias. Fresh leaves are widely used as a poultice on wounds, burns, bruises, sprains, insect bites, sore joints, pulled tendons, broken bones and irritated skin. Leaf decoctions or infusions have been used to treat colds, gum problems, rheumatism, arthritis, gout, scrofula, pleuritis, leucorrhoea, gastro-intestinal ulcers and as an anti-inflammatory, but internal use is now discouraged. Fresh rootstocks are commonly used for healing wounds and ulcers (including gastric ulcers), and flower infusions to treat cough and diarrhoea. Medicinal applications in

Africa are very limited, but the plant is used in Madagascar as a pain-killing poultice. In Europe and also in Madagascar *Symphytum officinale* is planted together with crops such as tomato and potato against bacterial diseases (mainly bacterial wilt caused by *Ralstonia solanacearum*) and insect pests, and as a green manure and mulch. The leaves are occasionally eaten as a cooked vegetable and fed to livestock, but these uses should be discouraged because of the presence of toxic pyrrolizidine alkaloids. The plant is a well-known ornamental, and also occasionally used for this purpose in Africa.

Production and international trade Most *Symphytum officinale* is cultivated in Europe and the United States, but amounts are not known.

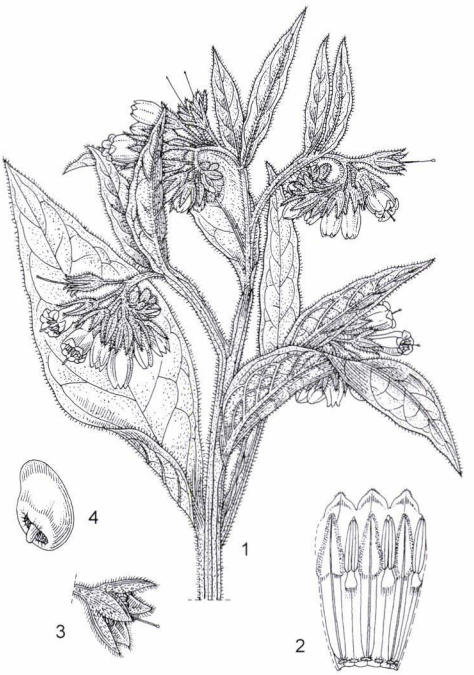
Properties All parts of *Symphytum officinale* contain allantoin (0.5–1.7%), mucilage (29%), triterpene saponins, choline, asparagine, tannins (8–9% in the aerial parts, 4–6% in the rhizomes), silicic acid (4%), and pyrrolizidine alkaloids (0.003–0.2% in the leaves, especially the young ones, 0.2–0.6% in the rhizomes). The major pyrrolizidine alkaloids are intermedine, lycopsamine, 7-acetyllycopsamine and 7-acetylintermedine. Many pyrrolizidine alkaloids are toxic and several have been shown to be hepatotoxic, pneumotoxic, carcinogenic and mutagenic. For this reason it is forbidden by law to use *Symphytum officinale* as an internal herbal remedy in many European countries. The external application of *Symphytum officinale* preparations for use in case of contusions, strains and spraining is considered safe because absorption of pyrrolizidine alkaloids through the skin is negligible.

All parts of *Symphytum officinale* contain allantoin, but the rootstock is richest (up to 1.7%). Allantoin is known for its healing, soothing and anti-irritating properties, and is used in anti-acne products, sun care products and clarifying lotions.

In a study using patients suffering from acute ankle sprains, the percutaneous efficacy of an ointment of *Symphytum officinale* rootstock extract was confirmed decisively, reducing pain as well as oedema. A crude extract of full-grown leaves only showed a slight analgesic activity in rats, and did not show anti-inflammatory activity.

Many pyrrolizidine alkaloids are not palatable and livestock avoid eating them if other forages are available. There are large differences in susceptibility to pyrrolizidine alkaloids in different animals; pigs are most susceptible, followed by horses and cattle, goats, and finally sheep.

Botany Perennial, roughly hairy herb up to 120 cm tall, with fleshy rootstock; stem stout, winged, hollow, often branched. Leaves in a rosette and alternate on the stems, simple and entire; stipules absent; petiole up to 10 cm long, stem leaves sessile; blade ovate-lanceolate to ovate, up to 25 cm × 15 cm, decurrent at base into petiole or stem, apex acuminate, pinnately veined. Inflorescence a terminal scorpioid cyme without bracts, many-flowered. Flowers bisexual, regular, 5-merous, pendulous; pedicel 2–6 mm long; calyx with lanceolate lobes; corolla with cylindrical tube 12–18 mm long and small lobes, white to pink or purple-violet, with scales at throat; stamens inserted at the middle of the corolla tube, filaments short; ovary superior, 4-celled, style slender and exserted, stigma head-shaped, small. Fruit consisting of 4 ovoid nutlets 5–6 mm long, glossy dark brown or black, enclosed by the calyx. Seedling with epigeal germina-



Symphytum officinale – 1, flowering stem; 2, part of opened corolla; 3, fruit enclosed by calyx; 4, nutlet.
Source: PROSEA

tion; hypocotyl 7–15 mm long, epicotyl absent; cotyledons elliptical-oblong, 1–2.5 cm long, leafy, shortly stalked.

Symphytum comprises about 35 species and is native to Europe and western Asia. There are no indigenous species in tropical Africa.

Symphytum officinale plants are long lived. The flowers are self-incompatible and are mainly pollinated by bumble bees. The nutlets have a fleshy appendix and are dispersed by ants.

Ecology *Symphytum officinale* occurs in its natural distribution area in damp grassland and on river banks. It tolerates most soils except the most sandy and dry ones, and grows well on heavy clay soils.

Management *Symphytum officinale* can be propagated by seed, division or through in-vitro propagation from root explants. Optimal planting distance is 70 cm × 70 cm. It should preferably be planted in open localities or with partial shade in a deep, rich soil. Comfrey rust (*Melampsorella symphyti*) is the biggest problem in cultivation. The infection can be reduced by removing the infested leaves. *Symphytum officinale* is a host for the nematode *Meloidogyne incognita*. The rootstocks should be harvested at the beginning or end of the growing season, when the allantoin levels are highest. Yields of dry rootstocks are 5–12 t/ha, depending on soil type. Harvested plant parts are used fresh or dried in the shade for future use. The rootstocks can also be split down the middle and dried in an oven at 40–60°C.

Genetic resources and breeding *Symphytum officinale* is widespread and common throughout its natural distribution area. Several cultivars and hybrids with other *Symphytum* spp. are commercially traded in Europe as garden ornamentals.

Prospects The use of *Symphytum officinale* in phytotherapy should be restricted to external applications due to the presence of toxic pyrrolizidine alkaloids. The efficacy in the treatment of sprains, small wounds and skin irritation without adverse effects has been confirmed by clinical tests, and for these purposes *Symphytum officinale* deserves wider application. The use as a vegetable should be discouraged, but the interplanting with crops to reduce diseases and pests, as practised locally in Madagascar, is interesting and warrants more attention from research.

Major references B.I.M.T.T., 2000; Rahetlah, 2002; Schmelzer & Horsten, 2001; van Wyk & Gericke, 2000.

Other references Evreux, 1989; Koll et al., 2004; Mei et al., 2005; Rajaobelimahefa, 1990; Stickel & Seitz, 2000.

Sources of illustration Schmelzer & Horsten, 2001.

Authors R.H.M.J. Lemmens

Based on PROSEA 12(2): Medicinal and poisonous plants 2.

SYNCLISIA SCABRIDA Miers ex Oliv.

Protologue Ann. Mag. Nat. Hist. ser. 3, 20: 171 (1867).

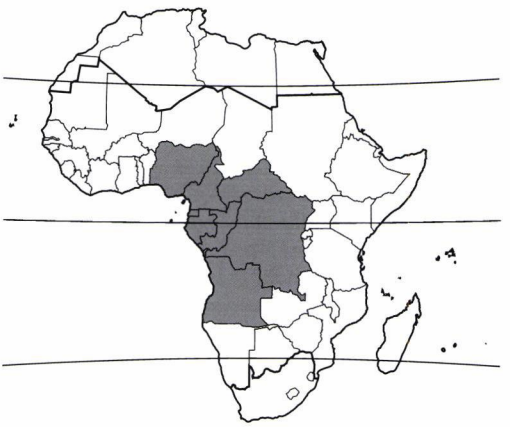
Family Menispermaceae

Vernacular names Goat weed (En).

Origin and geographic distribution *Synclisia scabrida* occurs from Nigeria east to the Central African Republic and south to DR Congo and Angola.

Uses In Nigeria and Cameroon an alcoholic leaf decoction is drunk to treat gastric ulcers. In Nigeria the root soaked in alcohol or macerated in boiling water is taken to treat malaria, to prevent threatened abortion and as a common medicine to calm patients with mental disorders, e.g. psychoses. In Gabon the bitter root, sometimes mixed with stem bark of *Garcinia klainii* Pierre ex Engl., is put in palm wine, which is drunk to treat venereal diseases and as an aphrodisiac and also to treat prostate problems, asthma and hernia. In Congo pregnant women may tie a piece of liana around the waist to avoid spontaneous abortion.

In Gabon a root decoction is used in trial by ordeal ceremonies; when it causes constipation one is innocent, when it causes diarrhoea, one



Synclisia scabrida – wild

is guilty.
The root bark contains a yellow dye of unrecorded use. The leaves are used as protein-rich fodder for ruminants.

Production and international trade *Synclisia scabrida* is only traded in local markets.

Properties From the stem the bisbenzylisoquinoline alkaloids cycleanine, cycleanine N-oxide, norcycleanine, and the related dioxines cocsoline and cocsuline have been isolated. The leaves contain little alkaloids, but contain a glycoside, provisionally called scabridoside. Cycleanine has also been isolated from the root bark, and showed low toxicity in mice (LD_{50} = 1 g/kg intraperitoneally). In mice and rats it reduced spontaneous motor activity. In vitro it evoked muscle contractions in isolated rat uterus that could be blocked by salbutanol, but not by atropine.
An ethanol extract of the leaves fed to rats simultaneously with a high dose of aspirin significantly reduced the damage to the glandular tissues of the stomach caused by the aspirin in a dose-dependent way. The same extract also slowed down the transit rate in the small intestine, while in rats, in which the transition between the stomach and the duodenum had been blocked, the total stomach secretion and its acidity were reduced. These results are in line with the traditional use in the treatment of gastric ulcers. An aqueous extract of the leaves showed antihistamine and anticholinergic activity, but no analgesic activity. Aqueous and ethanol extracts of the leaves administered to rats caused slightly increased motor activity and transient hyperthermia. The extracts also slowed down the coagulation of human blood. Aqueous and ethanol extracts of the leaves delayed and shortened the sedative effects of apomorphine in chickens, while an ethanol extract induced catalepsy in rats.
An aqueous extract of the leaves induced an oestrogen-like activity in immature female rats, increasing the uterine weight by about 70% compared to oestradiol benzoate.
A hot-ethanol extract of the leaves inhibited the growth of *Pseudomonas aeruginosa* and *Staphylococcus aureus*. Ethanol, cold water and hot water extracts of the root were tested for activity against strains of *Escherichia coli*, *Salmonella* sp., *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Proteus* sp. and *Bacillus subtilis*. The ethanol extract was bactericidal against 8 of the 10 test organisms. The cold water extract was bactericidal against strains of *Escherichia coli* and *Bacillus subtilis* and bacteriostatic against 5 others, while the hot water extract was bacteriostatic against only 2 of the organisms.

Description Dioecious liana with twining stems up to 40 m long, with clear sap or sometimes white latex; bark dark brown; stems with long, stiff hairs. Leaves opposite, simple and entire; stipules absent; petiole 2–4 cm long, swollen at base and apex, reddish hairy; blade lanceolate-ovate, 5–12(–20) cm × (4–)7–9 cm, base cordate, apex acuminate, upper surface thinly hairy, lower surface densely hairy, pinnately veined, but with 1–2 pairs of basal veins and 4–5 pairs of lateral veins. Flowers axillary, solitary or in pairs, unisexual; pedicel slender, c. 2 cm long, densely hairy, with 2 minute bracts; sepals 9, 6 outer ones bract-like, linear-lanceolate, 1–2 mm × 0.5–1 mm, apex acute, densely hairy outside, 3 inner ones linear-lanceolate, basally merged into an urn-shaped tube, 7–8 mm × c. 1.5 mm, fleshy; petals 6, c. 0.5 mm long, rounded, fleshy, glabrous; male flowers with 6(–9) stamens, basally fused, 3 outer ones c. 2 mm long, 3 inner ones c. 3 mm long, filaments slender at apex, inner ones bending outwards, outer ones bending inwards; female flowers with spoon-shaped staminodes c. 3 mm long, ovary superior, composed of 15–30 laterally compressed carpels, with long, stiff hairs, styles lateral, slender, c. 3 mm long, stigma small, triangular. Fruit composed of a dense head of obovoid-ellipsoid drupes 12–17 mm × 8–9 mm, orange, densely reddish hairy, with swollen apex, stone bony, fine-hairy outside, 1-seeded. Seed horseshoe-shaped, 1–1.5 cm long, cotyledons very unequal.

Other botanical information *Synclisia* comprises a single species. It is closely related to *Albertisia*.

Ecology *Synclisia scabrida* occurs in rainforest, including secondary forest, at low and medium altitudes.

Management Plants are only collected from the wild. Leaves for fodder can be harvested at any time of the year. Individual leaves or the whole liana are cut and fed fresh or dried.

Genetic resources *Synclisia scabrida* has a wide distribution and also occurs in secondary vegetation; there are no indications that it is in danger of genetic erosion.

Prospects *Synclisia scabrida* is an important medicinal plant in Central Africa, but its chemical and pharmacological properties have been insufficiently investigated. More research is therefore warranted, especially into its effects on gastric ulcers.

Major references Obi et al., 2000; Ohiri, Verpoorte & Baerheim Svendsen, 1989; Okoli & Iroegbu, 2005; Orisakwe et al., 1996b; Troupin, 1962; Wambebe et al., 1997.

Other references Afonne et al., 2000; Akah et al., 1998; Feodor, Eric & Osa, 1980; Gassita, 1968; Gassita et al. (Editors), 1982; Keay & Troupin, 1954; Ohiri, Verpoorte & Baerheim Svendsen, 1983a; Orisakwe, Afonne & Dioka, 1997; Orisakwe et al., 1996a; Sokomba et al., 1986; Wambebe et al., 1982.

Authors P. Nana & H.S. Foyet

SYRRHEONEMA FASCICULATUM Miers

Protologue Ann. Mag. Nat. Hist. ser. 3, 13: 124 (1864).

Family Menispermaceae

Origin and geographic distribution *Syrrheonema fasciculatum* occurs from Cameroon and Bioko (Equatorial Guinea) east to western Uganda and south to DR Congo.

Uses In Congo the leaf sap is used against ophthalmia.

Botany Dioecious liana up to 20 m long; stem up to 2.5 cm in diameter, hairy. Leaves alternate, simple and entire; stipules absent; petiole 4.5–10 cm long, bent at base and apex, densely short-hairy; blade ovate to almost orbicular, 5–25 cm × 5–25 cm, base cordate or truncate, apex acute to acuminate, thinly leathery, densely short-hairy, becoming nearly glabrous, palmately veined with 2–3 basal veins, prominent on the lower surface. Inflorescence an axillary head-like cyme 1–1.5 cm long; peduncle 1–2 cm long. Flowers unisexual; male flowers with 9–12 sepals, 1.5–2 mm × c. 1 mm, whitish, outside densely hairy, inside slightly hairy, petals 3–6, elliptical, c. 1.5 mm long, somewhat fleshy, apex fringed, stamens 6, c. 2.5 mm long, fused to halfway, free part of the filament thickened. Fruit composed of 3–5 almost globose drupes 1.5–2 cm in diameter, base truncate, short-hairy; stone hard and brittle, 1-seeded. Seed 12–17 mm long.

Syrrheonema comprises 3 species, 2 in Central Africa and 1 in West Africa.

Ecology *Syrrheonema fasciculatum* occurs in rainforest, forest regrowth and fallow land, at 1200–1400 m altitude.

Genetic resources and breeding *Syrrheonema fasciculatum* has a wide distribution and there are no indications that it is in danger of genetic erosion.

Prospects As long as nothing is known about the chemical constituents and pharmacological properties of *Syrrheonema fasciculatum*, it will remain of local importance only.

Major references Burkill, 1997; Bouquet, 1969; Troupin, 1962.

Other references Neuwinger, 2000; Troupin, 1951.

Authors L.P.A. Oyen

TABERNAEMONTANA COFFEOIDES Bojer ex A.DC.

Protologue Prodr. 8: 370 (1844).

Family Apocynaceae

Synonyms *Hazunta coffeoides* (Bojer ex A.DC.) Pichon (1948); *Hazunta modesta* (Baker) Pichon (1948), *Hazunta velutina* Pichon (1948), *Hazunta costata* Markgr. (1970).

Origin and geographic distribution *Tabernaemontana coffeoides* is endemic to Madagascar, Comoros, Mayotte and Seychelles.

Uses In Madagascar the bitter twig bark of *Tabernaemontana coffeoides* is chewed to combat fatigue and to suppress hunger. A twig or bark infusion is reputed to promote weight loss as it reduces appetite. The bitter bark is added to alcoholic beverages, some of which are used during circumcision rituals. The bark was formerly used to make string for cloth. In Mayotte, branched twigs were formerly used as an oil-lamp support. In the Comoros the wood is used as firewood.

Properties *Tabernaemontana coffeoides* contains mainly monomeric indole alkaloids, although some bisindolic alkaloids occur in the leaves as well. The root bark contains most alkaloids (60 g/kg), followed by the stem bark (37 g/kg) and the leaves (22 g/kg). The alkaloids of the root bark, stem bark and leaves consist for up to 50% of vobasine, tabernaemontanine, dregamine, methuenine and silicine (all corynanthean class); small amounts of apparicine (pericalline, aspidospermatan class) are present. Additionally, the alkaloids of the stem bark and root bark contain 12–16% of ibogamine (ibogan class). The leaves also contain many alkaloids of the plumeran class including the pharmacologically active tabersonine. They also contain akuammidine and normacusine B (both corynanthean class), heyneanine (ibogan class) and vincanidine (strychnan class). In addition they contain the dimeric hazuntiphylline (plumeran-plumeran class) and stemmadenine (conynanthean-plumeran class).

Dregamine shows convulsant and respiration-stimulant activities. It also inhibits muscular fatigue in the same way as ibogaine from *Tabernanthe iboga* Baill. It has been used in treatments of muscular and nervous asthenia, respiratory depression and type III poliovirus (HPV-3). Tabernaemontanine has a vasodilatory effect and can be used in humans in cases of arteriosclerosis, cerebral trauma and circular irregularities. It shows antibacterial activity against several human pathogenic bacterial strains, and is cytotoxic to human nasopharyngeal epidermoid carcinoma cells in vitro, but is inactive against P-388 lymphocytic leukaemia in mice. Methuenine might be effective in the control of cardiac arrhythmias since it mainly decreases the excitability of depolarized arterial fibres in frogs. It also showed a noncompetitive antagonistic activity against histamine and acetylcholine in guinea-pig ileum. Reserpiline produces hypotension in dogs and cats, but it exerts a tranquilizing action as well. It is about as potent as reserpine, which is commonly used against high blood pressure and it lacks the side effects of reserpine. Normacusine B is sympatholytic and its hypotensive activity is greater than that of reserpine. Akuammidine has hypotensive, skeletal-muscle-relaxant and local-anaesthetic activities. Its local anaesthetic activity is about 3 times as potent as cocaine. At low doses, vincanidine stimulates spontaneous mobility in mice, but at high doses it causes muscular paralysis. It has an emetic effect in dogs. It has significant antibacterial activity against *Staphylococcus* spp., *Micrococcus* spp. and *Escherichia coli*. Stemmadenine increases or decreases blood pressure in vitro and in vivo, depending on the conditions of the experiment. Tabersonine has about a quarter of the hypotensive activity of reserpine, and a spasmolytic effect on the smooth muscle of the intestine. Apparicine also showed strong activity against type III poliovirus, as well as significant cytotoxicity against P-388 lymphocytic leukaemia cell cultures. Apparicine showed opioid activity in opiate receptor studies. Vobasine exhibited little activity in general pharmacological screening tests.

Botany Shrub or small tree up to 7(–10) m tall, repeatedly dichotomously branched, glabrous; trunk up to 10(–20) cm in diameter; bark pale brown. Leaves opposite, simple and entire; ocrea widened into stipules in axils of petioles; petiole 5–25 mm long, slender; blade narrowly elliptical to ovate, 2–15 cm × 1–5(–7) cm, base cuneate, decurrent into the petiole, apex acuminate, pinnately veined with 5–15 pairs of lateral veins. Inflorescence a lax corymb, 2–11 cm long, usually 2 together in the forks of branches, few- to many-flowered; peduncle 1–4.5 cm long, slender. Flowers bisexual, regular, 5-merous, sweet-scented; pedicel 3–14 mm long; sepals almost free, ovate to suborbicular, 1–3 mm long, rather thick; corolla tube cylindrical, 5–15 mm long, pale green, slightly widened around the anthers, inside hairy or glabrous, lobes obliquely oblong or narrowly obovate, 5–13 mm × 1.5–6 mm, undulate, spreading, apex rounded, white; stamens inserted about halfway the corolla tube, included, anthers sessile; ovary superior, ovoid, consisting of 2 separate carpels, style slender, 2–5 mm long, pistil head 1–3 mm long, composed of an obscurely lobed ring, a narrow cylinder and a 2-lobed stigmoid apex. Fruit consisting of 2 separate obliquely ellipsoid follicles, 1–3 cm long, apex obtuse, acute or acuminate, green, 2-valved, 1–10-seeded. Seeds obliquely ellipsoid, 5.5–10 mm long, with longitudinal grooves, densely covered with small warts, brown or dark brown, aril red.

Tabernaemontana comprises about 110 species and is pantropical. About 18 species occur in mainland Africa and 15 in Madagascar, of which *Tabernaemontana coffeoides* is most widespread. *Tabernaemontana coffeoides* flowers in Madagascar and the Comoros mainly in October–December; in Madagascar, fruiting is mainly from December–March. In the Seychelles, flowering and fruiting probably occurs throughout the year.

Tabernaemontana ciliata Pichon occurs in northern and north-eastern Madagascar. The latex is poisonous and used as a strong purgative. The bark contains the bisindolic pandicine. *Tabernaemontana retusa* (Lam.) Palacký is a lowland forest tree of eastern Madagascar. The leaves are applied as an emollient and against lung conditions. The latex is used to prepare bird-lime. The seeds contain the pharmacologically active voaphylline, pachysiphine and tabersonine and the leaves contain 3-oxovoacangine and voacristine. Heyneanine occurs in the leaves, stem bark and root bark, while the root bark also contains ibogamine. Voacangine occurs in the seeds, leaves and stem bark, while coronaridine occurs in the seeds, stem bark and root bark.

Ecology *Tabernaemontana coffeoides* occurs on dunes or rocks, often on limestone, in dry forest, bush or savanna, up to 1300 m altitude.

Genetic resources and breeding *Tabernaemontana coffeoides* is not threatened by genetic erosion in Madagascar, but it is threatened in the Comoros and to a lesser extent in the Seychelles, because of habitat loss.

Prospects *Tabernaemontana coffeoides* is very rich in pharmacologically interesting indole alkaloids. This warrants more investigations towards the possible development of *Tabernaemontana coffeoides* as an important medicinal plant.

Major references Boiteau, Boiteau & Allorge-Boiteau, 1999; Leeuwenberg, 1991; Neuwinger, 2000; van Beek et al., 1984b; Zhu et al., 1990.

Other references Bui et al., 1979; Bui, Das & Potier, 1980; Gurib-Fakim & Brendler, 2004; Pascal, 2002; van Beek & van Gessel, 1988.

Authors G.H. Schmelzer

TABERNAEMONTANA CRASSA Benth.

Protologue Hook., Niger Fl.: 447 (1849).

Family Apocynaceae

Chromosome number $2n = 22$

Synonyms *Conopharyngia crassa* (Benth.) Stapf (1902), *Conopharyngia durissima* (Stapf) Stapf (1902).

Vernacular names Adam's apple flower (En).

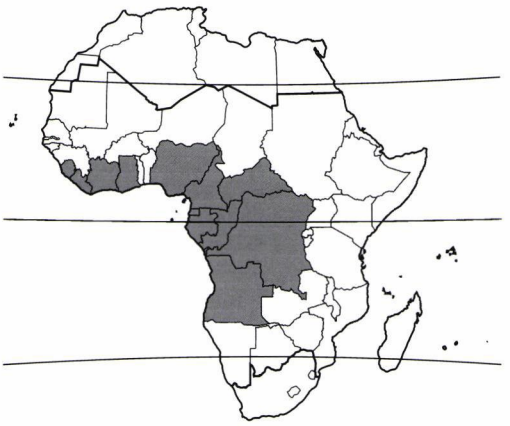
Origin and geographic distribution *Tabernaemontana crassa* occurs in humid tropical Africa, from Sierra Leone east to the Central African Republic and eastern DR Congo, and southwards to northern Angola.

Uses In West Africa pulped leaves and latex from the stem and bark of *Tabernaemontana crassa* have several uses, the main ones being as a local anaesthetic, e.g. to treat dislocated bones or headache, for the treatment of wounds, sores, abscesses and furuncles, and to treat dermal infections such as filaria, ringworm and fungal infections. The latex is also applied as a haemostatic, as it forms a film over the wound. It is taken internally as an anthelmintic. In Côte d'Ivoire 1–2 drops are instilled in the nose to soothe headache, acting as a counter-irritant on the nasal mucosae. The latex is also used as a sedative to calm fits of insanity. A decoction of the leaves is taken as a tonic, appetizer and aphrodisiac, while a bark decoction is given as enema to treat kidney troubles, rheumatism and persistent constipation. A leaf decoction is also used as a massage against rickets in children and to combat fatigue in adults. In Cameroon and the Central African Republic a leaf decoction is taken against fever. In the Central African Republic a drop of latex of the twigs or roots is put in the eye to treat conjunctivitis or ophthalmia, in spite of its strongly caustic properties. A root or stem bark decoction is used for nose drops to treat colds or sinusitis, or a vapour bath is taken with a leaf decoction. Like many lactiferous plants, the latex is considered to be galactagogue in Congo and DR Congo. In Côte d'Ivoire and the Central African Republic the latex is an ingredient of an arrow poison. A bark decoction is taken in Congo to treat haematuria and gonorrhoea. In DR Congo a decoction or maceration of the fruit is used as an enema to treat testicular swellings. A decoction of the stem bark is taken to treat diarrhoea.

Large leaves are woven into thatched roofs of houses in Gabon in the belief that their bitter taste keeps away cockroaches. The wood is suitable for general carpentry, plywood and boxboards. It is occasionally used in Liberia to make rice mortars. The bark latex produces an inferior rubber that remains sticky and which has been used occasionally. The plant is considered ornamental, because its flowers are showy and sweet scented. The leaves are eaten by the cultivated edible tiger snail *Achatina achatina*.

Production and international trade Powdered bark is traded internationally in herbal medicine shops.

Properties A considerable number of indole alkaloids has been identified in the stem bark, root bark and seeds of *Tabernaemontana crassa*. Most alkaloids isolated are monomers,



Tabernaemontana crassa – wild

mainly of the ibogan class, and a few of the corynanthean class, aspidospermatan class or plumeran class. The dimeric alkaloids conodurine and conoduramine of the corynanthean-ibogan-class have been isolated from the root bark and stem bark, while the stem bark also contains gabunine. The main monomeric alkaloids from the stem bark and root bark are the ibogan class alkaloids coronaridine and its mono- and di-methoxy derivatives isovoacangine and conopharyngine, and the aspidospermatan-class apparicine. The stem bark contains further minor amounts of ibogan class alkaloids, including crassinine, ibogamine and coronaridine and derivatives, as well as corynanthean class alkaloids, including akuammidine, perivine, vobasine and derivatives. The seeds are also rich in alkaloids, the main being the ibogan class coronaridine and coronaridine-hydroxyindolenine and the plumeran class tabersonine.

