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Medicinal and poisonous plants 2

J.L.C.H. van Valkenburg and N. Bunyapraphatsara
(Editors)

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DR J.L.C.H. VAN VALKENBURG graduated (with distinction) in biology from Wageningen University, the Netherlands in 1988. While still a student he spent a year in Papua New Guinea, studying the effects of human disturbance on mid-montane forest. Under the Tropenbos Gabon programme he was based at the former department of Plant Taxonomy at Wageningen University. Following this assignment he was involved in making forest inventories in various parts of Gabon. Having worked in both the private and public sector he started his PhD at the former Rijksherbarium, Leiden University, the Netherlands. His thesis, defended in 1997, was on the economic and ecological potential of non-timber forest products of East Kalimantan, Indonesia. This research was part of the Tropenbos Kalimantan programme, and involved three years of fieldwork. After this he joined the staff of the Prosea Publication Office to work on the trilogy on medicinal and poisonous plants (Prosea 12). He was associate editor for the subvolume Prosea 12(1) published in 1999. His publications on taxonomy, ethnobotany, plant ecology and forest classification are a reflection of his work in Gabon, Papua New Guinea and Indonesia.

DR N. BUNYAPRAPHATSARA graduated in pharmacy from Mahidol University in Bangkok, Thailand, in 1970. She earned her MSc degree in pharmacognosy at the Massachusetts College of Pharmacy in Boston, United States in 1973, and the PhD degree in phytochemistry at the same college in 1975. In 1981 she had postdoctoral training at the Department of Pharmacognosy and Pharmacology of the School of Pharmacy, University of Illinois in Chicago, United States. She has been Associate professor of pharmacognosy at the Faculty of Pharmacy of the Mahidol University in Bangkok since 1984. She has been a consultant for various organizations, particularly in the field of herbal medicine programmes in Thailand, and has organized several international seminars and presented papers at various national and international scientific meetings. From 1983 to 1998 she was Director of the Medicinal Plant Information Centre in Bangkok. She also has been member of the committee on traditional drug registration at the Ministry of Public Health. She has published numerous research papers, mainly on phytochemistry, and some handbooks on Thai medicinal plants.

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- L.J.G. van der Maesen, Wageningen University, Department of Plant Sciences, Biosystematics group, P.O. Box 8010, 6700 ED Wageningen, the Netherlands (*Cullen corylifolium*, *Entada*, *Eriosema chinense*, *Flemingia*)
- J.L.C.H. van Valkenburg, PROSEA Publication Office, Wageningen University, Department of Plant Sciences, Biosystematics group, P.O. Box 341, 6700 AH Wageningen, the Netherlands (introduction, *Ailanthus*, *Anamirta cocculus*, *Callicarpa*, *Clerodendrum*, *Dendrocnide*, *Dichroa febrifuga*, *Excoecaria*, *Glycosmis pentaphylla*, *Guazuma ulmifolia*, *Kadsura scandens*, *Laportea*, *Melastoma*, *Milletia*, *Ochrosia*, *Parameria laevigata*, *Pipturus*, *Rourea*, *Rubus*, *Soulamea amara*, *Stachytarpheta jamaicensis*, *Thevetia peruviana*, *Tinomiscium petiolare*, *Waltheria indica*)
- P.C. van Welzen, Nationaal Herbarium Nederland, Universiteit Leiden

branch, P.O. Box 9514, 2300 RA Leiden, the Netherlands (*Breynia*, *Croton*, *Dodonaea viscosa*, *Melanolepis multiglandulosa*)
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- F.I. Windadri, Puslitbang Biologi LIPI, Jl. Ir. H. Juanda 22, Bogor 16122, Indonesia (*Capparis*, *Cleome*)
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Foreword

The Prosea volume on medicinal and poisonous plants is intended to provide information concerning local knowledge as well as modern research findings. This is important in view of the resurgence of interest in medicinal plants in South-East Asia. This second part of the volume presents a mixture of species with a long-standing reputation in traditional medicine and species that have been quite well investigated phytochemically and/or pharmacologically, but are poorly known in the South-East Asian region.

Reading this volume, it becomes evident that the present knowledge of many medicinal and poisonous plants is still far from complete. Research on various species of current minor economic importance, especially on their phytochemistry, pharmacological activity and therapeutical applications, is undoubtedly necessary for the development of new plant-derived drugs. Through such research, mankind will be well prepared to keep pace with the growing resistance of various diseases to industrial drugs currently in use.

The information presented here is the result of a collective effort of many contributors and the approach of the Prosea organization. I hope that this volume will be instrumental in focusing attention to the important issue of further research and development of medicinal plants. This may well contribute to poverty alleviation by providing additional income through growing the plants and promoting the local production of herbal drugs in South-East Asia.

Wageningen, September 2001

Professor Dr C.M. Karssen
Vice-chairman
PROSEA foundation

1 Introduction

The general aspects of medicinal and poisonous plants have already been highlighted in the introduction of Prosea 12(1): 'Medicinal and Poisonous Plants 1'. These included definitions, subgrouping, role, phytochemistry, biological and pharmacological activity and therapeutical applications, botany, ecology, agronomy, harvesting and handling after harvest, processing, utilization and quality control, genetic resources and breeding, research and development, from plant to drug and prospects. The introduction to the present subvolume provides information on the choice of genera and species to be treated here and on aspects of quality control.

1.1 Choice of genera/species

The choice of the genera/species to be dealt with in each of the 3 subvolumes on medicinal and poisonous plants has been somewhat arbitrary. The importance attached to a given genus/species was based on existing information in handbooks on medicinal or useful plants for the South-East Asian region. In general, less information on the phytochemistry and pharmacology is available in the literature for the medicinal and poisonous plants to be covered in the present subvolume compared to those highlighted in Prosea 12(1). However, several genera/species covered in the present subvolume have a long-standing reputation in traditional medicine, such as *Alstonia*, *Alyxia*, *Capparis*, *Croton*, *Polygala* and *Quassia*. Other genera/species have been quite well investigated in the field of phytochemistry and may have prospects for the production of bioactive intermediates. Examples include *Strophanthus* and *Cerbera* for their cardiac glycosides, *Tabernaemontana*, *Ipomoea* and *Phaeanthus* for their alkaloids and *Dioscorea* for its steroidal glycosides.

1.2 Quality control of herbal drugs

1.2.1 Why quality control?

As long as mankind has existed, people have been dependent on the diversity of plant resources for food, feed and medicine. They learned by trial and error to distinguish useful plants with beneficial effects from those which were toxic or non-active, and also which combinations or processing methods had to be used to gain consistent and optimal results. This knowledge of plant-based drugs developed gradually and was passed on, thus laying the foundation for many systems of traditional medicine all over the world. Over centuries traditional medicine evolved, depending on local flora, culture and religion (Horsten, 1995).

Nowadays, plant materials are used throughout the industrialized and developing countries as home-remedies, over-the-counter drugs and raw materials for the pharmaceutical industry. As such, they represent a substantial proportion of the global drug market (WHO, 1998). In general all medicines, whether they are of synthetic or plant origin, should fulfil the basic requirements of being efficacious and safe. Ultimate proof of these can only be achieved by some form of clinical research. This applies for instance both to the multinational pharmaceutical company conducting a multi-centre, double blind placebo-controlled study with a herbal extract, as well as to the health-practitioner in a rural village who applies a locally produced herbal mixture. A defined and especially constant composition of the drug is therefore one of the most important prerequisites for any kind of clinical experiment. Otherwise, a statistical analysis of the results is almost impossible. Given the nature of products of plant origin, which by definition are never constant, and may furthermore vary with climatic and soil conditions, this is wheree quality control comes in (Bauer & Tittel, 1996; Bauer, 1998).

1.2.2 A practical approach to quality control

Natural products in medicine form a vast array of 'raw materials', making a clear definition important. The term *herbal drugs* denotes plants or plant parts (roots, bark, leaves, flowers, seeds) which have been converted into herbal drugs by means of simple processes such as drying (i.e. they are in an unprocessed state)(EMEA, 1998). A practical addition to the definition is also to include some more crude products derived from plants, which no longer show any organic structure, such as essential oils, fatty oils, resins and gums. Derived products in the processed state, e.g. extracts or even isolated purified compounds (strychnine from *Strychnos nux-vomica* L.) or mixtures of compounds (abrin from *Abrus precatorius* L.) are as a rule not included in the definition. Their production is already based on adequate quality control of the respective starting materials.

The following paragraphs will focus on quality control of herbal drugs in compliance with the above definition.

1.2.2.1 Identity, purity and content

In general, quality control is based on 3 important pharmacopoeial definitions:

- *Identity* : 'is the herb the one it should be?'
- *Purity* : 'are there contaminants e.g. in the form of other herbs which should not be there?'
- *Content (assay)* : 'is the content of active constituents within the defined limits?'

It is obvious that the content (assay) is the most difficult part, since in most herbal drugs the active constituents are unknown. Sometimes markers can be used which are by definition chemically defined constituents that are of interest for control purposes, independent of whether they have any therapeutic activity or not (EMEA, 1998). In all other cases, a simple determination of extractable matter is an approach often seen in Pharmacopoeias.

For a practical approach to control the quality of herbal drugs there are 2 possibilities: either a monograph has been published in a Pharmacopoeia of the material, or not.

Monograph available in a Pharmacopoeia

Several of the principal Pharmacopoeias contain monographs of herbal drugs, for instance the European Pharmacopoeia (Council of Europe, 1997–2001a) and the United States Pharmacopoeia – The National Formulary (USPC, 1994–2001). Pharmacopoeias which follow the guidelines stated by these globally recognized Pharmacopoeias and publish additional monographs on herbals include the German Pharmacopoeia (DAB 1997/2000) (Anonymous, 2000a) and regional Pharmacopoeias like the Asian Herbal Pharmacopoeia (ASEAN, 1993) and the Thai Herbal Pharmacopoeia (DMS, 1995). Other valuable sources of monographs include the World Health Organization (WHO, 1999), the journal Pharmeuropa (finalised drafts, which will be published in the European Pharmacopoeia) (Council of Europe, 1989–2001) and the German Homeopathic Pharmacopoeia (HAB 2000, HAB 1) (Anonymous, 2000b; Anonymous, 1978–1991); the latter is available in English translation as well (known as GHP) (British Homeopathic Association, 1990–1993).
The major advantage of an official monograph published in a Pharmacopoeia is that standards are defined and available, and that the analytical procedures used are fully validated. Especially the latter is of major importance since it can be a rather time-consuming process. By definition, validation is the process of proving that an analytical method is acceptable for its intended purpose (Green, 1996). For pharmaceutical methods, guidelines from the United States Pharmacopoeia (USPC, 1994–2001), the International Conference on Harmonization (ICH) (Anonymous, 1995), and the Food and Drug Administration (FDA) (FDA, 1987, 1994) provide a framework for performing such validations. In general, validation investigations must include studies on specificity, linearity, accuracy, precision, range, detection limit, quantitation limit and robustness, depending on whether the analytical method used is qualitative or quantitative (Green, 1996).

Monograph not available

When no pharmacopoeial monograph is available for the herbal drug, development and validation of the analytical procedure has to be done by the manufacturer himself. The best strategy is to follow closely the pharmacopoeial definitions of identity, purity and content (assay). Valuable sources for general analytical procedures include the methods sections of the Pharmacopoeias mentioned above, the guidelines published by the World Health Organization (1998), and Pharmeuropa (Council of Europe, 1989–2001). Additional information, especially on chromatographic and/or spectroscopic methods can be found in the general scientific literature.
Also of utmost importance is the availability of standards. For macroscopic and microscopic procedures in general, this means that reliable reference samples of the plant must be available. A defined botanical source e.g. voucher specimens, will normally solve this problem. Standards for chromatographic procedures might be less easy to obtain. Characteristic plant constituents, either ac-

tive or markers, are seldomly commercially available. Sometimes a liquid chromatography – mass spectroscopy approach can be referred to as a characterization. Going one step further, after isolating such a compound, elucidations to prove its definite structure will not be easy. The method often employed is to use readily available compounds which behave similarly in the chosen chromatographic systems, and to calculate retention values and/or times towards these compounds as a standard.
Following the Pharmacopoeial guidelines of identity, purity and content (assay), the next paragraphs will elaborate on factors involved in a quality control approach for herbal drugs.

1.2.2.2 Identity

Macroscopical examination

Quality control of herbal drugs has traditionally been based on appearance. A primary visual evaluation, which seldom needs more equipment than a magnifying lens, is to ensure that the plant is of the required species, and that the right part of the plant is used. Although the latter may seem obvious, it is of key importance when for instance different parts of the same plant are to be used for different treatments. Stinging nettle (*Urtica urens* L.) is a classical example: the aboveground parts are used to treat rheumatism, whereas the roots are applied for benign prostrate hyperplasia.

Microscopical examination

Microscopical analysis is a powerful tool to determine the correct species and/or the right part of that species. For instance in the case of flowers, pollen morphology may be used to identify the species. The presence of certain microscopical structures may be used to identify the plant part used, as illustrated by the presence of fragments with leaf stomata in case of a leaf preparation.

Thin layer chromatography (TLC)

A simple chromatographic technique like thin layer chromatography (TLC) may provide valuable additional information to establish the identity of the material. This is especially important for those species which consist of types accumulating different (active) constituents, i.e. chemical races. TLC-fingerprinting provides a powerful and relatively fast solution to distinguish between chemical races, where macroscopy and microscopy will fail.
Furthermore, TLC-fingerprinting is of key importance for those herbal drugs that no longer have any organic structure (essential oils, fatty oils, resins etc.). Chromatograms of e.g. essential oils are widely published in the scientific literature, which can be of invaluable help in identification.

1.2.2.3 Purity

Classically, purity is in general closely linked with the safe use of herbal drugs. It therefore deals with factors such as foreign matter, ash values and heavy metals. However, due to the application of improved analytical methods, a modern purity evaluation generally also includes microbial contamination, aflatoxins, radioactivity and pesticide residues as well.

Determination of foreign matter

Herbal drugs should be entirely free from visible signs of contamination by moulds or insects, including animal excreta. In general, no poisonous, dangerous or otherwise harmful foreign matter or residue should be allowed. Special care should also be taken to avoid the development of a strong microbial contamination, since micro-organisms might produce toxins (WHO, 1998).
Herbal drugs should be made from the plant part stated, should not be contaminated with another part of that plant, or even other plants, and should be free of sand, stones etc. Macroscopic examination can conveniently be employed for determining the presence of foreign matter in herbal drugs (sand, other parts), although microscopy is indispensible in certain special cases (e.g. starch deliberately added to 'dilute' the plant material). Furthermore, when foreign matter consists e.g. of a chemical residue, thin layer chromatography will often prove valuable (WHO, 1998).

Determination of ash

The ash that remains after herbal drug material has been burnt is generally determined by 2 subsequent procedures, which measure total ash and acid-insoluble ash, respectively. The total ash method is designed to measure the total amount of material remaining after burning. It includes both ash derived from the plant tissue itself, as well as acid-insoluble ash. The latter is the residue obtained after boiling the total ash with dilute hydrochloric acid, and igniting the remaining insoluble matter. This second method measures the amount of silica present, especially in the form of sand and siliceous earth (WHO, 1998).

Determination of heavy metals

Contamination of herbal drugs with arsenic and heavy metals like mercury, cadmium and lead can be attributed to many causes, including environmental pollution. They represent a possible danger for the health of the user and should therefore be limited (WHO, 1998).
A simple, straightforward determination of heavy metals can be found in many Pharmacopoeias, and is based on colour reaction with reagents such as thioacetamide or diethyldithio-carbamate (Council of Europe, 1997–2001a). The amount of arsenic in herbal drugs can be estimated by matching the depth of colour with that of a standard stain, as published by the WHO.
In those cases where the exact amounts of the different heavy metals and arsenic have to be known, instrumental methods have to be employed. The highly specific Atomic Absorption Spectrophotometry (AAS) is an appropriate method. In this technique, atoms of a metal are volutized in a flame, and their absorption of a narrow band of radiation is accurately measured (Watson, 1999). A draft method is available in Pharmeuropa (Anonymous, 2001).

Determination of microbial contamination including aflatoxins

Herbal drugs normally carry a great number of bacteria and moulds often originating in the soil. While a large range of bacteria and fungi are from the naturally occurring microflora, aerobic spore-forming bacteria frequently predominate. Also poor methods of harvesting, cleaning, drying, handling and storage may cause additonal contamination, as may be the case with *Escherichia coli* or *Salmonella* spp. (WHO, 1998).

In addition, the presence of fungi should be carefully investigated and/or monitored, since some common species produce toxins, especially aflatoxins. Aflatoxins in herbal drugs can be dangerous to health even if they are absorbed in minute amounts (WHO, 1998).

Laboratory procedures investigating microbial contamination are laid down in the well-known Pharmacopoeias, as well as in the WHO guidelines (WHO, 1998). In general, a complete procedure consists of determining the total aerobic microbial count, the total fungal count, and the total *Enterobacteriaceae* count, together with tests for the presence of *Escherichia coli* and *Salmonella* spp. Limit values can also be found in the sources mentioned; however, they may vary.

Procedures for the determination of aflatoxin contamination in herbal drugs are published by the World Health Organization (1998), and in Pharmeuropa (Anonymous, 1999). After a thorough clean-up procedure, thin layer chromatography is used for confirmation.

Radioactive contamination

A certain degree of exposure to ionizing radiation cannot be avoided since there are many sources, including radionuclides naturally occurring in the environment. Dangerous contamination, however, may be the consequence of a nuclear accident. The World Health Organization, in close cooperation with several other international organizations, has developed guidelines for use in the event of widespread contamination by radionuclides resulting from such a major nuclear accident. These publications emphasize that the health risks from food accidentally contaminated, not only depend on the specific radionuclide and the level of contamination, but also on the quantity of food consumed. In case of herbal drugs, however, taking into account the amounts which are normally used, they are unlikely to be a health risk. Therefore, at present, no limits for radioactive contamination are proposed (WHO, 1998).

Determination of pesticide residues

Herbal drugs are liable to contain pesticide residues which accumulate from agricultural practices, such as spraying, treatment of soils during cultivation, and administering of fumigants during storage (WHO, 1998).

Limits for pesticide residues are published in the European Pharmacopoeia (Anonymous, 1997–2001b) and by the World Health Organization (1998). Samples of herbal material are extracted by a standard procedure, impurities are removed by partition and/or adsorption, and the presence of a moderately broad spectrum of individual pesticides is measured in a single determination by gas chromatography.

Sometimes, however, it may be desirable to test herbal drugs for broad groups in general, rather than for individual pesticides. Many pesticides contain chlorine in the molecule, which for example can be measured by analysis of total organic chlorine. In an analogue way, insecticides containing phosphate can be analyzed for total organic phosphorus. Some simple procedures have been published by the World Health Organization (1998).

1.2.2.4 Content

Where no active constituent or marker can be defined for the herbal drug, the percentage extractable matter may be used as a form of assay. The choice of solvent depends as such on the nature of the compounds involved, and might be deduced from the traditional use. When, in general, a herbal drug is used to make a tea, the hot water extractable matter, expressed in mg/g air-dried material, may serve this purpose (WHO, 1998). The monograph for ginger (*Zingiber officinale* Roscoe) of the European Pharmacopoeia is a classic example. A special form of assay is the determination of essential oils by steam distillation. Many limits on content can be found in the literature, and thus serve their purpose.

In all other cases, when active constituents (sennosides in *Senna*) or markers (alkydamides in *Echinacea*) are known, the vast array of modern chemical-analytical methods can be employed. These include visible-light and ultraviolet spectroscopy, high pressure liquid chromatography (HPLC), gas chromatography (GC) and quantitative thin layer chromatography (TLC), to name a few (Watson, 1999; lit. ref. #3182). All are more or less instrumental systems, which generally consist of costly equipment. Of the methods mentioned, visible light spectroscopy uses a relatively inexpensive device, but is yet able to perform very precise measurements. This might explain why this method is rather popular, as well as the fact that it can be used to determine many natural substances (e.g. alkaloids, anthraquinones, cardioactive glycosides, flavonoids, tannins). Validation procedures are straightforward, and measurements can be made quickly, although clean-up of the samples may be more time consuming.

When more complex samples have to be analyzed, spectroscopy often performs less well, and chromatographic procedures are preferred because of their vast separating capacity. The most universal method is undoubtedly high pressure liquid chromatography and the literature available on plants, plant fractions, mixtures of isolated compounds and purified components is enormous.

Finally, for separation of essential and fatty oils, gas chromatography is the proven method of choice. Although the equipment for gas chromatography is more demanding in its operation (it uses for instance compressed, extremely purified gases), and although some oils also can be succesfully analyzed by using high pressure liquid chromatography, the latter is not likely to replace gas chromatography for oil analysis in the near future.

1.2.3 Anticipated developments

In conclusion, quality control for efficacy and safety of herbal products is of utmost importance. It is obvious that for a given plant product its quality will also be determined by the prevailing conditions during the growth cycle of the plant. Therefore for cultivated plants the concept of a system of 'good agricultural practices' (GAP) has been introduced in the literature. In such a system, every step has to adhere to a set of requirements, involving e.g. seed selection, growing conditions, use of fertilizers, optimization of harvest time, harvest and drying. In other words such a system will focus on total chain control. It is therefore likely that, GAP-procedures will become an integral part of quality control in the near future.