The plant is very toxic: a single injected dose of the crude ethanol extract of the stem bark or root bark killed rats in 30 minutes. The extract caused dilation of the pupils, decreased motor activity and caused muscle relaxation. Several laboratory tests with guinea pigs or frogs showed that a hot water extract of the aerial parts had stronger local anaesthetic activity than procaine, which was primarily used in dentistry before more effective alternatives were developed. The ethanolic stem bark extract showed significant activity against gram-positive bacteria, while leaf extract showed significant activity against amoeba.

The alkaloids present in major amounts have a variety of pharmacological effects.

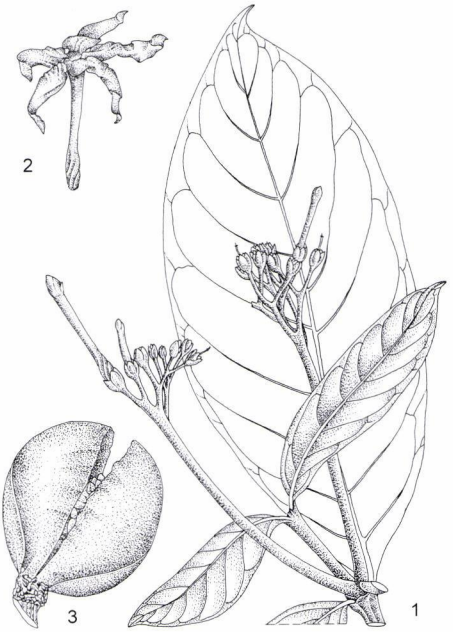
Coronaridine and conopharyngine exhibit central nervous system stimulant effects. In regular doses, conopharyngine has hypotensive properties, causes bradycardia and decreases body temperature. High doses of ibogaine, ibogamine and voacangine produce convulsions and asphyxia. Coronaridine showed diuresis and significant hypoglycaemic activity in rats. In mice it is an effective antifertility agent because of its oestrogenic activity. It also has leishmanicidal activity. Furthermore, apparicine, conopharyngine, coronaridine and perivine have local analgaesic activity. The monomers apparacine, coronaridine and the dimers conodurine and gabunine showed significant cytotoxicity against P-388 lymphocytic leukaemia cell cultures. Conoduramine, conodurine and apparicine also showed moderate to strong antibacterial activity against several human pathogens, while apparicine also showed strong activity against type III poliovirus (HPV-3).

The latex is extremely caustic: one drop in the eye may cause blindness.

The wood is yellowish white, moderately hard and easy to work, and it finishes smoothly. It is not resistant to fungal decay.

Adulterations and substitutes Indolic alkaloids of the classes found in *Tabernaemontana* are also found in other *Apocynaceae* genera, e.g. *Alstonia*, *Cabucala*, *Catharanthus*, *Hunteria*, *Ochrosia*, *Picralima*, *Rauvolfia*, *Tabernanthe* and *Voacanga*.

Description Shrub or small tree up to 15 m tall, glabrous, dichotomously branched; trunk up to 30 cm in diameter, large trees sometimes with buttresses; bark pale to dark grey-brown or brown, with large lenticels. Leaves opposite, simple and entire; ocrea conspicuous, widened into stipules in axils of petioles; petiole 5–25 mm long; blade broadly to narrowly elliptical, 10–46 cm × 3–25 cm, base cuneate or rounded, apex acuminate to acute, obtuse or rounded, leathery, pinnately veined with 7–17 pairs of lateral veins. Inflorescence a corymb 10–30 cm long, 2 together in the forks of the branches, rather lax to congested, many-flowered; peduncle 3.5–11.5 cm long, rather robust; bracts scale-like to sepal-like, leaving a conspicuous scar. Flowers bisexual, regular, 5-merous, sweet-scented; pedicel 3–20 mm long; sepals almost free, orbicular to broadly ovate, 2.5–8 mm long, fleshy, ciliate; corolla tube almost cylindrical, 3.5–10 cm long, fleshy, pale green, twisted at base, hairy inside from 0–10 mm below the mouth till the insertion of the stamens, throat pale yellow, lobes obliquely elliptical, 24–55 mm × 6–20 mm, with rounded or obtuse apex, twisted, undulate near apex, spreading and recurved later, white to pale yellow; stamens inserted 8–14 mm from the corolla base, included, anthers sessile, narrowly triangular, 9–13 mm long; ovary superior, almost cylindrical to ovoid, consisting of 2 carpels, connate at the base, styles fused, 2–8 mm long, pistil head almost cylindrical, 3–3.5 mm long, widened at the apex into 5 orbicular lobes, overtopped by 2 triangular peaks, widened at the base into a ring. Fruit consisting of 2 separate obliquely globose follicles 5–12 cm in diameter, pale green or glaucous, 2-valved, several- to many-seeded. Seeds obliquely ellipsoid, 8.5–14 mm long, with up to 8 longitudinal grooves, minutely warty, dark brown, aril white. Seedling with epigeal germination.



Tabernaemontana crassa – 1, flowering branch; 2, corolla; 3, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Tabernaemontana* comprises about 110 species and is pantropical. About 18 species occur in mainland Africa and 15 in Madagascar. It is closely related to *Voacanga*. Along the coast, the corolla tube of *Tabernaemontana crassa* is shorter, 35–45 mm long, whereas in other areas it is 60–100 mm long. *Tabernaemontana crassa* is closely allied to *Tabernaemontana africana* Hook., which can be distinguished by its stamens inserted at 25–45 mm from the corolla base, wider corolla tube and yellow to orange follicles.

Tabernaemontana stenosiphon Stapf is an endemic tree of São Tomé. The latex induces vomiting and is also used as a purgative. The root decoction is a tonic and febrifuge. The tree has been planted in Nigeria for the production of rubber.

The liana *Tabernaemontana eglandulosa* Stapf occurs in West and Central Africa. In the Central African Republic the leaves or twig bark are chewed and the juice swallowed to combat migraine. In DR Congo the roots are used to treat snakebites. The sap mixed with water used as eye drops to cure headache. The pounded root is a component of arrow poison. The latex was formerly used as an adulterant for *Hevea* rubber. All plant parts contain voacangine and coronaridine. The stem bark contains conopharyngine and 6-hydroxy-3-oxocoronaridine. The leaves and twigs contain as major components tacamine, tacamonine, 19-hydroxytacamine and 16-epitacamine (tacaman class), and also voaphylline, tubotaiwine, ibogamine and norfluorocurarine.

Growth and development *Tabernaemontana crassa* plants develop according to the architectural growth model of Leeuwenberg determined by a monopodial orthotropic trunk, which ends in a terminal inflorescence. After flowering the 2 uppermost axillary buds develop into branches, so that the growth is sympodial; the infructescence seems to be axillary. *Tabernaemontana crassa* can be found flowering and fruiting throughout the year. Fruits are mature after 1 year.

Ecology *Tabernaemontana crassa* occurs widely in the understorey of open forest, forest clearings or bush, also along the coast, less often in gallery forest, from sea-level up to 2000 m altitude.

Propagation and planting *Tabernaemontana crassa* can be propagated by seed and probably also by semi-ripe cuttings.

Harvesting The bark of *Tabernaemontana crassa* is stripped from the trunk. Leaves are harvested whenever the need arises.

Genetic resources *Tabernaemontana crassa* has a fairly large area of distribution and is therefore not likely to be threatened by genetic erosion.

Prospects *Tabernaemontana crassa* contains a large number of indole alkaloids with interesting pharmacological activities. The alkaloid content is similar to that of *Tabernaemontana pachysiphon*, another medicinally important species. Although several individual alkaloids have been tested for their pharmacological activity, more analyses are needed to evaluate their importance.

Major references Leeuwenberg, 1991; Neuwinger, 1996; van Beek, Verpoorte & Baerheim Svendsen, 1984; van Beek, de Smidt & Verpoorte, 1985; van Beek et al., 1984b; Zhu et al., 1990.

Other references Agwu & Akah, 1990; Betti, 2004; Burkill, 1985; Cooper & Record, 1931; Din Belle, Tolvanen & Lounasmaa, 1996; Neuwinger, 2000; Srivastava, Singh & Kulshreshtha, 2001; van Beek, 1984; van Beek &

van Gessel, 1988.

Sources of illustration Leeuwenberg, 1991.

Authors F.S. Mairura & G.H. Schmelzer

TABERNAEMONTANA ELEGANS Stapf

Protologue Bull. Misc. Inform. Kew 1894: 24 (1894).

Family Apocynaceae

Chromosome number $2n = 22$

Synonyms *Conopharyngia elegans* (Stapf) Stapf (1902).

Vernacular names Toad tree, low-veld toad tree (En). Mkuti, mbombo (Sw).

Origin and geographic distribution *Tabernaemontana elegans* occurs in East Africa and southeastern Africa, from Somalia south to South Africa and Swaziland.

Uses The seeds, stem bark and roots of *Tabernaemontana elegans* are used by the Wabondei and Wadigo people of Tanzania for treating heart diseases. The powdered root bark or fruits are used to treat cancer. In southern Africa the coagulated latex or pulverized root mixed with vaseline is applied as a styptic. A root decoction is applied as a wash for wounds and is taken as a remedy for pulmonary diseases and chest pains. A maceration of root ash is drunk to treat tuberculosis and stomach-ache. A root maceration acts as a purgative. Burnt root powder mixed with salt and water is used as a vaginal wash to treat menorrhagia, infertility and venereal diseases. In Zimbabwe a root decoction is taken as an aphrodisiac.

The wood is white and easy to work. It is used for firewood, and for making spoons, knife and sword handles, bows and arrows, building poles and pegs for animal traps. The latex is tapped for making birdlime or used as a glue for arrow heads. In Zimbabwe and Mozambique, the orange, slimy fruit pulp is relished by some people. Zulu people put the fruit into milk they wish to curdle fast. *Tabernaemontana elegans* is an unusual, but attractive garden tree with its sweet-smelling flowers and unusual fruits covered in brown warts, giving it the look of a toad's skin.

Properties The phytochemically important compounds of *Tabernaemontana elegans* root bark are the monomeric indole alkaloids dregamine and tabernaemontanine (corynanthean class), and the bisindole alkaloids conoduramine and tabernaelegantines (corynantheanibogan class). The tabernaelegantines are rare in other *Tabernaemontana* species, and are thus reliable chemotaxonomic markers for *Tabernaemontana elegans*. The main components of the aerial parts are dregamine, tabernaemontanine and vobasine (corynanthean class), followed by apparicine (pericalline, aspidospermatan class), and tabernaelegantine A and B. Minor components are dregaminol, tabernaemontanine (corynanthean class), tabernaemontaninol (vobasan), 3-hydroxyconodurine and tabernaelegantine C and D. The alkaloid content of callus cultures is similar to that of the whole plant, but the tabernaelegantines are absent. The main alkaloid in callus cultures is apparicine, followed by vobasine and tabernaemontanine. Minor components include 3-hydroxycoronaridine (ibogan class) and 3-hydroxyconodurine. 3-Hydroxyconodurine, 3-hydroxycoronaridine, conoduramine and apparicine show strong inhibitory activity against a range of gram-positive and gram-negative bacteria. Dregamine shows convulsant and respiration-stimulant activities. It also inhibits muscular fatigue in vitro and in vivo comparable to ibogaine from *Tabernanthe iboga* Baill. It has been used in treatments of muscular and nervous asthenia, respiratory depression and type III poliovirus (HPV-3). Apparicine has also shown strong activity against type III poliovirus, as well as significant cytotoxicity against P-388 lymphocytic leukaemia cell cultures. Apparicine has shown opioid activity in opiate receptor studies. Tabernaemontanine has a vasodilatory effect and can be used in humans in cases of arteriosclerosis, cerebral trauma and circular irregularities. It shows antibacterial activity against several human pathogenic bacterial strains, and is cytotoxic to human nasopharyngeal epidermoid carcinoma cells in vitro, but is inactive against P-388 lymphocytic leukaemia in mice. Vobasine exhibited little activity in general pharmacological screening tests.

Botany Shrub or small tree up to 15 m tall, repeatedly dichotomously branched, trunk up to 30 cm in diameter, bark longitudinally fissured, corky. Leaves opposite, simple and entire; ocrea widened into stipules in axils of petioles; petiole 7–30 mm long; blade elliptical or narrowly elliptical, 6–23 cm × 2–8 cm, base cuneate or decurrent into the petiole, apex acuminate, acute or obtuse. Inflorescence a corymb 5–20 cm long, 2 together in the forks of the branches, many-flowered; peduncle 1–8.5 cm long, lax. Flowers bisexual, regular, 5-merous, sweet-scented; pedicel 2–6 mm long;

sepals orbicular to broadly ovate, 1–2.5 mm long; corolla tube almost cylindrical, 5–7 mm long, lobes obliquely elliptical, slightly falcate, 8–15 mm long, entire, spreading, white, creamy or pale yellow; stamens inserted 2–2.5 mm above the corolla base, included, anthers sessile, narrowly triangular; ovary superior, almost globose, consisting of 2 free carpels, styles fused, slender, straight, pistil head composed of 2 rings, the upper one grading into the slender stigmoid apex. Fruit composed of 2 separate, obliquely ovoid or ellipsoid follicles 5–8 cm long, glaucous or green, with conspicuous brown warts, with 3 ridges, dehiscent, many-seeded. Seeds obliquely ellipsoid, 14–15 mm long, with reticulate grooves, papillose, dark brown, aril orange. Seedling with epigeal germination; cotyledons almost orbicular, c. 6 mm long, base cordate, apex obtuse.

Tabernaemontana comprises about 110 species and is pantropical. About 18 species occur in mainland Africa and 15 in Madagascar.

Tabernaemontana elegans flowers in Kenya from October to May, in Mozambique from April to September, and fruits there from July to October. In South Africa it flowers from September to March with a peak in November, and fruits from February to August.

Ecology *Tabernaemontana elegans* occurs in bushland, forest on coastal dunes, gallery forest or woodland, usually associated with *Brachystegia* spp., up to 1000 m altitude. It is semi-frost resistant and can grow in full sun to half-shade. It requires a moderate amount of water. Because of its corky bark, it is fairly fire resistant.

Genetic resources and breeding *Tabernaemontana elegans* is relatively widespread in eastern Africa and does not seem to be at risk of genetic erosion.

Prospects *Tabernaemontana elegans* contains many pharmacologically interesting indole alkaloids and deserves more attention from research.

Major references Leeuwenberg, 1991; Neuwinger, 2000; van Beek & van Gessel, 1988; van Beek et al., 1984b; van der Heijden, 1989.

Other references Beentje, 1994; Coates Palgrave, 1983; Graham et al., 2000; Le Roux, 2005; Lovett, Ruffo & Gereau, 2003; Steenkamp, 2003; Zhu et al., 1990.

Authors G.H. Schmelzer

TABERNAEMONTANA PACHYSIPHON Stapf

Protologue Bull. Misc. Inform. Kew 1894: 22 (1894).

Family Apocynaceae

Chromosome number $2n = 22$

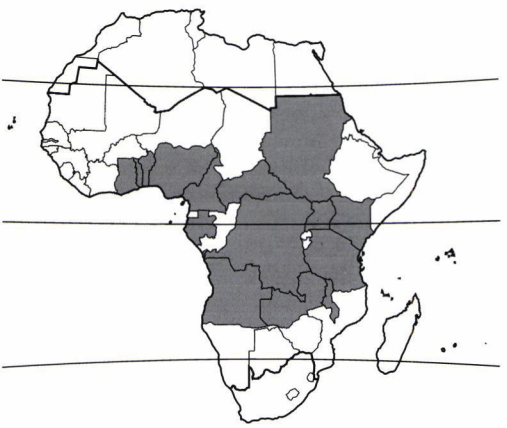
Synonyms *Tabernaemontana angolensis* Stapf (1894), *Tabernaemontana holstii* K.Schum. (1895).

Vernacular names Kibombo, muambe (Sw).

Origin and geographic distribution *Tabernaemontana pachysiphon* is widely distributed in tropical Africa, from Ghana east to southern Sudan and Kenya, and south to Malawi, Zambia and Angola.

Uses The latex of *Tabernaemontana pachysiphon* is generally used as a styptic and is applied to fresh wounds to prevent infection; it forms a film over the wound. The dried and powdered leaves are applied to sores and ulcers to heal them. Painful breasts of lactating women are treated with the latex from the petioles or bark. The latex of the fruit is rubbed into scarifications to treat lymphatic glandular swellings. In East Africa the latex is applied to sore eyes.

A decoction of the root bark is taken in Nigeria for the treatment of insanity. In East Africa a decoction is used against stomach-ache, constipation, flatulence, headache and as a hypnotic. Headache is also treated with a leaf infusion. The bark is used as medicine for hypertension. In DR Congo a maceration prepared from the stem bark is used to wash the body against scabies, in Kenya grated roots and crushed leaves are also used to treat scabies. The maceration is drunk against headache. The bark latex is rubbed locally to relieve cramps. In Tanzania a watery fruit extract is used as a



Tabernaemontana pachysiphon – wild

galactagogue for goats. In northeastern Tanzania, the Shambaa people formerly prepared a hunting poison from the roots.

The wood is used to make knife sheaths, handles and combs. Pollarded branches are used locally for firewood and to make charcoal. *Tabernaemontana pachysiphon* has an abundance of white latex, which does not coagulate and has been used to adulterate *Hevea* rubber. The latex thickens to a birdlime and is also used to mend broken pots and calabashes. The bark contains fibre, which is used in southern Nigeria to make cloth. In Benin small ropes are made from the inner bark. The tree is used as a shade plant and has ornamental value because of its dark green shiny leaves and sweet-scented white flowers. The pulp of the pounded leaves is used to colour hair brown.

Production and international trade *Tabernaemontana pachysiphon* is used at a local level only.

Properties Indole alkaloids are the most important compounds of *Tabernaemontana* spp. More than 40 alkaloids have been identified from *Tabernaemontana pachysiphon*. The main alkaloids present are monomers, although dimeric alkaloids of the corynanthean-ibogan class are present as well. The main dimeric alkaloids of the stem bark and root bark are voacorine, conoduramine, conodurine, and traces of gabunine. The most important monomers found in the root bark are tubotaiwine and apparicine (aspidospermatan class); conopharyngine (ibogan class) is also a major component, while ibogaine, ibogamine, voacristine, isovoacangine, coronaridine and 3-oxocoronaridine (all ibogan class), vobasine, perivine and affinine (all corynanthean class) occur in small amounts only. Of the stem bark, the main constituent is conopharyngine, with ibogan class derivatives occurring in small amounts. Tubotaiwine is a major constituent as well, while apparicine occurs as a minor component. Corynanthean class alkaloids occur only as minor components. The leaves contain apparicine and tubotaiwine, as well as conopharyngine. The fruits contain the dimers voacamine (voacanginine) and voacorine, and several ibogan class monomers in small amounts. The alkaloid composition of the seeds is very different, and consists almost exclusively of the plumeran class pachysiphine.

The various alkaloids in *Tabernaemontana pachysiphon* have a wide range of pharmacological activities. Coronaridine, conopharyngine, ibogaine, ibogamine, voacangine and voacristine exhibit central nervous system stimulant effects. In regular doses, voacangine, ibogaine, perivine and conopharyngine have hypotensive properties, cause bradycardia and decrease body temperature. High doses of ibogaine, ibogamine and voacangine produce convulsions and asphyxia. Coronaridine showed diuretic and hypoglycaemic activities in rats. In mice coronaridine is an effective antifertility agent because of its oestrogenic activity. It also has leishmanicidal activity as has the related dimer gabunine. Voacristine prevented pregnancy when administered during the pre-implantation period in rats. It was, however, found to possess also significant uterotrophic activity. Furthermore, voacangine, conopharyngine, ibogaine, coronaridine, perivine, tubotaiwine and apparicine have local analgesic activity. Most of the pharmacological work on voacorine and voacamine has focused on their cardiotonic properties. Voacamine shows little tendency to accumulate, and is less toxic than cardiac glycosides such as digitoxin. In high doses both voacamine and voacorine are hypertensive due largely to peripheral vasoconstriction. Both compounds also have parasympatholytic and sympatholytic properties, bringing about contraction of smooth muscle fibres. Voacorine, voacamine and affinine are also central nervous system depressants. At higher doses, affinine causes tremor, loss of coordination and hypothermia in mice. A cumulative increase of the dose in cats showed some toxicity, e.g. bradycardia, respiratory depression and cardiac arrhythmia. In experiments with rats and mice parenteral and oral administration of voacamine and voacorine retarded the growth of transplanted and primary induced neoplasms.

At low doses, ibogaine exerts primarily a stimulant effect, increasing alertness and reducing fatigue, hunger and thirst. At higher doses, the primary effects are hallucinations (see *Tabernanthe iboga* Baill.). Apart from the psychological effects, the physical effects include tremor, light sensitivity, nausea, vomiting, and loss of coordination. Toxic doses produce convulsions, paralysis and death from respiratory arrest although the heart continues to beat. Ibogaine is also a potent cholinesterase inhibitor.

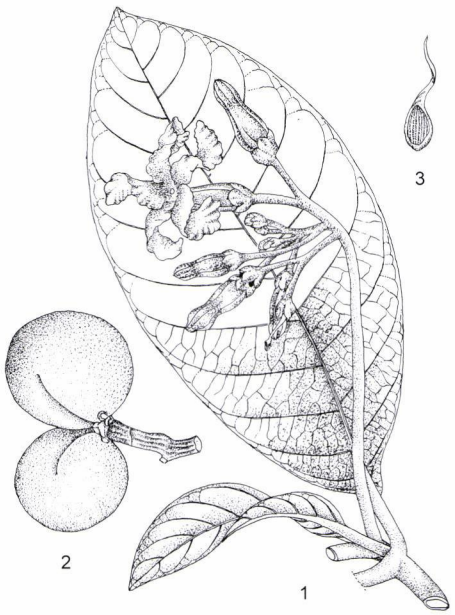
The monomers affinine, apparacine, coronaridine and the dimers voacamine, voacorine and gabunine showed significant cytotoxicity against P-388 lymphocytic leukaemia cell cultures. Conoduramine, conodurine, voacamine,

affinine and apparicine showed moderate to strong antibacterial activity against several human pathogens, whereas affinine and apparicine also showed strong activity against the type III poliovirus (HPV-3).

The wood is soft, easy to work and white to yellow; it is not durable in the ground. The sapwood and heartwood are not differentiated.

Adulterations and substitutes Indolic alkaloids of the classes found in *Tabernaemontana* are also found in other *Apocynaceae* genera, e.g. *Alstonia*, *Cabucala*, *Catharanthus*, *Hunteria*, *Ochrosia*, *Picralima*, *Rauvolfia*, *Tabernanthe* and *Voacanga*.

Description Shrub or small tree up to 15 m tall, glabrous, dichotomously branched; trunk up to 40 cm in diameter, without buttresses; bark pale brown or grey-brown, longitudinally fissured, with large lenticels. Leaves opposite, simple and entire; ocrea conspicuous, widened into stipules in axils of petioles; petiole 6–20 mm long; blade broadly to narrowly elliptical, 10–50 cm × 5–26 cm, base cuneate, apex acuminate to acute, leathery, with scattered minute black dots beneath, pinnately veined with 7–16 pairs of lateral veins. Inflorescence a corymb 8–26 cm long, fairly lax, 2 together in the forks of branches, few- to many-flowered, often flowering twice and then bearing both flowers and ripe fruits; peduncle 3–14 cm long, rather robust; bracts small and scale-like, leaving a conspicuous scar. Flowers bisexual, regular, 5-merous, sweet-scented; pedicel 8–22 mm long; sepals almost free, orbicular to ovate, 4–7 mm long, fleshy, ciliate; corolla tube 18–35 mm long, 5-angular, fleshy, pale green, hairy inside from the insertion of the stamens to the mouth, sometimes slightly twisted at the base, lobes obliquely elliptical, 14–50 mm × 6–18(–27) mm, rounded, undulate, spreading, later recurved, white to pale yellow, throat pale yellow; stamens inserted 8–14 mm above the corolla base, included, anthers sessile, narrowly triangular, 9–13 mm long; ovary superior, almost cylindrical, consisting of 2 carpels, connate at base, styles fused, slender, 7–10 mm long, pistil head 3–4.5 mm long, widened at the base into a ring and at the apex into 5 orbicular lobes. Fruit consisting of 2 free almost globose follicles, 7–15 cm in diameter, pale green, often dotted, 2-valved, several- to many-seeded. Seeds obliquely ellipsoid, 11–14 mm long, with 6–7 longitudinal grooves on each side, minutely warty, dark brown, aril white. Seedling with epigeal germination.



Tabernaemontana pachysiphon – 1, flowering branch; 2, fruit; 3, seed, aril partly removed. Redrawn and adapted by Iskak Syamsudin

Other botanical information *Tabernaemontana* comprises about 110 species and is pantropical. About 18 species occur in mainland Africa and 15 in Madagascar. *Tabernaemontana pachysiphon* is closely related to *Tabernaemontana contorta* Stapf, which is endemic to Cameroon.

Tabernaemontana brachyantha Stapf occurs in western Central Africa. In Cameroon, the crushed twigs, mixed with *Ocimum* sp., are taken as a febrifuge, and in southern Ghana and Nigeria the bark fibre is made into cloth. Several alkaloids have been isolated from it that are similar to those in *Tabernaemontana pachysiphon*. *Tabernaemontana psorocarpa* (Pierre ex Stapf) Pichon occurs from Liberia to Gabon, and the latex is used in Ghana to treat skin infections. The stem bark contains monomeric indole alkaloids, most of them rare in the genus. The leaves contain a high concentration of sweroside, which has strong anti-amoebic activity.

Growth and development *Tabernaemontana pachysiphon* plants develop according to the architectural growth model of Leeuwenberg determined by a monopodial orthotropic trunk, which ends in a terminal inflorescence. After flowering the 2 uppermost axillary buds develop into branches, so that the growth is sym-

podial; the infructescence seems to be axillary. *Tabernaemontana pachysiphon* can be found flowering and fruiting throughout the year. There are peaks in flowering in West Africa in February–March, in Central Africa in October–November and in DR Congo also in April. Fruits mature in 1 year.

The contents of the major alkaloids apparicine, tubotaiwine and isovoacangine vary with provenance, leaf age, shade position of leaves in the crown and plant age. Alkaloid content is highest in young leaves, and in leaves from shaded conditions.

Ecology *Tabernaemontana pachysiphon* occurs in the understorey of light forest, bush or riverine forest, from sea-level up to 2200 m altitude.

Propagation and planting *Tabernaemontana pachysiphon* can be propagated by seed and by semi-ripe cuttings. Soaking the seeds in cold water for 24 hours before sowing will hasten germination. The seeds germinate best when sown as soon as collected.

Management For firewood production *Tabernaemontana pachysiphon* can be pollarded.

Harvesting Roots of *Tabernaemontana pachysiphon* are dug up, bark is stripped from the trunk and leaves are harvested whenever the need arises.

Genetic resources *Tabernaemontana pachysiphon* has a large area of distribution. It does not seem to be at risk of genetic erosion.

Prospects *Tabernaemontana pachysiphon* contains a wide range of indole alkaloids with interesting medical properties, e.g. hypotensive, central nervous system stimulating, local analgesic or cardiotonic activities. These warrant more investigations towards the possible development of *Tabernaemontana pachysiphon* as a medicinal plant of importance.

Major references Ingkaninan et al., 1999; Katende, Birnie & Tengnäs, 1995; Leeuwenberg, 1991; Neuwinger, 2000; Omino, 2002; van Beek et al., 1984b; van Beek & van Gessel, 1988; Zhu et al., 1990.

Other references Beentje, 1994; Burkill, 1985; Chifundera, 2001; Höft, Verpoorte & Beck, 1998a; Höft, Verpoorte & Beck, 1998b; Lovett, 1991a; Lovett, 1991b; Neuwinger, 1996; Omino & Kokwaro, 1993; Patel, Thompson & Poisson, 1973; van Beek, 1984; van Beek et al., 1984a; Van der Heijden et al., 1986; van der Heijden, 1989.

Sources of illustration Leeuwenberg, 1991.

Authors J. Elia

TABERNAEMONTANA PERSICARIIFOLIA Jacq.

Protologue Collectanea 4: 139 (1791), *'Tabernaemontana persicariaefolia'*.

Family Apocynaceae

Synonyms *Tabernaemontana mauritiana* Lam. (1792).

Vernacular names Bois de lait (Fr).

Origin and geographic distribution *Tabernaemontana persicariifolia* is endemic to Réunion and Mauritius.

Uses A decoction of the stem bark and leaves of *Tabernaemontana persicariifolia* has astringent properties and is taken to treat gonorrhoea and dysentery. It is also taken to expel intestinal worms. The bark sap and roots are used as fish poison.

Properties Several indole alkaloids have been isolated from *Tabernaemontana persicariifolia*. The stem bark and root bark contain mainly the monomeric indole alkaloids dregamine and vobasine, and also some tubotaiwine, which occurs in the leaves as well. Dregamine shows convulsant and respiration-stimulant activities. It also inhibits muscular fatigue in vitro and in vivo. It is used in treatments of muscular and nervous asthenia, respiratory depression and type III poliovirus (HPV-3). Tubotaiwine has local analgesic activity. Vobasine exhibited little activity in general pharmacological screening tests. The bark also contains sterols, triterpenes and saponins.

Botany Shrub or small tree up to 5(–10) m tall, dichotomously branched; trunk up to 40 cm in diameter; bark rough. Leaves opposite, simple and entire; ocrea conspicuous, widened into stipules in axils of petioles; petiole 5–22 mm long; blade narrowly elliptical to elliptical, 4–18 cm × 1–9 cm, base cuneate or rounded, apex acute, obtuse or acuminate, leathery, pinnately veined with 7–20 pairs of lateral veins. Inflorescence a corymb 3–6 cm long, 2 together in the forks of the branches, 3–20-flowered, rather congested; peduncle 5–25 cm long, rather slender. Flowers bisexual, regular, 5-merous, sweet-scented; pedicel 3–10 mm long; sepals almost free, subtended by 1–2 bracteoles, suborbicular to broadly elliptical, 2–3.5 mm long; corolla tube cylindrical, 9–23 mm long, hairy inside from the insertion of the stamens to the mouth, slightly twisted at base, lobes obliquely elliptical, 9–16 mm × 3–7 mm, apex rounded, undulate, spreading, later recurved, white to pale yellow; stamens inserted 2–3 mm below mouth of corolla tube, slightly included or slightly exserted, anthers sessile,

narrowly triangular, base sagittate, apex acuminate; ovary superior, ovoid, consisting of 2 carpels, connate at base, styles fused, slender, 6–15 mm long, pistil head 0.5–1.5 mm long, composed of a fringed basal ring, an obovoid central part and a 2-lobed stigmoid apex. Fruit consisting of 2 separate ovoid follicles 3–6.5 cm in diameter, with 2 narrow lateral ridges, apex acute or acuminate, 2-valved, green, many-seeded. Seeds obliquely triangular or ellipsoid, 10–11 mm long, with longitudinal grooves, papillose, medium brown, aril deep red.
Tabernaemontana comprises about 110 species and is pantropical. About 18 species occur in mainland Africa and 15 in Madagascar. *Tabernaemontana persicariifolia* is the only species occurring in the Mascarene Islands. It flowers from December to May with a peak in February to March. Fruits develop slightly later.

Ecology *Tabernaemontana persicariifolia* occurs in forest and open, rocky localities, up to 1200 m altitude. In Réunion it is found in relatively dry forest at low altitudes, in Mauritius in more humid forest at medium to high altitudes.

Genetic resources and breeding *Tabernaemontana persicariifolia* is endemic to Réunion and Mauritius and may be easily liable to genetic erosion with ongoing forest clearings. In Réunion it occurs in heterogeneous, relatively dry forest at low altitudes, but this type of forest survives only in few, sheltered localities. In Mauritius, it is still locally fairly common in humid forest at medium to high altitudes.

Prospects Little is known about the indole alkaloids of *Tabernaemontana persicariifolia*. More research on the pharmacology and phytochemistry is needed to fully evaluate the potential of this species.

Major references Gurib-Fakim & Brendler, 2004; Kodja, Robène-Soustrade & Figier, 1997; Leeuwenberg, 1991; van Beek et al., 1984b.

Other references Lavergne, 2001; Markgraf & Boiteau, 1973; Picot et al., 1974; van Beek & van Gessel, 1988.

Authors G.H. Schmelzer

TABERNAEMONTANA VENTRICOSA Hochst. ex A.DC.

Protologue Prodr. 8: 366 (1844).
Family Apocynaceae
Chromosome number $2n = 22$
Synonyms *Tabernaemontana usambarensis* K.Schum. ex Engl. (1894).

Vernacular names Forest toad tree, small-fruited toad tree (En). Mwambe ziwa (Sw).

Origin and geographic distribution *Tabernaemontana ventricosa* has a disjunct area of distribution, occurring in eastern Nigeria and western Cameroon, and from eastern DR Congo to Kenya and south to Natal in South Africa.

Uses The latex of *Tabernaemontana ventricosa* is applied to wounds and sore eyes to promote healing. A bark decoction is taken to reduce fever. In Natal the seeds, bark and roots are used as medicine for nervous problems and high blood pressure. The fruits are edible. The latex is used for making birdlime. The soft whitish wood is used for making stools, beds and knife sheaths and in construction. *Tabernaemontana ventricosa* is also suitable for planting in swampy areas where other species fail to survive and it would make an attractive garden tree with its sweet-smelling flowers and unusual fruits.

Properties The major indole alkaloids extracted from the stem bark of *Tabernaemontana ventricosa* plants cultivated in a greenhouse were 10-hydroxyheyneanine (ibogan class) and akuammicine (strychnan class). Minor amounts of apparicine, tubotaiwine (aspidospermatan class), norfluorocurarine, akuammicine N_4-oxide (strychnan class), 16-epi-isositsirikine (corynanthean class) and 10-hydroxycoronaridine (ibogan class) were also detected.
Akuammicine showed opioid activity in opiate receptor studies. Bark extracts of *Tabernaemontana ventricosa* do not show antibacterial, antifungal and antimalarial activities in vitro. A leaf extract showed significant anti-amoebic activity.

Botany Shrub or small tree up to 15 m tall, glabrous, dichotomously branched; trunk terete up to 30 cm in diameter; bark longitudinally fissured, often corky. Leaves opposite, simple; ocrea widened into stipules in axils of petioles; petiole 3–15 mm long; blade narrowly elliptical, 4–27 cm × 1.5–10(–12) cm, base cuneate or rounded, apex acuminate, acute or obtuse, margins wavy, leathery, pinnately veined with 7–23 pairs of lateral veins. Inflorescence a corymb 5–23 cm long, 2 together in the forks of the branches, more or less congested, many-flowered; peduncle 2–15 cm long, rather robust. Flowers bisexual, regular, 5-merous, sweet-scented; pedicel 3–10 mm long; sepals orbicular to broadly ovate, 3.5–6 mm long, ciliate; corolla

tube cylindrical to narrowly bottle-shaped, 10–27 mm long, inflated at the insertion of the stamens, slightly twisted at base, lobes obliquely elliptical, 14–32 mm long, undulate, spreading and recurved later, white with a pale yellow throat and greenish tube; stamens inserted 6–8 mm above the corolla base, included or slightly exserted, anthers sessile, narrowly triangular; ovary superior, broadly ovoid, consisting of 2 free carpels, style slender, pistil head widened at the base into a thin ring, grading into 5 lateral lobes, overtopped by the stigmoid apex. Fruit composed of 2 separate, obliquely ellipsoid follicles 6–7(–10) cm in diameter, dark green, with 2 faint lateral ridges, smooth, dehiscent, several- to many-seeded. Seeds obliquely ellipsoid, 11–23 mm long, with longitudinal grooves, minutely warty, dark brown, aril orange. Seedling with epigeal germination.

Tabernaemontana comprises about 110 species and is pantropical. About 18 species occur in mainland Africa and 15 in Madagascar. In Nigeria and Cameroon *Tabernaemontana ventricosa* flowers from January to April, in DR Congo and Uganda from March to May, and in Kenya to South Africa from September to December. In South Africa, it fruits from June to August.

Ecology *Tabernaemontana ventricosa* occurs in open or secondary forest, gallery forest and thickets in woodland, from sea-level to 1850 m altitude. It is frost sensitive, prefers shade, and requires a moderate amount of water.

Management *Tabernaemontana ventricosa* can easily be grown from seed and grows relatively fast.

Genetic resources and breeding *Tabernaemontana ventricosa* has a relatively large distribution, and is also found in disturbed habitats. It is therefore not likely to be threatened by genetic erosion.

Prospects Little is known about the indole alkaloids of *Tabernaemontana ventricosa*. Because some of the traditional uses are similar to other, better-known *Tabernaemontana* spp., more research on the pharmacology and phytochemistry is needed to fully evaluate the potential of this species.

Major references Boudreau et al., 2005; Grace et al., 2002; Leeuwenberg, 1991; Schripsema et al., 1986.

Other references Burkill, 1985; Le Roux, 2005; Lovett, Ruffo & Gereau, 2003; Neuwinger, 2000; van Beek et al., 1984b.

Authors G.H. Schmelzer

TABERNANTHE IBOGA Baill.

Protologue Bull. Mens. Soc. Linn. Paris 1: 783 (1889).

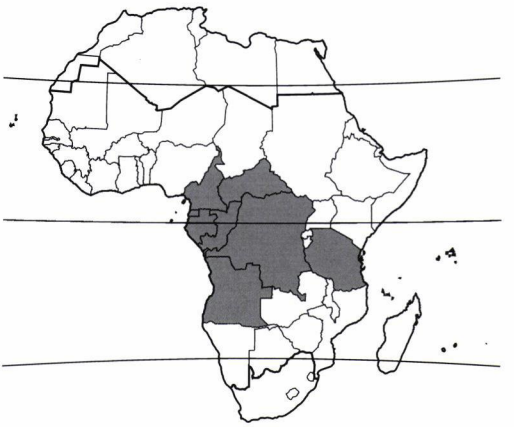
Family Apocynaceae

Chromosome number $2n = 22$

Vernacular names Iboga, eboka, bitter grass, sacred wood, leaf of God (En). Iboga, eboka, éboga, eraga, bois sacré, bois amer, dibughi (Fr). Dihoa, lihoka (Po).

Origin and geographic distribution *Tabernanthe iboga* is distributed naturally in Central Africa, from Cameroon east to eastern DR Congo and south to central Angola. It was once collected in Tanzania. *Tabernanthe iboga* is cultivated in several countries in West Africa, e.g. Côte d'Ivoire.

Uses *Tabernanthe iboga* is well known in Central Africa, as the root is very important in the initiation ceremonies of the Bwiti tradition in Gabon, which has expanded to southern Cameroon, Equatorial Guinea Congo and DR Congo. The root bark is eaten whole, or crushed and ground, rolled into small balls, sometimes mixed with other ingredients; sometimes a decoction of the crushed roots is taken. The root is mainly employed as a hallucinogenic, a catalyst for spiritual discovery, and to seek information from ancestors and the spirit world, hence 'coming to terms with death'. After the initiation ceremony, the initiate is reborn as an adult in the tribe, having been cleansed of illnesses and socio-psychological blockages accumulated during childhood. Iboga is taken in these ceremonies in large quantities. Ceremonies are also held for diagnostic or therapeutic reasons, and the quantities of iboga taken there are in general much lower,



Tabernanthe iboga – wild

allowing the participant a certain agility and endurance. A root decoction can also be taken as a tonic to combat tiredness, hunger and thirst when it is necessary to overcome physical stress, e.g. for hunting or formerly in tribal wars. It is also considered aphrodisiac, as is the leaf decoction. A root decoction is taken as a febrifuge. In DR Congo the decoction is used for eye drops to treat conjunctivitis. The pounded roots are also used in the curing ceremony (called 'zebola') for psychosomatic afflictions. In Congo a root macerate in palm wine is taken to soothe coughs, and the root decoction is drunk to treat urinary infections. In traditional medicine, the latex is taken as an anthelmintic and warmed leaves are rubbed on the gums to calm toothache, as they have an anaesthetic activity. The latex is mixed with *Periploca nigrescens* Afzel. and/or *Strophanthus* spp. and is used as arrow poison.

In the 1980s iboga became popular in the United States and Europe as a non-addictive interrupter of drug dependency, but soon thereafter it was classified as a hallucinogen and dangerous substance in the United States, where it is therefore illegal to buy, sell, or possess it without a licence. Its possession is also prohibited in Belgium, Switzerland, Sweden and Australia. There has been renewed interest in iboga since the late 1990s.

Production and international trade The roots or root bark of *Tabernanthe iboga* can be found commonly in local markets and pharmacies. At present, the market for *Tabernanthe iboga* is increasing because of the use of iboga outside Africa for the treatment of addictions to tobacco, alcohol and drugs, and also to treat psychological disorders. The trade of *Tabernanthe iboga* products is most important in Gabon. *Tabernanthe iboga* products, particularly the rootbark, are mostly bought and sold by members of the Bwiti society and traditional healers. Statistical information on trade is scarce. Powdered iboga root bark was sold on the local market of Libreville (Gabon) in 2005 at 5000 Fcfa (US$ 7.6) for 200 ml, while 1 l is sold at 15,000 Fcfa (US$ 22.8). In 2004 a Gabonese trader exported root bark to Europe with an estimated value of 6 million Fcfa (US$ 9100).

The roots are imported by several countries, e.g. France, Netherlands, Germany, United Kingdom, Canada and countries in the Caribbean. On internet, prices of powdered root ranged in 2005 from US$ 2.35 per g to US$ 1.5 per g depending on the quantity; prices of powdered root bark ranged from US$ 4.7 per g to US$ 2.6 per g also depending on the quantity; prices of ibogaine hydrochloride (98% pure) range from US$ 150 per g to US$ 300 per g; seeds were sold in packages of 5 seeds for US$ 19.

Properties The active compounds in the root, root bark, stem bark, leaves and seeds of *Tabernanthe iboga* are indole alkaloids. About 20 have been identified so far; the highest concentrations occur in the root bark (5–6%), followed by the roots (1–2.5%), stem bark (2%), seed (1%) and leaves (0.4–0.8%). Ibogaine (ibogan class) is the most important alkaloid present in all plant parts except the seeds. Ibogaine can be synthesized from nicotinamide via a 13- or 14-step process, but the yield is too low to be economically attractive. The main activities of ibogaine are on the central nervous system and on the cardiovascular system. Alkaloids structurally similar to ibogaine have analogous effects.

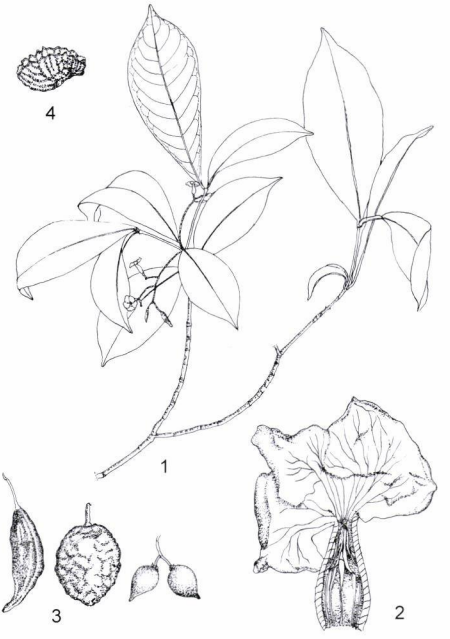
At low doses, ibogaine exerts primarily a stimulant effect, increasing alertness and reducing fatigue, hunger and thirst. At higher doses, the primary effects are hallucinations, with unpleasant possible side effects such as anxiety and depression with fear or rage. The peak effect is reached 1–3 hours after swallowing the drug; it subsides gradually, ending in complete insomnia and lethargy. These effects can last for 2–5 days. Apart from the psychological effects, the physical effects include tremor, light sensitivity, nausea and vomiting, loss of muscular coordination and prolonged and often painful muscle spasms, all in a dose-dependent way. Toxic doses may produce convulsions, paralysis and death from respiratory arrest. Most activities have been tested with purified ibogaine, but during initiation ceremonies powdered root bark is usually taken, which is more powerful as it contains a range of related alkaloids. Ibogaine is a potent cholinesterase inhibitor, and the root extract is even 100 times stronger in its inhibitory effect because of the additional effects of the alkaloids tabernanthine, ibogamine and the more distantly related iboluteine. This property contributes to the anti-fatigue properties of ibogaine, and results from an increased sensitivity to adrenaline, bringing about a transient excited state of the sympathic nervous system. Despite the reputation of iboga as an aphrodisiac, ibogaine did not produce a stimulation of sexual functions in tests with dogs, cats and sheep. Not does ibogaine have a significant analgesic effect in mice

Recent research indicates that ibogaine has a novel pharmacological mechanism of action, acting strongly on a variety of different receptors in the brain, resulting from complex interactions between neurotransmitter systems. There is no consensus yet on how ibogaine works precisely, but it is known to inhibit the re-uptake of the neurotransmitter serotonin, which can cause hallucinations. However, the suggestion by laymen that ibogaine has considerable potential in the field of psychotherapy is premature. Research on animals and humans reveal that ibogaine is converted in the liver to noribogaine, which fills opiate receptors, thus eliminating withdrawal symptoms. Ibogaine also stimulates nicotinic receptors in the cerebellum, which contributes to modulating the dopamine reward circuit. At high doses though, ibogaine is toxic as it destroys neurons in the cerebellum.

Research with animals and anecdotal reports of humans suggest that ibogaine has considerable potential in treating addictions to heroin, cocaine, alcohol, nicotine, caffeine, amphetamine, desoxyephedrine or methadone, or combinations of these. Several methods to arrest the physiological and psychological aspects of dependency on drugs by using ibogaine have been patented in the United States. Treatments are claimed to be effective for 70–100% of the cases. However, the serious side effects of ibogaine make its use potentially harmful and additional clinical studies are needed to determine if and how it can be used safely. The side effects of ibogaine are not present in the ibogaine congener 18-methoxycoronaridine (18-MC), nor in the metabolite noribogaine, and these compounds thus have potential in safe and effective treatments. Meanwhile, there are some clinics, e.g. in the Caribbean, that offer a controlled ibogaine treatment, and in Europe illicit treatments are available without medical facilities. In addition, ibogaine and iboga extracts have become available through the internet.

Adulterations and substitutes Several other *Apocynaceae* genera also contain compounds related to ibogaine, but they contain ibogaine as a minor compound only, e.g. *Tabernaemontana* and *Voacanga*.

Description Shrub up to 4 m tall, repeatedly dichotomously branched, with white latex in all parts, glabrous to hairy; trunk up to 10 cm in diameter; bark pale to dark grey, smooth. Leaves opposite, simple and entire; stipules absent; petiole 1–13 mm long, with three or more rows of colleters in the axils; blade narrowly elliptical, elliptical or narrowly obovate, 2.5–22 cm × 1–10 cm, base slightly cordate to cuneate, apex acuminate, pinnately veined with 7–20 pairs of lateral veins. Inflorescence an irregularly corymb 3–7 cm × 2–4 cm, 2 together just above the forks of the branches, few- to many-flowered; peduncle 0.5–4.5 cm long, fairly slender; bracts as long as the sepals, sparsely hairy at the apex. Flowers bisexual, regular, 5-merous, fragrant; pedicel 2–17 mm long, thickened at apex; sepals almost free, ovate to triangular, 1–3 mm long, apex acuminate, persistent in fruit; corolla tube almost cylindrical to urn-shaped 5.5–8.5 mm × 1.5–3.5 mm, contracted at base, lobes orbicular to obliquely ovate, 2.5–6 mm long, with obtuse or rounded apex, in bud overlapping to the left, undulate, spreading and recurved later, hairy inside from the insertion of the stamens to the mouth, white or cream, usually with red to purple dots or stripes in 5 groups in the throat; stamens inserted 2.5–4 mm above the corolla base, included, anthers almost sessile, base sagittate; ovary superior, only basally 2-celled, surrounded by a disk, style slender, pistil head composed of a basal ring, an almost globose



Tabernanthe iboga – 1, flowering branch; 2, opened corolla; 3, fruits; 4, seed.
Redrawn and adapted by Iskak Syamsudin

central part with 5 grooves and 2 slender apical lobes. Fruit a globose, ellipsoid or ovoid berry 3–6.5 cm long, apex rounded, obtuse, acute or acuminate, pendulous, smooth or less often bumpy, glabrous, yellow to red, many-seeded, with the seeds in spongy, white pulp. Seeds ellipsoid, 7–10 mm long, brain-like deeply indented. Seedling with epigeal germination, taproot firm, cotyledons leafy, rounded, epicotyl 3.5–7.5 cm long, glabrous.

Other botanical information *Tabernanthe* comprises 2 species, both restricted to Central Africa: *Tabernanthe iboga* and *Tabernanthe elliptica* (Stapf) Leeuwenb. *Tabernanthe elliptica* occurs in Congo, DR Congo and Angola and differs mainly from *Tabernanthe iboga* in having only 4–7 pairs of lateral leaf veins and having fruits consisting of 2 separate follicles bearing soft blunt prickles. Of the total alkaloids in the root bark (5.6%) and stem bark (2.4%), about 80% is ibogaine. The leaves do not contain ibogaine. Hybridization occurs between the 2 species, resulting in plants with the carpels more or less fused in fruit, without or with a few blunt prickles. The fruits of *Tabernanthe iboga* are quite variable; in Gabon plants with ovoid fruits are most commonly used in ceremonies.

Growth and development The seedling of *Tabernanthe iboga* grows rhythmically, extending by flushes, becoming about 60 cm tall in 3 years. The juvenile period lasts 5–6 years. The plant develops according to the architectural growth model of Leeuwenberg characterized by a monopodial orthotropic trunk, which ends in a terminal inflorescence. After flowering the 2 uppermost axillary buds develop into branches, so that the growth is sympodial and the infructescence seems to be axillary. Flowering and fruiting occurs almost throughout the year, but mostly between September and February. The fruits take 5–6 months to mature. *Tabernanthe iboga* regenerates well by forming shoots from the trunk.

Ecology *Tabernanthe iboga* occurs in the forest understorey, sometimes in riverine or swamp forest or relatively wet savanna, from sea-level to 1500 m altitude. In Gabon it is dominant in forest along the Atlantic coast, between Cocobeach and Ndindi. The seeds are dispersed by elephants as they feed on the fruit.

Propagation and planting Propagation of *Tabernanthe iboga* is by fresh seed or by cuttings. Germination is slow and irregular, ranging from a few weeks to a few months. Scarification prior to sowing increases the germination rate considerably, although this is rarely done in home gardens. After a few months the seed coat dries out, making it difficult for the seedling to emerge. Seedlings need to be protected from the sun. They can be transplanted to their final location after 2–3 months, when the root has become twice as long as the stem. Cuttings of about 25 cm long and 1 cm in stem diameter root easily in humid soil. These cuttings flower already after 4 months. *Tabernanthe iboga* can be propagated through tissue culture.

Management *Tabernanthe iboga* is commonly cultivated in home gardens. Once established, individual plants grow fast and require little maintenance, but need to be protected from fire.

Harvesting In the wild, whole plants of *Tabernanthe iboga* are uprooted to harvest the roots. This leads to large-scale destruction of natural stands. In home gardens, only a part of the roots is harvested. The roots can be harvested throughout the year although it is easier during the rainy season between October and May, as the soil is easier to work. Larger quantities are mainly collected from wild stands.

Handling after harvest The fresh roots are transported in jute bags. They are washed and sun-dried for local use or for the market. The bark of the root is then separated, and is again left to dry in the sun for 7–10 days, after which it is pounded and sieved through a coarse mesh. The powder is kept dry in bottles.

Genetic resources No germplasm collections of *Tabernanthe iboga* exist, and as large quantities of the plants are harvested from the wild, it is likely that the genetic diversity will be threatened in the near future. Also, an inventory of the morphological variation is needed to clarify the diversity within in the species, especially in the shape of the fruit. The government of Gabon considers iboga a national patrimony; however, there is no law protecting it against overexploitation.

Prospects *Tabernanthe iboga* is a plant with considerable socio-economic importance in Gabon and neighbouring parts of Africa because of its role in the Bwiti tradition, and outside Gabon because the root bark or purified ibogaine is used in Europe and America in treating addictions to drugs, alcohol and smoking. Apart from the need to investigate whether ibogaine really does suppress the craving for drugs, its toxic side-effects need to be

elucidated. *Tabernanthe iboga* is not yet threatened in its natural environment, but as most plants are harvested from the wild, and whole plants are uprooted, it may become endangered in the near future when demand remains high. More research on cultivation practices and methods of propagation of superior plant types is warranted. Iboga has ornamental value, especially when in flower and fruit.

Major references Alper, 2001; Bandarage, Kuehne & Glick, 2001; Bisset, 1989b; Erowid, 1995-2005; Glick, Maisonneuve & Szumlinski, 2000; Hunter, 1999; Lotsof & Alexander, 2001; Neuwinger, 1996; Vastag, 2005; Vonk & Leeuwenberg, 1989.

Other references Adjanohoun et al. (Editors), 1988; Alper et al., 1999; Ango Biyoghe, 2004; Bouquet & Botton, 1962; Bourobou Bourobou & Omvono, 2002; Bureau, 2000; Goutarel, Gollnhofer & Sillans, 1993; Hallé & Oldeman, 1970; Krauss, 1996; Leal, de Souza & Elisabetsky, 2000; Lotsof, 1995; Luciano, 1998; Mash et al., 2000; Mazzei, 2002; Molinari, Maisonneuve & Glick, 1996; Neuwinger, 2000; Ngavoura, 1990; Pawelka & Stöckigt, 1983; Popik & Skolnick, 1999; Silva et al., 2004.

Sources of illustration Vonk & Leeuwenberg, 1989.

Authors H.P. Bourobou Bourobou

TETRORCHIDIUM DIDYMOSTEMON (Baill.) Pax & K.Hoffm.

Protologue Engl., Pflanzenr. IV, 147, 14: 53 (1919).

Family Euphorbiaceae

Chromosome number $n = 33$

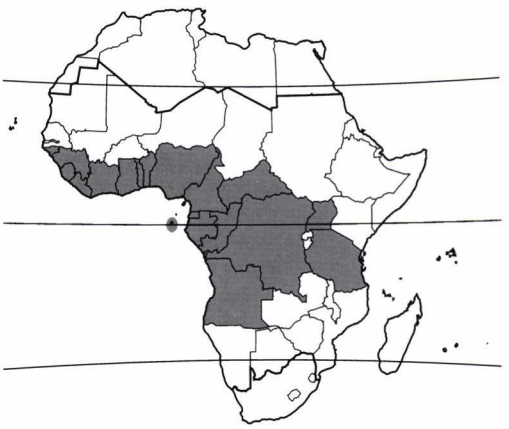
Synonyms *Tetrorchidium minus* (Prain) Pax & K.Hoffm. (1919).

Vernacular names Arbre à savon du Gabon (Fr). Pau branco, pau gamela (Po).

Origin and geographic distribution *Tetrorchidium didymostemon* occurs from Guinea Bissau east to Uganda and south to Tanzania and Angola.

Uses Throughout its distribution area the latex from the stem bark is used as eye drops to treat filariasis, and is also applied to abscesses, leprous sores and glandular swellings. Leaf sap is applied to wounds as a haemostatic. The leaf sap in water or rum, or a stem bark decoction, is commonly taken as a purgative and to treat fever. To treat constipation or enlarged spleen in babies, leaf sap is applied to nipples of nursing mothers or to scarifications. A stem bark infusion is rubbed on to rheumatic and painful limbs, painful kidneys and to treat oedema. In Gabon beaten stem bark is taken as a mouth wash to treat toothache. In Congo and DR Congo the leaves, crushed together with the stem bark of *Cola ballayi* Cornu ex Hack., are applied to broken limbs as an embrocation to treat swellings. Young leaves are cut and cooked with fish and eaten to treat enlarged spleen. Leaf sap or stem bark latex, sometimes with banana or in palm wine, is taken to treat stomach-ache, gonorrhoea, intestinal worms, coughing fits and food poisoning. Bark scrapings are applied as an enema to treat malaria and backache. A maceration of the stem bark is applied as a wash to treat hernia and urinary infections. The twig or root bark latex mixed with palm oil is applied as a lotion to treat measles. A root decoction is drunk as an emetic. The ash from the stem bark or root bark mixed with palm oil is applied to kill lice. A bark extract is rubbed on the body as a mosquito repellent. Bark latex is applied to snakebites. A stem bark decoction is drunk as an emetic and antidote against *Erythrophleum suaveolens* (Guill. & Perr.) Brenan poisoning in ordeal by poison. Cows are given leaf sap with salt to increase milk production.