S.F.A.J. Horsten, N. Bunyapraphatsara & J.L.C.H. van Valkenburg

2 Alphabetical treatment of genera, species and groups

Abutilon Miller

Gard. Dict., abr. ed. 4 (1754).

MALVACEAE

x = unknown; *A. hirtum*: $2n$ = 14, 36; *A. indicum*: $2n$ = 36, 42

Major species *Abutilon indicum* (L.) Sweet.

Vernacular names Mallow (En). Mauve (Fr).

Origin and geographic distribution *Abutilon* is a large genus comprising 100–150 species in the tropics and subtropics. Native species are encountered in all continents. Nine species are known from Malesia, but *A. indicum*, *A. hirtum* and *A. theophrasti* Medic. have gained a pantropical distribution as weeds or for fibre use.

Uses *Abutilon* is used medicinally and occasionally as a fibre plant. *A. indicum* leaves contain much mucilage, and are therefore used as a demulcent, a diuretic and a sedative, in Malesia, Thailand and in India. In general, a decoction of the leaves, flowers or seeds is also used to treat fever, colic and diseases of the urinary tract, for cleaning wounds and ulcers and for treating snake bites. In India, the leaves are believed to be an aphrodisiac. In Indonesia, a decoction of the leaves is rubbed on the body against rheumatism. In Peninsular Malaysia, a poultice of the leaves is applied on gums for toothache, and an extract is dropped into the ear for earache. The leaves of *A. indicum* in decoction are used in the Philippines and in India for enemas and vaginal rinses or lotions. In Indo-China, the leaves, flowers and seeds are applied against colds and headaches, and the juice is given as a medicine against jaundice in newborn babies. In India, an infusion of the roots or the leaves is used as a cooling medicine, and for relieving strangury or haematuria. The bitter bark is astringent and is used as a diuretic. In Thailand, the whole plant is considered a blood tonic, promoting digestion and appetite, the root in decoction relieves cough, leucorrhoea with unpleasant odour and gall bladder dysfunction, and the flower is used as a laxative.

In Malesia, *A. hirtum* has the same use as *A. indicum*, as a poultice or bath against kidney gravel, and also for fevers and on ulcers, often mixed with glutinous rice, to ease the pain.

The stems of *A. indicum* yield a good quality fibre, which resembles that of *A. theophrasti*, and is suitable for making ropes. In Malesia, it is used in a domestic way, but not commercially. In India and Kenya, the bark of *A. hirtum* is used to make string.

Production and international trade In South-East Asia, *Abutilon* is traded only at a local level by Chinese herbalists.

Properties Upon steam distillation, the flowering tops of *A. indicum* yield 0.15% of an essential oil, which contains several terpenes, e.g. α-pinene (0.1%), 1:8-cineole (1%), caryophyllene (11.6%), borneol (0.6%), geraniol (13%), geraniol acetate (2%), caryophyllene-oxide (2%), eudesmol (22%) and farnesol (2.8%).

Leaves of *A. indicum* are rich in mucilage. In general the aerial parts of the plant are a rich source of sugars, amino acids and simple phenolic compounds as vanillic, p-coumaric, p-hydroxybenzoic and caffeic acids. Two sesquiterpene lactones, alantolactone (helenin) and isoalantolactone, were isolated from the aerial parts, which are known contact-allergens. The herb also contains a considerable amount of β-carotene, and thus can help to overcome problems of vitamin A deficiency. The seeds contain raffinose and glycerides of linolenic, linoleic, palmitic and stearic acids.

In India, the hexane, benzene, chloroform, ethyl acetate, acetone and ethanol extracts from *A. indicum* roots were tested against 5 bacteria and 12 fungi. The acetone and ethanol extracts showed significant activity against *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiella aeruginosa*, *Proteus* sp. and *Staphylococcus* sp. The hexane extract showed good activity against *P. aeruginosa*, and the benzene extract against *E. coli* and *Proteus* sp. The ethanol extract also was active against *Aspergillus ochraceus*, and the hexane extract against *A. flavus*, *A. ochraceus*, *A. oryzae* and *A. terreus*.

The methanol extract of *A. indicum* was found to be active as an antifertility agent in a study on uterotropic and uterine peroxidase activities in ovary-ectomized rats. In Pakistan, *A. indicum* is mentioned as a potential male contraceptive. There are also some reports on the analgesic activity of *A. indicum*.

Adulterations and substitutes A decoction of the roots and leaves of *Abutilon* is used as an emollient in the same way as *Sida*, *Triumfetta* and *Urena*.

Description Annual or perennial herbs or undershrubs, stems and branches pubescent. Leaves alternate, simple, entire or divided, base mostly cordate, palminerved; petiole present; stipules present. Flowers axillary, solitary, or rarely in terminal cylindric panicles, bisexual, 5-merous; pedicels jointed; epicalyx absent; bracts absent; calyx usually campanulate; corolla adnate at base to staminal column and dehiscent, orange to yellow; staminal column usually shorter than the petals, anthers monothecal; styles equalling or twice as many as carpels (mericarps); carpels and style branches 5–40, cells of the ovary with 2–9 ovules. Fruit globular or cylindrical, lobed schizocarp, splitting into 5–40 carpels. Seeds 2–9 per cell, reniform, lying fairly loosely within the carpel, finally falling out. Seedling with epigeal germination.

Other botanical information *Abutilon* belongs to the tribe *Malveae* and is closely related to *Wissadula*, which has a different habit and inflorescence, and a constriction in the mericarp, so that 2 seeds are present in the upper part, and 1 in the lower part of the mericarp. Some authors recognize a number of subspecies or varieties within *A. indicum*.

Ecology The Malesian species of *Abutilon* are sun-loving, always occurring in open locations in lowland areas. All appear to prefer drier habitats. The flowers usually open in the afternoon or evening. *Abutilon* species are feed plants for humming-birds.

Propagation and planting *Abutilon* is propagated by seed. In a preliminary study on in vitro propagation of the floral buds and anthers of *A. indicum*, some callus formation of the explants occurred. Flower buds showed callusing in 25% of the cases in two weeks, when cultured on Bourgin and Nitsch medium with growth adjuvants + 2% sucrose + 1 ppm indole acetic acid, and some further rooting occurred later.

Diseases and pests *Abutilon* species are often effective hosts for diseases and pests that attack malvaceous crops. *A. indicum* is attacked by several powdery mildew fungi. *Abutilon* is a serious host for several insect pests of cotton, e.g. red cotton bug (*Dysdercus koeningii*), cotton bollworm (*Heliothis armigera*) and spotted cotton bollworm (*Earias vittella*). Root-knot nematodes such as *Meloidogyne javanica* and *M. incognita* also frequently attack *Abutilon*. In Nigeria, *A. hirtum* is a host for okra mosaic virus. *A. indicum* can be successfully controlled using phenoxy herbicides.

Harvesting *Abutilon* leaves are harvested throughout the year, whole plants are harvested after flowering or fruiting.

Handling after harvest Whole plants of *Abutilon* are used fresh or dried.

Genetic resources and breeding The *Abutilon* species described here have a wide distribution, and occur also as weeds in disturbed places; therefore they are not likely to be threatened by genetic erosion. Small germplasm collections of *A. indicum* are kept in the United Kingdom and the United States.

Prospects No changes in the current uses of *Abutilon* species are yet foreseen. Since little information on phytochemistry and pharmacology is available, they will likely remain of local importance.

Literature |1| Geda, A. & Gupta, A.K., 1983. Chemical investigation of essential oil of Abutilon indicum. Perfumer and Flavorist 8(3): 39. |2| Johri, R.K., Pahwa, G.S., Sharma, S.C. & Zutshi, U., 1991. Determination of estrogenic-antiestrogenic potential of antifertility substances using rat uterine peroxidase assay. Contraception 44(5): 549–558. |3| Mehta, B.K., Neogi, R., Kotra, S. & Mall, O.P., 1997. Antimicrobial activity of Abutilon indicum. Fitoterapia 68 (3): 273–274. |4| Nataraja, K. & Patil, J.S., 1984. Responses of isolated floral buds and anthers of Abutilon indicum in vitro. Current Science 53(14): 757–759. |5| Quisumbing, E., 1978. Medicinal plants of the Philippines. Katha Publishing Co., Quezon City, the Philippines. pp. 574–575. |6| Van Borssum Waalkes, J., 1966. Malesian Malvaceae revised. Abutilon. Blumea 14(1): 159–177.

Selection of species

Abutilon hirtum (Lamk) Sweet

Hort. Brit. 1: 53 (1826).

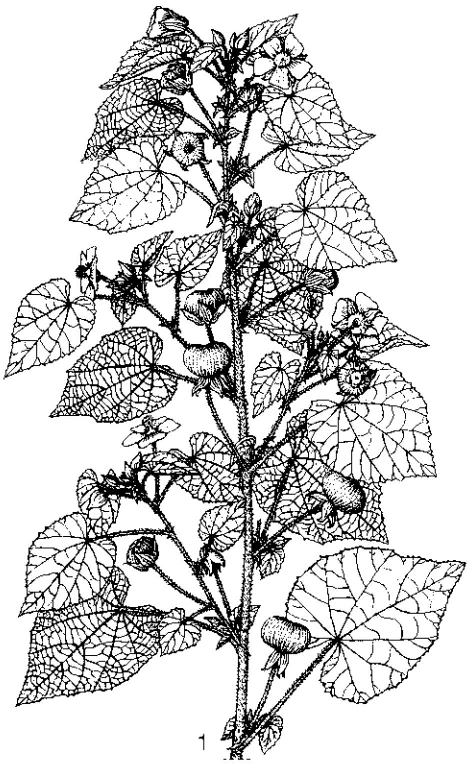
Synonyms *Abutilon graveolens* (Roxb. ex Hornem.) Wight & Arn. ex Wight (1833).

Vernacular names Indonesia: kecemplok (Javanese), kembang sore besar (Balinese), bunga waktu kuning (Moluccas). Malaysia: angouri, bunga petang. Thailand: khrop chak krawaan (central), top taap (northern), khrop see (peninsular).

Distribution *A. hirtum* occurs in the drier tropical regions of the Old World, and is introduced into the Americas. In Malesia, it occurs locally throughout the area, except for Sumatra, the Moluccas and New Guinea.

Uses In Malesia, *A. hirtum* is used as a poultice to ease the pain of kidney gravel and often mixed with glutinous rice and applied to ulcers. In Thailand, the roots are used against cough and toothache, and as an antipyretic. The leaves or flowers are applied to abscesses.

Observations An undershrub up to about 2.5 m tall; stems, petioles and pedicels densely covered with patent, long, shiny simple hairs, minute stellate hairs, and viscid by short glandular hairs; corolla orange-yellow, usually with a purple cen-



1

Abutilon hirtum (Lamk) Sweet – 1, flowering and fruiting branch.

tre; seed completely or partly covered with short, patent, white hairs. In Malesia, *A. hirtum* is found in waste places and along roadsides, especially in regions with a distinct dry season.

Selected sources 786.

Abutilon indicum (L.) Sweet

Hort. Brit. 1: 54 (1826).

Vernacular names Country mallow, moonflower (En). Fausse guimauve (Fr). Indonesia: belangan sumpa (Palembang), cemplok (Javanese), kecil (Moluccas). Malaysia: bunga kisar, kembang lohor (Peninsular). Philippines: malbas, tabing (Tagalog), dalupang (Bisaya). Thailand: phong phaang (eastern), khrop fan see (central), ma kong khaao (northern). Cambodia: dok toc lai. Laos: houk phao ton. Vienam: c[oos]i xay, d[awf]ng xay.

Distribution *A. indicum* occurs in tropical and warm temperate countries throughout the world. Some varieties are restricted to the Old World.

Uses *A. indicum* leaves are widely used as a demulcent and a diuretic. The decoction of the leaves, flowers or seeds is also used to treat fever, colic, and for cleaning wounds and ulcers.

Observations A very variable undershrub, usually up to 1 m tall; stems, petioles and pedicels densely covered with downy stellate hairs, no glandular hairs; corolla yellow to pale orange, without purple centre; seed glabrous, or covered with tiny scales or minute stellate hairs. *A. indicum* is very common ruderally around villages and roadsides, along the beach and in secondary bushes, at low altitudes.

Selected sources 75, 135, 201, 215, 264, 332, 380, 701, 739, 786.

Balu Perumal

Acalypha L.

Sp. pl. 2: 1003 (1753); Gen. pl. ed. 5: 436 (1754).

EUPHORBIACEAE

x = unknown; *A. hispida*: $2n = 112$, *A. indica*: $2n = 20, 28$, *A. lanceolata*: $2n = 40$, *A. wilkesiana*: $2n = 20, 80, 120, 140, 180, 200$

Major species *Acalypha indica* L., *A. wilkesiana* Müll. Arg.

Vernacular names Copper-leaf, three-seeded mercury (En)(for ornamentals only).

Origin and geographic distribution *Acalypha* is widespread throughout the tropics, and comprises about 430 species. In Thailand about 10 species occur, in New Guinea about 18, in Borneo about 4, in Sumatra about 6, in the Philippines about 16 and in Vietnam about 10.

Uses A considerable number of *Acalypha* is used in local medicine for a variety of complaints. Uses may vary from region to region, sometimes depending on the availability of specific species. The leaves of *A. indica* are used in decoction or powdered for their laxative properties. They are applied Externally to sores and ulcers. The expressed juice mixed with oil, lime or salt is externally applied to rheumatoid arthritis, and to cure scabies and other skin affections. In addition, the whole plant is used as an expectorant. In the Philippines, the leaves of *A. caturus* Blume (synonym *A. cardiophylla* Merr.) are externally applied to the head to relieve headache and the bark is applied on deep ulcers. In the Solomon Islands leaves of *A. novoguineensis* Warb. are used as an antiseptic and externally applied to reduce swellings.

The shoots of *A. indica* and *A. wilkesiana* without flowers are eaten as a cooked vegetable. *A. hispida* and *A. wilkesiana* are widely grown as pot plants and garden ornamentals all over the world.

Production and international trade As medicinal uses of *Acalypha* are found at local level only, trade statistics are not available. The ornamental *Acalypha*, commonly planted as a hedge plant, are commercially grown as pot plants as well, but trade statistics are only available for Western countries.

Properties The dried aerial parts of *A. indica* are known to contain a cyanogenic glycoside, acalyphine (0.3%) which is a 3-cyanopyridone derivative. Older publications also mention the alkaloid 'acalyphine', without structural elucidation. This compound is most probably identical to triacetonamine, mentioned in more recent reports. Other constituents include sterols (β-sitosterol, 0.1%), a resin and an essential oil. In addition to hydrocyanic acid, *A. indica* contains other substances which cause intense, dark chocolate brown discolouration of blood and gastro-intestinal irritation in rabbits. Furthermore, ingestion of herbal medicine containing *A. indica* may lead to haemolysis in patients suffering from glucose-6-phosphatase dehydrogenase deficiency. Crude extracts of shoots, leaves and roots show antibacterial and antifungal activity. Activity against gram-positive bacteria strains is more pronounced than against gram-negative strains. Susceptible fungi include *Aspergillus niger* and *Candida albicans*.

An amide (acalyphamide I, isolated as its acetate), together with the modified dipeptide aurantiamide and its acetate were isolated from the leaves and twigs of *A. indica* . Acalyphamide I has been characterized as an amide of tyramine (p-hydroxy-β-phenethylamine) and dotriacontanoic acid ($C_{31}H_{63}COOH$). Aurantiamide and its acetate are the first modified dipeptides to be reported from an *Euphorbiaceae*, and acalyphamide is one of the few natural tyramine amides. The occurrence of these compounds is therefore of considerable biogenetic and chemotaxonomic significance.

Very little is known about the chemical constituents of *A. wilkesiana*, although information is available on biological activities. The methanol extract of the leaves contains phenolic acids. In an ethanol extract of the leaves, no cyanogenic compounds or triacetonamine could be detected. Screening of an extract of the leaves of *A. wilkesiana* for antimicrobial activity using the agar diffusion method, showed activity against 7 test organisms: *Bacillus cereus*, *B. subtilis*, *Escherichia coli*, *Klebsiella pneumoniae*, *Proteus vulgaris*, *Serratia marcescens* and *Staphylococcus aureus*. In another experiment, water, ethanol, chloroform and hexane extracts of *A. wilkesiana* leaves were investigated for in vitro antimicrobial activities by agar-diffusion and tube-dilution techniques. The water and ethanol extracts inhibited the growth of standard and local strains of bacteria and fungi including *Staphylococcus aureus*, *Trichophyton rubrum*, *T. mentagrophytes*, *Candida albicans* and *Aspergillus flavus*. The water extract did not exert any inhibitory action on *Klebsiella pneumoniae* and *Proteus mirabilis*, while the ethanol extract was active. In general, the water extract was found to be bacteriostatic and fungistatic in action, while the ethanol extract was uniformly microbicidal in effect at a mimimal inhibitory concentration (MIC) of 1–64 mg/ml.

The water extract of the leaves of *A. wilkesiana* was subjected to a clinical laboratory study in Nigeria to assess its efficacy: i.e. ability to clear standard microorganisms in agar plates and to stop symptoms and clear skin lesions of eczema cases over a 3-week study period. The extract showed significant antibacterial and antifungal properties in vitro. Furthermore, it was found to be reasonably useful in the treatment of 4 patients with eczema using topical preparations (cream or ointment), since no allergy or irritation was documented.

Ethanol extracts of *A. indica* show selective activity against vesicular stomatitis viruses at an MIC of 5–100 μg/ml. Cytotoxic activity was observed against HeLa cell lines at a CD_{50} of 1–100 μg/ml.

Analysis of the shoots of *A. indica* yielded per 100 g edible portion: water 80.5 g, protein 6.7 g, fat 1.4 g, carbohydrates 6.0 g, fibre 2.3 g, ash 3.1 g; calcium 667 mg, phosphorus 99,0 mg, iron 17.3 mg and vitamin C 147 mg. The energy value is 269 kJ/100 g.

Description Shrubs, rarely small trees, occasionally scrambling, or nettle-like perennial or annual herbs, mostly monoecious. Leaves simple, alternate, crenate, dentate or subentire, palmati- or penninerved, petiolate; stipules lanceolate, subulate or setaceous, sometimes minute. Inflorescence unisexual or bisexual; when bisexual the sexes are very diversely arranged; male flowers commonly in slender dense-flowered spikes, with 1–few female flowers at the base, or female flowers alone in relatively short and less dense-flowered racemes; bracts often lobed or dentate and accrescent in fruit. Male flower mostly minute, calyx closed in bud, splitting valvately into 4 segments; petals absent; disk absent; stamens 8–12, free; pistillode absent. Female flower with 3–5 sepals, shortly connate, imbricate; ovary 2–3 locular, 1 ovule per locule, styles mostly conspicuous and laciniate. Fruit a small 2–3-locular capsule. Seed rounded, smooth sometimes with a conspicuous hilum or caruncle; testa crustaceous; albumen fleshy; cotyledons broad, flat.

Growth and development *A. hispida*, *A. indica* and *A. wilkesiana* flower throughout the year in regions without a pronounced dry season.

Other botanical information An overall revision of *Acalypha* for the Malesian region is badly needed. Some species appear to be well defined whereas other species complexes may well be considered as broad aggregate species. Here the more narrowly defined conservative concept has been followed. Two well-known ornamentals, *A. godseffiana* Masters and *A. hamiltoniana* Bruant, are regarded as cultigens and derived from *A. wilkesiana*. In general the widely cultivated *Acalypha* species are polyploids.

Ecology *Acalypha* is found in a wide range of vegetation types on various soils.

Propagation and planting Under greenhouse conditions *A. hispida* and *A. wilkesiana* are propagated from cuttings which root in 4 weeks at 22°C soil temperature and are ready for marketing in 6 months. *A. hispida* is pinched only once to produce large showy plants whereas *A. wilkesiana* hybrids must be pinched at least twice to produce low, compact plants that do not need chlormequat treatment. The most effective medium for in vitro propagation of *A. wilkesiana* is composed of Murashige and Skoog medium and vitamins, 2% sucrose, 170 mg/l $NaH_2PO_4.H_2O$ and 0.2 mg/l butyric acid (BA) without auxin. A modified White's medium without auxin gave effective rooting in 10–14 days. Plantlets set into soil in the greenhouse were ready for transplanting outdoors in 45 days.

Diseases and pests *A. indica* is often considered an obnoxious weed. Its leaves may suffer from *Alternaria* leaf spot; in India it is sometimes severely affected by *Pseudocercospora acalyphae*. Roots may suffer from nematode infestation (e.g. *Meloidogyne* spp.).

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

Handling after harvest After harvesting, plants of *A. indica* are simply dried for future use.

Genetic resources and breeding *A. wilkesiana* with mosaic foliage is raised in Denmark, under the name *Acalypha* cv. Musaica and includes the multicoloured cultivars 'Batik', 'Harlekin' and 'Kankan'. In the United Kingdom a multitude of cultivars of *A. wilkesiana* is distinguished by foliage colour and pattern like 'Ceylon', 'Hoffmanna', 'Macafeeana', 'Macrophylla', 'Marginata', 'Miltonia', 'Moorea', 'Musaica' and 'Obovata'.

Prospects Little is known about the chemical constituents and biological activity of *Acalypha*. They are, however, of local importance e.g. in the treatment of skin infections or eczemas.

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Selection of species

Acalypha australis L.

Sp. pl. 2: 1004 (1753).

Vernacular names Vietnam: tai t[uw][owj]ng l[as] hoa, tai t[uw][owj]ng nam, thi[ees]t hi[eej]n th[as]i.

Distribution From Japan, China and Taiwan, throughout Indo-China to the Philippines. Introduced and locally naturalized in Australia; records for Indonesia are disputed.

Uses The whole plant of *A. australis* is used to cure dysentery, diarrhoea, scrofula, dermatitis, nosebleed, haemoptysis, as well as to stop coughs and to cure swollen feet. The leaves are used in poulticing snake bites.

Observations An erect, annual herb, up to 30–60 cm tall; leaves rhomboid to lanceolate, 3–8 cm × 1.5–3.5 cm, margins serrate, petiole slender, 2–3 cm long; inflorescence axillary, racemose-spicate, unisexual, 1–2 cm long; female inflorescence enclosed in 4 bracts, each bract containing 4–5 flowers. *A. australis* is locally common in open disturbed habitats, and gardens from sea-level up to 1500 m altitude.

Selected sources 331, 786.

Acalypha grandis Benth.

in Hook., Lond. Journ. Bot. 2: 232 (1843).

Synonyms *Acalypha consimilis* Müll. Arg. (1866).

Vernacular names Indonesia: saboboku (Halmahera), lofiti roriha (Ternate), ekor kuching utan (Malay). Papua New Guinea: atepulopulo (Wagawaga, Milne Bay). Vietnam: tai t[uw][owj]ng l[ows]n.

Distribution From the Philippines southward to the Moluccas and eastward to New Guinea, Admiralty Islands and Bismarck Archipelago. Cultivated in Thailand and Vietnam.

Uses In the Moluccas, the sap of the pounded inner bark is employed as a mouthwash against thrush. The sap of heated leaves in combination with *Citrus* sap is given as a remedy for thrush in children. Finely crushed leaves and flowers are added to food as an antidiarrhoeal. A poultice of the leaves is an effective remedy for boils and other skin affections. In Milne Bay, Papua New Guinea, leaf sap is drunk with water, to treat diarrhoea and dysentery.

Observations A spreading shrub or small tree up to 10 m tall, young parts fulvous puberulous; leaves broadly ovate, 25 cm × 20 cm, base variably cordate, apex shortly caudate acuminate, margin variably crenate-serrate, petiole up to 17 cm long, stipules lanceolate, up to 1 cm long; male inflorescence up to 20 cm long; female inflorescence up to 17 cm long, lax-flowered, bract very variable, up to 10 cm diameter, toothed, accrescent. *A. grandis* is found in primary or secondary forest, on stream banks, or in regrowth along lava flows up to 150 m altitude.

Selected sources 31, 33, 35, 320, 407, 418, 786.

Acalypha hellwigii Warb.

Bot. Jahrb. 18: 198 (1894).

Synonyms *Acalypha scandens* Warb. (1891) non Benth. (1854).

Vernacular names Papua New Guinea: bluwa (Buang, Morobe Province).

Distribution Sulawesi and New Guinea.

Uses In Morobe Province, Papua New Guinea, leaves are used to hold a strongly heated quartz pebble and water is directed onto a sore through a funnel of leaves. The leaves are also used as cigarette wrapper, or smoked as such. The timber is locally used for house construction.

Observations A scrambling climber, sprawling shrub or tree up to 5 m tall; leaves narrowly ovate to elliptical, margins sharply serrate, stiff coriaceous, penninerved, petiole short; female inflorescence rather lax-flowered, up to 25 cm long with short 7–11 toothed bracts. New Guinea material is sometimes erroneously identified as *A. insulana* Müll. Arg., a very similar yet distinct species from Fiji. *A. hellwigii* is exceedingly variable and found on a wide range of soils in habitats ranging from strand vegetation, secondary scrub to primary forest from sea-level up to 2500 m altitude.

Selected sources 33, 35, 436.

Acalypha hispida Burm.f.

Fl. ind.: 203, t. 61, fig. 1 (1768).

Synonyms *Acalypha densiflora* Blume (1826).

Vernacular names Red hot cat-tail, chenille plant (En). Indonesia: buntut kuching (Malay, Jakarta), tali anjing (Sundanese), wunga tambang (Javanese). Malaysia: buntut kuching, ekur kuching. Thailand: mai prom (northern), haang krarok daeng (central), huu plaa chon (southwestern). Vietnam: tai t[uw][owj]ng xanh, tai t[uw][owj]ng du[oo]i ch[oof]n.

Distribution Supposed to have originated in New Guinea, frequently cultivated elsewhere throughout Malesia and other tropical regions.

Uses In Indonesia, the roots and flowers, fresh or in decoction, are considered a remedy for haemoptysis. The leaves are used to treat thrush. In Malaysia a decoction of the leaves and flowers is externally applied as an emollient to wounds and ulcers; internally it is used as a laxative and diuretic in gonorrhoea. The bark is applied as an expectorant in asthma.

Observations A shrub up to 3 m tall; leaves ovate, 9–20 cm × 7–15 cm, base broadly cuneate, apex narrowly acute or obtuse, margin serrate, petiole 1–5(–10) cm long; female inflorescence pendulous, 10–50 cm long, thick, with a dense mat of crimson styles. In cultivation, usually var. *sander* (N.E. Br.) J.J. Smith is encountered, which has a more robust habit, larger green, slightly cordate leaves, with longer petioles and longer female inflorescences.

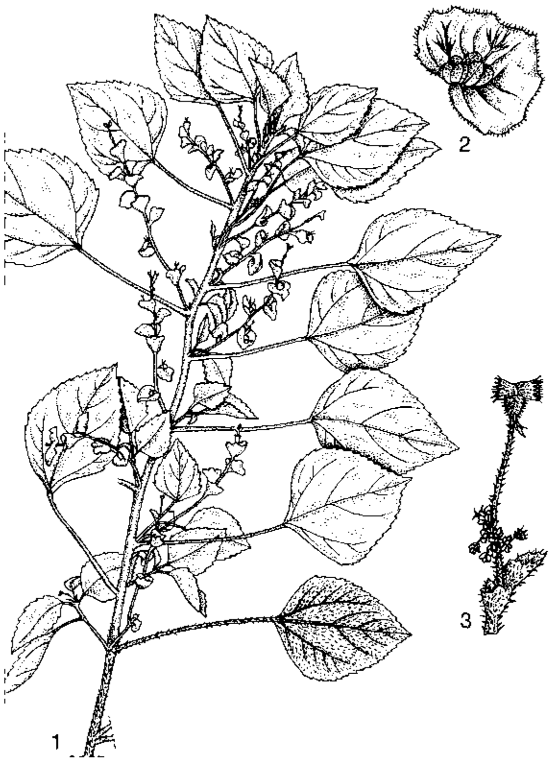
Selected sources 31, 33, 35, 36, 74, 135, 215, 407, 459, 662, 786, 813.

Acalypha indica L.

Sp. pl. 2: 1003 (1753).

Synonyms *Acalypha chinensis* Benth. (1861), *Acalypha caroliniana* Blanco (1837) non Walt. (1788).

Vernacular names Indian acalypha, three-seeded mercury (En). Indonesia: lelatang, rumput kokosongan. Malaysia: rumput lislis, tjeka mas. Philippines: bugos (Tagalog), maraotong, tapta-



Acalypha indica L. – 1, flowering twig; 2, female flowers with bract; 3, apex of inflorescence with allomorphic flower.

pingar (Ilokano). Thailand: tamyae tuaphuu, tamyae maeo (central), haan maeo (northern). Vietnam: tai t[uw][owj]ng [aas]n, tai t[uw][owj]ng xanh.

Distribution Widespread in the Old World tropics from West Africa throughout India, Indo-China to the Philippines and Java, but apparently absent from Borneo and rare in eastern Malesia.

Uses In Indonesia and Thailand, the leaves are externally applied on sores and swellings. In Malaysia and Thailand, a decoction of the plant is taken as a purgative. In the Philippines, fresh juice or a decoction of roots and leaves is, depending on dosage, given to children as an emetic or expectorant in bronchitis and asthma. A paste of fresh leaves is applied as a suppository to loosen the bowels of children. In southern Vietnam the leaves are used as an anthelmintic and the roots as a cathartic. In Indonesia, the root is considered a universal remedy for cats, based on observations of cats consuming the roots.

Observations An erect, annual herb, up to 1.5 m tall; leaves rhombic- ovate, (1–)3–5(–7) cm × (1–)2.5–3(–5) cm, base cuneate, margin shallowly serrate, petiole 2–6 cm long; inflorescences bisexual, solitary, with a short slender male portion, female flowers fewer and less crowded than in *A. lanceolata*, with broad, shallowly and obtusely toothed bracts, which are much less closely nerved, producing allomorphic female flowers at the apex; fruit 2–2.5 mm in diameter. *A. indica* is found in waste places and cropped land at low altitudes, and is locally common.

Selected sources 31, 33, 34, 35, 36, 74, 128, 135, 215, 380, 407, 412, 662, 714, 739, 786, 788, 810, 822, 841.

Acalypha lanceolata Willd.

Sp. pl. 4: 524 (1805).

Synonyms *Acalypha boehmeriodes* Miq. (1861), *Acalypha fallax* Müll. Arg. (1865).

Vernacular names Indonesia: klatang (Javanese), pulus hayam (Sundanese), daun brahman (Malay). Vietnam: tai t[uw][owj] thon.

Distribution From India eastward to the Philippines, throughout Malesia and Polynesia.

Uses In the Moluccas, the leaves are applied as an antiseptic on boils and swellings. In Indo-China the whole plant is used to relieve headache. In Fiji, the plant is used as a vermicide and a carminative, and is also applied to sores. Its close resemblance to *A. indica* may account for the overlap in uses and confusion concerning identity of the plants.

Observations An erect or straggling, annual, weedy herb up to 1 m tall; leaves ovate, 0.5–6(–11) cm × 0.5–3.5(–7) cm, base cuneate to truncate, apex acute to shortly acuminate, margin crenate, petiole 1.5–9 cm long; inflorescences bisexual, 1–4 together, shorter than or equalling the petioles, with a short slender male section, female flowers with small bracts, strongly parallel-veined, with numerous acute teeth, sepals 3, lanceolate; producing allomorphic female flowers in the transitional zone; fruit depressed globose, 1.5–2 mm × 2–3 mm. *A. lanceolata* is found along roadsides or abandoned fields, at low altitude, and is locally common.

Selected sources 31, 32, 33, 34, 35, 36, 74, 143, 407, 662, 786, 788, 813, 841.

Acalypha siamensis Oliv. ex Gage

Rec. Bot. Surv. India 9: 238 (1922).

Synonyms *Acalypha evrardii* Gagnep. (1923), *Acalypha sphenophylla* Pax & K. Hoffm. (1924).

Vernacular names Wild tea (En). Indonesia: pokok teh (Sumatra), teh-tehan (Javanese). Malaysia: teh hutan, teh kampung, tumput. Cambodia: taè préi. Thailand: cha-khoi (northern), charuesei (central), phakduk (south-western). Vietnam:tr[af] c[oj]c r[af]o, tai t[uw][owj]ng xi[ee]m, ch[ef] m[ax]n h[ar]o.

Distribution Native in Peninsular Malaysia, Burma (Myanmar), Thailand, Cambodia, Laos and Vietnam and currently cultivated in Thailand, peninsular Malaysia and Indonesia.

Uses In Indo-China an infusion of the leaves and flowers is taken as a diuretic. A hot infusion of dried leaves is drunk as a substitute for tea and considered beneficial for intestinal complaints by the Thais and Malays. The leaves are considered a remedy for worms, an emetic and expectorant. A poultice of the leaves is applied as a febrifuge. The plant is often cultivated as a hedge plant.

Observations A shrub or small scrambling tree up to 4 m tall; leaves rhombic-lanceolate, 2–10 cm × 1–5 cm, margin serrate, glabrous, petiole less than 1 cm long; inflorescence axillary, racemose-spicate, bisexual, up to 5 cm long, upper part male with 2–3 female flowers at the base, enclosed in a large herbaceous bract; fruit 2.5 mm long, covered with long protuberances. *A. siamensis* is locally common in dry evergreen or mixed forest or scrub vegetation, often on sandy soils, sometimes on limestone up to 400 m altitude.

Selected sources 31, 135, 331, 786, 788, 841.

Acalypha wilkesiana Müll. Arg.

in DC., Prodr. 15(2): 817 (1866).

Synonyms *Acalypha godseffiana* Masters (1898).

Vernacular names Papua New Guinea: kavus (Lamasong, New Ireland), kokoai (Raluana, Gazelle Peninsula, New Britain), haunuana (Delena, Central Province). Thailand: pho ngoen, pho daang (central), bai ngoen (southeastern). Vietnam: tai t[uw][owj]ng d[or].

Distribution Possibly a native of Polynesia, widely cultivated as an ornamental in South-East Asia.

Uses In New Ireland, leaves are heated over a fire and squeezed when soft. The juice is drunk to soothe throat infections such as laryngitis. In New Britain leaves are used to treat diarrhoea, whereas on the Gazelle Peninsula, leaf juice is drunk with water to treat diarrhoea and dysentery. In the Central Province boiled leaves are used to massage people suffering from fever. In the Southern Highlands the bark is used as a poison. In Fiji, an infusion of leaves and bark is drunk as a treatment for pleurisy. The leaves are squeezed and mixed with water, and drunk to regulate menstruation. A decoction of the leaves is used to treat gastritis and lymphoid swellings. In Central America, fresh leafy branches are externally applied to induce perspiration, apparently for their rubefacient effect. Similarly, heated leaves are applied to cure fevers. Likewise fresh or heated leaves are externally applied to relieve rheumatic pains, inflammations and swellings. In West Africa the water extract of the reddish form is traditionally used for treating skin problems.

Observations An erect or spreading, evergreen, monoecious shrub, up to 2(–6) m tall; leaves ovate, (4–)7–25 cm × (2–)5–15 cm, base cordate, cuneate or obtuse, apex acute to short acuminate, margin crenate, often variegated, or twisted and distorted, petiole 1.5–12 cm long; inflorescence axillary and single, usually unisexual; male inflorescence racemose, up to 14 cm long, densely flowered with glomerules along the axis; female inflorescence spicate, 10–14 cm long, one to several flowered, bracts deeply lobed; fruit depressed globose, 2.5 mm × 3 mm.

Selected sources 13, 31, 32, 33, 35, 36, 74, 143, 320, 418, 422, 430, 431, 459, 567, 662, 696, 813, 965.

Arbayah H. Siregar

Acanthus L.

Sp. pl. 2: 639 (1753); Gen. pl. 2: 1090 (1876).

ACANTHACEAE

x = unknown; *A. ebracteatus*: $2n = 44$; *A. ilicifolius*: $2n = 44, (48)$

Major species *Acanthus ebracteatus* Vahl, *A. ilicifolius* L.

Origin and geographic distribution *Acanthus* comprises 10–30 species, distributed mainly in the tropics and subtropics of the Old World, but also with a centre of diversity in the Mediterranean region.

Uses In Indonesia and Malaysia, *A. ebracteatus* and *A. ilicifolius* are often used in the same way, mainly for the treatment of boils, and as an antiphlogistic and expectorant. In China, the plants are prescribed in hepatosplenomegaly, hepatitis, lymphoma and asthma. The tender shoots and leaves of *A. ilicifolius* are also used as an antidote for arrow and snake poison; they are chewed and applied as a poultice on wounds. The leaves are mashed together with ginger, and put on sore legs or to treat rheumatic pains, while a porridge from the leaves and stems is taken for bowel complaints, stitches in the side, and as a purgative. In

Indonesia and Thailand, the powdered seeds are taken with water for purifying the blood, or the pounded seeds are applied on infected wounds, while a few seeds act as a vermifuge, when swallowed.

A. ebracteatus is commonly used in Peninsular Malaysia as a cough mixture, made from the boiled seeds. In the Philippines, Indo-China and India, a decoction of the mucilaginous leaves and roots is considered astringent, emollient and expectorant, and used on swellings, against coughs, asthma and rheumatism, and boiled in milk against leucorrhoea. In China, the roots are used to treat chronic fever.

In India, goats and cattle eat the young leaves of *A. ebracteatus*, but only when chopped and bruised. In the Philippines, lye is prepared from the ash of the whole plant for making soap. In Thailand, a decoction of the leaves of *A. ilicifolius* is used as a hair tonic, for wound healing and skin diseases.

Production and international trade Plants of both *Acanthus* species are generally collected from the wild for use within the region. International trade exists within the Chinese herbal medicine network, but export from South-East Asian countries is not known to exist.

Properties Besides the well-known sterols e.g. sitosterol, stigmasterol and their glycosides, *A. ilicifolius* contains the alkaloid 2-benzoxazolinone, which shows leishmanicidal activity in vitro. An extract of the plant also displays analgesic, anti-inflammatory and antileukaemic activity. A mosquito coil prepared with leaves of *A. ilicifolius* shows a high activity against biting of the mosquito *Aedes aegypti*, but the roots do not display any larvicidal action.

The seeds of *A. ebracteatus* contain 2(3H)-benzoxazolone. Several extracts of the aerial parts of this plant, especially those prepared by organic solvent extraction, strongly inhibit the mutagenicity of aflatoxin B1, an indirect mutagen, when tested in the presence of S-9 mix. These fractions also markedly inhibit the activity of rat liver aniline hydroxylase, an enzyme necessary for activation of indirect mutagens. An extract of the aerial parts inhibits pro-inflammatory eicosanoid synthesis in activated leucocytes. Finally, an ethanol extract of the aerial parts of *A. ebracteatus* shows 100% mortality on larvae of the tick *Boophilus microplus*.

Description Erect or reclining shrubby herbs, mostly perennial. Leaves decussate, simple, undulate to pinnatifid, rarely entire, margins often spiny, rigid, without cystoliths, dark green and shiny; petiole present; stipules absent, but often with a pair of spines from the leaves in the stipular position. Inflorescence a terminal uninterrupted spike. Flowers bisexual, asymmetrical; bracts imbricate, ovate, large; bracteoles in 2 pairs, oblong; calyx 4-partite, lobes imbricate, 2 outer ones larger, corolla tube short, horny, upper lip absent, lower lip elongate, obtusely 3-lobed; stamens 4, slightly didynamous, filaments stout, attached to the corolla throat, anthers 1-celled, linear oblong, bearded along 1 margin; ovules 2 in each loculus, style slender, stigma 2-fid. Fruit a capsule, erect, oblong to ellipsoid. Seeds 4, orbicular, muricate, glandular. Seedling with hypogeal germination.

Growth and development Growth of *A. ebracteatus* and *A. ilicifolius* is continuous in the sense that there are no resting terminal buds. In South-East Asia flowering and fruiting are non-seasonal. Flowers are pollinated by both sunbirds and insects. The weak protandry restricts self-pollination. Flowers usually last 2 days, only a few opened flowers are found at a time on a spike.

Other botanical information *Acanthus* is closely related to *Blepharis* and *Crossandra*, all having 1-celled anthers and 4 calyx segments. Some authors consider *A. ebracteatus* and *A. ilicifolius* as variations of one species. There is a lot of variation in leaf form in both species, they mostly have a sinuous dentate and spinous margin, but can also be spineless and entire. The form with entire, spineless margins has been assumed to be a separate species, *A. volubilis* Wallich, but is here considered a synonym of *A. ilicifolius*. This foliar variation is partly genotypic and partly phenotypic; lack of spines and undulate margins seems to be a juvenile character, but can also occur just below the inflorescence. The spininess seems to be accentuated with water stress, which is related to salinity, seasonality and light intensity.

The epidermal glands of *A. ilicifolius* are the source of secreted salt, which gives the upper leaf surface a greasy feel.

Ecology *Acanthus* species from India and South-East Asia are mangrove and salt-marsh plants, very common along banks of estuaries and lagoons close to the seashore. They grow well on fine silt or mud with high salt content and high water level. Diurnal fluctuations in inundation can be tolerated but not continuous water logging.

Propagation and planting *Acanthus* is propagated by seed. Release of the seed is explosive, with the capsule splitting violently, dispersing the seeds up to 2 m away. *A. ebracteatus* and *A. ilicifolius* grow in clumps in the wild, and division of these clumps is also a means of propagation.

Diseases and pests *A. ebracteatus* and *A. ilicifolius* are normally free from diseases and pests.

Harvesting Harvesting of *Acanthus* from the wild can be done throughout the year. When dug up for the roots, plants should be replanted with some small roots left.

Handling after harvest Fruits of *Acanthus* harvested for the seeds are sold fresh in Malaysia. Fruits and roots should be dried and kept as stock.

Genetic resources and breeding In India, flowering phenology and pollination of *A. ilicifolius* are being studied in order to plan regeneration and breeding programmes. With the help of molecular markers the genetic polymorphism was determined in 8 populations of *A. ilicifolius* along the Indian coast; moderate genetic polymorphism was found between populations and low polymorphism within populations. Destructive harvesting of the plants to obtain the roots and habitat destruction are affecting the *Acanthus* populations.

Prospects Very little is known about the phytochemistry and pharmacology of both *Acanthus* species. Their activities against mosquitos and ticks are interesting, and therefore *Acanthus* spp. might be of some local importance in controlling them.

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Selection of species

Acanthus ebracteatus Vahl

Symb. bot. 2: 75, t. 40 (1791).

Vernacular names Sea holly (En). Indonesia: daruju (Javanese), juruju (Sumatra). Malaysia: jeruju hitam, beruju (Peninsular). Thailand: ngueak plaa mo (general). Vietnam: [oo] r[oo].