The wood is used as firewood and for charcoal making. The stems are used as poles for making huts and sometimes also in carpentry. In Gabon the wood is used for plywood production. In West Africa the twigs are used as chew sticks. In Benin, Gabon and Congo the beaten stem bark is used as soap for washing clothes.

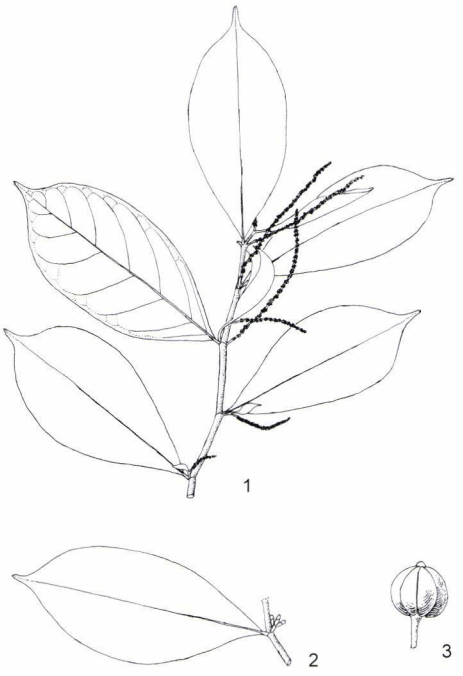


Tetrorchidium didymostemon – wild

Properties A preliminary screening of the

leaves and stem bark of *Tetrorchidium didymostemon* revealed the presence of saponins and traces of alkaloids.
The wood is pinkish, soft to moderately hard and perishable.

Description Dioecious, evergreen, glabrous liana, shrub or small tree up to 12 m tall, sometimes a medium-sized tree up to 25 m tall, with drooping branches; latex usually white, sometimes reddish or colourless; bark smooth or minutely fissured, brown; twigs slightly zigzag, prominently scarred at the nodes. Leaves alternate on flowering shoots, opposite on other branches; stipules small; petiole 0.5–1 cm long, channelled; blade obovate to elliptical-oblanceolate or elliptical, (4–)7–12(–17) cm × (2–)3–6(–8) cm, base cuneate, apex abruptly acuminate, margins entire or sometimes shallowly and remotely toothed, firmly papery, pinnately veined with 5–9 pairs of lateral veins. Inflorescence axillary to leaf-opposed, male inflorescence a densely flowered spike 2.5–8 cm long, female inflorescence a 3–5-flowered false umbel 1–1.5 cm long; peduncle 0.5–1 cm long. Flowers unisexual, 3-merous, petals absent; male flowers sessile, sepals broadly ovate, c. 0.7 mm long, minutely fringed, greenish yellow, stamens short; female flowers with pedicel 2–4 mm long, sepals triangular-ovate, c. 1 mm long, minutely fringed, greenish, disk glands petal-like, triangular-ovate, up to 1 mm long, yellowish green, ovary superior, almost globose, 1.5–2 mm in diameter, 3-celled, smooth, styles 3, forming a cap c. 1 mm in diameter. Fruit a 3-lobed capsule c. 5 mm × 6 mm, smooth, green becoming brownish green, 3-seeded. Seeds compressed ellipsoid, 4–5 mm × 3–4 mm, orange-red, pitted.



Tetrorchidium didymostemon – 1, branch with male inflorescences; 2, part of branch with female inflorescence; 3, fruit.
Redrawn and adapted by Iskak Syamsudin

Other botanical information *Tetrorchidium* comprises about 25 species, of which 5 occur in tropical Africa and the others in tropical America. Several other *Tetrorchidium* spp. are also used medicinally in Central Africa. In Congo bark latex of *Tetrorchidium congolense* J.Léonard, occurring in Gabon, Congo and DR Congo, is taken in palm wine to treat diarrhoea. *Tetrorchidium oppositifolium* (Pax) Pax & K.Hoffm. occurs in the forest area of West Africa, Cameroon and Gabon. In Liberia a bark infusion is taken as a febrifuge. In Gabon bark scrapings mixed with palm oil are massaged on painful areas caused by rheumatism. A bark infusion is used as eye drops to treat eye complaints.

Anatomy Wood-anatomical description (IAWA hardwood codes):
Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; (12: solitary vessel outline angular); 13: simple perforation plates; 22: intervessel pits alternate; (23: shape of alternate pits polygonal); 27: intervessel pits large (≥ 10 µm); 30: vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell; 31: vessel-ray pits with much reduced borders to apparently simple: pits rounded or angular; 41: mean tangential diameter of vessel lumina 50–100 µm; 42: mean tangential diameter of vessel lumina 100–200 µm; 47: 5–20 vessels per square millimetre. Tracheids and fibres: 61: fibres with simple to minutely bordered pits; (65: septate fibres present); 66: non-septate fibres present; 68: fibres very thin-walled; 69: fibres thin- to thick-walled. Axial parenchyma: 76: axial parenchyma diffuse; 77: axial parenchyma diffuse-in-aggregates; 78: axial parenchyma scanty paratracheal; 93: eight (5–8) cells per parenchyma strand; 94: over eight cells per parenchyma strand. Rays: 97: ray width 1–3 cells; (100: rays with multiseriate portion(s) as wide as uniseriate portions); 108: body ray cells procumbent with

over 4 rows of upright and/or square marginal cells; 116: ≥ 12 rays per mm. Mineral inclusions: (144: druses present); (145: druses in ray parenchyma cells); (148: druses in chambered cells).
(D. Louppe, P. Détienne & E.A. Wheeler)

Ecology *Tetrorchidium didymostemon* is common in secondary forest, at forest edges or along rivers, lakesides and swamps, from sea-level up to 1700 m altitude.

Propagation and planting The seeds are dispersed by birds that feed on the fruits.

Harvesting The leaves, stem bark and latex of *Tetrorchidium didymostemon* are harvested whenever the need arises.

Handling after harvest The harvested parts are usually used fresh.

Genetic resources *Tetrorchidium didymostemon* has a large distribution area and is common; therefore it is not threatened by genetic erosion.

Prospects *Tetrorchidium didymostemon* has many local medicinal uses, but virtually nothing is known concerning the chemical compounds or pharmacology of the plant parts and therefore more research is warranted.

Major references Burkill, 1994; CE-FAO, 1999; Keay, 1989; Latham, 2004; Masiala, 2002; Neuwinger, 2000; Radcliffe-Smith, 1987; Raponda-Walker, 2005; Toirambe, 1989; Wome, 1985.

Other references Adjanohoun et al. (Editors), 1988; InsideWood, undated; Léonard, 1962; Noumi, 2004; Stäuble, 1986; Terashima & Ichikawa, 2003; Vivien & Fauré, 1988; Yamada, 1999.

Sources of illustration Aubréville, 1959a.

Authors B. Toirambe

THECACORIS SPATHULIFOLIA (Pax) Leandri

Protologue Mém. Inst. Sci. Madagascar, sér. B, Biol. Vég. 8: 211 (1957).

Family Euphorbiaceae (APG: Phyllanthaceae)

Synonyms *Cyathogyne bussei* Pax (1903).

Origin and geographic distribution *Thecacoris spathulifolia* occurs from southern Somalia south to Mozambique and also in Madagascar.

Uses In Kenya the roots are soaked in water and the resulting liquid is drunk to cure a hernia. Fresh roots are chewed and the juice swallowed to treat tonsilitis. A small root is chewed and the juice swallowed or roots are boiled for half an hour and the warm liquid is drunk to treat snakebites. A decoction of the stem bark is drunk to treat abdominal pain and gonorrhoea.

Botany Dioecious shrub up to 2 m tall; branches straight, often erect and parallel; twigs pale greyish brown. Leaves alternate, simple and entire, crowded at apex of branches; stipules 1.5–2 mm long, triangular-lanceolate, brown; petiole 1–3 mm long; blade elliptical to obovate, 1–3 cm × 0.5–1 cm, base cuneate, apex notched, slightly fleshy, nearly glabrous, pinnately veined with 2–3 pairs of lateral veins. Inflorescence an axillary, solitary spike, yellow hairy, up to 1.5(–3) cm long. Flowers unisexual, regular, 5(–6)-merous; petals small or absent; male flowers with pedicel 1(–2) mm long, sepals obovate, c. 1 mm long, hairy, stamens c. 2 mm long; female flowers with pedicel c. 1 mm long, sepals oblong-ovate, fused at base, c. 1 mm long, ovary superior, almost globose, c. 1 mm in diameter, 3-celled, styles 1 mm long, stigmas red. Fruit a 3-lobed capsule 4–5 mm × 7–8 mm, nearly glabrous, green, up to 6-seeded. Seeds pear-shaped, c. 2 mm × 2 mm, brown, hilum white, grooved. Seedling with epigeal germination.

Thecacoris comprises about 20 species, all of them native to continental Africa and Madagascar.

Thecacoris lucida (Pax) Hutch. is a shrub or small tree found in Gabon, Congo, DR Congo, Uganda, Tanzania and Angola. In DR Congo the leaf or bark sap is drunk with sugar cane juice to cure syphilis. *Thecacoris stenopetala* (Müll.Arg.) Müll.Arg., a West African forest species, is used in Sierra Leone to cure toothache. The root extract of *Thecacoris viridis* (Müll.Arg.) G.L.Webster, occurring from Nigeria to DR Congo, is taken in DR Congo to treat stomach problems.

Ecology *Thecacoris spathulifolia* is found in dry evergreen woodland, miombo woodland, wooded grassland and thickets, often on sandy soil, up to 700 m altitude.

Genetic resources and breeding *Thecacoris spathulifolia* is fairly widespread and probably does not face serious threats.

Prospects Too little is known of *Thecacoris spathulifolia* to judge its prospects. Research into its phytochemistry and pharmacology would be a first step.

Major references Kokwaro, 1993; Radcliffe-Smith, 1996a.

Other references Bouquet, 1969; Chhabra, Mahunnah & Mshiu, 1990; Léonard, 1995;

Neuwinger, 2000.
Authors C.H. Bosch

THESIUM VIRIDE A.W.Hill

Protologue Bull. Misc. Inform. Kew 1910: 238 (1910).
Family Santalaceae
Origin and geographic distribution *Thesium viride* is distributed from Sierra Leone, Mali and Niger east to Sudan.
Uses In Benin the powdered aerial parts are eaten either pure or in a sauce to treat jaundice; a decoction of the branches is drunk for the same purpose.
Properties No chemical or pharmacological research on *Thesium viride* has been done. However, cardiac glucosides and quercitrin (a flavonoid glycoside) have been isolated from other *Thesium* species. A complicating factor of research into the properties is that compounds extracted from *Thesium* may have been produced by the host plant. Thesinine (a pyrrolizidine alkaloid) isolated from *Thesium* might well be an example of transfer from a host.
Botany Hemi-parasitic subshrub up to 45 cm tall, with tufts of stems arising from a woody rootstock; stems branched, c. 2 mm thick, greyish green. Leaves alternate, simple and entire, sessile, narrowly ovate to linear, c. 4 mm × 0.5 mm, apex acuminate. Flowers axillary and terminal, solitary, bisexual, regular, (4–)5-merous; bracts ovate to narrowly ovate, c. 2 mm long, apex acute; perianth tube c. 1 mm long, lobes oblong-ovate, c. 1.5 mm long; stamens inserted on perianth tube; ovary superior, style up to c. 3 mm long. Fruit an ellipsoid, ridged achene c. 3 mm × 2 mm, reticulately veined, perianth persistent, c. 2 mm long.
Thesium comprises about 300 species, and is distributed in Africa and Eurasia. In East Africa about 17 species occur and in southern Africa 175. *Thesium* is parasitic on a wide range of plants without evident host specificity. However, details are lacking for most of the African species. Species are distinguished by the minute flowers, which make identification difficult. For large parts of Africa treatment of the genus in regional floras is only recent or not yet published. Hence, many references of medicinal use relate to plants that are not identified at species level. In Namibia a decoction of the crushed roots of *Thesium lineatum* L.f. and *Thesium lacinulatum* A.W.Hill is taken to treat venereal diseases and uterine problems. *Thesium lineatum* has been a subject of study because it is responsible for fatal poisoning of cattle, sheep and goats. Thesiuside, a cardiac glucoside of the bufadienolide type, was identified as the active principle in poisoning.



Thesium viride – 1, flowering branch; 2, flower; 3, young fruits; 4, mature fruit.
Source: Flore analytique du Bénin

Ecology *Thesium viride* occurs in wooded savanna, in rocky terrain, along streams and in fallow fields at 800–1750 m altitude. It withstands regular burning.
Genetic resources and breeding As *Thesium viride* is distributed widely and as there are no signs of over-exploitation, no threats to its genetic diversity are envisaged.
Prospects *Thesium viride* and other *Thesium* species, including the African ones, have interesting characteristics that have yet to be exploited by research. A solid taxonomic foundation for further work is more or less in place. Studies into host specificity could yield a better understanding of chemical properties and toxicity.
Major references Adjanohoun et al., 1989; Lawalrée, 1972; Polhill, 2005; von Koenen, 2001.
Other references Akoègninou, van der Burg & van der Maesen, 2006; Burkill, 2000;

Keay & Hepper, 1958; van Heerden, Vleggaar & Anderson, 1988; van Wyk, van Heerden & van Oudtshoorn, 2002.

Sources of illustration Akoègninou, van der Burg & van der Maesen, 2006.

Authors C.H. Bosch

THEVETIA PERUVIANA (Pers.) K.Schum.

Protologue Engl. & Prantl, Nat. Pflanzenfam. IV, 2: 159 (1895).

Family Apocynaceae

Chromosome number $2n = 20$

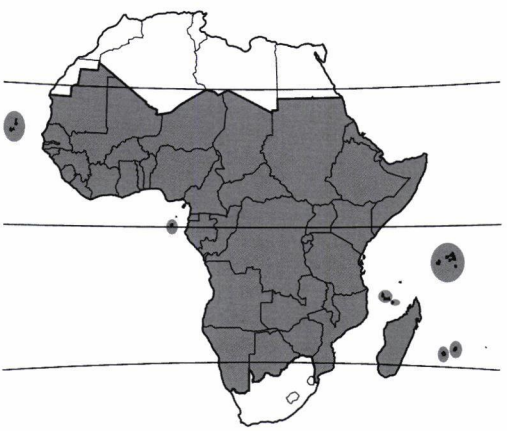
Synonyms *Thevetia neriifolia* Juss. ex Steud. (1841), *Cascabela thevetia* (L.) Lippold (1980).

Vernacular names Yellow oleander, lucky nut tree, trumpet flower, milk bush, exile tree, be-still tree (En). Laurier jaune des Indes, laurier à fleurs jaunes, chapeau de Napoleon, bois à lait (Fr). Loendro amarelo, chapéu de Napoleão (Po). Mbagi (Sw).

Origin and geographic distribution *Thevetia peruviana* originates from tropical America and is widely cultivated throughout the tropics as an ornamental, also in tropical Africa.

Uses *Thevetia peruviana* is used medicinally throughout the tropics in spite of its toxicity. A bark or leaf decoction is taken to loosen the bowels, as an emetic, and is said to be an effective cure for intermittent fevers. In Senegal water in which leaves and bark were macerated is taken to cure amenorrhoea. In Mali the latex is applied to soften corns and calluses. In Côte d'Ivoire and Benin the leaf sap is used as eye drops and nose drops to cure violent headaches; the leaf sap is also dropped in the nostrils to revive people that have fainted and to cure colds. In Kenya the Luo people use water in which leaves have been crushed to treat colds. The seeds may be used as a purgative. The seed oil is applied externally in India to treat skin infections. Care should be taken in all medical applications, in particular those used internally, as toxic doses are only a little higher than therapeutic ones. In Benin and Uganda an infusion of the roots is taken to treat snakebites. In Ghana the leaves in decoction are taken to treat jaundice, fever and as a purgative for intestinal worms. The bark and seeds are used to poison rats, and also for criminal purposes. In southern Africa and Cameroon the seeds are used as an arrow or ordeal poison. In India and Sri Lanka, seeds have been used for committing suicide or homicide. Other reports state the use of the seeds as an abortifacient. The seeds act as a contact poison; mashed with a soap solution they are used as an insecticide.

In Ghana and Uganda the wood is used to make tool handles and building poles. It is also used as fuel. The fruit pulp is sometimes eaten. The foliage is not grazed by stock, and the plants make a useful live fence. *Thevetia peruviana* is widely planted as an ornamental in gardens, and also as a hedge. In cooler climates it can be grown in tubs in the glasshouse and outdoors in summer. It is also planted for shade or for soil conservation. After purification, the originally poisonous seed oil is suitable for consumption.



Thevetia peruviana – planted

Production and international trade *Thevetia peruviana* is usually cultivated in home gardens for use in local medicine and as an ornamental. The plants do not enter international trade in Africa.

Properties Most parts of *Thevetia peruviana*, including the latex, are highly toxic; the seeds most highly so. The active principles are cardiac glycosides of the cardenolide type. The poison mainly affects the cardiovascular system (causing various types of arrhythmia, e.g. sinus bradycardia) and the gastro-intestinal tract. Vomiting is a common symptom of poisoning in about 30% of all cases; ischaemic changes (restrictions in the blood supply) occur in about 40%, and palpitations in about 10%. The most serious and immediate cause leading to death is peripheral vascular failure.

The cardiac glycosides of *Thevetia peruviana* are triosides or monosides, i.e. they contain an aglycone unit combined with 3 or 1 sugar moieties, respectively. These aglycones are either

digitoxigenin or the related cannogenin or cannogenol. The trioside thevetin is the major component of the seeds. It is a mixture of cerberoside (thevetin B) and thevetin A in a 2:1 ratio. Monosides isolated from the seeds include neriifolin, cerberin (2'-O-acetylneriifolin), peruvoside (cannogenin-thevioside), ruvoside (cannogenol-thevioside) and perubosidic acid (perusitin).

Peruvoside has been investigated most thoroughly. Preliminary work on the cardiotonic effect showed that it exerts a quick and powerful positive inotropic effect in experimental animals, comparable to that of ouabain. In therapeutic doses, peruvoside produced a fall in right atrial pressure, and a rise in the cardiac output. Furthermore, it was found that peruvoside inhibited Na^+,K^+-ATPase activity and that it has a strong competitive inhibition on (^3H)-ouabain binding to this enzyme. The inhibitory effects on the enzyme activity were stronger than the positive inotropic effect.

Large-scale clinical trials have shown that all forms of cardiac insufficiency can be successfully treated with peruvoside, and compensation can be maintained during continuous therapy in about 85% of the patients. However, peruvoside is no longer used in Western medicine because of the difficult dosage, small difference between therapeutic and toxic dosage, and poor bioavailability because of rapid breakdown. The use of peruvoside in antiherpes drugs has been patented.

Of the other cardiac glycosides of *Thevetia peruviana*, the mixture thevetin is practically identical in effect with ouabain, but much less potent. It has been effectively used clinically in cases of cardiac decompensation, although its effective dose is rather close to its toxic dose. As a cardiac glycoside, cerberoside (thevetin B) is much more potent than thevetin A and the related monosides neriifolin and cerberin.

From the leaves, a range of flavanone glycosides and flavonol glycosides have been isolated, and several of them have shown inhibitory effects against HIV-1 reverse transcriptase and HIV-1 integrase.

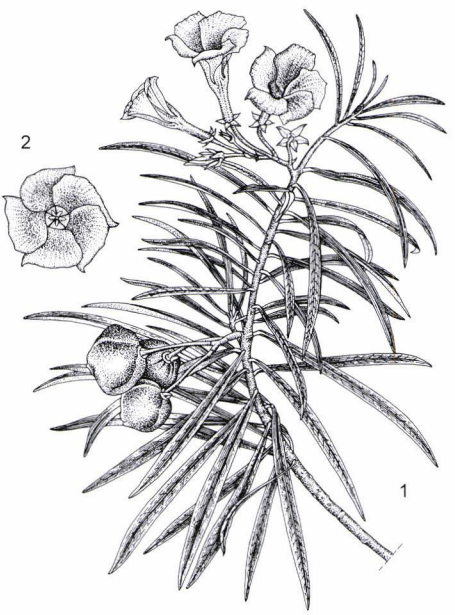
The seed oil has shown strong antibacterial activity, especially against *Bacillus subtilis* and *Staphylococcus aureus*. Different leaf extracts and seed extracts have shown strong antifeedant effects on slugs and insects (including termites) when sprayed on crops and also significant nematicidal activities. The leaf extract was also toxic to *Rhizoctonia solani*.

The seed contains 57–63% oil, which after purification consists mainly of oleic acid (60%), palmitic acid (16%), stearic acid (11%), linolenic acid (7%) and linoleic acid (5%). The oil can be detoxified and could serve as vegetable oil for domestic use.

Adulterations and substitutes Cardiac glycosides are present in several other genera of *Apocynaceae*, e.g. *Cerbera* and *Strophanthus*. Cerberoside (thevetin B) is for instance found in *Cerbera odollam* Gaertn.

In current medicine, cardiac glycosides are only applied in special forms of heart disease. In the Western world, the drug of choice is in general digoxin from *Digitalis lanata* Ehrh., or in acute situations strophanthins (e.g. ouabain) from *Strophanthus* spp. Although peruvoside has similar effects, it does not play a significant role in medicine.

Description Shrub or small tree up to 8 m tall; branchlets glabrous, with grey bark and white latex. Leaves arranged spirally, simple and entire, almost sessile; stipules absent; blade linear-lanceolate, 6–15 cm × 0.5–1 cm, base decurrent into the short petiole, apex long-acuminate, leathery, lateral veins obscure. Inflorescence a terminal or seemingly axillary cyme, few-flowered; bracts small, linear. Flowers bisexual, regular, 5-merous, faintly fra-



Thevetia peruviana – 1, flowering and fruiting branch; 2, frontal view of flower.
Source: PROSEA

grant; pedicel 1–2 cm long; sepals ovate, c. 1 cm long, acute, spreading; corolla tube trumpet-shaped, 35–45 cm long, corona lobes small, densely pubescent, alternating with the stamens, corolla lobes broadly oblong, c. 3 cm long, overlapping, yellow to peachy pink, rarely white; stamens inserted near apex of corolla tube, included, anthers almost sessile; ovary superior, consisting of 2 carpels fused in lower half, style long and slender, pistil head consisting of a 5-ridged basal part and a cone-shaped apex. Fruit a depressed-globose to turnip-shaped drupe 3–4 cm in diameter, yellowish green, ripening black, 2–4-seeded within the stony endocarp. Seeds obovoid, c. 2 cm × 1.5 cm, flattened. Seedling with epigeal germination.

Other botanical information *Thevetia* comprises 8 species and is related to *Cerbera*, which also has spirally arranged leaves and drupe-like fruits, but differs in its fruit consisting of 2 free parts. In 1980 it was proposed to transfer all *Thevetia* species except *Thevetia ahouai* (L.) DC. to *Cascabela* and the name *Cascabela thevetia* (L.) Lippold was published for *Thevetia peruviana*. However, this concept has not been generally accepted.

Growth and development In areas without a seasonal climate *Thevetia peruviana* flowers and fruits throughout the year, but with a peak in flowering during the rainy season. The ripe fruits remain on the plant for a long time. The plant coppices well. It shades out neighbouring plants and its litter is allelopathic.

Ecology In its native habitat, *Thevetia peruviana* is found in evergreen lowland or riparian forest, at 50–200 m altitude. It is tolerant of drought and moderately tolerant of salt.

Propagation and planting *Thevetia peruviana* can be propagated by seed or cuttings. Cultivars are propagated by semi-ripe cuttings of terminal shoots or by stem sections. Seed can be stored for up to 3 months before sowing; the germination rate is about 80%. There are about 300 seeds/kg. In-vitro propagation by direct shoot morphogenesis without any intermediate callus phase is also possible. This method may be used for mass propagation of superior plant material.

Management *Thevetia peruviana* is grown in full sun or light shade, in fertile, well-drained loamy soils with additional leaf mould, but it will grow in rather poor and dry soils as well. The plants are shallow-rooted and should be protected from strong winds. Stem tips of young plants are pinched out to encourage a bushy habit, and established plants are pruned to shape and size after flowering or shortly before the growing season to induce profuse flowering.

Diseases and pests In Ghana *Thevetia peruviana* is the preferred host of the parasitic weed *Cuscuta* sp. Under glass, scale insects, mealy bug, red spider mite and aphids may be pests.

Harvesting The plant parts used can be harvested whenever the need arises.

Yield One plant produces 400–800 fruits/year, depending on rainfall and plant age.

Handling after harvest Ripe fruits of *Thevetia peruviana* are sun-dried and split to obtain the seeds.

Genetic resources The widespread cultivation of *Thevetia peruviana* as an ornamental throughout the tropics minimizes the risk of genetic erosion.

Breeding A selection of ornamental *Thevetia peruviana* with white flowers is traded as cv. 'Alba'.

Prospects As digitalis and ouabain are preferred to peruvoside in heart medicine, it is unlikely that *Thevetia peruviana* will become an important medicinal resource. Because of the toxicity of all parts of the plant, its use in traditional medicine should be discouraged. Its potential as an ornamental is brighter.

Major references Arbonnier, 2002; Gulati, Jain & Srivastava, 2000; Ibiyemi et al., 2002; Katende, Birnie & Tengnäs, 1995; Leeuwenberg & Rudjiman, 2005; Lippold, 1980; Neuwinger, 2000; van Valkenburg & Horsten, 2001.

Other references Adjanohoun et al., 1989; Adjanohoun et al., 1979; Adjei, 2003; Bose et al., 1999; Damiano, Ferraiolo & Baudoin, 2000; Geissler et al., 2002; Heloo, 2000; Latham, 2004; Saxena & Jain, 1990; Tabuti, Lye & Dhillion, 2003; van Wyk, van Heerden & van Oudtshoorn, 2002; Ye & Yang, 1990.

Sources of illustration van Valkenburg & Horsten, 2001.

Authors G.H. Schmelzer

Based on PROSEA 12(2): Medicinal and poisonous plants 2.

TILIACORA LEONENSIS (Scott-Elliot) Diels

Protologue Engl., Pflanzenr. IV, 94: 67 (1910).

Family Menispermaceae

Synonyms *Tiliacora dinklagei* Engl. (1899),

Tiliacora dielsiana Hutch. & Dalziel (1927).

Origin and geographic distribution *Tiliacora leonensis* occurs in Guinea, Liberia, Côte d'Ivoire and Ghana.

Uses In Côte d'Ivoire an extract of the aerial parts is prescribed against dysentery, alone or in combination with leaves of *Mallotus oppositifolius* (Geiseler) Müll.Arg. Preparations of the bark, leaves or root are taken to treat cough, amenorrhoea and tachycardia. A paste of dried and ground leaves is given as an enema to pregnant women to help in the delivery of a heavy baby. The crushed leaves are applied to wounds. In Ghana a root decoction is taken against gastric fever, oedema of the legs and anaemia. The root is put in palm wine and drunk, or an extract of the aerial parts is drunk, in combination with *Paullinia pinnata* L., to improve sexual vigour.
The stem is used to make chew sticks and as tying material. The black fruits are edible.

Properties The root contains bisbenzylisoquinoline alkaloids with curare-like action, including dinklacorine, funiferine, tiliacorinine, tiliageine and nortiliacorine A. Funiferine and nortiliacorine A have weak antimalarial and antimicrobial action. The root also contains the benzylisoquinoline alkaloid oblongine. In an in-vitro test the leaves did not show antitrypanosomal or antiplasmodial activity.

Botany Dioecious, robust liana; bark greyish, striped; branches sparsely hairy. Leaves simple and entire; stipules absent; petiole 1–1.5 cm long, fine-hairy; blade lanceolate or oblanceolate to elliptical, 9–20 cm × 3–7 cm, base cuneate, apex acuminate, papery, glabrous except for the main vein, pinnately veined with 3–4 pairs of lateral veins, very prominent below. Inflorescence an axillary, many-flowered panicle with flowers in clusters, several inflorescences together; peduncle 4–12 cm long, shorter in female plants, densely hairy. Flowers small, unisexual; sepals 9(–12), 6(–9) outer ones bract-like, triangular to ovate, 1–2 mm long, 3 inner ones obovate to oblong, 2.5–6 mm long; petals 6, obovate-oblong, slightly fleshy; male flowers with 6–9 stamens 2–2.5 mm long, filaments fused to the middle; female flowers with superior ovary, composed of 25–30 carpels. Fruit composed of almost sessile, compressed-ovoid drupelets 1.5–2 cm × 1–1.5 cm, stone compressed oblong, leathery but brittle, 1-seeded.
Tiliacora comprises about 20 species of which 3 occur in tropical Asia and 17 in Africa; it is in need of a taxonomic revision.