Distribution Distributed from South-East Asia to northern Australia. Very common in Malaysia, but less common in Indonesia.

Uses The boiled seeds of *A. ebracteatus* are commonly used in Peninsular Malaysia, as an ingredient of a cough medicine. The seeds are also used for poulticing boils, or the decoction is drunk against boils. In Thailand, the roots and stem are used for skin diseases and for longevity.

Observations An erect or reclining, smooth herb, up to 1 m tall, scarcely branched, with adventitious aerial roots; leaves oblong, 12–20 cm × 3–5 cm; spike up to 10 cm long, many-flowered, bracts ovate, 6–8 mm long, bracteoles early caducous, calyx lobes ovate, corolla lobe elliptical-oblong, 2.5 cm × 2 cm, white, rarely blueish. *A. ebracteatus* is gregarious and very common in tidal rivers.

Selected sources 135, 297, 449, 786, 846.

Acanthus ilicifolius L.

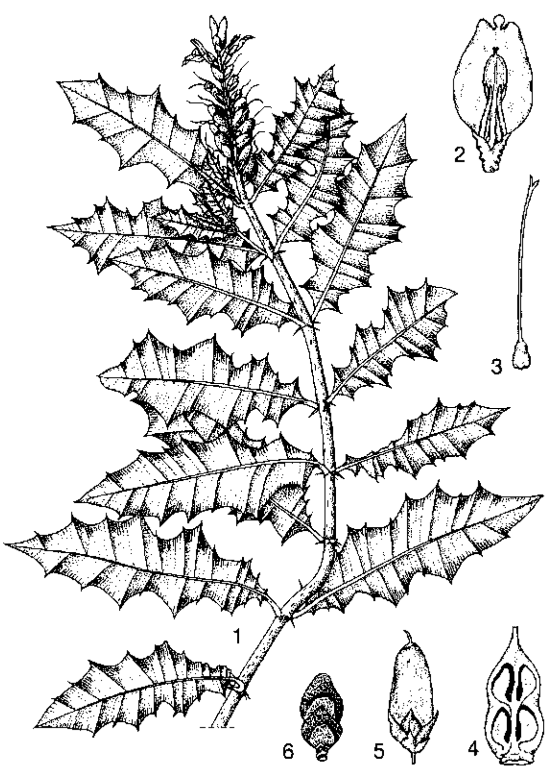
Sp. pl. 2: 639 (1753).

Synonyms *Acanthus volubilis* Wallich (1831).

Vernacular names Sea holly (En). Indonesia: jeruju (Sumatra), daruju (Javanese). Malaysia: jeruju, jeruju puteh (Peninsular). Philippines: daguari, diluariu (Tagalog), kasumba (Iloko). Papua New Guinea: kikia (Kavataria, Trobriand Island, Milne Bay Province). Thailand: kaem mo (peninsular), cha kreng (central), ngueak plaamo namngoen (general). Vietnam: [oo] r[oo], n[uw] [ows]c, l[ax]o th[uwr] c[aa]n.

Distribution Distributed from South India and Sri Lanka to Indo-China, Indonesia, the Philippines and northern Australia, but rather scarce in Malaysia.

Uses The aerial parts of *A. ilicifolius* are used as a poultice on wounds, and together with ginger, they are ground and put on sore legs, while a porridge from them is taken for bowel complaints. In Indonesia, a poultice of the leaves may be applied to treat rheumatic pain, or as an emollient. In



Acanthus ilicifolius L. – 1, flowering stem; 2, corolla with stamens and pistil; 3, pistil; 4, ovary in longitudinal section; 5, fruit; 6, seeds.

Thailand, the stem and leaves are also used to promote longevity. In Papua New Guinea the leaves, crushed in water, are drunk to facilitate delivery. The solution can also be drunk before an operation.

Observations A stout, erect or reclining shrub, up to 1.5 m tall, scarcely branched, glabrous, with adventitious aerial roots; leaves oblong, 6.5–11 cm × 4–6 cm; spike up to 16.5 cm long, dense or interrupted, bracts lanceolate, 10 mm long, bracteoles in 2 pairs, oblong-lanceolate, up to 1.5 cm long, calyx lobes obovate-oblong, ciliolate, corolla lobe obovate, 3 cm × 2.5 cm, pale to bright blue, corolla tube white. *A. ilicifolius* is gregarious and very common along banks of estuaries and lagoons, and in marshy land and mangroves close to the seashore. It is rarely found inland.

Selected sources 135, 297, 407, 579, 786, 838, 867, 962, 1069.

H.C. Ong

Achyranthes L.

Sp. pl. 1: 20 (1753).

AMARANTHACEAE

$x = 21$; *A. aspera*: $2n = 42$; *A. bidentata*: $2n = 42$, 84

Major species *Achyranthes aspera* L.

Origin and geographic distribution *Achyranthes* is a small genus of 8–10 species, distributed throughout the Old World, from Africa and Asia to Polynesia, also introduced into America.

Uses In South-East Asia, China, India and Africa, the leaves and fruits of *A. aspera* are considered healing and are applied to wounds, abscesses, boils and eczema. The plant, especially the bitter root, has anodynal properties, and a decoction of the roots is drunk for rheumatism, stomach-ache, menstruation pains and stitch. In India, a maceration of the roots or flower stalk is applied to scorpion stings and snake bites, while in Peninsular Malaysia, the seeds are applied to snake bites. In Malaysia and Indonesia, *A. aspera* is rubbed on the body of young children against convulsions. In Indonesia, Fiji, the Philippines, China and India, the root or the whole plant is considered diuretic and purgative, and are used for dysentery, malaria and other fevers, tonsilitis, pneumonia, dysmenorrhoea, induction of labour and haematuria. In the Philippines, Java, India and Tanzania the sap is used in the form of eye drops to clear corneal opacity. In India, the plant is considered a remedy for inflammations of the internal organs, piles, itch, abdominal enlargements and enlarged cervical glands. Hindus use the ashes for preparing caustic alkaline preparations (vegetable salt). A decoction of the root is drunk with honey within one month of conception as an abortifacient, and a 10 cm-long root is inserted into the vagina for abortion of a three-month-old foetus. In China, the root is also used for urinary tract infections, syphilis, nose bleeding, toothache and bleeding gums. In Nigeria and Senegal, an infusion of the leaves is taken as a tonic, an astringent, a diuretic and an expectorant. In Samoa, *A. aspera* is used as a tonic for children. In India and Ivory Coast, suppositories are made from the leaves for the treatment of haemorrhoids. In India, the flowers, ground and mixed with sugar are given for menorrhagia and rabies. Powdered seeds are soaked in milk and given for biliousness. In China, the plant is contra-indicated in pregnancy, excessive menstruation and spleen deficiencies.

In Korea, Vietnam and China, the roots of *A.*

bidentata are widely used as an expectorant, anti-inflammatory, antipyretic, antirheumatic, anti-arthritic and diuretic. In China, the root is prescribed as an emmenagogue, to facilitate delivery, and for vaginal discharges. The stem and leaves are taken for malaria. The whole plant is considered a tonic. In Malaysia, it is used internally as an anthelmintic. In Vietnam, the roots are widely applied for rheumatism, lumbago, dysmenorrhagia, hypertension, hypercholesterol, arteriosclerosis, dysuria, haematuria, contusion, congestion and angina. They are also used in decoction in the case of placenta retention. In Java, *A. bidentata* is used as a vermifuge for horses, and chewed with betel leaf (*Piper betle* L.) for infections or malignant ulcers in the mouth.

The young leaves of *A. aspera* are eaten in Indonesia (Java, the Moluccas), China and in Tanzania. In India, the seeds of *A. bidentata* have been used as a substitute for grain in times of famine. The stem is used as a toothbrush.

Production and international trade *A. bidentata* is cultivated in China and Vietnam, and exported to Indonesia, but no statistics on trade are known.

Properties The water soluble alkaloid achyranthine was isolated from the roots of *A. aspera*. They also contain 0.05% of the triterpene oleanolic acid and its glycosides. The shoots are rich in alkanes, e.g. 17-pentatriacontanol, tritriacontanol, and 36,47-dihydroxyhenpentacontan-4-one. From the seeds a series of triterpene saponins (saponins A–D) was isolated, which gave oleanolic acid, glucose, galactose, xylose and rhamnose upon hydrolysis.

Several extracts and purified fractions and/or compounds showed pharmacological activities. For example, achyranthine produces hypotension, cardiac depression, dilatation of blood vessels in dogs, spasmogenic effect in frog rectus muscle and diuretic and purgative effect in albino rats. In addition, an alkaloidal extract of the stems of *A. aspera* also exhibited activity against *Bacillus subtilis*, *Pseudomonas aeruginosa*, *Shigella dysenteriae* and *Staphylococcus aureus* in vitro.

The isolated triterpene saponins from the seeds increased the tone and force of contraction of isolated heart preparations of frog, guinea-pig and rabbit. This effect was quicker in onset and shorter in duration than that exerted by digoxin. On a molecular level it was also found that the saponins increased the phosphorylase activity of rat heart.

Powdered *A. aspera* plants, methanol or water extracts of the whole plant, administered orally to normal and alloxan diabetic rabbits, produced a dose-dependent hypoglycaemic effect in both normal and diabetic animals. In addition, a 7-day acute toxicity study did not reveal any adverse effects at doses of up to 8 g/kg/day given orally. Furthermore, an ethanol extract of the plant showed 30% anti-implantation activity in early pregnancy of albino rats, at a dose of 250 mg/kg, but had no effect in late pregnancy. A benzene extract of *A. aspera* is found to be abortifacient in rabbits.

The diuretic activity of *A. aspera* is probably due to the presence of a large quantity of potassium salts.

In leprosy patients, a decoction of the whole plant of *A. aspera*, together with diamino-diphenyl-sulphone showed definite improvement in general health and the bacterial index. It is useful for sub-acute and medium types of leprosy. Furthermore, the seeds show large inhibition zones for the growth of the bacteria *Bacillus subtilis*, *Escherichia coli*, *Pseudomonas cichorii* and *Salmonella typhimurium* in vitro. The crude extract of the whole plant showed 70–85% activity against the larvae of the cattle tick *Boophilus microplus*. The roots also contain the insect-moulting hormones ecdysterone and inokosterone.

The roots of *A. bidentata* contain about 1% betaine, and 0.9–1.4% oleanolic acid. Besides several common sterols, flavonoids and phenolic acids, they also contain the anthracene derivative chrysophanol.

An extract of the roots had a hypotensive effect on normal and renal-type hypertensive rats as well as spasmodic effects in mice. A root extract also showed significant hypotensive action and blood cholesterol concentration in humans, in Vietnam. The anti-inflammatory effects of the roots, tested in 4 acute and/or sub-acute inflammatory models in vivo, are marked. An extract of the roots containing polysaccharides (ABP) inhibited tumour growth in S180-bearing mice by 31–40%, and when co-administered with cyclophosphamide by up to 58%. ABP at 50 and 100 mg/kg intraperitoneally potentiated LAK cell activity and increased Con-A-induced production of tumour necrosis factor from murine splenocytes. ABP at 1–2 μg/ml also strongly inhibited S180 and K562 cell proliferation in vitro. Sulphated ABP showed high activity against HSsAG and HBeAg and herpes simplex virus type 1. In addition, the benzene extract of the whole plant of *A. bidentata* administered orally showed significant anti-fertility, anti-implantation and anti-early-pregnancy effects in mice; the chloroform extract was devoid of these activities, however.

Adulterations and substitutes In China, roots of *Cyathula prostrata* (L.) Blume are used as a substitute for *Achyranthes* roots.

Description Erect or ascending, branched herbs. Leaves opposite, simple; petiole present; stipules absent. Inflorescence an erect, terminal or axillary spike, elongated after flowering, many-flowered, few flowers open at the same time. Flowers bisexual, solitary, deflexed after anthesis, bract membranaceous, acute, persistent, subtended by 2 bracteoles, base concave, with a short wing, apex long spinescent; tepals 5, membranaceous to herbaceous-coriaceous, 1-more-veined, very acute, spreading during anthesis, erect in fruit, pungent in fruit or not; stamens 5, much shorter than perianth, filaments connate at base in a short cup, alternating with short, broad pseudo-staminodes, fimbriate or not, anthers oblong, 2-celled; ovary superior, ovule 1, style filiform, short, persistent, stigma capitate. Fruit an ellipsoid utricle, thin-walled, indehiscent, falling off with perianth and spines. Seed solitary, ovoid. Seedling with epigeal germination.

Growth and development *Achyranthes* can be found flowering throughout the year when sufficient water is available. It has no photoperiodic requirements for flowering. On arable land and in areas with a distinct monsoon, *A. aspera* grows like an annual, while in shaded and protected areas it is a perennial.

Other botanical information *A. aspera* and *A. bidentata* are very closely related. In southern India, Sri Lanka to Japan and Malaysia, morphological transitions between *A. aspera* and *A. bidentata* have not been observed. However, in north-western India, Pakistan and Africa, intermediate types occur for important morphological characteristics such as the adnate wings on the bracteoles and the hairiness of the pseudo-staminodes. Their ecological preferences are also not strictly differentiated either throughout the distribution area. Reducing *A. bidentata* to the rank of subspecies under *A. aspera* would not solve this problem, and more field and genetic studies are needed in order to elucidate their status.

Ecology *Achyranthes* comprises weedy herbs usually found near human settlements or along roads and footpaths, in humid and drier climates.

Propagation and planting *Achyranthes* is propagated by seed. Because the bracts are reflexed, they adhere easily to animal fur and clothes. Individual *A. aspera* plants may produce up to about 3000–9500 seeds, whereas the 1000-seed weight fluctuates between 1.3 g and 2.6 g. The seeds germinate equally under light, shade and dark conditions. Planting distance of *A. bidentata* is 60–90 cm, in full sunlight 30–60 cm. In Vietnam, the best time for sowing is November. The seeds are soaked for 24 hours in water before sowing or are sown directly, and are sown at 30–40 kg/ha. *Sesbania* sp. (*Leguminosae*) is sown beforehand to provide shade.

Husbandry *A. bidentata* is cultivated in China on rich, slightly acid, sandy soils.

Diseases and pests In India, several diseases including leaf spot caused by *Cercospora achyranthes*, leaf blight caused by *Alternaria alternata* and cucumber mosaic virus are found on *A. aspera*. *Meloidogyne javanica* nematodes attack its roots. *A. aspera* is often infected with the thrips *Caliothrips indicus*.

Harvesting In China and Vietnam, the roots from 1 and 2 year-old plants of *A. bidentata* are dug up in autumn or early winter, when the foliage dies back. Leaves and stems are harvested in summer for use in tinctures or crushed for the juice.

Handling after harvest In China, the root of *A. bidentata* is traditionally sun-dried and used in decoctions, extracts and powder. The roots can also be stir-fried in rice wine or used fresh. In Vietnam, the roots are washed, small roots removed, and then dried in the shade for several days. Afterwards they are stacked for a week in the shade, till ridges appear on the roots. They are then fumigated with sulphur for 24 hours, and completely dried.

Genetic resources and breeding. Both *Achyranthes* species are widespread, weedy, readily found near settlements, and therefore not endangered. No germplasm collections of *Achyranthes* are known to exist.

Prospects Several fractions and/or purified constituents of *Achyranthes* showed various interesting pharmacological effects, both in vitro and in vivo. Therefore, further research is needed to fully evaluate these preliminary results for future applications.

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Selection of species

Achyranthes aspera L.

Sp. pl. 1: 204 (1753).

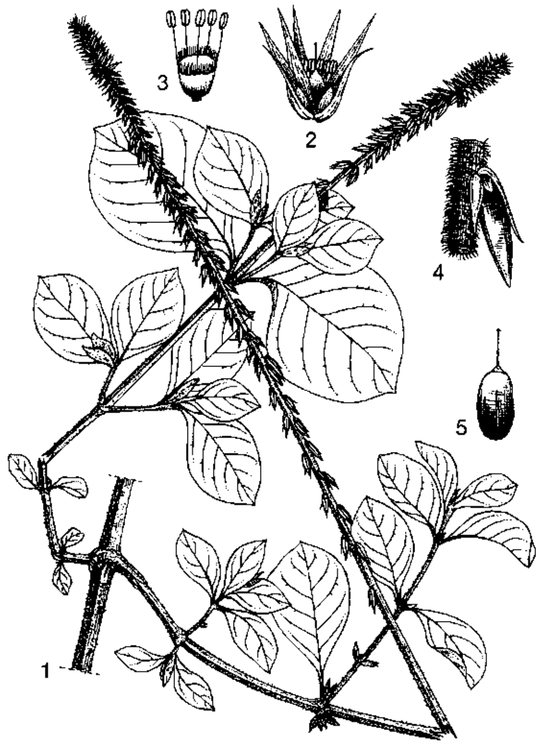
Synonyms *Achyranthes obtusifolia* Lamk (1785), *Achyranthes canescens* R.Br. (1810), *Achyranthes argentea* Decne (1834).

Vernacular names Prickly chaff flower (En). Indonesia: jarong (Javanese), jarong lalaki (Sundanese), sangko hidung (Moluccas). Malaysia: ara songsang, nyarang sunsang. Papua New Guinea: towano (North Bougainville). Philippines: hangod (Tagalog), higad-higad (Iloko), saramat (Bisaya). Thailand: khuai nguu, phan nguu (central), yaa teen nguu khaao (Bangkok). Laos: khoy ngou. Vietnam: c[or] x[uw][ows]c.

Distribution Throughout the Old World tropics, including Malesia and Australia, and introduced into tropical America.

Uses The root, seeds or whole plant are widely used for medicinal purposes. The leaves are applied to wounds, and to mature abscesses and boils. A decoction of the root is drunk for rheumatism, stomach-ache, menstruation pains, absence of menstruation or as an abortifacient. The sap from the plant is taken for dysentery and rheumatism. In Papua New Guinea, the leaves or roots are applied on boils and swollen legs. In Thailand, the roots are used as an anti-inflammatory and a diuretic.

Observations A variable, annual to perennial herb, 30–120 cm tall, stem angular, ribbed, stiff, nodes thickened, variably pubescent, reddish-brown; leaves ovate-obovate or elliptical-oblong, 1–10 cm × 1–5 cm, base attenuate, apex obtuse or acute, glabrous to densely hairy, petiole 5–15 mm long; spike terminal and axillary, 10–75 cm long, including peduncle 0.5–15 cm long, rachis stiff, ribbed, more or less densely white hairy, bracts



Achyranthes aspera L. – 1, part of flowering and fruiting stem; 2, flower; 3, stamens; 4, deflexed fruit; 5, utricle.

ovate, 2–3.5 mm long, apex acuminate, not pungent, silvery, bracteoles ovate, spines 2.5–4.5 mm long, sharp, basal wing adnate to spine, easily detaching, 1–2 mm long; tepals ovate-lanceolate, 3.5–6.5 mm long, 3-veined, green, pungent in fruit, pseudo-staminodes with a fimbriate scale; utricle oblong, about 3 mm long, dark brown. *A. aspera* occurs as a ruderal often in sunny, dry localities, in regions with a well defined rainy season, along roadsides and in waste places, from sea-level up to 2500 m altitude.

Selected sources 134, 135, 215, 310, 379, 570, 605, 729, 739, 752, 760, 788, 821, 1071.

Achyranthes bidentata Blume

Bijdr. 545 (1825).

Synonyms *Achyranthes javanica* Moq. (1849), *Achyranthes mollicula* Nakai (1920).

Vernacular names Chaff flower (En). Genou de buffle (Fr). Papua New Guinea: denogil, kul (Simbu Province). Thailand: khuai nguu noi, phan nguu noi (northern). Vietnam: ng[uw]u t[aas]t.

Distribution Throughout tropical Africa and

Asia, in Malesia occurring in Sumatra, Java, Lombok, the Philippines, Sulawesi, the Moluccas and New Guinea. It is cultivated in China and Vietnam.

Uses In Malaysia, the leaves are chewed against malignant ulcers in the mouth. In Java, the plant is used as a vermifuge for horses. In Papua New Guinea, the heated young leaves are eaten with salt to relieve abdominal pains and to destroy hook worms and other intestinal parasites. In China and Vietnam, the root is commonly prescribed as a diuretic and emmenagogue, in rheumatism, to facilitate delivery, and for vaginal discharges.

Observations A perennial herb, 40–170 cm tall, stem quadrangular, furrowed, rather flaccid, thinly to densely pubescent, often purple in upper part; leaves elliptical-oblong, lanceolate or ovate, 5–20 cm × 2–8 cm, base attenuate, apex mostly long acuminate, sparsely to densely velvety tomentose on both sides, petiole 0.5–3.5 cm long; spike terminal and axillary in the upper leaf axils, 4–45 cm long, including 1–15 cm long peduncle, more or less whitish-tomentose, bract ovate-oblong, 3–3.5 mm long, apex acuminate, not pungent, margin ciliate, bractoles spinescent, as long as perianth, 3.5–5.5 mm long, apex often recurved, basal wing inserted on lower part of spine; tepals membranaceous, veins absent, acute, 4.5–7 mm long, not pungent in fruit, pseudo-staminodes truncate, dentate; utricle oblong, 2–2.5 mm long. *A. bidentata* occurs often in forests and well-shaded localities, and along footpaths or streams, under per-humid conditions, in Java from 350–2500 m altitude.

Selected sources 135, 177, 191, 215, 262, 264, 310, 605, 608, 732, 739, 788, 808, 1003.

J. Raymakers & G.H. Schmelzer

Adenostemma viscosum J.R. Forster & J.G. Forster

Char. gen. pl.: 90, t. 45 (1775).

COMPOSITAE

$2n = 20$

Synonyms *Adenostemma lavenia* auct. non (L.) O. Kuntze (1891).

Vernacular names Dung weed (En). Indonesia: legetan warak (Javanese), rumput babi (Malay, Jakarta), udu tai (Kenyah Dayak, Kalimantan). Papua New Guinea: tigtoni (Pala, Bismarck Archipelago), pisirokot (Lamekot, Bismarck Archipelago). Philippines: boton (Tagalog). Thailand: yieo muu (Chiang Mai). Vietnam: c[us]c tr[aws]ng, c[or] m[ij]eh, c[us]c d[is]nk.

Origin and geographic distribution *A. viscosum* is found from Pakistan and India to Japan, South-East Asia, Australia, and the Pacific Islands, and also in tropical Africa.

Uses In Malaysia, Indonesia, Papua New Guinea and southern China, *A. viscosum* is widely used as a medicinal plant. In Malaysia the crushed stems and leaves are applied as a poultice for headache, ulcerations of the nose, and on the abdomen against diarrhoea, also in association with *Persicaria barbata* (L.) Hara, and leaves of *Uraria* and *Momordica* species. The boiled leaves are rubbed on the skin to relieve itch and treat infected sores, and the whole body is rubbed in case of fever. In Indonesia, a lotion of the leaves is used to arrest baldness, a paste of the leaves is used to poultice sun-burned skin, and scorched, they are applied to boils and ulcers to ripen them. The leaves are also used for treating palpitations, dysuria, toothache, aphthae and sore throats. In Sabah, the leaf extract is given to prevent infections after childbirth. The leaves are chewed against dysentery, or together with those of *Centella asiatica* (L.) Urb. and *Phyllanthus urinaria* L. against colic. Fresh juice of the plant is used to treat ear infections, or together with that of the leaves of *Mimusops elengi* L. and of the bark of *Baccaurea motleyana* Müll. Arg., obtained by pounding these together, to treat sore eyes. In Peninsular Malaysia, a decoction of the root is given as a cure for stomach-ache. In Indonesia, the roots are chewed alone or together with *Piper betle* L. leaves and ginger against cough. In Taiwan, the whole plant is used to treat lung congestion, pneumonia, oedema and inflammation, while in the Bismarck Archipelago the stems and leaves are used as an antiscorbutic.

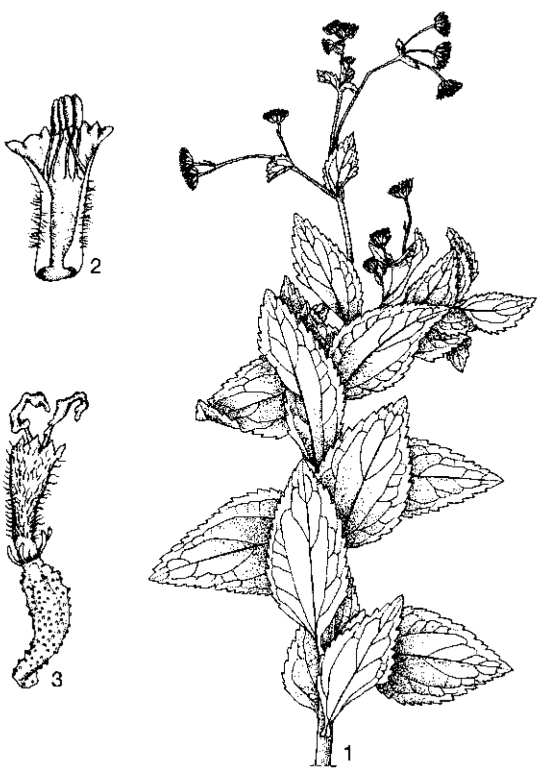
In Bali, the leaves of *A. viscosum* are eaten as a vegetable, but always in combination with other vegetables, because of their bitterness; they are also fed to pigs.

Production and international trade *A. viscosum* is medicinally only used locally and is not traded on the international market.

Properties Several kaurane-type diterpenes have been isolated from the extract of fresh whole plants of *A. viscosum*,, for example adenostemmoic acids (11-oxygenated kauran-19-oic acids), and adenostemmosides (their corresponding glucosides). Two of these terpenes, ent-11α-hydroxy-15-oxo-kaur-16-en-19-oic acid and adenostemmic acid B showed cytotoxic activity in vitro against

L-5178Y cultured leukaemia cells, and in vivo prolonged the survival of female mice inoculated with Sarcoma 180 cells. The extract of *A. viscosum* also shows cytotoxic activity in the brine shrimp assay. The aqueous alcohol extract exhibited hypoglycaemic and diuretic activities in rat.

Description An annual or sometimes perennial herb, 30–100 cm tall, often rooting at the lower nodes, sparsely branched, subglabrous to glandular pubescent. Lower leaves opposite, upper ones alternate, simple, lanceolate-elliptical to oblong to broadly ovate, 4–20 cm × 3–12 cm, base rounded-cuneate, apex acute to obtuse, margins dentate to serrate; petiole of lower leaves up to 9 cm long, upper leaves subsessile; stipules absent. Inflorescence consisting of heads in a lax terminal paniculate corymb; peduncle 1–4 cm long, involucre campanulate or cup-shaped, 2-seriate, scales subequal, herbaceous, more or less connate at the base, often glandular, head 3–7 mm × 6–10 mm, about 30-flowered. Flowers all tubular; corolla 1.5–2 mm long, 4-lobed, on the outside with glandular hairs, white or violet; stamens 5; ovary inferior; style bifid, branches slender, long thickened at the top. Fruit an achene, obovate-oblong, irregularly triangular, 2.5–4 mm × 1 mm, glandular when young, afterwards glabrous or warty, crowned with a pappus consisting of a few clavate setae, usually thickened at the top and glandular. Seedling with epigeal germination.



Adenostemma viscosum J.R. Forster & J.G. Forster – 1, flowering stem; 2, corolla tube split open; 3, entire flower.

Growth and development *A. viscosum* starts flowering 3 months after germination and flowers throughout the year when sufficient water is available.

Other botanical information *Adenostemma* is pantropical and comprises 24 species with nearly equal amounts of diversity in the Old and New World tropics. *Adenostemma* belongs to the tribe *Eupatorieae*. The correct name of the species commonly referred to as *A. lavenia* is *A. viscosum*, whereas *A. lavenia* (L.) O. Kuntze is restricted to Sri Lanka only.

Ecology *A. viscosum* is found in open, disturbed sites and wet places along streams, in forests, thickets, and along roadsides, from sea-level to 2100 m altitude. In Pakistan it is a vigorous monsoon weed with a rich seed production. The sticky knobs of the pappus in combination with the more convex older receptacles of *Adenostemma* seem particularly suited for animal dispersal, which apparently accounts for the great distributional success of the genus.

Propagation and planting *A. viscosum* is propagated by seed.

Harvesting *A. viscosum* is simply collected from the wild whenever the need arises. Plants are readily available nearby human habitation.

Genetic resources and breeding In view of its wide distribution and weedy nature, *A. viscosum* is unlikely to be at risk of genetic erosion in South-East Asia. No germplasm collections are known to exist.

Prospects The kaurane-type diterpenes in *A. viscosum* show interesting cytostatic activities in vitro and in vivo, but further research is necessary.

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Other selected sources 74, 135, 139, 215, 253, 329, 369, 370, 407, 524, 558, 588, 750, 772, 786, 788, 810, 841, 966.

G.H. Schmelzer

Ailanthus Desf.

Mém. Acad. Sci., Paris 1786: 265 (1788).

SIMAROUBACEAE

x = unknown; *A. altissima*: $2n = 64, 80$, *A. integrifolia* subsp. *calycina*: $2n = 62, 64$

Major species *Ailanthus altissima* (Miller) Swingle.

Origin and geographic distribution *Ailanthus* consists of 5 species and its natural distribution is from Turkestan and India to China, through Malesia towards the Solomon Islands and north-western Australia. Two species occur naturally within Malesia. A third, *A. altissima*, is widely cultivated throughout the world, and was introduced to Europe in 1751.

Uses *Ailanthus* has a history of use in traditional medicine, particularly for the treatment of dysentery. *A. altissima* is noted as an antibacterial, anthelmintic, amoebicide and insecticide. The Indian *A. excelsa* Roxb. is noted as a medicine for respiratory problems and *A. triphysa* is applied for the treatment of dyspepsia, bronchitis, ophthalmia and snakebite. *A. altissima* is widely planted as an ornamental and shadetree, in shelter belts and for erosion control in tropical, subtropical and temperate countries. *Ailanthus* timber is used for furniture, laminated wood, ceilings, wooden shoes, moulding, toys, shingles, matchsticks, matchboxes, core of plywood, weather boards, interior trim, brush stocks, pattern making, paper pulp, fuel and charcoal. The leaves of *A. altissima* are used as fodder for silkworms in China.

Properties The phytochemical composition of the bark and root bark of *A. altissima*, known as Ailanthi Cortex, has been quite extensively investigated. A variety of compounds were isolated, belonging to different groups. Most pronounced are the quassinoids (in the case of *Simaroubaceae*, sometimes also known as simaroubolides), of which components of several sub-types are present: the ailanthone type (e.g. ailanthone, chaparrinone, shinjulactone A (= 2-dihydroailanthone)), the ailanthone-ester type (e.g. glaucarubinone), the amarolide type (e.g. amarolide, shinjulactone H), the amarolide-acetate type (e.g. 11-acetylamarolide, shinjulactone K), the amarolide-monoglucoside type (e.g. shinjuglycoside E), and a non classified group (e.g. shinjulactone C, shinjudilactone). Furthermore, 2 categories of indole alkaloids (biosynthetically derived from the amino acid tryptophan) have been identified: the β-carbolines (e.g. 1-acetyl-4-methoxy-β-carboline) and the canthin-6-ones (e.g. canthin-6-one). Other isolated compounds include: 2,6-dimethoxybenzoquinone (characteristic for *Simaroubaceae*), a series of substituted naphthofuran-diones, and several phenolic compounds (e.g. 3,4,5-trimethoxyphenol-1-(6-xylopyranosyl)glucopyranoside, ferulic acid, vanillic acid).

Several isolated compounds from *A. altissima* possess pharmacological activities. The quassinoids ailanthone, glaucarubinone and 13,18-dehydroglaucarubinone were found to be active in the lymphocytic leukaemia system of mice (P-388) and Eagle's carcinoma of the nasopharynx (9KB) in vitro. Ailanthone and glaucarubinone also show strong antimalarial activity against *Plasmodium falciparum* in vitro and *Plasmodium berghei* in mice. However, their strong cytotoxicity limits their potential as future antimalarials. Short-term in vitro assays for tumour promoters and antitumour promoters (Epstein-Barr virus activation test) were also carried out for 14 quassinoids isolated from *A. altissima*. Some quassinoids, including ailantinol B, ailantinol C, aflanthone, and shinjulactone A, showed moderate activity at a molar ratio of 1:100 (TPA/quassinoids), and the results led to the elucidation of structure-activity relationships. Other activities include: a strong anti-amoebic activity against *Entamoeba histolytica* (ailanthone), a low in vitro antituberculosis activity (ailanthone, shinjulactone K and shinjudilactone), and a potent anti-ulcer activity for ailanthone and its α-epoxide. Finally, shinjulactone C demonstrated inhibition of HIV replication in H9 lymphocytic cells with an EC_{50} of 10.6 μM in the absence of cytotoxicity.

Of the alkaloids isolated, the cytotoxicity of canthin-6-one, 1-methoxycanthin-6-one, 5-methoxycanthin-6-one, and canthin-6-one-3-N-oxide to guinea-pig ear keratinocytes have been compared; the IC_{50} values range from 1.11 to 5.76 μg/ml. The β-carboline- and canthin-6-one alkaloids also have strong inhibitory effects on cAMP phosphodiesterases in vitro: 1-(1-hydroxy-2-methoxy)ethyl-4-methoxy-β-carboline and 5-hydroxymethyl-canthin-6-one have inhibitory activity in the same order of magnitude as the commonly used standard papaverine. The water extract of dried bark of *A. altissima* showed CNS-stimulant activity when administered intraperitoneally to mice. Lipid peroxide stimulation is also reported. Other pharmcological effects include severe rashes that develop after direct contact with the plant and nephrotoxic effects in rats after intragastrical administration of an extract at at a dose of 100 mg/kg.

Chaparrinone and 6-α-tigloyloxychaparrinone were shown to be responsible for the antitumour and cytotoxic activities of the root bark of *A. integrifolia* ssp. *calycina*. In addition to 6-α-tigloyloxychaparrinone (an α-ketol) *A. integrifolia* also contains the related quassinoid 6-α-tigloyloxychaparrin (a glycol). While both the glycol and α-ketol were found to significantly inhibit growth of the murine P-388 lymphocytic leukaemia cell line, only the α-ketol inhibited growth of the corresponding in vivo system as well.

Alcoholic extracts of leaf and stem bark of the Indian *A. excelsa*, at a dose of 250 mg equivalent of plant material/kg body weight, exhibited remarkably high anti-implantation and early abortifacient activities. These results bear out its traditional use as an abortifacient in some parts of India.

Methanol extracts of *A. altissima* furthermore showed antifeedant activity towards the beetle *Epilachna varivestis* as well as insect growth regulating activity. Topical application of a non-polar extract of *A. altissima* at 3 μg/larva gave a 70–100% killing of the flour beetle, *Tribolium castaneum*, a pest in stored grain.

Aqueous extracts of *A. altissima* bark and foliage were previously shown to be toxic to other plants. The phytotoxic compound from the root bark was identified as ailanthone. This compound was highly phytotoxic, with concentrations of 0.7 ml/l causing 50% inhibition of radicle elongation in a standardized bioassay with garden cress (*Lepidium sativum* L.) seeds. Ailanthone exhibited potent pre- and postemergence herbicidal activity in greenhouse trials. Postemergence activity was especially striking; even the lowest application rate (0.5 kg/ha) caused complete mortality of 5 of the 7 plant species tested within 5 days of treatment. In contrast, the highest application rate (8 kg/ha) did not cause any detectable injury to *A. altissima* seedlings, indicating the presence of a protective mechanism in the producer species to prevent autotoxicity. Ailanthone was rapidly detoxified in field soil as a result of microbial activity. Applications of ailanthone equivalent to 0.5 and 4.0 kg/ha completely lost their phytotoxicity within 5 days when incubated in the presence of non-sterile soil. When incubated with sterile soil under identical conditions, however, ailanthone remained highly phytotoxic throughout the 21-day duration of the investigation. The high level of postemergence herbicidal activity in conjunction with its rapid biodegradation in soil suggest ailanthone may have potential for development as a plant-product herbicide.

Description Dioecious, evergreen or sometimes deciduous trees up to 60 m tall; bole cylindrical, up to 85(–175) cm in diameter, buttresses absent; bark surface smooth or with irregular fissures; branches thick, with large leaf scars. Leaves more or less tufted at the end of twigs, arranged spirally, paripinnate or imparipinnate; stipules absent or caducous; leaflets opposite or subopposite, stalked, generally with some glands below or at the base. Inflorescence an axillary panicle. Flowers unisexual, 5(–6)-merous, zygomorphic; calyx small, 5(–6)-lobed or closed in bud and later irregularly splitting to the base (often in two parts), rarely cupular; petals 5(–6), free, induplicate-valvate in bud, concave, oblong or narrowly oblong; stamens 10, in female flowers either subnormal but without pollen, or vestigial, or absent; carpels 2–5, free, flat, in male flowers vestigial or absent, ovule 1 per locule, styles 2–5, free or united. Fruit a linear or oblong-lanceolate samara. Seed flat, orbicular or obovate or somewhat triangular, without endosperm, with a thin testa. Seedling with epigeal germination.

Growth and development *Ailanthus* trees are in general fast growing. In Java, the mean height of planted *A. integrifolia* was 1.8 m 2 years after planting and 4.0 m 3 years after planting. In India, 10- and 50-year-old trees of *A. integrifolia* were 5 m and 39 m tall. In Pennsylvania (United States) 1-year old seedlings and root sprouts of *A. altissima* were on average 0.4 m and 0.8 m tall, respectively; 2-year old trees were 1.2 m and 1.7 tall respectively. Pollination is probably done by insects. The fruits are dispersed by wind. Natural regeneration of planted trees of *A. integrifolia* has been observed after only four years, but annual seed production varies greatly and seems unpredictable. Early flowering and early profuse production of seed is recorded for *A. triphysa*, although there are reports from India that every other year is a good seed year. *A. triphysa* is strictly cross-pollinated and seed maturation takes about 45 days.

Other botanical information *Ailanthus* belongs to the subfamily *Simarouboideae*, which is by far the largest subfamily within the *Simaroubaceae*. Numerous ornamental cultivars of *A. altissima* are registered.

Ecology *A. integrifolia* and *A. triphysa* occur in humid rain forest and in monsoon forest, and in Bengal (India) even in dry mixed forest. They occur scattered, never gregariously, in valleys, along streams and in open locations below 1000 m altitude. Variation in mean annual rainfall ranges from 1600 mm to 4560 mm. They are most often found on well-drained deep soils like fertile sandy loams. *A. altissima* prefers a cooler climate and is indigenous at higher elevations in North Vietnam.

Propagation and planting *Ailanthus* is usually propagated by seed. *A. altissima* can be propagated by seed, but is usually multiplied by root suckers. Seedlings are adversely affected by high root-zone temperatures of 30–36°C. *A. integrifolia* is propagated by seed; it has about 1800 wingless seeds per kg and germination of fresh seed is about 60% but varies greatly. No pretreatment is required. Germination starts 3–6 weeks after sowing. Seeds of *A. triphysa* remain viable for about three months and germination takes place within 1–3 weeks; up to 100% germination has been observed. Seeds are broadcast and seedlings need only occasional watering, as they are susceptible to rot and damping-off. Seedlings of *A. triphysa* develop better when provided with partial shade, although the species is light demanding. When 8–10(–30) cm tall they are planted in fertile, well-drained sites at spacings of 1–2 m × 1–2 m. Seedlings are susceptible to damage by transplanting; the root system is especially vulnerable.

In vitro production of active compounds In vitro culture of *Ailanthus* using hypocotyl, stem, leaf or anther explants is usually on Murashige and Skoog medium with various supplements. Canthin-6-one and 1-methoxycanthin-6-one can be isolated from callus- and cell-suspension cultures of *A. altissima*. The combined yield of the two alkaloids was 1.38% of dry weight from callus and 1.27% of dry weight from cell suspensions. Whereas this alkaloid production is 100-fold greater than in the plant, production of quassinoids is very poor.

Diseases and pests No serious diseases and pests have been recorded for *Ailanthus*, although *A. triphysa* seedlings are liable to attack by a fungus and a defoliator.

Harvesting Trees of *A. altissima* harvested for medicinal purposes are usually felled in spring or autumn in temperate zones. Bark is removed and dried in the sun.

Genetic resources and breeding *A. integrifolia* is stored in a germplasm bank in India. *A. altissima* can be found in botanical gardens throughout the world but is nowhere maintained specifically for its medicinal value.

Prospects The biological activities of the quassinoids and canthin-6-one alkaloids of *Ailanthus* confirm the uses in traditional medicine; some of these constituents are of potential use as templates for new drugs. The herbicidal activity of ailanthone also has potential for development as a plant-product herbicide.

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Selection of species

Ailanthus altissima (Miller) Swingle

Journ. Wash. Acad. Sci. 6: 495 (1916).

Synonyms *Ailanthus glandulosa* Desf. (1786), *Ailanthus vilmoriniana* Dode (1904).

Vernacular names Tree of heaven (En). Vietnam: ph[uw][owj]ng nh[ax]n th[ar]o, thanh th[aas]t n[us]i cao.

Distribution Native to China, now widely cultivated as an ornamental throughout the world in particular in areas with a subtropical or temperate climate, often naturalized. In Malesia occasionally grown as an ornamental in the cooler parts.

Uses In Vietnam, the stem bark is used in folk medicine to treat diarrhoea and dysentery and sometimes against tapeworms. A decoction of the fruit is employed for cough and irregularity of menstruation. The resin is used externally as a counterirritant or vesicant. The stem bark is astringent, antispasmodic and powdered dried bark has narcotic properties. The fruits are used as an emmenagogue and for ophthalmic purposes. The leaves are astringent and applied in lotions prescribed in seborrhoea and scabies. Leaves and flowers sometimes cause dermatitis. The wood can be used for the production of furniture and utensils. The female trees are preferred for ornamental purposes in view of the odour of the male flowers.

Observations A deciduous tree up to 30 m tall, sometimes suckering from roots, forming dense thickets; leaves imparipinnate with (4–)6–12(–15) pairs of oblique and lobed or dentate leaflets (4–)10–15 cm long, glabrous or puberulous with an abaxial gland near the tip of basal lobes; petals woolly on inner surface and lower margins; carpels 5, glabrous; samara 4(–6) cm long. *A. altissima* is tolerant of drought, saline soils and air pollution. These qualities in combination with its resistance to fungal and insect attack make it an ideal urban tree despite its sometimes weedy nature.

Selected sources 52, 135, 216, 248, 304, 311, 341, 362, 402, 406, 537, 561, 566, 739, 746, 765, 776, 786, 788, 798, 817, 888, 898, 933, 956, 980, 1072.