Ecology *Tiliacora leonensis* occurs in rainforest and fringing forest.

Genetic resources and breeding *Tiliacora leonensis* is fairly widespread and relatively common. It is not in danger of genetic erosion.

Prospects *Tiliacora leonensis* will probably remain of local importance, mainly as a medicinal plant.

Major references Atindehou et al., 2004; Burkill, 1997; Neuwinger, 2000; Troupin, 1962.

Other references Adjanohoun & Aké Assi, 1979; Dwuma-Badu et al., 1983; Dwuma-Badu et al., 1976a; Hawthorne & Jongkind, 2006; Oliver-Bever, 1983b; Tackie et al., 1975; Tackie et al., 1976.

Authors L.P.A. Oyen

TINOSPORA BAKIS (A.Rich.) Miers

Protologue Hook., Niger Fl.: 215 (1849).

Family Menispermaceae

Origin and geographic distribution *Tinospora bakis* occurs from Mauritania and Senegal through the Sahel east to Somalia and south to Kenya, Uganda and Tanzania. It is also reported from Cameroon.

Uses The woody part of the root has a high reputation in West Africa as a diuretic and febrifuge. The root is used against various liver and gall bladder problems, such as jaundice, haematuria, bilious fever and yellow fever. A decoction of the root is taken against malaria as it is better tolerated than quinine. It is also taken against schistosomiasis, as an emmenagogue or cholagogue and to stop gonorrhoeal discharge. Externally the decoction is applied against various skin problems. The leaves are similarly used as cholagogue, diuretic and general tonic.

Production and international trade The roots of *Tinospora bakis* are commonly traded in local markets, especially in West Africa.

Properties The root contains alkaloids, including the protoberberine type alkaloid palmatine, and 2–4% columbin, a diterpenoid furanolactone. The aqueous extract of the root containing the alkaloidal fraction showed moderate activity against a chloroquine-resistant strain of *Plasmodium falciparum* in vitro. A syrup made from an aqueous root extract induced a significant increase of biliary secretion in rats. Columbin, in small doses, was found to increase the secretion of the bile and the glands of stomach and intestines; at higher

doses it produces greasy degeneration of the liver. Palmatine shows a stronger antipyretic effect than a total alkaloid extract in rabbits. It paralyses the respiratory centre more than morphine. It is supposed that the antipyretic effect is due, like that of berberine, to paralysis of the peripheral vessels and the resulting heat dispersion, and not to its toxicity towards microorganisms. A lyophilized aqueous root extract showed hepatoprotective activity of rat hepatocytes in vitro after treatment with CCl_4. In mice, the aqueous extract of the root powder administered intraperitoneally or subcutaneously showed LD_{50} values of 360 mg/kg and 425 mg/kg, respectively. This extract showed a similar inhibition of the contractions of isolated rat duodenum as atropine.

The root can produce toxic effects, including vomiting and depression of the respiratory centre. Toxicity trials on the total alkaloids have shown that 5 mg/kg given orally is not toxic for guinea pigs, whereas 100 mg/kg causes death within 20 minutes, without convulsions. In experimental hyperthermia in guinea pigs, a root extract lowered the temperature more than did quinine sulphate.

Botany Dioecious, deciduous liana up to 10 m long; bark flaking off in orange scales; branches glabrous, with numerous warty lenticels. Leaves alternate, simple and entire; petiole 0.5–4(–8) cm long, sparsely hairy or glabrous; blade broadly ovate-triangular, 3–5 cm × 3–5 cm, base cordate, apex acuminate, pale green, palmately veined with 5–7 main veins, short-hairy or glabrous below. Inflorescence an axillary, elongate false raceme up to 12 cm long, male inflorescence with 3–7-flowers per bract, female one with 1 flower per bract. Flowers unisexual, small, yellowish green; pedicel 2–3 mm long; sepals 6 in 2 whorls, translucent or membranous, outer sepals ovate-triangular, 1–1.5 mm × c. 0.5 mm, inner sepals 2.5–4 mm × 2–3 mm; petals 6, 2–3 mm × 1–2 mm, fleshy; male flowers with 6 free stamens 2.5–3 mm long; female flowers with 6 staminodes, ovary superior, consisting of 3 free carpels 1–2 mm long. Fruit consisting of up to 3 drupes, 6–9 mm × 4–5 mm, each 1-seeded.

Tinospora bakis flowers towards the start of the rainy season. In northern Senegal the natural regeneration is rather poor.

Tinospora comprises about 30 species, of which about 20 occur in Asia, 7 in continental Africa and 2 in Madagascar.

Ecology *Tinospora bakis* occurs mainly in dry areas in bushland and semi-desert scrub vegetation, in thickets in sandy-clayey depressions or on sand dunes, from sea-level up to 1200 m altitude. On Mount Cameroon it occurs in forest gaps, in more humid conditions.

Genetic resources and breeding *Tinospora bakis* is widespread and locally common. There are no signs that it is in danger of genetic erosion.

Prospects In view of its many medicinal uses and pharmacological results so far, further chemical and pharmacological screening of *Tinospora bakis* seems warranted.

Major references Burkill, 1997; Keay & Troupin, 1954; Somé et al., 1998; Thioune et al., 2002; Troupin, 1962.

Other references Akpo & Grouzis, 1996; Arbonnier, 2000; Diallo Sall et al., 1999; Diallo Sall et al., 1997; Fortin, Lô & Maynart, 1990; Neuwinger, 2000; Oliver-Bever, 1986; Ouattara et al., 2006; Somé et al., 1996; Zafinindra et al., 2003.

Authors L.P.A. Oyen

TINOSPORA CAFFRA (Miers) Troupin

Protologue Bull. Jard. Bot. Etat 25: 137 (1955).

Family Menispermaceae

Vernacular names Orange grape creeper (En).

Origin and geographic distribution *Tinospora caffra* occurs from the Central African Republic east to Kenya and south to the Caprivi Strip (Namibia), Botswana, Mozambique and eastern South Africa.

Uses Juice from the pounded leaves is applied to wounds as an antiseptic. In South Africa the steam of the leaves in boiling water is inhaled to sooth body pain. The leaves mixed with leaves of other plants and sprinkled with water are spread through the bedroom against sleeping problems. In South Africa the plant is used to prepare fish poison.

Botany Dioecious, briefly deciduous, climbing herb; young stems glabrous, older stems warty. Leaves alternate, simple and entire, V-shaped; stipules absent; petiole 2.5–15 cm long; blade broadly ovate to nearly orbicular, 2.5–14 cm × 1.5–12.5 cm, base rounded to cordate, apex rounded and abruptly mucronate or slightly acuminate, glabrous, yellowish green, leathery, palmately veined with 5–7 main veins. Inflorescence an axillary, elongate false raceme, male inflorescence 7–30 cm long, with 1–4 flowers per bract, sometimes panicle-like,

female inflorescence up to 4(–15) cm long with 1 flower per bract; bracts linear, up to 1.5 cm long. Flowers unisexual, small; male flowers with pedicel up to 7 mm long, sepals 6 in 2 whorls, outer ones triangular to ovate, 0.5–1.5 mm long, inner ones oblong to oblanceolate, 1.5–4 mm × 1–1.5 mm, glabrous, petals 6 in 2 whorls, outer ones 1.5–2.5 mm × 0.5–1 mm, inner ones shorter, stamens 3, filaments 1.5–3 mm long, completely fused; female flowers with pedicel up to 2.5 mm long, sepals 6 in 2 whorls, outer ones triangular, c. 1 mm long, with 2 small appendages at base, inner ones elliptical to ovate, 2–3 mm × 2–2.5 mm, glabrous, petals 6 in 2 whorls, linear, 1.5–2 mm × 0.5–1 mm, staminodes 6, ovary superior consisting of 3 free carpels 2–3 mm long, stigma sessile. Fruit consisting of 1–3 ovoid drupes c. 10 mm × 6–7 mm, orange when ripe, glabrous, stone ellipsoid, with prominent knobs at both ends, 1-seeded.

In South Africa *Tinospera caffra* flowers from December–February.

Tinospora comprises about 30 species, of which about 20 occur in Asia, 7 in continental Africa and 2 in Madagascar.

Tinospora fragosa (Verdoorn) Verdoorn & Troupin (Moses' staff, marvel creeper) is a semisucculent liana, which occurs in northern Namibia, northern Botswana, Zimbabwe and the dry parts of northern South Africa. An infusion of the leaves and twigs is taken against anthrax, whereas the whole plant is fed to cattle for this purpose. Twigs are chewed against cough and sore throat. Stems and leaves are used in a bath against rheumatism and body pain. *Tinospora fragosa* is an attractive ornamental with bright orange-red fruits just when the bright green leaves appear. *Tinospora oblongifolia* (Engl.) Troupin is a liana occurring in lowland rainforest and coastal evergreen bushland in Kenya and Tanzania, including Zanzibar. A decoction of the roots or an infusion of the roots in cold water is drunk as a purgative. *Tinospora tenera* Miers is a semisucculent liana, which occurs in Tanzania, Mozambique, Swaziland and north-eastern South Africa. A leaf extract is drunk against pain in the joints and as a sexual tonic for men. A decoction of the leaves and roots is drunk or used as enema against kidney stones, whereas the steam is inhaled to treat influenza. A decoction of the leaves is used as a wash against venereal sores, steam from the decoction is applied to treat skin problems. *Hyalosepalum uviforme* (Baill.) Troupin (synonym: *Chasmanthera uviformis* Baill.) occurs in northern Madagascar and closely resembles *Tinospora* spp. A decoction of its stem bark is taken to treat malaria.

Ecology *Tinospora caffra* occurs in dense humid forest, deciduous bushland, in drier areas often on rock outcrops, up to 2000 m altitude.

Genetic resources and breeding *Tinospora caffra* has a wide distribution and there are no signs that there is immediate danger of genetic erosion.

Prospects In view of its medicinal uses and many medicinal uses of related species, chemical and pharmacological screening of *Tinospora caffra* and other African *Tinospora* spp. seems warranted.

Major references de Wet, 2005; Kokwaro, 1993; Neuwinger, 2000; Troupin, 1956; Troupin, 1960.

Other references de Wet & van Wyk, 2008; Troupin, 1962.

Authors L.P.A. Oyen

TOURNEFORTIA ACUMINATA DC.

Protologue Prodr. 9: 520 (1845).

Family Boraginaceae

Vernacular names Bois de Laurent-Martin (Fr).

Origin and geographic distribution *Tournefortia acuminata* is endemic to Réunion.

Uses The leaves of *Tournefortia acuminata* are considered to have diuretic properties and are traditionally used to treat kidney stones in Réunion.

Properties The presence of alkaloids has been confirmed by general tests on *Tournefortia acuminata* but otherwise nothing is known of its chemistry. Laboratory tests with leaf extracts of *Tournefortia acuminata* did not confirm the diuretic properties claimed in folk medicine. Leaf extracts of *Tournefortia argentea* L.f. have been proven efficient in counteracting poisoning by ciguatoxins (produced by the dinoflagellate *Gambierdiscus toxicus* and transferred by fish): they counteract the neurocellular effects and have beneficial action on the gastro-intestinal disturbances. Pyrrolizidine alkaloids have been isolated from twigs of *Tournefortia argentea*. Several phenolic compounds, including salicylic acid and tournefolin A–C, have been isolated from the stems of *Tournefortia sarmentosa* Lam., a species from tropical Asia that is widely used medicinally.

Botany Shrub or small tree; stem with min-

ute, closely appressed brown or golden hairs or glabrous. Leaves alternate, simple and entire; blade obovate to elliptical, 12–17 cm × 3.5–7 cm, acute at base and at apex, with 10–15 pairs of veins. Inflorescence a terminal, dichotomously branched, scorpioid cyme. Flowers bisexual, regular, 5-merous, sessile; calyx 1.5–2 mm long, sparsely hairy; corolla white, tube 3.5–7 mm long, lobes c. 4 mm wide. Fruit a small, white, globose drupe c. 6 mm in diameter, splitting into two 2-seeded parts.

Tournefortia and related genera are in need of revision. *Tournefortia* comprises about 100 species, most of them native in America and with about 15 species in the Old World, 2 in mainland Africa and 4 endemic to the Indian Ocean islands.

The widespread *Tournefortia argentea* L.f. (synonym: *Argusia argentea* (L.f.) Heine), 'octopus tree', 'veloutier blanc' or 'bois tabac', occurs on coastal beaches from Kenya to Mozambique, the Indian Ocean islands and through Asia to Australia. The leaves are used as a poison antidote in Vietnam and New Caledonia; they are eaten raw as a vegetable and smoked like tobacco.

Ecology *Tournefortia acuminata* is found throughout Réunion, but is nowhere abundant. It tends to flower in the cyclone season (November–April).

Genetic resources and breeding In Réunion *Tournefortia acuminata* is considered rare and vulnerable, and in need of protection. The other African *Tournefortia* species, with the exception of *Tournefortia argentea*, are uncommon and vulnerable as well.

Prospects Almost nothing is known about the phytochemistry and pharmacological properties of the African *Tournefortia* species. Research into the chemistry and pharmacology is long overdue. However, they are likely to remain of limited importance. Survival of the vulnerable species should be assured by protection of their habitats.

Major references Adsersen & Adsersen, 1997; Gurib-Fakim & Brendler, 2004.

Other references Aguilar, 2003b; Diane, Förther & Hilger, 2002; Friedmann, 1994; Johnston, 1935; Lin et al., 1999; Miller, 2001; Riedl, 1997.

Authors C.H. Bosch

TRAGIA BREVIPES Pax

Protologue Bot. Jahrb. Syst. 19: 103 (1894).

Family Euphorbiaceae

Vernacular names Climbing nettle (En). Chavi, weni (Sw).

Origin and geographic distribution *Tragia brevipes* occurs from Ethiopia south to Malawi, Zambia and Zimbabwe. It has erroneously been reported for Cameroon and Somalia.

Uses A root decoction is taken in Kenya as a purgative, especially for babies and small children. The roots are given to women with labour pain. Pain caused by rheumatism is treated by rubbing the leaves on the painful joints. A leaf extract is drunk to cure gonorrhoea, to kill internal parasites including tapeworm and to treat stomach-ache, diarrhoea and gastroenteritis. A decoction of roots and leaves is drunk to promote conception. Leaves, roots and twigs are used to treat polio. The ash of burnt leaves is inhaled to cure elephantiasis.

Properties A methanol extract of the fruits has antibacterial activity against *Staphylococcus aureus*; extracts of leaves, stems and roots did not show activity against a panel of bacteria and fungi. An ethanolic leaf extract showed significant activity against *Entamoeba histolytica*.

Botany Monoecious, straggling, twining, scandent or rarely erect shrub up to 1(–4.5) m tall, with stinging hairs. Leaves alternate, simple; stipules linear-lanceolate, up to 7 mm long; petiole 1–6(–10) cm long; blade ovate or ovate-lanceolate, 4–10 cm × 3–7 cm, base cordate, apex acuminate, margins toothed, hairy beneath with stinging hairs along midrib and main veins. Inflorescence a leaf-opposed, rarely axillary or lateral raceme, lax-flowered, usually with (1–)2(–4) female flowers at base and many male flowers higher up; peduncle up to 4 cm long. Flowers unisexual; petals and disk absent; pedicel 0.5–1.5 mm long, extending to 5 mm in fruit; male flowers with calyx closed in bud, splitting in 3(–5) ovate to round lobes, c. 1.5 mm long, greenish white, stamens (1–)3(–5); female flowers with 6 calyx lobes c. 2.5 mm long, extending up to 1.5 cm in fruit, ovary superior, 3-lobed, 3-celled, styles 3, c. 3.5 mm long, broadened at apex. Fruit a 3-lobed capsule c. 9 mm in diameter, short-hairy, dull pale brown when ripe, 3-seeded. Seeds globose, c. 4 mm in diameter, pale grey, mottled brown.

Tragia comprises about 170 species and occurs throughout the tropics, with the majority of species in tropical Africa and tropical America.

In continental tropical Africa about 55 species occur, and in Madagascar about 10.

Tragia benthamii Baker occurs in West, Central and southern Africa and is difficult to distinguish from *Tragia brevipes*. In West Africa the medicinal uses of *Tragia benthamii* are similar to those of *Tragia brevipes* in eastern Africa, and root extracts are taken as an abortifacient, to ease child delivery and as a cure for gonorrhoea. *Tragia preussii* Pax occurs in Central Africa. In the Central African Republic pulped leaves are rubbed on the body to treat fever and rheumatic pain; abscesses are dressed with boiled leaves. Root sap and root powder of the West African *Tragia senegalensis* Müll.Arg. are taken to treat insanity in Togo. Leaf sap of the West African *Tragia spathulata* Benth. is applied to cure headache in Ghana. *Tragia tenuifolia* Benth. occurs from West Africa east to Sudan and Rwanda and also in Zimbabwe. In Sierra Leone a poultice of the leaves is rubbed on the abdomen of a pregnant woman to induce foetal movement and a leaf infusion is drunk against threatening abortion. Several other *Tragia* species from East and southern Africa also have documented medicinal uses. In Tanzania the ash of burnt plants of *Tragia furialis* Bojer (synonym: *Tragia schefferi* Baker) is rubbed into the skin to cure headache. In Kenya a plant decoction is drunk or root powder is applied to snakebites. A leaf infusion is used as a wash to relieve skin irritation caused by stinging hairs of plants. In Ethiopia the leaves of *Tragia hildebrandtii* Müll.Arg. are used to treat uterine complaints. The bark fibre can be made into textile. In Zimbabwe the pulverized roots of *Tragia okanyua* Pax are rubbed into the skin to cure headache. In Somalia the roots of *Tragia plukenetii* Radcl.-Sm. are used in a cure for male impotence. In Kenya the leaves are eaten as a vegetable and the plants are browsed by goats. In Ethiopia a hot water extract of the roots of *Tragia pungens* (Forsk.) Müll.Arg. is drunk to prevent pregnancy.

Ecology *Tragia brevipes* occurs in riverine vegetation, along lake shores, in thickets and in high rainfall *Brachystegia* woodland, from sea-level up to 2150 m altitude.

Genetic resources and breeding *Tragia brevipes* is widespread and fairly common, and is not threatened by genetic erosion.

Prospects *Tragia brevipes* will probably remain only locally important as a medicinal plant, unless additional chemical and pharmacological research reveal interesting properties.

Major references Boily & Van Puyvelde, 1986; Burkill, 1994; Neuwinger, 2000; Radcliffe-Smith, 1987.

Other references Heine & Heine, 1988a; Lebbie & Guries, 1995; Murengezi & Sano, 1993; Vlietinck et al., 1995.

Authors C.H. Bosch

TRICHODESMA AFRICANUM (L.) Lehm.

Protologue Pl. Asperif. nucif.: 195 (1818).

Family Boraginaceae

Chromosome number $n = 14$

Synonyms *Trichodesma gracile* Batt. & Trab. (1911).

Origin and geographic distribution *Trichodesma africanum* occurs from Cape Verde, Mauritania and Senegal east to Ethiopia and extends into Asia up to India and Afghanistan. It is also found in Namibia and South Africa.

Uses Leaves of *Trichodesma africanum* are used as a diuretic in Nigeria and Sudan. In Senegal and Nigeria the leaves are also used to treat diarrhoea, and as an emollient, antipyretic and anti-inflammatory. An infusion of the roots is used to treat hepatitis. The plant is an excellent fodder for camels, but other livestock seem to avoid it.

Properties The pyrrolizidine alkaloid trichodesmine and 2 saponins have been isolated from *Trichodesma africanum*, as well as β-amyrin, β-methyl oleanate, β-sitosterol and stigmasterol.

Botany Annual or short-lived perennial herb up to 80 cm tall, much-branched mainly from the base; stem with rigid tubercle-based prickles. Leaves simple and entire, lower leaves opposite and petiolate, upper leaves alternate and sessile; stipules absent; blade ovate to ovate-lanceolate, rarely oblong, up to 10(–12) cm × 4(–5) cm, base truncate, narrowing towards apex. Inflorescence a lax terminal or axillary, few-flowered cyme. Flowers bisexual, regular, 5-merous; calyx lobes ovate-lanceolate, 6–8 mm long, enlarging in fruit; corolla blue, tube up to 1.5 mm long, lobes 3.5–4.5 mm long; stamens with 1 mm long filaments, anthers c. 7 mm long; ovary superior, 4-lobed, up to 2 mm in diameter, glabrous. Fruit splitting into 4 ovoid, smooth, brown nutlets 4–5 mm in diameter.

Trichodesma comprises about 45 species and is confined to the Old World.

Ecology *Trichodesma africanum* occurs in dry grassland, fallow land, stony wadis and

sandy desert plains.

Genetic resources and breeding *Trichodesma africanum* is widespread and is not threatened with genetic erosion.

Prospects Although knowledge on several *Trichodesma* species is considerable, *Trichodesma africanum* deserves further study of its pharmacological properties.

Major references Aguilar, 2003c; Berhaut, 1974; Boulos, 2000a; Burkill, 1985; Martins, 1995.

Other references Friedrich-Holzhammer, 1967; Neuwinger, 2000; Omar et al., 1983; Verdcourt, 1991.

Authors C.H. Bosch

TRICHODESMA AMBACENSE Welw.

Protologue Apont.: 589 (1859).

Family Boraginaceae

Synonyms *Trichodesma hockii* De Wild. (1913).

Origin and geographic distribution *Trichodesma ambacense* is widespread in East and southern Africa. In West Africa it is reported only from Nigeria, in Central Africa only from Cameroon and south-eastern DR Congo.

Uses In Zimbabwe the woody rhizome of *Trichodesma ambacense* has multiple medicinal uses. It is applied to incisions made in the skin to treat backache, headache, painful swellings and syphilitic swelling of glands. For swellings caused by oedema, a decoction is applied as a hot compress. For depressed fontanelle, the crushed rhizome is applied and an infusion given to drink. An infusion is drunk to dilate the birth canal. Powdered rhizome is taken orally to cure bilharzia. In DR Congo the leaf ash is applied to corns, and the macerated leaves are used to dye white hair black.

Properties No information is available on the phytochemical or pharmacological properties of *Trichodesma ambacense*. In other *Trichodesma* spp. with similar medicinal uses pyrrolizidine alkaloids appear to be the pharmacologically or toxicologically active ingredients.

Botany Perennial, erect herb up to 50(–70) cm tall, usually unbranched. Leaves simple and entire, sessile, lower leaves opposite, upper leaves subopposite or alternate; stipules absent; blade ovate to elliptical, oblanceolate or linear-oblong, 4–7 cm × 0.5–3 cm, exceptionally on sterile shoots up to 16 cm × 5 cm, base cuneate to rounded, apex acute or obtuse. Inflorescence terminal, up to 30 cm long, with up to 9(–12) branches each with up to 8(–12) flowers. Flowers bisexual, regular, 5-merous; calyx lobes ovate, up to 18 mm × 9 mm, enlarging in fruit; corolla 17–25 mm long, tube white or cream, lobes spreading or reflexed, triangular, blue, rarely white. Fruit a single discoid nutlet, c. 13 mm × 8 mm.

In *Trichodesma ambacense* 2 subspecies are recognized: subsp. *ambacense* has only been found in Angola, whereas subsp. *hockii* (De Wild.) Brummitt is found in the rest of the range of the species. *Trichodesma physaloides* (Fenzl) A.DC. occurs largely in the same area as *Trichodesma ambacense*, but is absent from Nigeria and extends into South Africa. The former has glabrous stems and pedicels, whereas in the latter these are hairy. Intermediates that are thought to be hybrids do occur. The woody rootstock of *Trichodesma physaloides* is used in a paste to treat wounds in Zimbabwe, and the powdered rootstock mixed with beer or porridge as an aphrodisiac in Malawi. In Tanzania an infusion made of the peduncles is given to calves that suffer from diarrhoea. In DR Congo the leaves are rubbed on the skin to treat lumbago. Apart from the mention that *Trichodesma physaloides* contains a toxic alkaloid, nothing appears to have been published on its properties.

Ecology *Trichodesma ambacense* is found in grassland and woodland that is subject to annual burning. Its altitudinal range is 600–1500 m.

Genetic resources and breeding *Trichodesma ambacense* is widespread and not threatened with genetic erosion.

Prospects In view of its medicinal uses and the apparent lack of knowledge on its pharmacological properties, *Trichodesma ambacense* and related species deserve more attention in research.

Major references Brummitt, 1982; Gelfand et al., 1985; Taton, 1971.

Other references Kokwaro, 1993; Verdcourt, 1991.

Authors C.H. Bosch

TRICHODESMA ZEYLANICUM (Burm.f.) R.Br.

Protologue Prodr.: 496 (1810).

Family Boraginaceae

Chromosome number $2n = 24$

Vernacular names Camel bush, cattle bush, northern bluebell (En). Herbe cipaye,

bourrache sauvage, herbe tourterelle (Fr). Msasa mlanda, mwagewage (Sw).

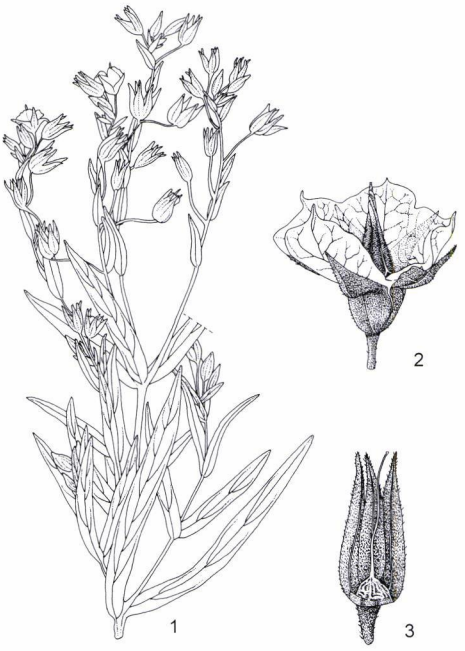
Origin and geographic distribution *Trichodesma zeylanicum* is widespread in the tropics and subtropics of the Old World and in Australia. It occurs throughout tropical Africa, but is absent from West Africa.

Uses In Tanzania green leaves and roots of *Trichodesma zeylanicum* are chewed and applied as a poultice to wounds, boils and snakebites. Roots are chewed or pounded and soaked in water, and the infusion is used as a remedy for tuberculosis, stomach-ache, poisoning and rheumatism. In Malawi both leaves and roots are used for treating wounds, the roots also for treating diarrhoea. In the Mascarene Islands a decoction of the plant is used against fever, dysentery and as a diuretic. The powdered root is analgesic when applied to wounds. In Zimbabwe and Comoros powder of dried leaves is applied to infected wounds. In Zimbabwe the leaves are used to prevent stillbirth. The ash of burnt plants enters in prescriptions for cough and scabies. In South Africa the plant is used as an analgesic and for wound healing. In India and Sri Lanka it is used as a snakebite remedy. The seed oil is used for its emollient properties in Tanzania, India and Pakistan.
The young leaves and shoots are cooked and eaten as a vegetable in Tanzania, Malawi and Madagascar. Camels appear to be partial to *Trichodesma zeylanicum* but other livestock seem to avoid it.

Production and international trade The seed oil/flower essence of *Trichodesma zeylanicum* is traded on the international market under the name of 'wild borage oil'. The main producer is Australia and the main market is western Europe. Quantities and value of the trade are unknown.

Properties Pyrrolizidine alkaloids, with supinine as the principal component, have been isolated from *Trichodesma zeylanicum* seeds. These compounds also occur in other *Boraginaceae*, e.g. *Borago officinalis* L., *Cynoglossum* spp. and other *Trichodesma* spp., and this may explain similar uses. Pyrrolizidine alkaloids can cause fatal liver conditions and several *Trichodesma* spp. have been implicated in poisoning of livestock. Ricinoleic acid and cyclopropene acid were found in the seed oil.