Ailanthus integrifolia Lamk

Dict. 3(2): 417 (1792).

Synonyms *Ailanthus moluccana* DC. (1825), *Ailanthus blancoi* Merr. (1918), *Ailanthus peekelii* Melch. (1930).

Vernacular names White siris (En). Indonesia: ai lanit (Moluccas), kayu ruris (Minahassa), pohon langit (Ambon). Philippines: malasapsap (general), balokas, makaisa (Tagalog). Vietnam: thanh th[aas]t l[as] nguy[ee]n.

Distribution Western India (Assam), Vietnam, throughout Malesia (except for the Lesser Sunda Islands) towards the Bismarck Archipelago and the Solomon Islands.

Uses *A. integrifolia* is not used in traditional medicine, despite the active compounds revealed by phytochemical research. The wood is traded as timber, and also used for local house building and furniture manufacture.

Observations A large tree up to 60 m tall, bark surface smooth or irregularly fissured; leaves paripinnate with 2–9 pairs of entire leaflets 10–40 cm long, lower surface sometimes pubescent and with a few large black glands; petals puberulous, carpels 5, puberulous; samara 11–22 cm long. *A. integrifolia* is divided into two subspecies: subsp. *integrifolia* and subsp. *calycina* (Pierre) Noot. The former has up to 15 mm long pedicels and 6–10 mm long petals and occurs in primary rain forest up to 900 m altitude throughout Malesia, except for Java and the Lesser Sunda Islands, and on the Bismarck Archipelago and the Solomon Islands. The latter has pedicels up to 5 mm long and petals about 4 mm long and occurs in mixed seasonal primary forest in western India, southern Vietnam and Java. *A. integrifolia* is potentially of medicinal interest.

Selected sources 74, 216, 311, 406, 746, 949.

Ailanthus triphysa (Dennst.) Alston

Handb. fl. Ceylon 4, Suppl.: 41 (1931).

Synonyms *Ailanthus malabarica* DC. (1825), *Ailanthus imberbiflora* F. Muell. (1862), *Ailanthus philippinensis* Merr. (1906).

Vernacular names White siris (En). Indonesia: kayu langit (general), ki pahit(Sundanese), kirontasi (Sulawesi). Philippines: malakamias (general), kalauag (Bikol). Burma (Myanmar): o-dein. Thailand: makkom (northern), mayom-pa (central), mayom-hom (south-eastern). Vietnam: b[us]t, c[af]ng hom th[ow]m.

Distribution India, Sri Lanka, Burma (Myanmar), Indo-China, southern China, Thailand, Peninsular Malaysia, Java, Borneo (Sabah, East Kalimantan), Sulawesi, the Philippines, and northern Australia (Queensland and northern New South Wales). It is planted in the arid zones of Africa.

Uses The resin is used medicinally in India and as incense in India and Indo-China. The bark and

Ailanthus triphysa (Dennst.) Alston – 1, leafy twig; 2, leaflet; 3, fruit.

leaves are renowned as a tonic and appetitive and possess febrifuge properties. The bark is employed in dyspepsia and diarrhoea as well as to relieve cough and bronchitis. In Vietnam, the leaves are recommended in cephalalgia and gastralgia. The leaves are also used to dye silk black.

Observations A large tree up to 45 m tall, bark dimpled; leaves paripinnate with 6–17(–30) pairs of entire leaflets,(5–)9–15(–26) cm long, covered with velvety hairs below and with many glands scattered over the lower surface; petals glabrous, carpels (2–)3(–4), glabrous; samara 4.5–8 cm long. *A. triphysa* is comparatively rare and occurs in evergreen and seasonal forests up to 600 m altitude.

Selected sources 74, 135, 216, 311, 406, 465, 739, 746, 788, 949.

J.L.C.H. van Valkenburg

Allamanda L.

Mant. pl. 2: 146 (1771) ('Allemanda').
APOCYNACEAE
$x = 9$; *A. cathartica*, *A. schottii*: $2n = 18$

Major species *Allamanda cathartica* L.

Origin and geographic distribution *Allamanda* comprises 14 species native to South America and the Caribbean. Several species, including *A. cathartica* and *A. schottii*, are distributed throughout the tropics as ornamentals.

Uses *Allamanda*, in particular *A. cathartica*, has long been known in East and South-East Asia for its purgative and emetic properties when administered in small doses. Larger doses are toxic, and great care should be taken in prescribing *Allamanda*. *A. cathartica* and *A. schottii* are grown for their bright and large flowers as well as their foliage; they are also suitable as pot plants.

Production and international trade *Allamanda* is used on a local scale only. The prickly fruits of *A. schottii* are used in floral arrangements.

Properties *A. cathartica* contains hydrocarbons (long chain esters) in the whole plant, e.g. 1-triacontanol, 1-dotriacontanol, docosanoic-, tetracosanoic- and hexacosanoic acid in the roots; β-sitosterol and triterpenes e.g. ursolic acid and β-amyrin in the leaves or stem, and lupeol in the roots.

Other components isolated from the roots include a series of iridoid lactones: allamandin, allamandicin, allamdin, plumericin, isoplumericin, plumieride and fluvoplumierin. Both the ethanolic root extract, as well as the purified allamandin, exhibit in vivo antitumour activity against P-388 leukaemia in the mouse, and against human carcinoma of the nasopharynx (KB cells) in culture. Plumericin and its related iridoid lactones also show antifungal and antibacterial properties against a broad spectrum of micro-organisms in vitro.

The antitumour and antimicrobial activities of the iridoid lactones may therefore explain the biological activity in this field of several extracts of *A. cathartica*. This includes inhibition of Ehrlich ascites tumour cells by an extract of the leaves in 5% sodium bicarbonate solution (an excellent potential leaf extract fungicide) and inhibitory activity of ethanolic root- and flower extracts against *Klebsiella* species.

Other pharmacological activities of *A. cathartica* include hypertension in male cats after application of aqueous and alcoholic root- and leaf extracts, the alcoholic root extract being the most powerful. The laxative use of the plant was confirmed by experiments in rats.

A series of iridoid lactones were isolated from the stems and leaves of *A. schottii*. These included allamandin, allamandicin, allamdin, plumericin, isoplumericin, plumieride as well as further iridoids e.g. isoallamandicin, allamcin, allamancin, 3-O-methyl derivatives of allamcin and allamancin, allamcidin, allamcidin glucoside, 13-O-acetylplumieride, plumiepoxide and protoplumericin B. In addition, some non-iridoid compounds were also present: coumarins and lignans (e.g. 9α-hydroxypinoresinol and 9α-hydroxymedioresinol, and their corresponding glycosides).

Iridoids, coumarins and a lignan, isolated from the roots of *A. schottii*, were active in the brine shrimp and potato disk (*Agrobacterium tumefaciens*) assays.

Adulterations and substitutes The iridoid lactones derived from allamandin and plumericin, which are both very similar in structure, were also isolated from several *Plumeria* species (*Apocynaceae*).

Description Climbers or shrubs, all parts exuding white sap. Leaves in whorls of 3–5, simple, entire, with glands in the axils, intramarginal vein present; petiole present; stipules intrapetiolar, small. Inflorescence a terminal or axillary cyme. Flowers 5-merous, actinomorphic, large, showy; sepals with or without colleters inside; corolla lobes overlapping to the left in bud, mature corolla infundibuliform, narrowly cylindrical at base, widening at point of stamen insertion, lobes broadly ovate; stamens 5, inserted on the corolla tube, weakly coherent to the pistil head, completely included in the corolla tube, filaments short, anthers lanceolate; disk annular or crenate; ovary 1-locular, syncarpous with 2 parietal placentas, style filiform, pistil head with a collar. Fruit a spiny, 2-valved capsule, dehiscent. Seed ovoid, smooth.

Growth and development *A. cathartica* flowers throughout the year. *A. schottii* in Java flowers from March–August. In Brazil, butterflies, bees and wasps are frequent visitors of *A. schottii* flowers. Successful fertilization is only achieved by butterflies of the genus *Phoebis*.

Other botanical information Within the *Apocynaceae*, *Allamanda* is placed in the subfamily *Plumerioideae* and the tribe *Allamandeae*. The name refers to Frederik Allamand, a Swiss doctor who collected plants in Suriname around 1770 and sent them to Linnaeus. Linnaeus remarked that he had learned more from the one letter that Allamand sent with the plants than from 100 books because of the curious and precise observations Allamand had recorded.

Ecology *Allamanda* grows best in full sun to light shade and is moderately drought resistant. *Allamanda* plants prefer a well-drained but moisture-retentive, highly fertile, loam-based soil mixture, with additional organic matter.

Propagation and planting *A. schottii* is usually propagated by seed. *A. cathartica* can be propagated from stem tip cuttings or ripe wood cuttings, of 2–3 internodes. Cuttings are best grown under shade in a mixture of equal parts sharp sand and leaf mould. Rooting success can be increased by applying indole butyric acid at 2000 ppm for softwood and 3000 ppm for hardwood cuttings.

Husbandry Pinching out stem tips of *Allamanda* when young encourages a bushy habit. Pruning at the beginning of the growth season is recommended in seasonal climates. Providing support and binding is advised when grown as a climber. Flowering is best maintained by applying a substantial amount of manure or fertilizer.

Diseases and pests Ringspot caused by cucumber mosaic virus in *A. cathartica* or *A. schottii* occurs in South America.

Harvesting Leaves of *Allamanda* are collected whenever the need arises.

Genetic resources and breeding As both *Allamanda* species are cultivated worldwide and natural populations do not appear to be seriously threatened, the risk of genetic erosion seems very limited. Breeding focuses on developing cultivars with better ornamental value.

Prospects The iridoid lactones from *Allamanda* show some interesting pharmacological effects in the field of antimicrobial and antineoplastic activity. This merits further research to fully evaluate their potential as possible lead compounds in drug development.

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Selection of species

Allamanda cathartica L.

Mant. pl. 2: 214 (1771).

Synonyms *Allamanda hendersoni* W. Bull ex Dombrain (1866).

Vernacular names Common allamanda, golden-trumpet (En). Indonesia: lame areuy (Sundanese). Malaysia: akar chempaka hutan, akar chempaka kuning, bunga akar kuning. Philippines: kampanero, campanilla (Tagalog). Thailand: ban buri lueang (general). Vietnam: huynh anh, d[aa]y hu[yf]nh.

Distribution Native to tropical America and the Caribbean, *A. cathartica* is now cultivated throughout the tropics.

Uses Throughout South-East Asia, a decoction of the leaves is used as a purgative or emetic. In the Philippines, a decoction of the plant is used as an antidote. However, large doses may result in poisoning. In Java a steaming infusion is used to relieve coughs and headaches; the patient breathes in the vapour. In South America, the leaves or latex are used as a purgative. In Peru, the bark is used as a febrifuge. In Suriname, a decoction of the root is taken as a remedy for jaundice and enlarged spleen resulting from malaria.

Observations A robust climbing shrub up to 6 m tall, branchlets glabrous; leaves elliptical to obovate, 2.5–15 cm × 1–5 cm, base cuneate, apex acuminate to caudate, glabrous or pilose beneath; inflorescence 8.5–18 cm long, sepals lanceolate or narrowly elliptical, 10–17 mm × 3–4 mm, without colleters inside, corolla tube about 5–7 cm long, distinctly widened halfway, lobes 1.6–4 cm long, style with stigmatic pistil head about 3.5 cm long; in cultivation rarely fruiting. In its native area, *A. cathartica* is found in mangrove swamp and on river banks. Several cultivars have been developed in *A. cathartica*. 'Grandiflora' has flowers of exceptional size, 'Hendersonii' has orange-yellow flowers with white spots in throat, tinged bronze, lobes thick and waxy, and 'Nobilis' has large and strongly whorled leaves, with very large, pure gold flowers.

Selected sources 37, 74, 135, 380, 407, 459, 696, 739, 786, 810.

Allamanda schottii Pohl

Pl. bras. icon. descr. 1: 73, pl. 58 (1827).

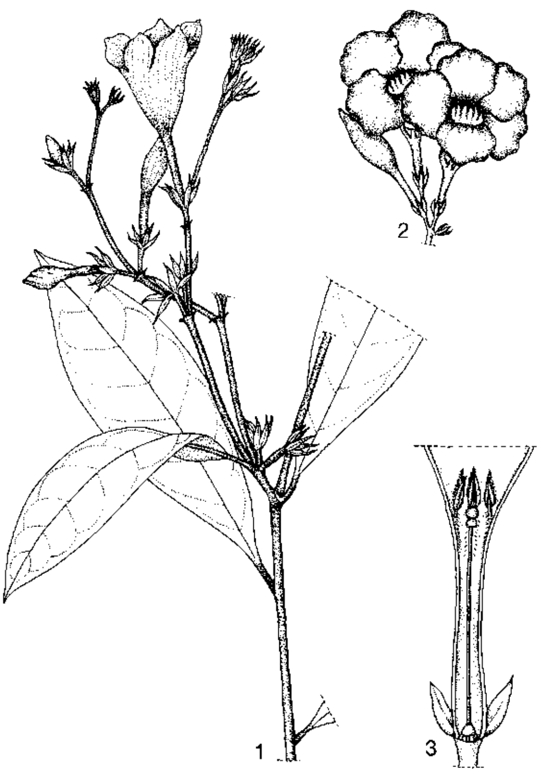
Synonyms *Allamanda neriifolia* Hook. (1851).

Vernacular names Bush allamanda (En). Thailand: ban phara (Bangkok). Vietnam: d[aa]y hu[yf]nh l[as] h[ej]p.

Distribution Native to southern Brazil, *A. schottii* is now cultivated throughout the tropics and is locally naturalized in South-East Asia.

Uses The traditional use in South-East Asia is limited to cultivation as ornamental.

Observations A semi-erect shrub up to 2 m tall, branches minutely puberulent when young; leaves elliptical to weakly obovate, 3.7–8(–14) cm × 1.3–2.5(–4 cm), base cuneate, apex acuminate, pilose beneath, subsessile; inflorescence 5–12 cm long, sepals lanceolate, 6–7 mm × 2–3 mm, with colleters inside, corolla tube about 4 cm long, dis-



Allamanda cathartica L. – 1, flowering branchlet; 2, detail of inflorescence; 3, dissected flower.

tinctly widened near the base, lobes 1–1.6 cm long, style with stigmatic pistil head about 1.2 cm long; fruit 2.5–3 cm in diameter, with spines up to 1 cm long. In Java, *A. schottii* is found in grassy fields, railway embankments and thickets.

Selected sources 74, 135, 459.

Slamet Sutanti Budi Rahayu

Alpinia Roxb.

Asiat. Res. 11: 350 (1810).

ZINGIBERACEAE

$x = 24$; *A. galanga*: $2n = 48$, *A. malaccensis*: $2n = 48$; *A. mutica*: $2n = 48$, *A. zerumbet*: $2n = 42$

Major species *Alpinia galanga* (L.) Willd., *A. officinarum* Hance, *A. zerumbet* (Pers.) B.L. Burtt & R.M. Smith

Vernacular names Papua New Guinea: esege (Sui, Northern Province), henigugau (Maiwara, Milne Bay), patu (Wapenamanda, Enga).

Origin and geographic distribution *Alpinia* is a large, polymorphic genus, comprising over 250 species. It occurs throughout South and South-East Asia, from India to Japan, southward to New Guinea, the Solomon Islands, Fiji, Samoa and Australia.

Uses The rhizome of medicinally used *Alpinia* is generally taken as a stomachic, for indigestion, stomach-ache and diarrhoea, and also as an emetic and as an expectorant. It is also externally applied for rheumatism, wounds, sores and ringworm. The leaves are used for the latter purpose as well, with the intention of drawing blood to the skin.

In Peninsular Malaysia *A. conchigera* is frequently used, often externally. A poultice of the boiled leaves, or of the leaves and rhizome together, is applied for rheumatism, and the same ingredients are also used for bathing. The pounded leaves are used as a poultice after confinement. The fruits are very pungent. On the eastern coast of Peninsular Malaysia juice of the rhizome is mixed with milk and drunk as a tonic. In Indo-China the rhizome is considered stimulating, bechic, diaphoretic, and to regulate menses. It is used in the treatment of bronchitis, jaundice, headache, vertigo or metritis. A poultice of the rhizome serves as an external treatment for fungal skin infection.

The rhizomes of *A. galanga* are official in several European pharmacopoeias and have a strong pungent taste. They are widely used in traditional medicine, in skin diseases, respiratory diseases, as a stomachic after childbirth, in indigestion, flatulence, colic, dysentery, cancers of mouth and stomach, for treatment of systemic infections and cholera, and as an expectorant. In India, Indo-China and China the rhizome is taken for dyspepsia, for convulsions as a carminative, and as an expectorant for bronchitis, externally it is applied for rheumatism. In Thailand the rhizome is used for a large array of ailments, for purifying blood, indigestion, contusions, diarrhoea, tetanus infection, chronic malaria, beriberi, yaws, stomach-ache, cholera, itching, ringworm, skin diseases, impetigo, urticaria, toothache, and as an antispasmodic, anthelminthic, carminative, antiflatulence and laxative. In the Philippines the rhizomes are considered carminative and stimulant, and a decoction of the leaves is used for antirheumatic and stimulant baths. The rhizomes of *A. officinarum* are more aromatic and pungent than those of *A. galanga*, and the local use of both species is more or less the same.

In the Philippines a decoction of the leaves of *A. zerumbet* is used as a bath against fevers. In China the seed is used to clear away cold, invigorate the spleen and warm the stomach. Components from the seed have shown anti-stomach-ulcer properties. The rhizome has antibacterial properties and stimulates digestion. It is indicated in the treatment of dyspepsia, flatulence, vomiting, gastralgia, colic, diarrhoea and malaria.

The rhizomes are used in Taiwan in the treatment of vomiting, dyspepsia and gastric ulcers. In China the plant is employed to treat stomach disorders, vomiting and dyspepsia. Its rhizome is traditionally used as a stomachic, carminative, astringent, tonic and sedative.

The slender *A. aquatica* (Retz.) Roscoe (synonyms *Languas melanocarpa* Burkill, *Alpinia melanocarpa* Ridley) is found on sandy localities near the sea in Peninsular Malaysia, and has stout, aromatic, perhaps even bitter rhizomes. It is not used widely for medicinal purposes, although a decoction of the plant is known to be taken during the first 3 days after confinement, and a decoction of the flowers is taken for cholera. A hot water fomentation of the leaves, or the heated leaves of the stout *A. scabra* (Blume) Baker (synonym *Languas scabra* Burkill), occurring in the hills of Peninsular Malaysia and Java, are applied to the abdomen for vertigo.

In China the rhizome of *A. chinensis* (Retz.) Roscoe (synonym *Languas chinensis* Retz.) is taken as a stomachic, for indigestion and to relieve stomach-ache, diarrhoea, rheumatism and pain in the joints, and has therefore been planted in gardens in Peninsular Malaysia by the Chinese. The rhizome is also taken for sunstroke, and activates slow blood circulation. In China and Indo-China the seed of *A. katsumadai* Hayata is used to strengthen the spleen, as a stomachic and to arrest vomiting, also for stomach problems such as dyspepsia, diarrhoea and alcoholic intoxication.

Many species of *Alpinia*, including *A. bracteata* Roxb., *A. malaccensis, A. mutica, A. nigra* Burrt and *A. zerumbet*, are cultivated as garden plants and as potplants for their attractive, often variegated leaves and striking inflorescences.

Production and international trade Data on the production, consumption and trade of the rhizome of *A. galanga* and *A. officinarum* are scarce and unreliable because often no distinction is made between the 2 species. Production in South-East Asia is considerable as it is a common spice used daily by millions of people. No information is available on the production and trade of lesser-known *Alpinia*.

Properties *Alpinia* is a genus in which many complex compounds are found in the aerial parts and in the rhizomes. Several species contain diarylheptanoids, which in structure resemble the curcuminoids (e.g. curcumin, from *Curcuma*) and which possess potent anti-inflammatory properties. Several tests with 3 such compounds, yakuchinone B, dimethyl-yakuchinone B and 1-(3,5-dimethoxy-4-hydroxyphenyl)-7-phenylhept-1-en-3-one, were performed *in vitro* and *in vivo*, and the results suggest that their anti-inflammatory action is at least in part due to their suppressive effect on the surface expression of inducible adhesion molecules in endothelial cells, and subsequent leukocyte adhesion. In addition, the diarylheptanoids were found to be potent inhibitors of the prostaglandin biosynthesizing enzyme (PG synthetase) and arachidonate 5-lipoxygenase, an enzyme of the leukotriene biosynthesis. This was verified by testing their inhibitory effects of 5-lipoxygenase prepared from RBL-1 cells. A diarylheptanoid with a catechol group was the most active compound against 5-lipoxygenase. Besides the presence of diaryheptanoids (e.g. 1-(4-hydroxyphenyl)-7-phenylheptane-3,5-diol), the rhizome of *A. officinarum* contains several flavonoids: quercetin, kaempferol, quercetin-3-methylether, isorhamnetin, kaempferide, galangin, galangin-3-methylether and probably also rhamnocitrin and 7-hydroxy-3,5-dimethoxyflavone.

The crude water extract showed significant in-vivo activity against five sorts of experimentally induced acute ulcers (stress ulcers, Shay's ulcers, aspirin-induced gastric ulcers, mepirizole-induced duodenal lesions and cysteamine-induced duodenal lesions) and two experimentally induced chronic ulcers (acetic acid-induced ulcers and thermocautery ulcers).

An extract from the rhizomes also showed strong antifungal properties. The ethanol extract of the rhizomes was tested in vitro for acaricidal activity on adult tropical cattle ticks (*Boophilus microplus*) by the dipping method, and 86–100 % acaricidal activity occurred after 5 days. Finally, the methanol extract of the rhizomes was tested for its nematicidal activity on the second-stage larva of *Toxocara canis* and was found to be active even at a concentration as low as 0.1–0.2 mg/ml.

Several parts of *A. galanga* yield an essential oil, e.g. the rhizomes contain on dry weight basis about 0.2–1.5%, and on fresh weight basis about 0.1%. The major compound is myrcene, which may account for up to 95% of the rhizome oil. Other constituents of the oil include the pungent galangol (which on distillation gives cineole), and furthermore 1,8-cineole, linalool, geranyl acetate, eugenol, methyl-eugenol, chavicol acetate, 1'-acetoxy chavicol acetate, β-bisabolene, trans-β-farnesene, α-bergamotene, α-pinene and caryophyllene epoxide. The leaf essential oil also contains myrcene (up to 52%), and the seed essential oil contains mainly cineole together with small quantities of citral. In addition to volatile constituents, the rhizome also contains flavonoids: galangin (3,5,7-trihydroxyflavone), galangin monomethyl ether, kaempferol and quercetin.

The essential oil from both fresh and dry rhizomes shows strong in vitro and in vivo antibacterial, antifungal, antiprotozoal, insecticidal and expectorant activities. The water, alcohol or ether extract, but not the petroleum extract, of the rhizome had strong antibacterial properties against *Bacillus subtilis*, *Escherichia coli*, *Staphylococcus aureus* (several strains), *Aeromonas hydrophila* and *Pseudomonas aeruginosa*. The alcohol and chloroform extracts, but not the water extract, possessed antifungal activity against *Candida albicans*, *Cryptococcus neoformans*, *Epidermophyton floccosum*, *Microsporum gypseum*, *Trichophyton rubrum*, and *Saccharomyces* sp. The ether extract also had significant effects on *Klebsiella pneumoniae*.

In addition, the antioxidant and microbial stabilities of an extract of the rhizome (0.01–0.10%) in raw minced beef were examined, and it was found that the extract improved oxidative stability, while the highest concentrations of the extract were also found to extend the shelflife of minced beef. Addition of α-tocopherol to the extract increased the oxidative but not the microbial stability of minced beef during the storage period of 7 days.

Of the isolated volatile compounds, 1'-acetoxychavicol acetate shows strong antitumour activity in numerous in-vitro and in-vivo tests, e.g. against Sarcoma 180 ascites in mice, inhibition of the development of azoxymethane-induced colon tumorigenesis in human cells, and inhibition of endogenous rat-liver carcinogenesis. Other potential anticarcinogenic compounds from the rhizome oil of *A. galanga* are ethyl trans-cinnamate and ethyl 4-methoxy-trans-cinnamate, which showed significant capacity to induce glutathione S-transferase (GST) activity in mice tissues. A methanolic extract of the rhizome showed potent inhibition of mutagenesis induced by 3-amino- 1,4-dimethyl-5H-pyrido[4,3-β]indole (Trp-P-1) in *Salmonella typhimurium* TA98.

Furthermore, an ethanolic extract of the rhizomes at a dose of 500 mg/kg showed anti-ulcer activity in Shay rats while the chavicol derivatives depressed the gastric secretion of these rats significantly. The extract also significantly reduced gastric secretion and showed marked cytoprotective activity. In another model, the powdered rhizomes were tested for their effect on oxalate urolithiasis in male rats and showed moderate activity.

Acute (24 h) and chronic (90 days) oral toxicity studies on the ethanolic extract of the rhizome of *A. galanga* were carried out in mice. Acute dosages were 0.5–3 g/kg body weight while the chronic dosage was 100 mg/kg/day. All external morphological, haematological, and spermatogenic changes were recorded, as were body weight and vital organ weights. The weight gain was significant, as well as the rise in the red blood cell level. Also, highly significant gain in weights of sexual organs and increased sperm motility and sperm counts were observed, but no spermatotoxic effects.

The essential oil from the rhizomes of *A. zerumbet* (from Egypt) was rich in terpinen-4-ol, 1,8-cineole, sabinene, γ-terpinene and fenchyl acetate. A comparable oil distilled in Martinique consisted mainly of terpinen-4-ol (nearly 50%) and α-terpineol. Fresh leaves contain 0.1–0.2% essential oil, with marked quantitative and qualitative differences, depending on their origin. The oil obtained from flowers, originating from Brazil, was dominated by 1,8-cineole (23%), terpinen-4-ol (20%) and sabinene (15%). Furthermore, the seeds contain about 0.4% essential oil, with as main components para-cymene, 1,8-cineole and torreyol, but also the labdane-type diterpenes zerumin A B, as well as (E)-15,16-bisnorlabda-8(17), 11-diene-13-one and coronarin E.

The essentials oils from all parts of *A. zerumbet* (from Egypt), exhibited significant antimicrobial activity against certain Gram-positive bacteria (*Bacillus subtilis*, *Mycobacterium phlei*, *Sarcina lutea* and *Staphylococcus aureus*) and Gram-negative bacteria (*Escherichia coli* and *Pseudomonas aeruginosa*), as well as *Candida albicans*. Geraniol and isothymol from the essential oil from the rhizome possess high antimicrobial activity against plant pathogenic fungi.

In addition, volatile sesquiterpenes and their derivatives were isolated from the rhizomes of *A. zerumbet* and *A. japonica* (Thunb.) Miq. (from Japan). These inhibited histamine- or barium chloride-induced contractions of excised guineapig ileum when tested by the Magnus method. Major spasmolytic principles contained in these extracts were sesquiterpenes including β-eudesmol, nerolidol, humulene epoxide II and 4-α-hydroxydihydroagarofuran.

Furthermore, from the aqueous extract of the leaves (from Brazil), flavonoids (rutin, kaempferol-3-O-rutinoside, kaempferol-3-O-glucuronide, (+)-catechin and (–)-epicatechin) and lactones of the kava-pyrone type (dihydro-5,6-dehydrokawain (DDK) and 5,6-dehydrokawain (DK)) were obtained. In general, flavonoids are well-known substances that can contribute to the hypotensive and diuretic effects of the aqueous extract of this plant. The kava pyrones have been described as antiulcerogenic and antithrombotic.

As an example, *A. zerumbet* is used in local medicine as a diuretic and to control hypertension. In a test, a concentrated extract of the rhizome was administrated to 10 healthy volunteers, but only a light significant increase in diuresis was observed, which also lowered the mean diastolic and systolic blood pressure. Furthermore, DK and DDK inhibited the aggregation and ATP release of rabbit platelets induced by arachidonic acid and collagen, without affecting those induced by ADP, PAF and thrombin. This inhibition was reversible and occurred in a concentration-dependent manner. Thromboxane B2 formation caused by arachidonic acid was also suppressed by both antiplatelet agents. The antiplatelet effect of both DK and DDK is therefore likely to be due to the inhibition of thromboxane A2 formation. In addition, the activity of *A. zerumbet* leaves against stomach-ache, vomiting and dyspepsia has also been attributed to the compounds dihydro-5,6-dehydrokawain (DDK) and 5,6-dehydrokawain (DK). Subsequently, DDK and DK were investigated for their subchronic toxicity in mice and rats and both DDK and DK exhibited a weak sedative activity but their toxic effects were negligible. When an alcoholic extract was injected intra-peritoneally in mice (dose range of 100–1400 mg/kg intra-peritoneally (i.p.), or orally (2500–18000 mg/kg (p.o.)), it produced writhing, psychomotor excitation, hypokinesis and pruritus. Therefore, the LD_{50} by i.p. route was determined to be about 0.8 g/kg, and 11 g/kg p.o.

Dihydro-5,6-dehydrokawain was also found to be a plant growth inhibitor, causing reduction in hypocotyl length of lettuce (*Lactuca sativa* L.) seedlings, etiolation and necrosis at increasing dose. DDK also inhibited the germination and growth of *Arabidopsis thaliana* (L.) Heynh. seeds.

More than 40 constituents are present in the rhizome oil of *A. conchigera*. The major include β-sesquiphellandrene (20%), β-bisabolene (12%) and 1,8-cineole (11%), but also 1,7-diphenyl-3,5-heptanedione, together with four other diarylheptanoids.

From the essential oil of fresh rhizomes of *A. mutica*, collected from cultivated plants in Malaysia, 24 components were identified which constituted 88% of the oil, the major components being camphor (36%), 1,8-cineole (9%) and borneol (8%) but also pinocembrin. Chalcone flavokawin B, 5,6-dehydrokawain and 1,7-diphenyl-5-hydroxy-6-hepten-3-one were isolated both from rhizomes of *A. mutica* and *A. rafflesianum*, and methyl cinnamate also from *A. rafflesianum*. The dichloromethane and methanol extracts of *A. rafflesianum*, *A. vitellina*, *A. malaccensis* and *A. mutica* showed strong antioxidant and antimicrobial activity. The antioxidant activity was comparable with or higher than that of α-tocopherol.

Steam distillation of the leaves of *A. malaccensis* yielded up to 0.2% essential oil, consisting mainly of methyl cinnamate (75%). The rhizomes yielded up to 0.3% of a similar essential oil. The essential oil from the seed of *A. malaccensis* from China contains 1,8-cineole, citronellol, 4-phenyl-3-buten-2-one, geranyl acetate, nerolidol, and α- and β-farnesol.

The essential oil of the leaves of *A. chinensis* (from Vietnam), contains more than 40 components, of which β-bisabolene (48%) is the major compound. About 30 components were identified from the essential oil of the flowers, of which the main were (E,E)-α-farnesene (27%), α-humulene (22%), β-bisabolene (17%) and β-caryophyllene (13%).

The major components of the leaf oil of the ornamental *A. purpurata* (Vieill.) K. Schum. are 1,8-cineole (22%), β-pinene (15%) and (E)-methyl cinnamate (13%). The oil obtained from flowers was dominated by β-pinene (28%) and α-pinene (17%).

The Chinese *A. oxyphylla* Miq. ('bitter cardamom') has been extensively tested for its biological activity. The rhizome contains the following main compounds: diarylheptanoids yakuchinone A and B and oxyphyllacinol, 3 sesquiterpenes, i.e. valencene, nootkanone and nootkanol, 2 flavones, tectochrysin and chrysin, and 2 steroids, β-sitosterol and daucosterol. The structures of the diarylheptanoids are analogous to that of curcumin, which has been widely shown to inhibit tumour promotion in experimental carcinogenesis. Topical application of the methanol extract of dried fruits significantly ameliorated skin tumour promotion as well as ear oedema in mice. Several other findings confirm that *A. oxyphylla* possesses potential chemopreventive and antitumorigenic activities.

In addition, the acetone extract of the fruits was tested for its anti-ulcer effect. At 50 mg/kg p.o. the extract significantly inhibited HCl/ethanol-induced gastric lesions in rats by 57%. Nootkatone at 20 mg/kg p.o. also inhibited significantly gastric lesions. The effect of a water extract on immunoglobulin E(IgE)-mediated anaphylaxis activated by anti-dinitrophenyl IgE antibody was furthermore evaluated. The results indicated that the extract may possess strong anti-anaphylactic action and also suggest that differential activity following administration routes seen during the experiments may be caused by differences in bioavailability.

Two diarylheptanoids, katsumadain A and B, were isolated from the seeds of *A. katsumadai*. Both compounds showed anti-emetic activities on copper sulphate-induced emesis in young chickens. An extract of the aerial parts was effective in suppressing the growth of food poisoning bacteria and fungi.

Adulterations and substitutes The dried powdered rhizome of the primarily medicinally used *A. officinarum* is often adulterated with the dried rhizome of *Acorus calamus* L. or *A. galanga*, and sometimes with other *Alpinia* or *Zingiber* species. Several other *Zingiberaceae* genera contain compounds that also have well-known anti-inflammatory activities, e.g. curcumin from *Curcuma domestica* Valeton (synonym *C. longa* L.).

Description Perennial, erect herbs, with numerous leafy stems, 0.5–4 m tall, rhizomes fleshy, creeping. Leaves numerous, distichous, lanceolate to ovate, lower and upper ones smallest, finely pinnately veined, subglabrous; usually petiolate, often sheathing; ligule well-developed. Inflorescence usually terminal on leafy stem, spicate, paniculate or racemose, erect or occasionally drooping, when young usually protected by spathe-like sterile bracts; fertile bracts subtending a cincinnus of 2–many flowers; bracteoles normally present, sometimes tubular. Flowers bisexual, small to large, red, orange, yellowish to cream or white; calyx tubular, sometimes splitting unilaterally when flower expands; corolla tubular, tube usually not longer than the calyx, 3-lobed, lobes unequal, dorsal one largest, more or less hooded; labellum (anterior staminode) usually large and showy, 2 lateral staminodes small or absent; fertile stamen one, subsessile or with well-developed filament, anther sometimes crested; ovary inferior, 3-locular, surrounded by massive glands, stigma expanded with a narrow, hairy orifice. Fruit a few–many-seeded, dehiscent capsule, crowned by calyx remnants. Seed angular, arillate, often aromatic.

Growth and development After vegetative propagation from a portion of rhizome of *Alpinia*, a large clump of up to 1 m in diameter may develop within a year. Shoots from pieces of an *A. galanga* rhizome emerge about 1 week after planting, and 2–3 leaves have developed about 4 weeks after planting. Rhizomes develop quickly and can best be harvested about 3 months after planting when used as a spice. If left longer in the field, they become too fibrous and the large clumps of plants that are formed hamper harvesting. Flowering occurs after exceptionally dry weather. In India, plants start flowering in the latter half of the hot season (April–May) and seeds ripen in November. However, seeds rarely reach maturity. In Java *A. malaccensis* flowers throughout the year. *Alpinia* is pollinated by insects, often bees.

Other botanical information *Alpinia* belongs to the tribe *Alpinieae*, which also includes *Amomum*, *Elettaria* and *Riedelia*. *Alpinia* is a large genus, and there have been several attempts at a subgeneric classification. The most recent classification divides the genus into 2 subgenera, and is based mainly on the character of the labellum (petaloid or non-petaloid). In subgenus *Alpinia* the labellum is usually concave with incurved margins, commonly striped or spotted, the margins extending into a petaloid area with divergent venation, while in subgenus *Dieramalpinia* (K. Schum.) K. Schum. the labellum is held erect and almost always closely pressed against the stamen, usually not striped or spotted, lateral margins not well developed, the apex only occasionally expanding into a small petaloid area. Subgenus *Alpinia* occurs throughout the area of distribution of the genus but has a centre of diversity in continental Asia, and subgenus *Dieramalpinia*, which is absent from continental Asia and has a centre of diversity in New Guinea and the Moluccas. The largest subgenus, *Alpinia*, is divided into 7 sections, two of them further divided into several subsections. Subgenus *Dieramalpinia* is divided into 4 sections, one of them with 2 subsections. All species treated here belong to section *Alpinia*, but to several subsections.

Several cultivars of *A. galanga* exist. Those with yellow-white rhizomes are used as a spice, and are about 3 m tall, with stems 2.5 cm and rhizomes 3–4 cm in diameter, while those with pink to red rhizomes are mainly used medicinally, and are about 1–1.5 m tall with stems up to 1 cm and rhizomes up to 2 cm in diameter. White-rhizomed cultivars with similar characteristics to the red-rhizomed ones also exist.

Plants with broad leaves, tomentose beneath, are sometimes distinguished as var. *pyramidata* (Blume) K. Schum., occurring both wild and cultivated in Java, Borneo and the Philippines.

The identity of *A. chinensis* is problematic as the type specimen has been lost and its description shows characteristics common both to *A. calcarata* Roscoe and *A. officinarum*.

Ecology *Alpinia* normally prefers humid, shady conditions and not too high temperatures, at least during the night, e.g. 27–30°C during daytime and 17–18°C at night. They often occur in secondary vegetation, bamboo and teak forest, brushwood and ravines, rarely in primary forest. Near villages, they usually grow in the open. They require rich soils.

A. galanga requires sunny or moderately shady locations. Soils should be fertile, moist but not swampy. Sandy-clay soils rich in organic matter and with a good drainage are preferred.

Propagation and planting *Alpinia* is propagated by division of rhizomes, which are planted 50–100 cm apart, and given enough water and liquid fertilizer. Planting is done during the rainy season.

In-vitro multiple-shoot production of *A. galanga* has been successful through excised rhizome buds, cultured on Murashige & Skoog (MS) medium, supplemented with an auxin. On the best medium, 80% of the explants produced on average 7 shoots, and 70% of the shoots produced roots on MS containing 2.5 mg naphthalene acetic acid. The micropropagated plants were transplanted to soil with 75% survival.

A. zerumbet is produced commercially in the United States and Europe as an ornamental and can be propagated by tissue culture.

Husbandry *Alpinia* requires cool, shaded conditions; it needs clipping and thinning to keep the plants low.

Diseases and pests Ginger strain, a bacterial wilt caused by *Pseudomonas solanacearum*, may attack *Alpinia*. *Alpinia* is also sensitive to several root-knot nematodes, like *Meloidogyne arenaria*, *M. incognita* and *Radopholus similis*.

Harvesting The rhizomes of *A. officinarum* are harvested in Vietnam at the end of the rainy season. The fruits are collected in July and August. In India, the rhizomes of *A. galanga* are collected at the end of the rainy season. The dried rhizome of *A. galanga* is 2.5–10 cm in diameter, reddish-brown skinned, orange-brown inside. It is larger than the rhizome of *A. officinarum*, and the taste and odour are less pronounced than in the latter species. *A. officinarum* is whitish inside.

If produced for the market, rhizomes of *A. galanga* are harvested about 3 months after planting. Whole plants are pulled out, the shoots cut off and the rhizomes washed and cleaned. For local use plants are left in the field and, as they tiller vigorously, small quantities of good quality rhizome can always be harvested. For the production of essential oil rhizomes are harvested when the plants are more than 7 months old.

Yield An 8-month-old plant of *A. malaccensis* yields about 1 kg rhizomes and 35 kg leaves.

Handling after harvest The leaves and rhizomes of *Alpinia* are used fresh or dried for future use. Whole plants are pulled up, the shoots cut off and the rhizomes washed and dried in the sun or in an oven. The fruits are dried and powdered. The dried rhizomes of *A. galanga* are usually ground before use, but ground rhizomes are not traded in bulk, as adulteration can occur, e.g. with *A. officinarum*.

Genetic resources and breeding The *Alpinia* species treated here are widespread and common throughout South-East Asia, and therefore not endangered. Neither germplasm collections of *Alpinia* nor breeding programmes are known to exist.

Prospects The interesting pharmacological activities of *Alpinia*, shown by isolated compounds such as the diarylheptanoids and pyrones, merit further research. A combined approach to the future possibilities in medicine, together with their potential as an insecticide, may give rise to cultivation of selected *Alpinia* species on a larger scale. Furthermore, they are likely to remain important as ornamentals.

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Selection of species

Alpinia conchigera Griffith

Not. pl. asiat. 3: 424, pl. 354 (1851).

Synonym *Languas conchigera* (Griffith) Burkill (1930).

Vernacular names Malaysia: langkuas kechil, lengkuas padang, chengkenam. Thailand: khaa ling (eastern). Vietnam: ri[eef]ng r[uwf]ng.

Distribution Eastern India through continental Asia to Peninsular Malaysia and Sumatra.

Uses In Peninsular Malaysia, a poultice of the boiled leaves, or of the leaves and rhizome together, is applied topically for rheumatism, and also for bathing. The pounded leaves are also used as a poultice after confinement. In Indo-China, the rhizome is considered stimulating, diaphoretic and used in the treatment of bronchitis, jaundice, headache and vertigo. It is also mixed with other herbs for a post partum tonic. In Thailand, the rhizomes are used for ringworm, indigestion and abscesses, while the leaves are poulticed for ringworm.

In Indo-China, the rhizome is also used for flavouring rice alcohol and food, and the fruits are also considered edible and medicinal.

Observations A slender herb, 0.6–1.5 m tall, rhizome slender; leaves oblong, 15–30 cm × 4–8 cm, margins ciliate, glabrous, petiole about 5 mm long, ligule entire, up to 5 mm long, pubescent; raceme 20–30 cm long, sometimes with 1 basal branch, cincinni numerous, bracts small, broadly funnel-shaped; flowers small, up to 1.5 cm long, calyx short, 3 mm long, thick, corolla tube short, lobes elliptical-oblong, about 13 mm long, white to greenish-white, labellum obovate, strongly concave, yellowish or pinkish-white with red stripes on each side, 2 short teeth (staminodes) at base, filament 5 mm long, curved, yellow; capsule globular, about 8 mm in diameter, pink or red, glabrous; seed strongly aromatic. *A. conchigera* occurs in rubber or oil-palm plantations, swampy areas, open country near villages, semi-wild or planted.

Selected sources 135, 215.

Alpinia elegans (C. Presl) K. Schum.

Bot. Jahrb. Syst. 27: 288 (1899).

Synonyms *Kolowratia elegans* C. Presl (1827), *Alpinia gracilis* Rolfe (1884), *Languas elegans* (K. Schum.) Burkill (1935).

Vernacular names Philippines: bagombon, tagbak (Tagalog), katkatan (Bisaya).