Botany Short-lived perennial, less often annual herb, up to 1.5(–2) m tall, much-branched. Leaves simple, lower leaves opposite, upper leaves alternate; stipules absent; petiole up to 1 cm long; blade oblong to oblong-lanceolate, up to 16 cm × 5 cm, base rounded to slightly cordate; narrowing towards apex. Inflorescence a terminal, lax, many-flowered cyme; axes densely clothed with spreading hairs. Flowers bisexual, regular, 5(–6)-merous; calyx lobes ovate-lanceolate, up to 10 mm × 3.5 mm, truncate at base, enlarged in fruit; corolla blue or rarely white with blue margins, with dark reddish purple spot on base of each lobe, tube 4–5 mm long, lobes up to 4.5 mm × 6 mm; stamens sessile; ovary superior, up to 2 mm in diameter, 4-lobed, glabrous. Fruit splitting into 4 ovoid, smooth, brown nutlets c. 5 mm × 2 mm.



Trichodesma zeylanicum – 1, part of flowering plant; 2, flower; 3, fruit in calyx.
Source: PROSEA

Trichodesma comprises about 45 species and is confined to the Old World. *Trichodesma zeylanicum* and *Trichodesma indicum* (L.) J.E.Smith are closely related and both have fruits consisting of 4 smooth nutlets. They can be distinguished by the base of the calyx lobes: truncate in the former, hastate, sagittate or cordate in the latter. *Trichodesma indicum* is considered indigenous in Mauritius, Réunion and tropical Asia. It is found along the coast of Kenya and Tanzania where it probably has been introduced and occurs on sand just above

the high-tide mark, in grassland, waste localities and coconut fields. In the Philippines the flowers of *Trichodesma indicum* are used as a sudorific and pectoral, as a substitute for *Borago officinalis*. *Trichodesma angustifolia* Harv. differs from *Trichodesma zeylanicum* by the appressed hairy inflorescence axes and a larger corolla. It is found in Namibia, Botswana, Mozambique and South Africa. In Namibia the pulverized root is applied to wounds.

Ecology *Trichodesma zeylanicum* is found in disturbed ground and waste places, sometimes in woodland. It is often abundant and is widely regarded as a serious weed of cultivation. In Africa it is found up to 1700 m altitude.

Genetic resources and breeding As *Trichodesma zeylanicum* is widely distributed and abundant wherever it occurs, it is not threatened.

Prospects Further research is needed to evaluate the traditional medicinal uses of *Trichodesma zeylanicum* and related species. As pyrrolizidine alkaloids have serious long-term toxic effects, these should be included in the evaluation as well.

Major references Aguilar, 2003c; Gurib-Fakim, Guého & Bissoondoyal, 1995; Martins & Brummitt, 1990; Ruffo, Birnie & Tengnäs, 2002; Verdcourt, 1991.

Other references Adjanohoun et al. (Editors), 1982; Burkill, 1985; Decary, 1946; Gelfand et al., 1985; Haerdi, 1964; Hosamani, 1994b; Kokwaro, 1993; Martins, 1993; von Koenen, 2001; Williamson, 1955.

Sources of illustration Aguilar, 2003c.

Authors C.H. Bosch

Based on PROSEA 12(3): Medicinal and poisonous plants 3.

TRICLISIA DICTYOPHYLLA Diels

Protologue Engl., Pflanzenr. IV, 94: 70 (1910).

Family Menispermaceae

Synonyms *Triclisia gilletii* (De Wild.) Staner (1933).

Origin and geographic distribution *Triclisia dictyophylla* occurs from Liberia east to the Central African Republic and south to Angola and Tanzania.

Uses In Côte d'Ivoire *Triclisia dictyophylla* root pulp or root sap is rubbed into scarifications to treat joint pain, epileptic attacks, oedema, venereal diseases and anaemia. Leaf juice eases cough and a bark or root decoction



Triclisia dictyophylla – wild

is used as a wash to calm palpitations. Powdered stem bark is used in the treatment of leprosy. In central DR Congo a decoction of the twig bark is widely taken to treat fever and malaria, and also to treat diarrhoea, stomach problems and purulent catarrh. In south-eastern DR Congo leaves are suspended from the ceiling to help children with breathing problems. In Congo a root bark decoction is taken against stomach problems and dysentery, convulsive coughing and feverish stiffness of the limbs; the root juice is taken to treat rheumatism and inflammation of the joints; the juice of young leaves is diluted and administered as a painkiller to patients with mental health problems during attacks. In south-western parts of the Central African Republic, the macerated root is taken as an abortifacient and emmenagogue. In Tanzania a root decoction is drunk as a vermifuge, whereas roots are taken raw to treat venereal diseases. In Ulanga district in south-eastern Tanzania, grated roots are taken to treat snakebites and expel roundworm.

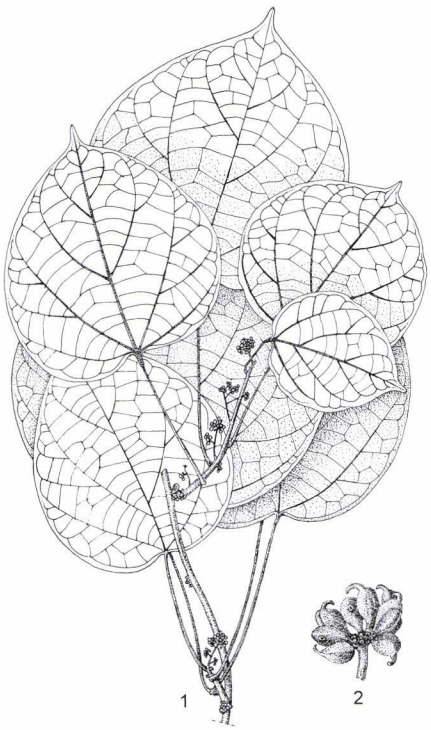
In several parts of Central Africa the root, especially the root bark, is an ingredient of arrow poison.

Properties The characteristic bioactive compounds in *Triclisia dictyophylla* are bis-benzyl-isoquinoline alkaloids and related dioxin alkaloids. From the roots and stems the bisbenzyl-isoquinolines phaeanthine, N,N'-dimethylphaeanthine, tetrandrine and the bisbenzyl-isoquinoline dibenzodioxins cocsuline (trigilletine) and trigilletimine were isolated. The stems also yielded the oxo-isoquinoline O-methylmoschatoline and the indeno-

isoquinoline triclisine. Analyses of the leaves found the bisbenzyl-isoquinolines stebisimine and obamegine (stepholine), the bisbenzyl-isoquinoline dioxins gilletine and isogilletine-N-oxide, and the morphinan alkaloid tridictyophylline.

Although the pharmacological properties of several *Triclisia* species containing similar alkaloids have been studied, very few studies have been done on the pharmacological properties of *Triclisia dictyophylla*. A methanol extract of the stem bark has shown strong activity against *Plasmodium falciparum* in vitro and a less strong, but significant effect against *Trypanosoma brucei*. N,N'-dimethylphaeanthine is the principal toxic compound which showed a curare-like paralysing action on muscle tissue in mice and rats. Phaeanthine and cocsuline show high inhibitory activities against *Leishmania* spp. and *Trypanosoma cruzei*. Gilletine showed antimalarial activity at IC_{50} = 110 µg/ml against *Plasmodium* sp. in vitro.

Description Dioecious liana up to 30 m long, or scrambling shrub; stems up to 10 cm in diameter; bark greyish, longitudinally striped; young branches sparsely short-hairy, becoming glabrous. Leaves alternate, simple and entire; petiole 10–20 cm long, stout, swollen at the base and apex, slightly hairy when young; blade broadly elliptical to almost circular, up to 32 cm × 27 cm, base rounded, cordate or almost cuneate, apex acuminate, leathery, glabrous, pinnately veined, but with 1–2 pairs of basal lateral veins, lateral veins in 3–5 pairs, mostly looping, secondary and tertiary venation very prominent below. Inflorescence an axillary panicle of dense to lax cymes, 1–3 cm long; peduncle densely hairy. Flowers unisexual; pedicel c. 2 mm long, hairy; bracts c. 0.5 mm long; sepals 9–15, densely hairy, pale brown to dull orange, 3–9 outer ones ovate, 1–1.5 mm long, 3 middle ones ovate, c. 1 mm long, 3 interior ones elliptical-obovate, 4–4.5 mm × 2–2.5 mm; male flowers with 3–6 petals c. 0.5 mm long, stamens 3–6, free, c. 5 mm long, filaments slender; female flowers without petals, ovary superior, composed of 50–60 densely hairy carpels, styles 1–1.5 mm long, glabrous. Fruit composed of many obovoid, flattened drupes c. 2.5 cm × 1.5 cm, bright orange, base rounded, apex long-acuminate, recurved, slightly rough; stone very hard, 1-seeded. Seed 1–1.5 cm × 1 cm.



Triclisia dictyophylla – 1, male flowering branch; 2, fruit.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Triclisia* comprises about 20 species, approximately 12 in mainland tropical Africa, 7 in Madagascar and 1 in Mayotte.

Triclisia sacleuxii (Pierre) Diels occurs from Congo east to Kenya and south to Angola and Mozambique; the root is chewed and the sap swallowed to treat kidney problems, sore throat, schistosomiasis, intestinal worms and venereal diseases, while root scrapings are rubbed into topical scarifications to treat snakebites. The roots contain the bisbenzyl-isoquinoline alkaloids phaeanthine, 1,2-dehydroapateline, N-methylapateline, O-methylcocsoline and gasabiimine; the stem contains a mixture of N-(4-hydroxyphenethyl) ferulamides. A decoction of stem bark or root bark of *Triclisia macrocarpa* (Baill.) Diels from Madagascar is drunk against malaria.

Ecology *Triclisia dictyophylla* occurs in dense, humid lowland to medium-altitude forest.

Genetic resources As *Triclisia dictyophylla* occurs in a very wide area, it does not seem to be in danger of genetic erosion.

Prospects Because *Triclisia dictyophylla* is widely used in traditional medicine and be-

cause of its significant antiplasmodial activity, further pharmacological research is warranted. The genus *Triclisia* is in need of a revision.

Major references Burkill, 1997; Mesia et al., 2008; Neuwinger, 1998; Troupin, 1956; Troupin, 1962.

Other references de Wet, 2005; Disengomoka, Delaveau & Sengele, 1983; Kokwaro, 1993; Kronlund, Kristiansson & Sandberg, 1970; Murebwayire et al., 2006; Neuwinger, 2000; Owusu et al., 1981; Spiff et al., 1981.

Sources of illustration Troupin, 1951.

Authors B.J. Pollard

TRICLISIA PATENS Oliv.

Protologue Fl. trop. Afr. 1: 49 (1868).

Family Menispermaceae

Origin and geographic distribution *Triclisia patens* occurs from Senegal east to Ghana and Benin.

Uses In Côte d'Ivoire root pulp is rubbed in or root sap is rubbed into scarifications to treat rheumatism, arthritis, anaemia and sleeping sickness. A decoction of the root is drunk to treat fever and malaria. A root decoction is also taken as an emmenagogue and abortifacient. A leaf or root decoction is used as a wash against palpitations, as it has a sedative effect on the heart. Leaf sap has a soothing effect on cough. A decoction of the stem is drunk against stomach-ache and a decoction of the leaves and twigs is drunk, or leaf pulp is rubbed in, to treat oedema of the legs. In Sierra Leone a leaf decoction is used as a nasal or ocular instillation and as a purgative or bathe against epilepsy. Stem bark is powdered and applied to syphilitic sores and leprosy; the bark pulp is used as a purgative. Leaf or root juice mixed with salt in palm wine is drunk against cough and bronchial disorders.

In Sierra Leone the stems are made into slings used for climbing oil palms, while sections of the stem or parched, scraped roots are added to palm wine to make it more intoxicating.

Production and international trade *Triclisia patens* is commonly sold on local markets.

Properties From a methanol extract of dried leaves of *Triclisia patens* the bisbenzylisoquinoline alkaloids phaeanthine, aromoline, N,N'-dimethylphaeanthine and pycnamine, and the dioxin derivatives of bisbenzylisoquinoline alkaloids cocsuline and trigilletimine were isolated.

A methanol extract of dried leaves showed significant antiprotozoal activities against *Leishmania donovani* (IC_{50} = 1.5 µg/ml) and the blood stream form of *Trypanosoma brucei brucei* (IC_{50} = 31 µg/ml). Phaeanthine was three times more active (IC_{50} = 2.4 µM/ml) than Pentostam, a standard drug for the treatment of leishmaniasis, but at this concentration it is reported to be toxic to mammalian macrophages. In contrast, cocsoline (IC_{50} = 12.3 µM/ml) was as active as the standard drug, and was not toxic to macrophages at this concentration.

Both phaeanthine and aromoline showed antiprotozoal activity against *Trypanosoma brucei* but less strongly than the standard drug. Crude ethanolic extracts of the wood and bark showed significant antiplasmodial activity, but no significant anti-amoebic effect. Phaeanthine was effective against chloroquine-resistant and non-resistant strains of *Plasmodium falciparum* in vitro; at the used concentrations the alkaloid was found to be non-toxic to mammalian cells. An aqueous extract of the root showed antispasmodic activity on the respiratory tract and intestinal smooth muscle tissue of several test animals, which supports the use of the root against bronchial and intestinal problems.

Botany Dioecious liana up to 12 m long; stem up to 6 cm in diameter; branchlets puberulous. Leaves alternate, simple and entire; stipules absent; petiole 5–10 cm long; blade ovate to elliptical, 10–18 cm × 2–12 cm, base cuneate to slightly cordate, apex triangular-acuminate, leathery, pinnately veined with 3–4 pairs of lateral veins, of which the lowest pair basal, densely short-hairy on main veins below. Inflorescence an axillary umbel-like cyme, 2.5–8 cm × 2–12 cm or a false panicle up to 20 cm long; female inflorescence more compact than male one; branchlets and pedicels finely grey hairy. Flowers unisexual; bracts 2, tiny; sepals 6–9, yellow to orange, outer ones very small, slightly concave, 1–1.5 mm long, inner ones oblong to lanceolate, 2–5 mm × 1.5–2 mm, with recurved apex, all densely short-hairy outside; petals 1–3, much reduced or absent; male flowers with 3 stamens 2–2.5 mm long, free, with thick filaments; female flowers with staminodes, ovary superior, composed of 6–40 carpels, short-hairy, styles cylindrical. Fruit composed of ellipsoid, flattened drupes 1–2.5 cm × 1–1.5 cm on a stipe 3–5 mm long, short-hairy, yellow, stone wrinkled, 1-seeded. Seed with endosperm.

Triclisia comprises about 20 species, approxi-

mately 12 in mainland tropical Africa, 7 in Madagascar and 1 in Mayotte.

Triclisia macrophylla Oliv. has a sketchy distribution from Sierra Leone to Cameroon and Bioko (Equatorial Guinea); a root decoction is drunk to treat hernia. It is listed in the IUCN Red List as critically endangered because of habitat loss. *Triclisia subcordata* Oliv. occurs throughout West and Central Africa, and has similar medicinal uses to *Triclisia patens*. A methanolic leaf extract showed significant anti-ulcer effects in rats. The stems are used as rope. The fruits are reported as edible.

Ecology *Triclisia patens* occurs in rainforest and gallery forest, and is also common in secondary forest and on fallow land, at low and medium altitudes.

Genetic resources and breeding *Triclisia patens* has a fairly wide distribution and grows in both primary and secondary vegetation; there are no indications that it is endangered.

Prospects *Triclisia patens* has shown strong antiprotozoal and antiplasmodial activities and is widely used in traditional medicine. Further pharmacological research into its uses and active compounds is therefore warranted. The genus *Triclisia* is in need of a revision.

Major references Burkill, 1997; Camacho et al., 2002; Keay & Troupin, 1954; Marshall et al., 2000; Troupin, 1962.

Other references Akoègninou, van der Burg & van der Maesen, 2006; Asuzu & Anaga, 1995; Boissier et al., 1963; Camacho et al., 2003; Dramane & Mahieux, 1986; Dwuma-Badu et al., 1975b; Hawthorne & Jongkind, 2006; Hoët et al., 2004a; Neuwinger, 2000; de Wet, 2005.

Authors D.M. Mosango

UAPACA GUINEENSIS Müll.Arg.

Protologue Flora 47: 517 (1864).

Family Euphorbiaceae (APG: Phyllanthaceae)

Chromosome number $2n = 26$

Vernacular names Sugar plum, red cedar, false mahogany, rikio (En). Palétuvier de rivière, palétuvier d'eau douce (Fr). Sambi, cor de mogno (Po).

Origin and geographic distribution *Uapaca guineensis* occurs from Senegal east to the Central African Republic and south to DR Congo and Tanzania. It probably also occurs in Uganda.

Uses Especially the roots of *Uapaca guineensis* are widely used medicinally; stem bark, leaves and fruits are used to a lesser extent. Root preparations are commonly taken as an aphrodisiac and to treat male impotence. In Sierra Leone a steam bath with the roots is used to treat headache. In Côte d'Ivoire a root bark preparation is applied to leprous sores and taken as a tonic by women who have just given birth. In Côte d'Ivoire and Congo a root bark decoction is taken orally or as an enema to treat oedema and gastro-intestinal problems. In Gabon a root bark decoction is applied in the form of an enema as an emetic; a stem bark extract is drunk for the same purpose. Powdered root bark is sniffed to treat nasal cancer. In Congo and DR Congo a root bark decoction is taken to treat female sterility, toothache, rheumatism and piles. In Congo a root infusion is taken to treat headache caused by fever. Painful parts are embrocated with the crushed roots to ease the pain. A root infusion is taken with sugar cane juice to treat a blocked nose and pulmonary afflictions. In Gabon stem bark scrapings mixed with salt are rubbed in to treat skin complaints. In DR Congo a decoction of leaves, stem bark or root bark is taken to treat dysentery, diarrhoea, stomach-ache and venereal diseases. Pulped leaves with palm oil are applied to furuncles to mature them and to relieve migraine and rheumatism. They are also massaged onto legs of rachitic children to strengthen them. In Tanzania a stem bark decoction is taken to treat malaria. In Liberia unripe fruits are taken as a cough medicine. In northern Nigeria the flowers and bark enter into arrow poison preparations.



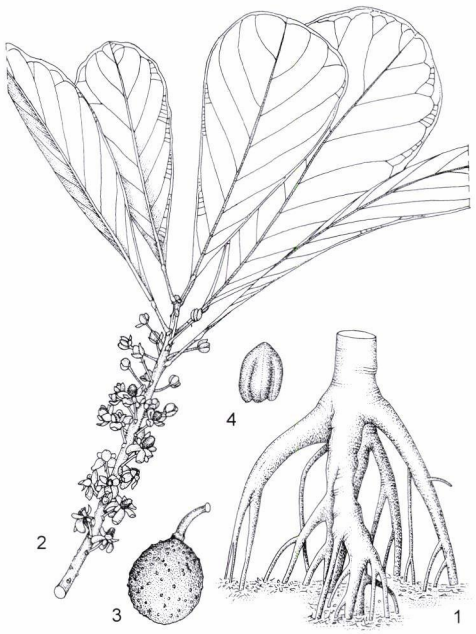
Uapaca guineensis – wild

The fruits have a sweetish edible pulp which can be eaten raw. Its taste resembles that of dried prunes or avocado. In Nigeria the pulp is made into a refreshing drink. The wood is used locally in carpentry and to make planks, railway sleepers, beams, furniture, beds and kitchen utensils. Throughout West Africa the bole is used to make dugout canoes. The stilt roots and branches are suitable for boat ribs. The wood produces good firewood and charcoal. Young twigs exude a red sticky sap, which dries like a gum and is used as a dye, e.g. for fishing lines. In Nigeria the large leaves are used to wrap kola nuts. The tree is used for shade and could be planted in coffee and cocoa plantations. It can also be planted to stabilize river banks.

Production and international trade In Liberia, Cameroon and DR Congo *Uapaca guineensis* is commercially exploited under its trade name 'rikio', but nowadays only at a local level. In Liberia the wood has been exported in the past as 'false mahogany'.

Properties An ethanol extract of the wood showed moderate antiplasmodial activity in vitro. An ethanolic root bark extract and an ethanolic stem bark extract did not show significant antibacterial or antifungal activity against human pathogens in vitro. The wood and bark contain much tannin. The sapwood is whitish tinged red, and the heartwood red to reddish brown. The wood is hard, durable and moderately heavy, and when quarter-sawn it has an attractive silver grain. It is easy to work.

Description Dioecious, small to medium-sized, much-branched, evergreen tree up to 18(–30) m tall; bole fluted, up to 100 cm in diameter, often on rounded stilt roots up to 3 m high; bark dark brown to blackish, cracked or scaly; crown dense and low branching; branches long, slender, almost glabrous, hollow when dry, leaf scars conspicuous; terminal bud sticky. Leaves alternate, crowded towards the end of the branches, simple; stipules linear, c. 0.5 mm long, soon falling; petiole 1.5–4(–7) cm long, jointed at top; blade broadly obovate, (5–)9–24 cm × (2–)4–10(–17) cm, base cuneate, apex rounded, margins usually wavy, papery, with numerous minute glandular raised dots, pinnately veined with 5–13 pairs of lateral veins. Male inflorescence an axillary globular to ovoid head 4–7 mm in diameter, female flowers solitary; peduncle of male inflorescence 1–1.5 cm long, with 2–4 small dispersed bracts; involucral bracts 8–10, elliptical to rounded, 1–1.5 cm long, bright yellow, enclosing the flowers in bud. Flowers unisexual, petals absent; male flowers sessile, with c. 9 unequal calyx lobes, c. 5 lobes oblong, c. 1 mm long, the others linear, small, stamens 5, filaments up to 1.5 mm long, rudimentary ovary c. 1 mm long, short-hairy; female flowers with 8–15 mm long pedicel, 6 unequal calyx lobes, triangular to rounded, 1–1.5 mm long, short-hairy, ovary superior, globose, 2.5–3 mm in diameter, 3-celled, smooth, styles 3, 4–5 mm long, reflexed, twice bifid towards apex. Fruit an almost globose drupe 2–2.5 cm in diameter, warty, glabrous, greenish, with 3 stones, usually 1 seed per stone.



Uapaca guineensis – 1, base of bole; 2, branch with male flowers; 3, fruit; 4, stone.
Redrawn and adapted by Achmad Satiri Nurhaman

Other botanical information *Uapaca* comprises 50–60 species from tropical Africa and Madagascar, and is in need of a complete revision. Many *Uapaca* spp. are similarly used as medicinal plants. The distribution area of *Uapaca guineensis* is not easy to establish as several *Uapaca* species are very similar. The presence of *Uapaca guineensis* in the drier parts of West Africa is doubtful and local specimens possibly belong to *Uapaca togoensis* Pax. In older floras the distribution area of *Uapaca*

guineensis extended to southern Africa, but nowadays the plants from southern Africa are considered to belong to a separate species, *Uapaca lissopyrena* Radcl.-Sm.

Anatomy Wood-anatomical description (IAWA hardwood codes):
Growth rings: 2: growth ring boundaries indistinct or absent. Vessels: 5: wood diffuse-porous; 13: simple perforation plates; (14: scalariform perforation plates); (15: scalariform perforation plates with ≤ 10 bars); 22: intervessel pits alternate; 23: shape of alternate pits polygonal; 27: intervessel pits large (≥ 10 µm); 31: vessel-ray pits with much reduced borders to apparently simple: pits rounded or angular; 32: vessel-ray pits with much reduced borders to apparently simple: pits horizontal (scalariform, gash-like) to vertical (palisade); 42: mean tangential diameter of vessel lumina 100–200 µm; 43: mean tangential diameter of vessel lumina ≥ 200 µm; (46: ≤ 5 vessels per square millimetre); 47: 5–20 vessels per square millimetre; (56: tyloses common). Tracheids and fibres: 61: fibres with simple to minutely bordered pits; 66: non-septate fibres present; (69: fibres thin- to thick-walled); 70: fibres very thick-walled. Axial parenchyma: 76: axial parenchyma diffuse; 77: axial parenchyma diffuse-in-aggregates; 78: axial parenchyma scanty paratracheal; (79: axial parenchyma vasicentric); 92: four (3–4) cells per parenchyma strand; 93: eight (5–8) cells per parenchyma strand; 94: over eight cells per parenchyma strand. Rays: 98: larger rays commonly 4- to 10-seriate; 102: ray height > 1 mm; (103: rays of two distinct sizes); 108: body ray cells procumbent with over 4 rows of upright and/or square marginal cells; (109: rays with procumbent, square and upright cells mixed throughout the ray); 115: 4–12 rays per mm. Mineral inclusions: 159: silica bodies present; 160: silica bodies in ray cells.
(D. Louppe, P. Détienne & E.A. Wheeler)

Growth and development In southern Cameroon seedlings of *Uapaca guineensis* are found to be fast growing, both in shade or in full sun, and even in relatively dry localities. They may become 4–5 m tall in 6 years. The fruits of *Uapaca guineensis* are eaten by fruit bats, monkeys, chimpanzees and gorillas, which may disperse the seeds. The tree grows in symbiosis with several ectomycorrhizal fungi.

Ecology *Uapaca guineensis* occurs in humid localities in rainforest and is common along river banks, where it sometimes forms pure stands. It also occurs in mixed evergreen forest and forest margins, in bushland on steep slopes, from sea-level up to 1100 m altitude.

Propagation and planting Multiplication of *Uapaca guineensis* is by seed or wildlings. In Tanzania fruits can be collected throughout the year with a peak in November–December. The seeds must be sown when still fresh, as they do not store well. The germination rate is up to 80%. In DR Congo seed set and germination are often poor.

Management *Uapaca guineensis* can be coppiced and pollarded. It has been planted as a forest regeneration tree in Guinea, to provide a green corridor for large forest animals. In Burundi it has been planted in an arboretum as an experiment to stabilize river banks.

Diseases and pests No diseases are known on *Uapaca guineensis*, but several insects feed on the leaves and buds, especially beetles (*Anthribidae*, *Chrysomelidae* and *Scolytidae*), whereas other beetles such as *Xylosandrus crassiusculus* feed on the wood.

Harvesting All plant parts can be harvested whenever the need arises. The root bark can be easily harvested from the stilt roots.

Genetic resources Although *Uapaca guineensis* is much exploited for its wood, it is also widespread and locally common and there are no signs that it is threatened by genetic erosion.

Prospects *Uapaca guineensis* is commonly used as a medicinal plant against a variety of diseases. No phytochemical analyses have been effected, and only few pharmacological tests have been done. Additional research is recommended so that the active compounds can be identified and the potential of these compounds can be evaluated. It is also recommended to plant *Uapaca guineensis* along rivers with a large difference in water flow to stabilize the banks.

Major references Burkill, 1994; Carter & Radcliffe-Smith, 1988; Lubini & Mandango, 1981; Marshall et al., 2000; Neuwinger, 2000; Ruffo, Birnie & Tengnäs, 2002; Voorhoeve, 1979.

Other references Atindehou et al., 2002; Betti, 2004; Eyog Matig et al. (Editors), 2006; Gassita et al. (Editors), 1982; InsideWood, undated; Katende, Birnie & Tengnäs, 1995; Stäuble, 1986; Vivien & Fauré, 1996.

Sources of illustration Wilks & Issembé, 2000; Voorhoeve, 1979.

Authors M.M. Kitambala

UAPACA PALUDOSA Aubrév. & Leandri

Protologue Bull. Soc. Bot. France 82: 50 (1935).

Family Euphorbiaceae (APG: Phyllanthaceae)

Chromosome number $2n = 26$

Vernacular names Rikio des marais (Fr).

Origin and geographic distribution *Uapaca paludosa* occurs from Guinea east to Uganda and Tanzania and south to Cabinda (Angola).

Uses In Congo a root infusion is taken to treat headache caused by fever. Painful parts are embrocated with the crushed roots to ease the pain. A root infusion is considered expectorant and taken to treat a blocked nose and pulmonary afflictions. A root bark or stem bark decoction is drunk to treat female sterility, dysentery and food-poisoning. It is used as a mouth wash to treat toothache, as a vapour bath to treat rheumatism and oedema, as an enema to treat piles and in baths to strengthen rachitic and premature children. Pulped leaves or stem bark with palm oil are applied to furuncles to mature them and also to treat migraine and rheumatism. No medicinal uses are recorded for West Africa.

The fruits are edible and taste like avocado. The wood is used for general carpentry, boxes and kitchen utensils. In Ghana it is considered good firewood.

Properties The ethanolic and dichloromethane stem bark extracts showed moderate antiplasmodial activity in vitro.

The sapwood is pinkish white; the heartwood is darker and shiny when sawn.

Botany Dioecious, small to medium-sized, much-branched, deciduous tree up to 15(–40) m tall; bole fluted, usually on stilt roots up to 4 m high; bark surface grey; crown dense and low branching; branches fairly robust, twigs reddish short-hairy, hollow when dry, leaf scars conspicuous. Leaves alternate, crowded towards the end of the branches, simple and entire; stipules lanceolate to ovate-lanceolate, (0.5–)1–2 cm long, persistent; petiole (3–)5–9(–13) cm long, robust; blade obovate to oblanceolate, 9–30(–50) cm × 4–17(–25) cm, base cuneate to rounded-cuneate, apex rounded, papery to leathery, short-hairy on veins, later almost glabrous, pinnately veined with 7–15(–20) pairs of lateral veins. Male inflorescence an axillary globular to ovoid head 8–10 mm in diameter, female flowers solitary; peduncle of male inflorescence 2–3.5 cm long, with 2–3 small dispersed bracts; involucral bracts 7–10, elliptical-oblong to broadly elliptical-ovate, 5–9 mm × 2–7 mm, strongly concave, outside short-hairy, pale yellow to yellowish green. Flowers unisexual, petals absent; male flowers sessile with c. 9 unequal calyx lobes, several lobes oblong, c. 1 mm long, the others linear, small, stamens 5, filaments up to 2 mm long, rudimentary ovary c. 1 mm long, short-hairy; female flowers with 1–2 cm long pedicel, 6 unequal calyx lobes, triangular to rounded, c. 1 mm long, densely short-hairy, ovary superior, ovoid, 3–4 mm in diameter, densely short-hairy, 3-celled, smooth, styles 3, 3–4.5 mm long, reflexed, 5–6-fid towards apex. Fruit an ovoid to globose drupe 2.5–3 cm × 1.5–2 cm, slightly rough, sparingly short-hairy, greenish becoming brown, with 3(–4) stones, usually 1 seed per stone.

Uapaca comprises 50–60 species from tropical Africa and Madagascar, and is in need of a complete revision. The fruits of *Uapaca paludosa* are eaten by fruit bats, monkeys, chimpanzees and gorillas, which may disperse the seeds.

Ecology *Uapaca paludosa* occurs in swamp and lakeside forest, fringing forest and rainforest, on slopes and crests as well as in well-drained valley bottoms, up to 1400 m altitude. It prefers soils of granitic origin.

Management *Uapaca paludosa* can be propagated by seed and wildlings. It can be pollarded and coppiced.

Genetic resources and breeding There are no signs that *Uapaca paludosa* is threatened by genetic erosion.

Prospects In Central Africa *Uapaca paludosa* has many medicinal uses. The antiplasmodial activity of the root bark is promising, and more research is warranted to elucidate the chemical compounds and evaluate the potential of these compounds for future medicine development.

Major references Burkill, 1994; Carter & Radcliffe-Smith, 1988; Mbatchi et al., 2006.

Other references Vivien & Fauré, 1996.

Authors G.H. Schmelzer

USTERIA GUINEENSIS Willd.

Protologue Schr. Berlin.Ges. Naturf. Fr. 10: 55 (1790).

Family Loganiaceae

Chromosome number $2n = 22$

Vernacular names Burodé (Po).

Origin and geographic distribution *Usteria*

guineensis occurs from Senegal east to the Central African Republic and south to Angola.

Uses In West Africa a decoction of the fruits or roots is taken to treat coughs and common cold. Sap of warmed stems is used as ear drops to treat earache. In Senegal a twig decoction is taken or used as a bath to treat fever in children. In Sierra Leone the Mende people rub the roots on the forehead, neck and joints to treat malaria. In Togo a root decoction is taken to treat gonorrhoea. In Liberia the Dan people use the leaves as an ingredient of arrow poison. In Benin the fruits are used for this purpose. In Senegal the stem is used to make ropes for beehives.

Production and international trade Leaves, roots, twigs, and fruits of *Usteria guineensis* are collected from the wild and traded only locally.

Botany Climbing shrub or liana up to 3(–12) m tall; stems glabrous. Leaves opposite, simple and entire; stipules reduced to ridges between the petioles; petiole 2–15 mm long; blade orbicular to oblong-elliptical, 2–15 cm × 2–10 cm, base cuneate to rounded, apex acute, obtuse, rounded or occasionally acuminate, leathery, pinnately veined with 3–6 pairs of lateral veins. Inflorescence a terminal dichasial cyme, many-flowered; lower bracts leafy, the others very small. Flowers bisexual, zygomorphic, 4-merous; pedicel hairy; sepals connate at the base, 3 small, c. 1 mm long, 1 much larger, 6–10 mm long, hairy outside, pale green, pale yellow or creamy; corolla with cylindrical tube 9–14 mm long, hairy outside, lobes slightly unequal, oblong-triangular, acute, mauve, violet, purple or white, often with yellow on the lobes; stamen 1, inserted near apex of corolla tube, exserted; ovary superior, globose, 2-celled, glabrous, style filiform, exserted, glabrous, stigma minute. Fruit an oblong capsule 2–6 cm × 1–1.5 cm, dark brown, shining, opening by 2 valves, many-seeded. Seeds flat, 3–5 mm × 2–3 mm, surrounded by a large membranaceous wing up to 8 mm wide, dark brown. *Usteria* comprises a single species. It belongs to the tribe *Antonieae* together with two South American genera and one from tropical Asia.

Ecology *Usteria guineensis* occurs in secondary forest and thickets, in open localities in rainforest and in tree savanna from sea-level up to 1200 m altitude.

Genetic resources and breeding *Usteria guineensis* is widely distributed and hence not threatened by genetic erosion.

Prospects It seems likely that *Usteria guineensis* will remain of limited use only.

Major references Burkill, 1995; Leeuwenberg, 1963; Leeuwenberg, 1980; Neuwinger, 1998; Neuwinger, 2000.

Other references Adjanohoun et al., 1986; Backlund, Oxelman & Bremer, 2000; Kerharo & Adam, 1974.

Authors A. de Ruijter

VOACANGA AFRICANA Stapf

Protologue Journ. Linn. Soc., Bot. 30: 87 (1894).

Family Apocynaceae

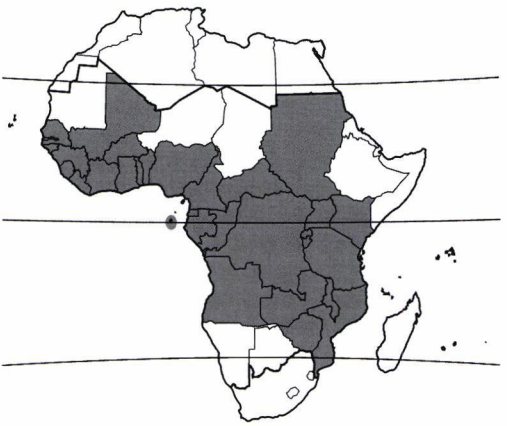
Chromosome number $2n = 22$

Synonyms *Voacanga angolensis* Stapf ex Hiern (1898).

Vernacular names Small-fruit wild frangipani (En). Voacanga d'Afrique (Fr). Cata grande (Po).

Origin and geographic distribution *Voacanga africana* is widespread in mainland tropical Africa, from Senegal east to Kenya and south to Angola, Zimbabwe and Mozambique.

Uses Different plant parts of *Voacanga africana* are used medicinally throughout its distribution area. The latex or decoctions or infusions of the stem bark, leaves or roots are put on wounds, boils and sores, and used to treat gonorrhoea, eczema, fungal infections and scabies. They are also taken to treat heart problems, hypertension and rheumatic afflictions. The latex is put in teeth to treat caries or dripped in the eye to cure ophthalmia. In Senegal a leaf decoction is drunk as a tonic and against fatigue. A root decoction is drunk three times daily to treat post-partum pains



Voacanga africana – wild

and hernia. In Côte d'Ivoire a decoction of the leaves is applied as a wash against diarrhoea, put into a bath against oedema, and is used as a friction and in a drink in the treatment of leprosy. Pulp from the leaves or stem bark is applied to soothe convulsions in children and the juice is put in the nostrils as a tranquilizer. In Cameroon the fruit is used in infusion to treat peptic ulcers. In DR Congo the bark in decoction is taken against intestinal worms, but this is considered a dangerous remedy. An infusion of the twigs is applied in bronchitis. A paste of the roots is applied to the head to kill lice. The dried and powdered roots without the outer bark are mixed with porridge and taken against kidney troubles and menstruation problems in women. In Tanzania the fruit and seeds are extracted with cold water and the extract taken against internal sores. The seeds are also used to treat high blood pressure. The root bark of *Voacanga* species is generally ingested to combat fatigue and increase endurance of drummers and hunters and, in higher doses, also for magic and religious purposes.
Pharmaceutical companies in Europe extract tabersonine from the seeds, which is readily converted into vincamine, a compound widely used in medicines for geriatric patients. Seed extracts are also used in medicines to treat heart diseases, to lower blood pressure and to treat cancer.
In Senegal the fruits are considered edible. In West Africa the copious latex has been used for adulterating *Hevea* rubber and children use it to make balls to play with. As it is sticky, it is used to catch birds. In Zambia and Ghana wood is burnt to obtain salt. *Voacanga africana* supplies poles for building purposes but the wood is considered inferior. Arrows and knife sheaths are made from the branches. In DR Congo, the wood is used to make musical instruments. The wood is also used for firewood. Good fibre can be obtained from the bark and is made into rope. In Nigeria, a yarn is made, which is mixed with cotton or other fibres to make mats. In Tanzania *Voacanga africana* is planted for ornamental purposes because of its sweet-scented white flowers.

Production and international trade There is a steady market for *Voacanga* seeds since the 1980s. Several hundred tonnes of seeds of *Voacanga africana* and some other *Voacanga* species, e.g. *Voacanga thouarsii* Roem. & Schult., are exported from Côte d'Ivoire, Ghana, Cameroon and DR Congo to pharmaceutical companies in France and Germany. Export prices from Cameroon in 2004 were (per kg): stem bark US$ 14, stem bark powder US$ 18, roots US$ 14, root powder US$ 18, root bark US$ 47, root bark powder US$ 51, seeds US$ 6. In the United States, prices of seed or root bark taken from the internet in 2005 were: 30 g seed US$ 20, 30 g root bark US$ 24, 115 g root bark US$ 80, 450 g root bark US$ 280, 1 kg root bark US$ 400.

Properties Indole alkaloids are by far the most important compounds of *Voacanga* spp. *Voacanga africana* has been studied most extensively. The total amount of alkaloids in root bark is 5–10%, in trunk bark 4–5%, in leaves 0.3–0.45% and in seeds 1.5–3.5%. The main alkaloids of the root bark are corynanthean-ibogan class dimers, chiefly voacamine, voacamidine and voacorine; vobtusine (a rare plumeran-plumeran class dimer) has also been isolated. Among the monomers found, the ibogan class voacangine and voacristine (= voacangarine) are the most important constituents; the plumeran class tabersonine has also been found. In the stem bark, voacamine and congeners predominate; vobtusine has also been identified. The leaves contain mainly dimeric alkaloids of both the voacamine and vobtusine groups; but the monomeric plumeran class voaphylline is the main alkaloid. The alkaloid composition of the seeds is very different, and consists almost exclusively of tabersonine.
The alkaloids show a vast range of pharmacological activities. Tabersonine is only slightly toxic. It has about a quarter of the hypotensive activity of reserpine (which is commonly used to treat high blood pressure), and a spasmolytic effect on the smooth muscle of the intestine. It has no tumour-inhibiting activity. High doses of voacangine bring about convulsions and asphyxia, but in lower doses voacangine exhibits mostly rather moderate central nervous sytem-stimulant activity. It exhibits some cataleptic activity. In regular doses, it has anticonvulsant activity, increases hexobarbital sleeping time in mice and decreases body temperature. In addition, it has local analgesic activity, hypotensive properties and causes bradycardia. The hydrochloride salt of voacangine has significant diuretic activity.
Most of the pharmacological work on voacamine and voacorine has focused on their cardiotonic properties. Voacamine shows little tendency to accumulate, and is less toxic than cardiac glycosides such as digitoxin. Voacamine sulphate resembles cardiac glycosides. When

tried clinically on patients with chronic cardiac insufficiencies of various origins, it caused considerable improvement in their clinical status and in haemodynamic parameters, while there was little effect on the heart rate. The alkaloid was effective both orally and intravenously. In high doses both voacamine and voacorine are hypertensive, due largely to peripheral vasoconstriction. These compounds also have parasympatholytic and sympatholytic properties, bringing about contraction of smooth muscle fibres, and they are also central nervous system depressants. Voacamine, voacorine and voacamidine are all cytotoxic in the P-388 cell culture assay. In experiments with rats and mice, parenteral and oral administration of these compounds slowed the growth of transplanted and primary induced neoplasms. Vobtusine causes hypotension as a result of peripheral vasodilatation and a direct depressant action on the heart. In moderate doses initial agitation is followed by a sedative effect; high doses may bring about convulsions and death. Vobtusine is of no clinical interest.

Tabersonine, the major alkaloid from the seeds, is readily converted to vincamine and vincamine derivatives. Vincamine shows protective activity and improves performance in animal models of cognitive dysfunction produced experimentally by cerebral ischaemia, and by amnesia producing agents. Subsequently, vincamine was shown to increase cerebral blood flow as a result of cerebral vasodilatation and may also enhance cellular respiration. It has become very popular in Europe especially for geriatric patients and for patients suffering from cerebral arteriosclerosis; there is improvement in the EEG and clinical status, it ameliorates disturbances of attention, memory and mood.

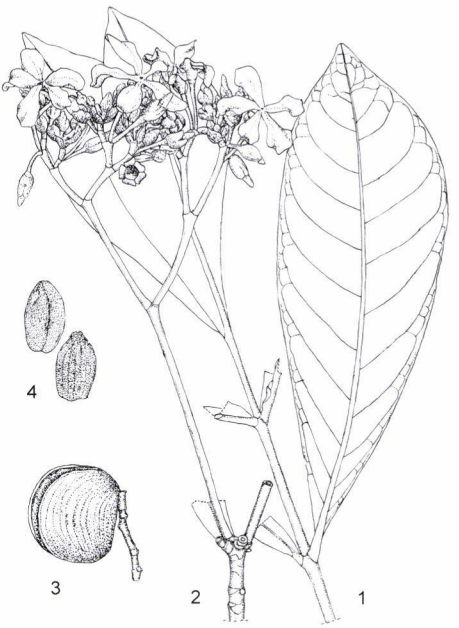
The aqueous extract of the root bark showed antibacterial activity, anti-amoebic activity against *Entamoeba histolytica* and antispasmodic activity on the guinea-pig ileum. This triple action may well explain its traditional use as an antidiarrhoeal. The fruit extract contains a compound with cytoprotective and ulcer-healing properties. Finally, the stem bark was tested for molluscicidal activity on the freshwater snail *Bulinus globulus*, but was found to be only moderately effective.

Leaf-cell suspension cultures of *Voacanga africana*, grown for 20 days under standard conditions, yielded 6 alkaloids. Tabersonine, lochnericine and minovincinine were the major ones. Voafrine A and B, dimers of the plumeran-plumeran class not previously detected from nature, were also produced. These compounds are of pharmacological interest because of they are related to vincaleucoblastine (vinblastine).

The seed oil is a by-product of the commercial extraction of tabersonine for vincamine synthesis. The main fatty acids are palmitic (15–20%), stearic (7–16%), oleic (49–60%) and linoleic (15–20%) acid. The oil has cosmetic and nutritional value.

Adulterations and substitutes Plants producing alkaloids of the ibogan and bisindole type occur in several other *Apocynaceae* genera, e.g. *Catharanthus*, *Hunteria*, *Picralima*, *Rauvolfia*, *Tabernaemontana* and *Tabernanthe*. Vincamine is commercially extracted from *Vinca major* L.

Description Shrub or small tree up to 10(–25) m tall, repeatedly dichotomously branched, glabrous to hairy in all parts; trunk up to 30(–40) cm in diameter; bark pale grey-brown, smooth or shallowly fissured, with some white latex. Leaves opposite, simple and entire; stipules absent; petiole 0–2 cm long with a short ocrea at base; blade elliptical or narrowly elliptical, 7–42 cm × 3–20 cm, base cuneate or decurrent into the petiole, apex acuminate, pin-



Voacanga africana – 1, leafy branch; 2, inflorescence; 3, fruit; 4, seeds.
Redrawn and adapted by Iskak Syamsudin

nately veined with 8–22 pairs of lateral veins. Inflorescence a fairly lax cyme, 2 together in the forks of branches, usually many-flowered; peduncle 6–25 cm long, slender; bracts as long as the calyx, ovate, obtuse, deciduous, leaving a conspicuous scar. Flowers bisexual, regular, 5-merous, with bad smell; pedicel 3–20 mm long; calyx campanulate, tube 3.5–9 mm long, twisted, lobes broadly ovate to oblong, 3.5–8 mm long, with rounded to truncate or emarginate apex, usually partly recurved, imbricate in bud, pale green, deciduous; corolla tube almost cylindrical, 7–15 mm long, twisted, lobes obovate, narrowly obovate or elliptical, 12–37 mm × 7–16 mm, rounded, spreading and often recurved later, creamy, greenish-creamy, yellow or less often white; stamens inserted 2–3 mm below the corolla mouth, slightly exserted, anthers sessile, narrowly triangular, 4–5 mm long, base sagittate; ovary superior, consisting of 2 carpels connate at base, surrounded by a ring-shaped disk, style narrowly obconical, split, twisted and curled at the base, pistil head 1–1.5 mm long, with a thin ring at base and 5 short lobes, coherent with the anthers. Fruit consisting of 2 separate globose follicles, but often only one developing, 3–8 cm in diameter, green with numerous whitish spots, yellow when mature, 2-valved, many-seeded. Seeds obliquely ellipsoid, 7–10 mm long, laterally with 5 grooves, rough, minutely warty, dark brown, aril yellow or orange, pulpy. Seedling with epigeal germination.

Other botanical information *Voacanga* is an Old World genus comprising 12 species, 7 in Africa and 5 in Asia. It is closely related to *Tabernaemontana*. The seeds of *Tabernaemontana* are difficult to distinguish from those of *Voacanga* but are usually larger.

Voacanga bracteata Stapf occurs in rainforest from Sierra Leone to DR Congo. The pulped root, latex and juice are used in frictions to cure rheumatism. In Gabon the bark is taken in decoction in magic and religious rituals. In DR Congo the fruit is considered edible. The root bark and stem bark have an alkaloid composition similar to that of *Voacanga africana*, but lack alkaloids of the plumeran class. The seeds, however, contain tabersonine. The abundant latex was formerly used in Liberia as an adulterant of *Hevea* rubber. *Voacanga chalotiana* Pierre ex Stapf occurs in Congo, DR Congo and Angola. It enters in a preparation to cure hernia in Congo. The stem bark has antifungal properties against pathogens affecting humans and plants.

Growth and development *Voacanga africana* plants develop according to the architectural growth model of Leeuwenberg determined by a monopodial orthotropic trunk, which ends in a terminal inflorescence. After flowering the 2 uppermost axillary buds develop into branches, so that the growth is sympodial. The infructescence seems to be axillary. *Voacanga africana* flowers mainly at the end of the dry season.

Ecology *Voacanga africana* occurs in the understorey of open forest, often secondary forest, and in gallery forest in savanna areas. It is often gregarious in coastal forest. It occurs from sea-level to 1100 m altitude.

Propagation and planting *Voacanga africana* is readily propagated by seed; vegetative propagation using cuttings is possible but success rates are generally low. It is not frost resistant, but plants will survive if protected for the first 3 years. Dry seeds store well under cool conditions. Seed storage behaviour is orthodox; viability is maintained for more than 3 years in airtight storage at ambient temperature with 11–15% humidity. Seeds are pressed into seedling trays filled with pure river sand, covered with a shallow layer of sand or compost and kept moist. Germination starts within 10–25 days. Soaking the seed overnight may hasten germination. Germination is generally good but slow, reaching 50% after 4 weeks and 90% after 7 weeks.

Management The fruits, bark and roots of *Voacanga africana* are mainly collected from the wild. In south-western Cameroon enrichment planting has been done in a 60 ha plot, and a plantation of 100 ha was established in 1992.

Harvesting Fruits of *Voacanga africana* are picked from the tree when mature. The follicles are opened by hand to release the pulp with the seeds. The pulp is gently squashed in water to release the seeds, which are dried in the sun. Bark should preferably be collected at the end of the growing season in view of the higher alkaloid content. Roots are simply cleaned to obtain the root bark. Careless harvesting, even of fruits, often leads to the destruction of the tree.

Handling after harvest Dried seeds are pulverized and the powdered material is usually subjected to extraction for alkaloids by standard methods. Other more sophisticated methods have been patented. A kg of seed yields 25–30 g tabersonine. Trunk bark, after being removed in strips, is dried. Patented ex-

traction procedures have been developed to obtain cardioactive components from the bark.

Genetic resources Destructive harvesting methods for the international pharmaceutical market cause concern as the species is rapidly becoming endangered. The extensive collection of fruits to obtain the seeds limits regeneration. The apparent tolerance of *Voacanga africana* to disturbed habitats and its quick regeneration ability lowers the risk of genetic erosion. Except for some occasional representations in botanical gardens no germplasm collections or breeding programmes are known to exist.

Prospects Many of the indole alkaloids found in *Voacanga africana* and related species display very distinct and interesting pharmacological activities. Some of them have potential as candidates for lead compounds in the development of future medicines. Much research has been done already, but much more will be needed in future to fully exploit their possibilities.

The extensive harvesting of fruits and the cutting of trees to gather fruits to fulfil the demand for seeds of large pharmaceutical companies are causing rapid disappearance of *Voacanga africana* from the wild in many regions. Investigation to develop methods of sustainable production (e.g. plantations) is needed to counteract this development. In the meantime, local authorities should be vigilant in stopping the destructive harvesting to preserve the species for the future.

Major references Bisset, 1985a; Bisset, 1985b; Burkill, 1985; Hendrian, 2001b; Leeuwenberg, 1985; Neuwinger, 2000; Tona et al., 1999; Tona et al., 1998.

Other references Adjanohoun & Aké Assi, 1979; Adjanohoun et al., 1989; Arbonnier, 2002; Cunningham, 1997; Hedberg et al., 1982; Kuster-Laine, 1985; Latham, 2004; Lovett, Ruffo & Gereau, 2003; Rafidison et al., 1987; Tan & Nyasse, 2002.

Sources of illustration Leeuwenberg, 1985.

Authors A. Maroyi

VOACANGA THOUARSII Roem. & Schult.

Protologue Syst. veg. 4: 439 (1819).

Family Apocynaceae

Synonyms *Orchipeda thouarsii* (Roem. & Schult.) Baron (1905).

Vernacular names Wild frangipani (En). Voacanga de Thouars (Fr). Mlindaziwa (Sw).

Origin and geographic distribution *Voacanga thouarsii* occurs throughout tropical Africa, from Senegal eastwards through the forest zone to Sudan and Kenya, and south to Mozambique and the east coast of South Africa. It also occurs in Madagascar.

Uses The uses of *Voacanga thouarsii* are similar to those of *Voacanga africana* Stapf. The latex or decoctions or infusions of the stem bark, leaves and roots are applied to wounds, boils and sores, and are used to treat gonorrhoea, eczema, fungal infections and scabies. The infusions are also taken to treat heart problems, hypertension and rheumatic afflictions. The latex is put in carious teeth as a temporary filling. In Tanzania the bark, roots and seeds are used as medicine for stomachache, snakebites and high blood pressure.

The wood is used in Liberia for hut posts and in Uganda for tool handles and sheaths for knives. The wood is also used as firewood and for making charcoal. The latex was formerly used to adulterate *Hevea* rubber. It is used as birdlime, e.g. in rice fields in Madagascar and as a glue for fastening handles to knife blades and to repair baskets. The wood is burnt in Sudan and Ghana to produce a salt. The bark yields a fibre, which is used for making hunting nets in East Africa. *Voacanga thouarsii* is planted along watercourses for soil and water conservation.

In France and Germany tabersonine is extracted from the seed, which is converted into vincamine, a compound widely used in Europe as a depressant of the central nervous system and for the treatment of cerebral vascular disorders in geriatric patients. Seeds are also exported to be used in medicines to treat heart diseases, to lower blood pressure and to treat cancer.

Production and international trade There is a steady market for *Voacanga thouarsii* seed, as there is for *Voacanga africana*. Several hundreds of tonnes of *Voacanga* seed are exported especially from West Africa, Cameroon and Madagascar to pharmaceutical companies in France and Germany for processing.

Properties In pharmacology indole alkaloids are by far the most important compounds of *Voacanga* spp., including *Voacanga thouarsii*. The main alkaloids of the root bark are dimers of the corynanthean-ibogan class dimers, chiefly voacamine, but also voacamidine and voacorine; vobtusine (a dimer of the plumeran-plumeran class) is an important alkaloid from

the root bark. In the stem bark, voacamine and congeners predominate, while vobtusine is often also present. Voacangine and voacristine (= voacangarine) are also major constituents. The leaves contain mainly dimeric alkaloids of the corynanthean-ibogan and the plumeran-plumeran classes, but ibogan monomers, including ibogaine and voacangine, are also found. The alkaloid composition of the seeds is similar to other *Voacanga* species, and consists almost exclusively of the plumeran-class tabersonine (1.6–1.8%). Voacamine, vobtusine and voacangine have hypotensive, cardiotonic and sympatholytic activities. The leaves of specimens from Madagascar were shown to contain the flavonoid-glycosides rutin and kaempferol-3-glucoside. Callus grown in vitro from leaf material containing 0.9% alkaloids produced 0.3% alkaloids (0.2% in the tissue and 0.1% excreted into the medium). Tabersonine was the only alkaloid isolated from the culture; it was not a constituent of the leaves.

The wood is reddish brown, tough and difficult to saw. It does not plane smoothly because of picking up of grain.

Botany Small tree up to 15(–20) m tall, repeatedly dichotomously branched, glabrous to shortly hairy on all parts; trunk up to 40(–80) cm in diameter; bark pale grey-brown, smooth, with some white latex. Leaves opposite, simple and entire; ocrea widened into stipules in the axils of petioles; petiole 8–25 mm long; blade narrowly obovate, 6–25 cm × 2–9 cm, base cuneate or decurrent into the petiole, apex acuminate, leathery, pinnately veined with 12–20 pairs of lateral veins. Inflorescence a cyme, 2 together in the forks of branches, few-flowered; peduncle 5–14 cm long, stout; bracts ovate, up to 10 mm × 7 mm, apex rounded, deciduous. Flowers bisexual, regular, 5-merous, sweet-scented; pedicel 8–15 mm long; calyx campanulate, 10–16 mm long, fleshy, lobes broadly ovate, apex rounded, with hyaline margin, erect, clasping the corolla tube and shed together with the corolla; corolla tube almost cylindrical, 17–23 mm long, twisted, lobes broadly obcordate, 19–30 mm × 28–43 mm, spreading or recurved, pale green, creamy or white; stamens inserted 3–4 mm below the corolla mouth, exserted for 2–3 mm, anthers sessile, narrowly triangular, base sagittate, apex acuminate; ovary superior, consisting of 2 separate carpels, surrounded by a ring-shaped disk, style gradually thickened at apex, pistil head 1–1.5 mm long with a fimbriate ring at base. Fruit consisting of 2 separate globose follicles 4–10 cm in diameter, pale and dark green spotted, 2-valved, many-seeded. Seeds obliquely ovoid or ellipsoid, 8–10 mm long, minutely warty, with shallow grooves, dark brown, aril orange, pulpy. Seedling with epigeal germination.

Voacanga is an Old World genus comprising 12 species, 7 in Africa and 5 in Asia. It is closely related to *Tabernaemontana*. *Voacanga thouarsii* plants develop according to the architectural growth model of Leeuwenberg determined by a monopodial orthotropic trunk, which ends in a terminal inflorescence. After flowering the 2 uppermost axillary buds develop into branches, so that the growth is sympodial; the infructescence seems to be axillary. *Voacanga thouarsii* flowers throughout the year.

Ecology *Voacanga thouarsii* occurs mostly in semi-deciduous forest and savannas, often in moist localities, from sea-level up to 600 m altitude. It easily colonizes disturbed habitats.

Management The fruits of *Voacanga thouarsii* are collected immediately when they open, and the seeds are removed from the arils. Seeds can be sown directly; soaking overnight in cold water may hasten germination. Since the seeds are sticky, they should be stored in a medium such as sand. *Voacanga thouarsii* regrows well when coppiced or pollarded.

Genetic resources and breeding In West Africa destructive harvesting of the fruits of *Voacanga thouarsii* for the international pharmaceutical market is a cause for concern. The extensive collection of fruits to obtain the seeds limits regeneration. On the other hand, the adaptation of *Voacanga thouarsii* to disturbed habitats, its wide distribution and its quick regeneration ability lower the risk of genetic erosion.

Prospects Many of the indole alkaloids found in *Voacanga thouarsii* and related species display very distinct and interesting pharmacological activities. Some of them have potential as candidates for lead compounds in the development of future medicines.

In some regions the extensive harvesting of fruits and the cutting of trees to gather fruits to fulfil the demand for seeds of large pharmaceutical companies are causing rapid disappearance of *Voacanga thouarsii* from the wild. Domestication and the development of adapted agronomic practices are needed to counteract this development. In the meantime, local authorities should be vigilant in stopping the destructive harvesting to preserve the species

for the future.

Major references Bisset, 1985a; Bisset, 1985b; Hendrian, 2001b; Leeuwenberg, 1985; Neuwinger, 2000.

Other references Beentje, 1994; Burkill, 1985; Cunningham, 1997; Gurib-Fakim & Brendler, 2004; Katende, Birnie & Tengnäs, 1995; Latham, 2004.

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WITHANIA SOMNIFERA (L.) Dunal

Protologue DC., Prodr. 13(1): 453 (1852).

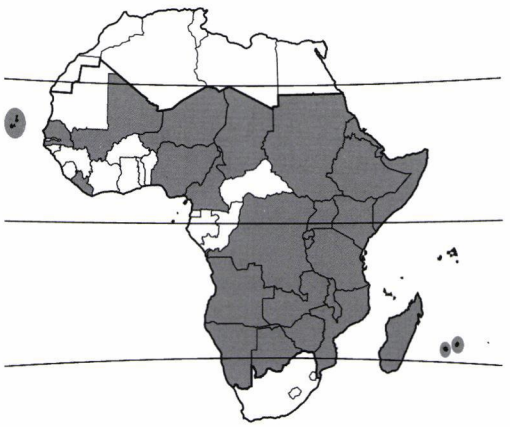
Family Solanaceae

Chromosome number $2n = 48$

Synonyms *Physalis flexuosa* L. (1753).

Vernacular names Ashwagandha, winter cherry, Indian ginseng, poison gooseberry (En). Coqueret somnifère, poc-poc sauvage, ti-poc-poc (Fr). Erva moura sonífera, pontadeira, malagueta de galinha, uva caneça (Po). Mtemua shamba, mhulapori (Sw).

Origin and geographic distribution The distribution area of *Withania somnifera* extends from the Canary Islands and the Mediterranean region through Africa, the Middle East, India and Sri Lanka to China. It also occurs in Australia. In Africa it occurs wild or naturalized throughout the drier parts of the continent including South Africa and in several Indian Ocean islands. *Withania somnifera* is of ancient use; it is mentioned in Ayurvedic literature as an important medicine, but it is difficult to ascertain whether the drug then described was *Withania somnifera*. It is mostly collected from wild stands, but in India it has been cultivated for centuries, mainly in Madhya Pradesh and Rajasthan.



Withania somnifera – wild and naturalized

. **Uses** *Withania somnifera* is more important as a drug plant in India than in Africa. In Ayurvedic medicine it has been used for centuries as a 'rasayana', a group of drugs that improve overall physical and mental health and increase longevity and vitality by rejuvenating the body. It is also considered narcotic, hypnotic, aphrodisiac, liver tonic, purgative and diuretic, and is used in the treatment of tuberculosis, senile debility, nervousness, rheumatism, furuncles, sores, dropsy, cough and hiccup, as well as to induce abortion. An ointment is made from the leaves that is applied to wounds and bed sores. It is an alternative for ginseng (*Panax ginseng* C.A.Mey.), but its mode of action is different. In India a plant extract is also applied to the skin as an antidote against cobra poison.

Although less popular than in India, *Withania somnifera* has many medicinal uses in Africa. In Cape Verde an infusion of the leaves is taken to purify the blood. Several preparations from the plant are diuretic and are used to cleanse the body of gonorrhoea. In Ethiopia the plant is used in the treatment of cough, asthma and epilepsy. In Somalia smoke of the burning plant is wafted over patients with slow blood circulation. The leaves or roots are pounded together with parts of other plants as an abortifacient. The leaves are given as a purgative and to treat general body pain. Ash of the leaves is rubbed in to treat ulcers and gingivitis. Leaves or decoctions of them are used to treat erysipelas and haemorrhoids. Leaf or root powder is boiled with fat and applied as an ointment on sores, abscesses or smallpox. Leaf sap is applied on anthrax pustules, and anthrax infected meat is boiled in water to which leaves are added. Leaf sap is used as ear drops to cure purulent otitis. Leaves or roots are also used in preparations to treat poorly healing open wounds. In Madagascar a plant infusion is used to treat asthma. In Mauritius a poultice made from the fresh leaves and roots is applied on rheumatic limbs. The plant is also used as a tonic, aphrodisiac and to treat skin problems.

Pounded roots or root powder are used in medicines against ringworm. Root powder mixed with milk is drunk as an aphrodisiac. A root decoction is drunk to treat dysuria, gonorrhoea or upset stomach, while a maceration of the roots is given as an enema against gangrenous inflammation of the rectum. A decoction of the root bark is drunk to treat asthma. Roots are used as an abortifacient, which seems to con-

tradict their use in South Africa to enhance fertility in women with a history of miscarriages or the use in Somalia to regulate menses. In southern Africa the hypnotic effects of an alcoholic extract are used in the treatment of alcoholism, tuberculosis and emphysema. In Somalia a root decoction is given to children with fever and disturbed sleep, e.g. from nightmares; rubbing preparations of crushed leaves has similar effects. Roasted roots are placed around the house to repel snakes and scorpions.

In veterinary medicine in southern Africa, an ointment containing green fruits, stems and leaves is applied to wounds due to belts and saddles.

Leaves are sometimes eaten by goats and even by humans as a vegetable, but there are several reports that they are poisonous. The fruits are rich in saponins and can be used as a soap substitute; they also have an emetic effect. The seeds are used to curdle milk to make cheese. The leaves have insect repellent properties.

Production and international trade The root of *Withania somnifera* is in great demand in the crude drug market. The annual requirement of the drug in the Indian market has been estimated at 9000 t (2004/2005). The current farm gate price for the roots in India stands at US$ 1.50 per kg.

Properties Pharmaco-chemical analysis of *Withania somnifera* has revealed a very large number of bio-active compounds. Attention was first drawn to its alkaloids, including the piperidine and pyrrolidine alkaloids anaferine, anahygrine, isopelletierine and cuscohygrine, and the tropane-alkaloids pseudotropine and tropine and derivatives thereof. Currently, research attention focuses on ergostane-type steroidal lactones, the most important ones being withaferin A and a number of withanolides (especially withanolide E), withadienolides, withasomniferols and withanone, and on the related glycosides called sitoindosides and withanosides. A dimeric thiowithanolide, ashwagandhanolide, has been isolated from the roots.

In India an aqueous alcohol extract of the root called 'ashwagandha' is widely available as a commercial product. Extracts of various plant parts and their active compounds have a broad spectrum of pharmacological activities, and anti-oxidant effects or modulation of oxidative processes play a predominant role. Extensive research has been done on their effects on brain stimulation, heart disease, anxiety and stress, Parkinson's disease, snake venom, inflammation, immunomodulation and especially cancer.

Withaferin A and sitoindosides VII-X given daily to rats increased the levels of the major free-radical scavenging enzymes (superoxide dismutase, catalase, glutathione peroxidase) in a dose dependent manner. An aqueous alcohol root extract showed positive cardioprotective effects in tests with rats. When studying the effect on the liver, a similar protective effect was found in the livers of rats treated with a toxic overdose of iron. The sitoindosides extracted from the roots showed significant antidepressant and anxiety-relieving properties in several rat models. In a test for chronic stress in rats, a root extract was compared with an extract from *Panax ginseng*; both extracts had a positive effect on several chronic stress symptoms, but the *Withania somnifera* extract did not cause the ginseng abuse syndrome, indicating a different mode of action. Cognition enhancing tests of an aqueous ethanol extract containing withaferin A and sitoindosides, studied in rat and mice models, showed a positive effect on cholinergic signal transduction in the forebrain, which may partly explain its cognition-enhancing effect. Mice injected with amyloid-β from plaques of Alzheimer's patients showed less degeneration of memory and neurons when simultaneously injected with withanoside IV. Chronic administration of ashwagandha reversed reserpine-induced and scopolamine-induced memory deficits; the extract also had a consolidating effect on the memories of mice administered chronic convulsive electroshocks. Ashwagandha furthermore reversed or attenuated the catalepsy, tardive dyskinesia and toxic effects of 6-hydroxydopamine (6-OHDA), which may provide leads towards treatments for Parkinson's disease. Aqueous alcohol extracts of the roots showed a positive effect on the cartilage of osteoarthritis patients both in vitro and in vivo in tests with rats.

The immunomodulatory effects of withanolides have been studied extensively. Enhanced white blood cell counts and activity and inhibition of delayed-type hypersensitivity are among the processes reported. In tests with mice treated with drugs that cause bone marrow damage, glyco-withanolides, including sitoindosides IX and X, caused increased counts of platelets and red and white blood cells and increased activity of peritoneal macrophages and lysosomal enzymes. Administration of ashwagandha also

prevented suppression of macrophage motility and suppression of the production of interleukin-1 and tumour necrosis factor-α.

Aqueous root extracts fed to mice caused lower morbidity due to *Bordetella pertussis*, the causal agent of whooping cough, compared to the control animals. In another series of trials, intraperitoneal administration of the root extract to mice increased the white blood cell count, the number of bone marrow cells and antibody-forming cells. Delayed hypersensitivity was prevented in a Mantoux test.

The properties of root extracts of *Withania somnifera* are very promising in cancer therapy and several studies indicate that they are correlated with the antioxidant effects. The extracts not only affect tumour growth but also have positive adjuvant effects in radiation and chemo-therapy. In an in-vitro experiment, withaferin A inhibited growth in human cell lines of breast, central nervous system, colon and lung cancer. Another recent study found that a chloroform extract of ashwagandha prevented cell proliferation by disrupting mitosis and inhibiting angiogenesis in several models. The relation between the antioxidant properties of root extracts and cancer was shown in an experiment with mice with lung tumours induced by benzopyrene. The extract reinforced the action of the anti-cancer drug paclitaxel; in mice treated with benzopyrene and administered both the extract and paclitaxel, levels of ATPase activity were as low as in untreated control mice. Increased ATPase levels are an indication of oxidative stress associated e.g. with cancer. The radiosensitizing effect of the root extract and of withaferin A was confirmed in several studies, e.g. on fibrosarcoma tumours and on more radio-resistant melanoma tumours in mice. The aqueous alcohol root extract had a positive effect on the immune system of normal and tumour-bearing mice treated with mitogens. The extract enhanced the proliferation of spleen cells, lymphocytes, bone marrow cells and thymocytes in response to mitogens. The effects of aqueous leaf extracts on cancer cells have been investigated mainly in vitro. Cultured osteocarcinoma and breast cancer cells showed reduced proliferation and symptoms of senescence when treated with the extract. When the cells were exposed to high oxidative stress, they became more susceptible to oxidative damage after treatment with the leaf extract. Withanolides inhibit cyclooxygenase enzymes, lipid peroxidation and proliferation of tumour cells, acting through modulation of the activation of nuclear transcription factor kappa-B (NF-κB) and NF-κB-regulated expression of genes that regulate cellular proliferation, carcinogenesis, metastasis and inflammation.

Addition of root powder to the diet of rats has shown hypoglycaemic effects in both normal and hyperglycaemic animals. A withanolide-free hydrosoluble fraction from the roots has been found to exhibit significant anti-stress activity in a dose-related manner in experiments with rats and mice. Although ashwagandha is used as an aphrodisiac, adding root powder to the diet of male rats impaired their libido and sexual performance. The methanolic extract of the roots showed significant antibacterial activity against a range of bacteria. Oral administration of the extract controlled *Salmonella* infection in mice. Stem bark extracts from Kenyan plants were tested for their activity against *Plasmodium falcifarum*, but the effect was minimal. When studying the anti-snake-venom properties of *Withania somnifera*, it was found that a glycoprotein isolated from an aqueous extract of the plant neutralized the toxic effects of phospholipase A2 from cobra venom. However, its mode of action may be too slow to provide a basis for pharmacological developments.

Side effects of the medicinal use of ashwagandha are rarely reported, but a case of thyrotoxicosis caused by its use was reported in the Netherlands. Symptoms disappeared when the treatment was stopped.

Description Evergreen, erect or spreading, rarely decumbent shrub 60–100(–200) cm tall; younger parts densely short stellate-hairy; roots stout, fleshy, pale brown; stem woody at base, profusely branched. Leaves alternate, upper ones usually nearly opposite, simple; stipules absent; petiole 0.5–3.5 cm long, sheathing at base; blade ovate to obovate, 2.5–17.5 cm × 1–7 cm, base slightly unequal, obtuse to cuneate, apex acute to obtuse, margins entire to sinuate, whitish stellate-hairy, later becoming sparsely hairy. Inflorescence an axillary cluster of 2–8 flowers. Flowers erect or nodding, bisexual, 5-merous, regular, yellowish to greenish white; pedicel 2–5 mm long, extending to 9 mm in fruit; calyx campanulate, tube 3–5.5 mm long, lobes triangular to nearly linear, 1–3 mm long, densely stellate-hairy; corolla campanulate to funnel-shaped, 5–8 mm long, hairy, lobes triangular, 2–2.5 mm long; stamens inserted near base of corolla and alternating with the lobes, scarcely exserted,



Withania somnifera – 1, flowering and fruiting branch; 2, calyx, cut open to show fruit. Redrawn and adapted by Iskak Syamsudin

filaments 2.5–3 mm long, anthers forming a cone around the style, up to 1 mm long; disk annular; ovary superior, ovoid, 1–2 mm × 0.5–1.5 mm, 2-celled, stigma head-shaped. Fruit a pendulous, globose berry 5–7 mm in diameter, orange to red, many-seeded, enclosed by persistent, membranous to papery calyx 10–24 mm × 8–17 mm, somewhat 5-angled, brownish. Seeds lens-shaped to kidney-shaped, 2–2.5 mm × 1.5–2 mm, orange, bright red or pale brown, reticulately wrinkled. Seedling with epigeal germination.

Other botanical information *Withania* comprises about 10 species and is indigenous to the warm and temperate regions of the Old World. It is morphologically and chemically related to *Physalis*. *Withania somnifera* is the only species occurring in Africa. Cultivated plants in India differ from wild ones morphologically as well as in the amounts of the various chemical constituents present. They have been classified in a distinct species, *Withania ashwagandha* Kaul, but they are currently no longer considered a separate species.

Growth and development Flowering occurs throughout the year. Flowers are self-fertile, but are also visited by bees.

Ecology *Withania somnifera* occurs on disturbed soil, along roadsides, in cultivated land, on termite mounds in grassland, in open woodland and riverine vegetation, from sea-level up to 2300 m altitude. It is grown in areas with 500–750 mm annual rainfall and prefers well-drained soil; waterlogging is harmful. It grows well in sandy loams and stony red clay soils with pH 7.5–8. It thrives in full sun, but tolerates some shade.

Propagation and planting *Withania somnifera* is propagated by seed, either sown in a nursery or directly in the field. Traditional land preparation consists of several ploughings and planking to prepare a weed-free seedbed. When sown in a nursery, seeds are sown at the onset of the rains and the seed requirement is (0.5–)2–5 kg/ha. Treatment with a fungicide is recommended. Germination starts after 10–12 days. Seedlings are sufficiently tall after 25–30 days to be transplanted into the field, normally at a spacing of 60 cm × 60 cm. For direct sowing in the field, either in line or broadcasting, 5–10 kg seed per ha is needed. The sowing depth is 1–3 cm. When seedlings have 2–4 leaves they are thinned to a spacing of about 15 cm × 15 cm.

Management In India *Withania somnifera* is grown as an annual. One hand weeding at an early stage of the crop is often sufficient. Manure or fertilizer is rarely applied as it is believed to result in leafy plants with poor root quality, but in experiments, moderate applications of N (50 kg/ha) and P (25 kg/ha) increased yields to more than 800 kg/ha and gave thicker roots.

Diseases and pests No serious diseases or pests have been reported. Damping off and root rot of young plants caused by *Fusarium solani* can be controlled by seed treatment or fungicide application.

Harvesting In India cultivated plants start flowering in December and the crop is ready for harvesting in January–March, about 6 months after sowing when leaves start to wilt and fruits are ripe. Whole plants are uprooted and roots are cut from the plant about 2 cm above the collar. Fruits are picked by hand.

Yield A good crop in India yields 650–800 kg/ha of fresh roots (350–450 kg/ha dry roots), but the average is 300–500 kg/ha. The average yield of seed is 50–75 kg/ha.

Handling after harvest Roots are carefully cleaned, cut into 7–10 cm long pieces, dried and graded. Fruits are also dried and the seeds are

removed by crushing the dry fruits.

Genetic resources *Withania somnifera* occurs naturally or has become naturalized in many parts of the tropics. Although it is nowhere common, it is unlikely to be liable to genetic erosion. The Regional Research Laboratory of the Indian Council of Agricultural Research (ICAR), Jammu Tawi, India maintains a collection of germplasm.

Breeding Several improved cultivars have been released in India, including 'Rakshita', 'Poshita', 'WS-20' and 'WS-22'.

Prospects With the medicinal potential presented by *Withania somnifera*, the prospects for further exploitation look promising. Modern research confirms the activity of the drug, although the information has not yet resulted in registered drugs in mainstream medicine. The efficacy and relative safety of this plant, coupled with the ease of propagation, seem to warrant the planting of *Withania somnifera* for medicinal purposes. Nonetheless, the standardization of the drug ashwagandha needs to be effected so that it can be integrated in pharmacopeias.

Major references Burkill, 2000; D'Arcy & Rakotozafy, 1994; Gonçalves, 2005; Gurib-Fakim & Brendler, 2004; Gupta & Rana, 2007; Ichikawa et al., 2006; Indian Institute of Integrative Medicine, undated; Khanna et al., 2006; Mishra, Singh & Dagenais, 2000; Winters, 2004.

Other references CSIR, 1976; Dhar et al., 2006; Diwanay, Chitre & Patwardhan, 2004; Felson & Kim, 2007; Hepper, 1991; Jayaprakasam et al., 2003; Kirira et al., 2006; Kumar et al., 2007; Malik et al., 2007; Mohanty et al., 2004; Panchbhai et al., 2006; Siddiqi, 1978; Singh, Chandan & Gupta, 2003; Subbaraju et al., 2006; Tiwari, Shah & Tiwari, 2002; Trigunayat et al., 2007; Uma Devi & Kamath, 2003; van der Hooft et al., 2005; Watt & Breyer-Brandwijk, 1962.

Sources of illustration Gonçalves, 2005.

Authors A. Gurib-Fakim

WRIGHTIA DEMARTINIANA Chiov.

Protologue Ann. Bot. Roma 13: 405 (1915).

Family Apocynaceae

Origin and geographic distribution *Wrightia demartiniana* occurs in Ethiopia, Somalia, Kenya and northern Tanzania.

Uses In Kenya ground roots are boiled and the filtrate is drunk to treat kidney problems. Soup made of the fresh roots and chicken is eaten to cure gonorrhoea. Ground twigs in milk are taken as a laxative. Latex is added to goat milk to curdle it to make cheese. The bark is crushed and rubbed on the skin as a perfume. The branches are used to make fire by friction. The plant is eaten by camels and sheep, but is not browsed by goats.

Properties The phytochemistry of *Wrightia demartiniana* has not been elucidated yet. Other *Wrightia* species contain triterpenes.

Botany Shrub or small tree up to 5 m tall, with white latex; bark black, branches pale brown or grey, branchlets pubescent. Leaves opposite, simple and entire; stipules very small; petiole 0.5–2 mm long, shortly hairy; blade narrowly elliptical, elliptical or obovate, 12–5.5 cm × 0.5–2 cm, base cuneate or decurrent into the petiole, apex rounded to obtuse, short hairy, papery, lateral veins obscure. Inflorescence a terminal cyme on short lateral shoots, few-flowered, 1.5–2.5 cm long; peduncle 1–3 mm long, shortly hairy; bracts sepal-like. Flowers bisexual, regular, 5-merous, sweet-scented; pedicel 4–6 mm long, shortly hairy; sepals fused at base, 1.5–3 mm long, erect, apex obtuse, shortly hairy outside, inside with 5 scales as long as sepals; corolla white or creamy, tube 5–7 mm long, gradually narrowed towards the throat, shortly hairy outside, corona 1–1.5 mm long, shortly lobed, undulate, corolla lobes oblong, 10–15 mm long, overlapping to the left, spreading, apex rounded, inside hairy; stamens inserted at corolla mouth, exserted; ovary superior, consisting of 2 free carpels, style 2–5 mm long, thick, persistent, ending in a pistil head with a globose basal part, a ring in the middle and a 2-lobed apical part. Fruit consisting of 2 narrowly ellipsoid follicles, united at the extreme base, 12–30 cm × c. 8 mm, tapering into a narrow apex, 2-valved, shortly hairy, grey-green, many-seeded. Seeds spindle-shaped, flattened, 19–25 mm long, longitudinally ribbed, pale brown, with a tuft of dirty white hairs 3.5–4 cm long.

Wrightia occurs in the Old World and comprises about 25 species, of which 2 in continental Africa. The Asian *Wrightia arborea* (Dennst.) Mabb. is cultivated as an ornamental in Senegal and Kenya. *Wrightia natalensis* Stapf is a small tree occurring in Zimbabwe, Mozambique, Swaziland and eastern South Africa. In South Africa the ground roots are steeped in water and the pulp is applied to fontanelles of babies to close them. The root is chewed or the root powder is drunk in beer as

an aphrodisiac.

Ecology *Wrightia demartiniana* occurs in dry rocky *Acacia* and *Commiphora* bushland, at 100–1000 m altitude.

Genetic resources and breeding As *Wrightia demartiniana* is not uncommon in its distribution area, and not much used, it is probably not threatened by genetic erosion.

Prospects *Wrightia demartiniana* will remain of local importance only, unless promising information on its pharmacological activity becomes available.

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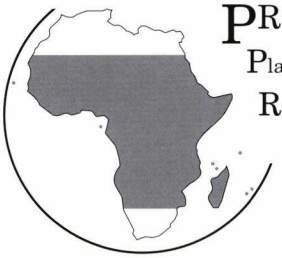

PROTA

Plant Resources of Tropical Africa

Ressources végétales de l'Afrique tropicale

PROTA in short

The Plant Resources of Tropical Africa (PROTA) programme was initiated in 2000 and developed into an international partnership of 11 institutions in 11 countries during the Preparatory Phase 2000–2003. Since 19 February 2003, PROTA operates as an international foundation domiciled in Wageningen, Netherlands.

PROTA is a major 'information brokerage and knowledge repatriation' programme. The objectives are to bring the 'world literature' on the useful plants of Tropical Africa, now accessible only to the resourceful happy few, into the (African) public domain, and contribute to greater awareness and sustained use of the plants, with due respect for traditional knowledge and intellectual property rights. PROTA will describe the estimated 7,000 useful plants during the Implementation Phase 2003-2015. The information carriers will be freely accessible Web databases (www.prota.org), a low-price Handbook and CD-Rom series featuring 16 Commodity groups, and Special Products per commodity group for rural development, education, research and policy actors (all in English and French).

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The Technical Centre for Agricultural and Rural Cooperation (CTA) was established in 1983 under the Lomé Convention between the ACP (African, Caribbean and Pacific) Group of States and the European Union Member States. Since 2000, it has operated within the framework of the ACP-EC Cotonou Agreement.

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CTA is financed by the European Union.

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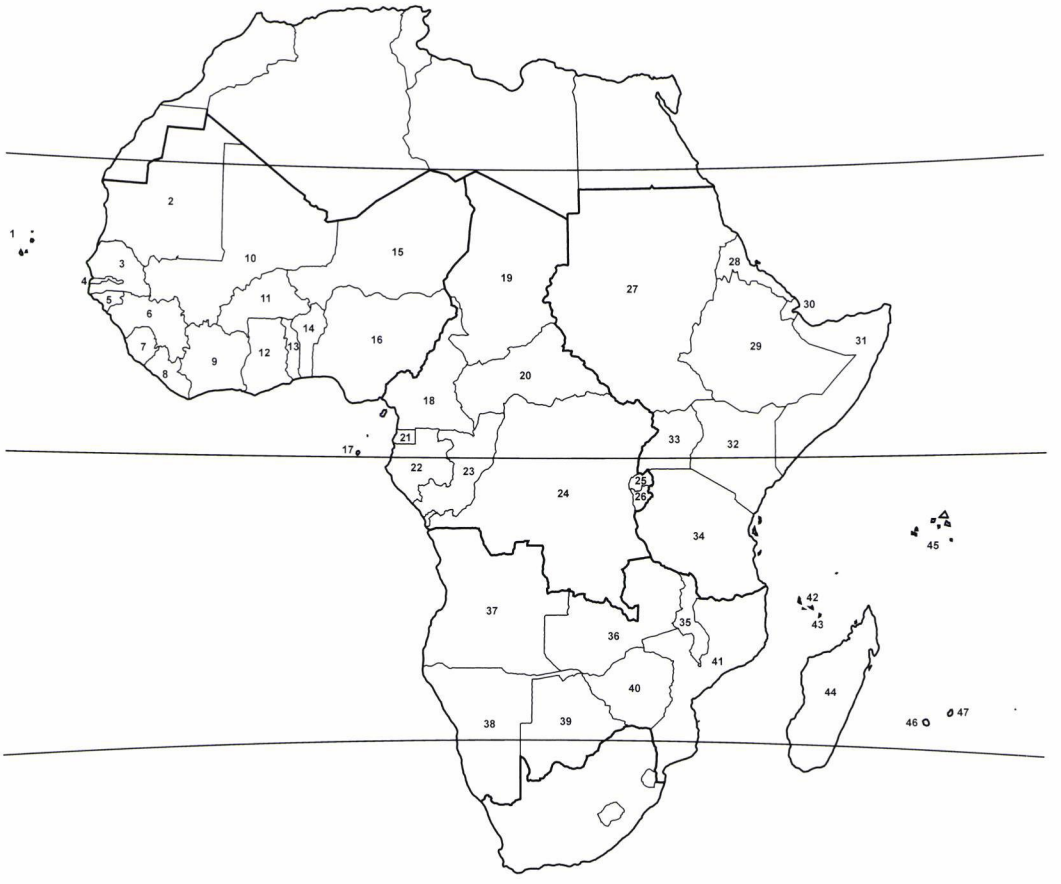

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18. Cameroon
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PROTA, short for 'Plant Resources of Tropical Africa', is an international programme focused on the 7,000 useful plants of Tropical Africa. Its purpose is to make available the wealth of dispersed knowledge on these plant resources for education, extension, research and industry through Internet databases, books, CD-Roms, and derived products such as brochures, leaflets, and manuals. A thorough knowledge of the plant resources is essential for arriving at ecologically balanced and sustainable land-use systems. A large international team of experts is contributing the texts on particular species. All species are described according to a standard format with details on uses, trade, properties, botany, ecology, agronomy or sylviculture, genetic resources, breeding, prospects and literature. In the printed series the species are grouped into commodity groups. More information on www.prota.org. 'Protabase' can be searched at: database.prota.org/search.htm.

Medicinal plants 1

PROTA 11 deals with the medicinal plants of Tropical Africa. PROTA's database 'SPECIESLIST' presents 5917 species used as such. 3222 among them are 'primary use' medicinal plants, qualifying for treatment in volume 11, which is subdivided into 4 tomes. Tome 11(1) describes 894 medicinal plants belonging to a selection of botanical families. The remaining 'primary use' medicinal plants will be included in tomes 11(2) to 11(4). In the final tome 11(4), the 'secondary use' medicinal plants will be listed as 'Medicinal plants with other primary use' and referred to other Handbook volumes.
In tome 11(1), the 894 'primary use' medicinal plants are described in 406 review articles, implying that about half the species are briefly mentioned and described in the articles of more important related species; they have no separate article due to lack of information.

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