Distribution Endemic to the Philippines.

Uses A decoction of the rhizomes is taken for haemoptysis. The leaves, pounded with a little salt, are rubbed on paralyzed parts of a patient. The juice expressed from young stems is used for urticaria. The young rhizomes are soaked in water and the infusion is drunk for headache.

Observations A stout herb, 2–4 m tall, rhizome stout; leaves oblong-ovate to lanceolate, 25–60 cm × 5–20 cm, glabrous, petiole short, stout; panicle about 30 cm long, pendulous, branches short, about 8, covered with persistent bracts, bracts at base of peduncle oblong-lanceolate, 8–12 cm long, 1-several flowers per cincinnus, one opening at a time; calyx 4 cm long, corolla up to 7 cm long, tube cylindrical, upper lobe 4 cm long, concave, erect, other 2 as long but oblong-ovate, reflexed, pale yellow, labellum as long as corolla lobes, obovate, spreading, yellowish, lateral staminodes present, stamen with developed filament, anther with small crest; capsule ellipsoid, woody, 3–4 cm long. *A. elegans* occurs in thickets along streams, at low and medium altitudes.

Selected sources 810.

Alpinia galanga (L.) Willd.

Sp. pl. 1(1): 12 (1797).

Synonyms *Languas vulgare* J. Koenig (1783), *Amomum galanga* (L.) Lour. (1790), *Languas galanga* (L.) Stuntz (1912).

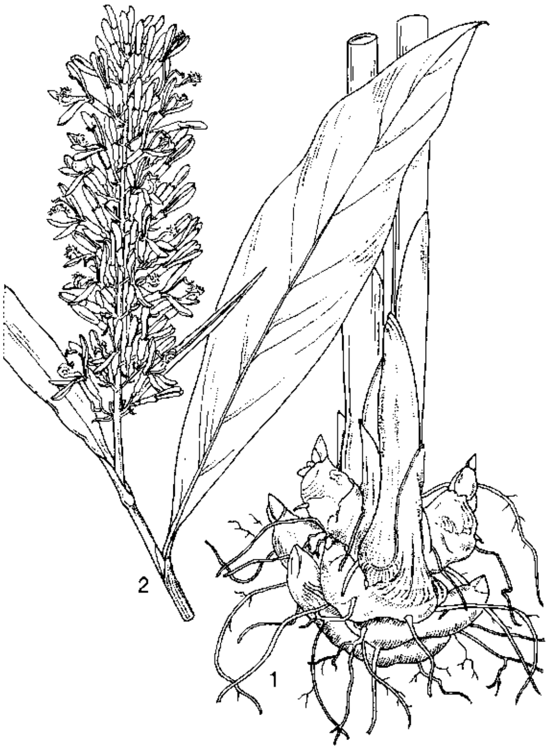
Vernacular names Galanga, greater galangal (En). Galanga (Fr). Indonesia: langkuas (general), laos (Javanese), laja (Sundanese). Malaysia: lengkuas, puar. Philippines: langkauas (general), pal-la (Mandaya). Burma (Myanmar): padagoji. Cambodia: rumdéng, pras. Laos: kha:x ta: dè:ng. Thailand: kha, kha yuak (northern), katuk karohinee (central). Vietnam: ri[eef]ng n[ees]p, s[ow]n n[aj]i, h[oof]ng d[aaj]u kh[aas]u.

Distribution Cultivated and semi-wild near villages in all tropical Asian and South-East Asian countries and also in China and Suriname.

Uses The rhizomes are widely used in traditional medicine, in skin diseases, respiratory diseases, as a stomachic after childbirth, for intestinal problems, cancers of mouth and stomach, and as an expectorant. In Java the grated rhizome with a little salt is given on an empty stomach for an enlarged spleen. In the Philippines the rhizomes are considered carminative and stimulant, and a decoction of the leaves is used as an antirheumatic and for stimulant baths. The rhizomes have also been used as an aphrodisiac by the Arabs, for other stimulating properties and as a veterinary medicine. The seeds have the same taste and odour as the rhizome and are prescribed in Peninsular Malaysia in colic, diarrhoea, vomiting and herpes. An infusion of the leaves is taken as a post-partum medicine.

The rhizome of *A. galanga* is generally used as a spice or source of essential oil throughout its distribution area. The flowers and young shoots are used as a vegetable or as a spice. The compound galangin dyes wool yellow and yellowish-green with appropriate mordants.

Observations A robust herb, up to 3.5 m tall, rhizome copiously branched, 2–4 cm in diameter, light red or pale yellow, fragrant; leaves oblong-lanceolate, (20–)50(–60) cm × (4–)9(–15) cm, subglabrous, glossy green, densely white-dotted,



Alpinia galanga (L.) Willd. – 1, rhizome; 2, shoot with inflorescence.

ligule truncate, 1 cm long, densely pubescent, petiole 1–1.5 cm long, hairy; inflorescence racemose, erect, many flowered, 10–30 cm × 5–7 cm, pubescent, bracts ovate, up to 2 cm long, each subtending a cincinnus of 2–6 flowers, bracteoles smaller; flowers fragrant, 3–4 cm long, yellow-white, calyx tubular, about 1 cm long, white, corolla tube terete, about 1 cm long, lobes 3, recurved, oblong-lanceolate, 1.5 cm × 0.6 cm, margins ciliate, greenish-white, labellum spatulate, 1.5–2.5 cm × 0.5–0.75 cm, white veined with lilac to purple, clawed, margin undulate crenate, apex recurved inwards, lateral staminodes represented by 2 subulate lobes at the base of the labellum, 7–8 mm long, reddish, stamen erect, anther incurved, 2–2.5 cm long; capsule globose to ellipsoid, 1–1.5 cm in diameter, orange-red to wine red, black when mature, 2–3-seeded. *A. galanga* occurs in cultivation and semi-wild near villages, or at the borders of secondary forest.

Selected sources 51, 135, 165, 178, 215, 230, 237, 297, 407, 484, 545, 549, 590, 691, 739, 747, 810, 811, 1096, 1126.

Alpinia malaccensis (Burm.f.) Roscoe

Trans. Linn. Soc. 8: 345 (1807).

Synonyms *Languas malaccensis* (Burm.f.) Merrill (1921), *Catimbium malaccense* (Burm.f.) Holttum (1950).

Vernacular names Indonesia: laja gowah (Sundanese), langkuas malaka (Moluccas), susuk (Lampung). Malaysia: puar, bangle. Philippines: tagbak babae (Tagalog), barapat (Igorot), birao-birao (Sulu). Thailand: kha paa (northern, north-eastern). Vietnam: ri[eef]ng malacca.

Distribution Widespread from the moister parts of mountainous regions of India towards Malaysia, Indonesia and the Philippines. Cultivated in north-eastern India, Java and southern China.

Uses All plant parts are fragrant, and contain essential oils. In Java the pounded rhizome is used to cure wounds and sores. An infusion of the ripe and unripe fruits with a little salt is taken as an emetic. In the Philippines a decoction of the fruit or the crushed seed is applied for gastralgia with tympanites. A decoction is used for bathing feverish people. The rhizomes were chewed in the Moluccas together with betel nut (*Areca catechu* L.) to make the voice strong and clear. The rhizome is occasionally used as a spice, and is eaten as a vegetable in India. The pounded rhizome is also used as an ingredient of poison.

Observations A robust herb, 2–4 m tall, strongly aromatic when bruised; leaves narrowly lanceolate, 40–90 cm × 7(–20) cm, acuminate, usually densely pubescent below or pubescent on margins and midrib, sheath densely short hairy near the blade, ligule entire, up to 1 cm long, hairy, petiole 3–7 cm long; inflorescence racemose, erect or slightly curved, about 35 cm long, with 30 or more cincinni usually of 2 flowers each, bracts absent, bracteoles 1.5–2 cm long, caducous as the flower opens, white, cincinni of 2 very shortly pedicellate flowers or reduced to a single flower, pedicel 0.5–1.5 cm long; calyx 2 cm long, shortly 3-lobed and deeply split unilaterally, white, pubescent, corolla white, tube up to 1 cm long, lobes ciliate, lateral lobes 3 cm × 1 cm, dorsal lobe up to 4 cm × 2.5 cm, labellum broadly ovate, 3–5 cm long and at widest part 3 cm across, sides incurved, narrowing to an emarginate apex, at the base with 2 papillose fleshy swellings, yellow-orange with scarlet lines, lateral staminodes subulate, up to 5 mm long, filament of stamen about 1 cm long, anther connective not prolonged into a crest; capsule globose, up to 3 cm in diameter, shortly pubescent, red; seed 3–4-angular, about 5 mm long. *A. malac-*

censis is commonly found in primary forest and shaded rocky outcrops at low and medium altitudes.

Selected sources 135, 215, 381, 407, 810.

Alpinia mutica Roxb.

Asiat. Res. 11: 354 (1810).

Synonyms *Languas mutica* (Roxb.) Merrill (1929).

Vernacular names Malaysia: chengkenam (Peninsular). Vietnam: ri[eef]ng hoa th[uw]a.

Distribution Malaysia, planted in Vietnam and India as an ornamental.

Uses In Peninsular Malaysia an infusion of the rhizome is taken as a stomachic and for abdominal trouble.

Observations A rather slender herb, 1–2 m tall, rhizome rather slender; leaves narrowly lanceolate, up to 45 cm × 5 cm, long acuminate, glabrous, petiole about 2 cm long, ligule ovoid, 7–8 mm long, blunt; panicle few–many-flowered, up to 15 cm long, branches several, short, cincinni 3–5-flowered, bracts absent, bracteoles very small, oblong, 6 mm long, white, caducous; calyx tubular, 15–20 mm long, split halfway during flowering, white, corolla tube shorter, lobes oblong, 2.5–3 cm long, white, labellum broadly ovate, somewhat 3-lobed, basal part strongly concave, apex straight, bright yellow to orange with numerous red dots and veins, a dark red swelling at the base at each side, staminodes absent, stamen as long as corolla lobes, filament white, tinged pink, anther without crest; capsule ovoid, up to 2 cm in diameter, sparsely short hairy, orange-red, seeds numerous. *A. mutica* occurs in swampy localities, but is common as a garden plant in Singapore.

Selected sources 135, 381, 941.

Alpinia officinarum Hance

Journ. Linn. Soc., Bot. 13: 6 (1873).

Synonyms *Languas officinarum* (Hance) Farw. (1919).

Vernacular names Lesser galangal (En). Galanga officinal, vrai galanga (Fr). Thailand: khaa lek (central). Vietnam: ri[eer]ng, ri[eer]ng thu[oos]c, cao l[uw][ow]ng kh[uw][ow]ng.

Distribution Southern China, Indo-China, wild and cultivated. Imported to Peninsular Malaysia, India and the Middle East.

Uses The rhizomes of *A. officinarum* are more aromatic and pungent than those of *A. galanga*, but they contain more or less the same compounds, although *A. officinarum* has larger quantities of them. The local use of both species is approximately the same. The rhizomes are widely used in Vietnam for stomach problems including dyspepsia, flatulence, vomiting, gastralgia, colic, diarrhoea, fever and malaria, and are locally applied to infected gums. In Thailand, the rhizomes are used as carminative and for indigestion. The seeds are also used in China, for heartburn, cholera, toothache, ague and colds.
The rhizome is the source of true galangal oil used in flavour and perfume compositions to which it imparts unique, warm, spicy notes. It is also used for flavouring soft drinks such as ginger ale.

Observations *A. officinarum* is very similar to *A. galanga*, but is smaller in all vegetative characteristics. It is about 1–1.5 m tall, rhizomes 8–12 mm in diameter, glabrous, reddish-brown, dark brown to black; leaves oblong-lanceolate, 20–40 cm × 4–10 cm, coriaceous, glabrous, shiny, ligule acuminate, pubescent; raceme erect, up to 25 cm long, many-flowered; flowers up to 3 cm long, white, labellum white, veined with purple; capsule globular, finely pubescent. *A. officinarum* occurs wild and semi-wild near villages, and open country.

Selected sources 62, 135, 215, 264, 613, 739.

Alpinia rafflesianum Wallich

Wall. Cat. no. 6575 (1832).

Synonym *Languas rafflesiana* (Wallich) Burkill (1935).

Vernacular names Malaysia: puar mengkang, tepus kijai.

Distribution Malaysia.

Uses In Peninsular Malaysia the leaves are used for poulticing boils.

Observations A somewhat slender herb, 1–1.2 m tall; leaves lanceolate, up to 30 cm × 7.5 cm, pubescent; panicle short, compact, 5–10 cm long, 7.5 cm in diameter; calyx cup-shaped, 1.2 cm long, red, corolla tube nearly twice as long, lobes orange, red-tipped, up to 3 cm long, labellum broadly ovate, orange, darker veined, staminodes 2, short, apex purple; capsule globose, about 1 cm in diameter, hairy, green. *A. rafflesianum* is rather common in secondary forest from sea-level up to 1200 m altitude.

Selected sources 135, 381, 841, 941.

Alpinia vitellina (Lindley) Ridley var. cannaefolia (Ridley) I.M. Turner

Novon 6(2): 223 (1996).

Synonyms *Alpinia cannaefolia* Ridley (1899), *Languas cannifolia* (Ridley) Burkill (1935).

Vernacular names Malaysia: puar minyak, temu (Peninsular).

Distribution Malaysia.

Uses The leaves and rhizomes are boiled and drunk for fever.

Observations A stout herb, 1.2–1.5 m tall; leaves lanceolate to oblong, up to 30 cm × 15 cm, base narrowed, petiole up to 2–5 cm long; panicle erect, 10–15 cm long, pubescent, bracteoles small; calyx 2.5 mm long, pubescent, corolla tube slender, lobes linear, 2.5 cm long, rounded, yellow, labellum 2–2.5 cm long, oblong, bifid, margins crisped, orange, staminodes short, red, stamen 2.5 cm long, filament broadly winged, orange, pubescent, anther crested, 3-lobed; capsule oblong, pubescent, 2–3-seeded; seed oblong, 8 mm long, black. *A. vitellina* occurs in dense secondary forest, and is rather rare.

Selected sources 135, 381, 841.

Alpinia zerumbet (Pers.) B.L. Burtt & R.M. Smith

Notes Roy. Bot. Gard. Edinburgh 31(2): 204 (1972).

Synonyms *Zerumbet speciosum* J.C. Wendl. (1798), *Alpinia speciosa* (J.C. Wendl.) K. Schum. (1903), *Languas speciosa* (J.C. Wendl.) Small (1913), *Catimbium speciosum* (J.C. Wendl.) Holttum (1950).

Vernacular names Shell ginger, shell flower, light galangal (En). Atoumau (Martinique)(Fr). Indonesia: galoba merah, goloba koi, langkuas laki-laki (Moluccas). Philippines: langkuas na pula (Tagalog). Thailand: khaa khom (northern). Vietnam: ri[eef]ng[aas]m, g[uwf]ng [aas]m.

Distribution Considered native to north-eastern India, Burma (Myanmar), Indo-China, China and Japan. Cultivated throughout South-East Asia and in many other tropical and subtropical countries.

Uses In the Philippines a decoction of the leaves is used as a bath against fevers. The rhizome stimulates digestion, and is also employed in the treatment of dyspepsia, flatulence, vomiting, gastralgia, colic, diarrhoea and malaria. In China the plant is used to treat stomach disorders, vomiting and dyspepsia. Its rhizome is traditionally applied as a stomachic, carminative, astringent, tonic and sedative. The seed is used to clear cold, invigorate the spleen and warm the stomach.

In Ambon the leaves are used as perfumed wrappers for cooked rice. The pith of the young stem was commonly eaten in parts of Malaysia. In eastern Asia the leaf sheaths are sometimes used as fibre for rope, while paper is made from the whole plant. In the Philippines it is occasionally planted for ornamental purposes.

Observations *A. zerumbet* is similar to *A. malaccensis*. The main differences are: leafy stem up to 2–3 m tall; petiole up to 2.5 cm long; inflorescence decurved or drooping, up to 20 cm long, bearing 25 or more cincinni of 2 flowers each, but the flowers are larger; bracteoles white with pink apex; labellum entire or shallowly lobed; fruit orange. *A. zerumbet* occurs naturally in open, shaded forest.

Selected sources 135, 215, 242, 326, 407, 583, 694, 747, 805, 810, 998.

Halijah Ibrahim

Alstonia R.Br.

On Asclepiad.: 64 (1810).

APOCYNACEAE

$x = 11, 20, 21$; *A. macrophylla*: $2n = 22$, *A. scholaris*: $2n = 22, 44$

Major species *Alstonia macrophylla* Wallich ex G. Don, *A. scholaris* (L.) R.Br.

Vernacular names Pulai (trade name, (very) lightweight hardwood species), white cheesewood, white pine, milkwood (En); hard alstonia (trade name, medium-heavy hardwood), hard milkwood (En).

Origin and geographic distribution *Alstonia* consists of 43 species and has a pantropical distribution. It ranges from Central America, tropical Africa to the Marquesas in the far eastern Pacific, and from the Himalayas and China in the north to New South Wales in the south. One species is native in Central America, 2 in tropical Africa, 6 in Australia, 16 in the Pacific region, 18 in the Malesian region and the rest occur in continental Asia. *A. scholaris* is the most widespread species and occurs from India and Sri Lanka through Indo-China and southern China towards Malesia, south to Queensland and east to the Solomon Islands. Several species have been planted outside their natural area of distribution.

Uses The bark, the latex from the bark or other plant parts of *Alstonia* are widely used in traditional medicine throughout South-East Asia. The bitter taste may explain its popularity as a tonic and febrifuge, and it is further credited with astringent and anthelmintic properties. It is employed in liver and intestinal troubles, heart diseases, asthma, various skin diseases, fever and as a vulnerary, as well as an emmenagogue.

The latex or an extract from the bark of *A. costata* (J.G. Forster) R.Br. (syn. *A. vitiensis* Seem.) is used as an eye lotion in Fiji and the Solomon Islands. In southern Vietnam, an infusion of the roots or leaves of *A. annamensis* (Monach.) Sidiyasa (syn. *A. angustifolia* var. *annamensis* Monach.) is employed to treat respiratory afflictions. The fruits of *A. venenata* R.Br. from India, posses tonic and anthelmintic properties, and are used as a remedy for impure blood, syphilis, insanity and epilepsy. *Alstonia* includes economically important timbers. The timber of pulai species (*A. angustiloba*, *A. iwahigensis*, *A. scholaris* and *A. spatulata*) is used for pencil manufacture, matches, tea chests, crates, plywood, pulp, carpentry and carving. The timber of hard alstonia species (*A. angustifolia*, *A. macrophylla* and *A. spectabilis*) is used for construction purposes, furniture and flooring. The latex of *A. scholaris* is used for chewing gum. Outside Malesia other species are used for this purpose too. Some species of *Alstonia* are planted as ornamental trees because of their pagoda-like crown.

Production and international trade The bark of *Alstonia* is stocked by local drugstores, while the latex is tapped and used on a local scale. Mention is made of *A. scholaris* bark being traded as 'dita bark'.

Properties Thirty-one monoterpenoid indole-alkaloids have been isolated from the leaves and stem bark of *A. angustifolia* from Malaysia. Several of them are known compounds; these include for instance yohimbine, O-acetyl-yohimbine, tubotaiwine and (derivatives of) echitamine, akuammicine, alstonisine, alstonerine and carpamine. Examples of the new alkaloids include N-oxide-, methoxy- and dehydro-derivatives of yohimbine, villalstonine, macrocarpamine and akuammicine. In addition, a crude root alkaloidal extract displayed an IC_{50} of 0.35 µg/ml against *Plasmodium falciparum* K1. Furthermore, yohimbine is a well-known α_2-adrenergic receptor antagonist.

From *A. angustiloba*, a series of vallesamine-type alkaloids were isolated, which included: vallesamine, O-acetylvallesamineangustilobine A, 15-hydroxyangustilobine A, angustilobine B, 4,6-secoangustilobinal, 6,7-seco-19,20-epoxyangustilobine B, 6,7-seco-6-cyanostemmadenine, 6,7- secoangustilobine B, and nor-6,7-secoangustilobine A.

Series of monomeric and bisindole and oxindole alkaloids have been isolated from several parts of *A. macrophylla*. These include 2 new bisindole alkaloids, alstomacrophylline and alstomacroline, which have been isolated from the root bark, along with 6 known alkaloids: alstonerine, alstophylline, macrocarpamine, alstoumerine, 20-epi-antirhine and villastonine-N-oxide. New oxindole alkaloids such as N-b-demethylalstophyllal oxindola nd alstonal, together with three known alkaloids, N-b-demethylalstophylline oxindole, alstonisine and talcarpine, have been isolated from the bark. In addition, new alkaloids from the leaves include (−)-strictaminolamine, 19-hydroxyvincamajine, alstonamide, demethoxyalstonamide alstoumerine and macroxine. The known indole alkaloids alstonisine, alstonerine, alstophylline, macralstonine, anhydromacralstonine, (−)1,2-dihydro- N-methylstrictamine, talcarpine, vincamajine, vincorine, cabucraline and quebrachidine, were also isolated and identified from the bark and leaves. Furthermore, rare alkaloids such as N(4)-oxides of cathafoline and 11-methoxyakuammicine, vincamajine 17-O-veratrate and vincamajine N(1)-tri-O-methylgallate were isolated from the leaves of *A. macrophylla*.

Crude extracts of the bark and leaves of *A. macrophylla* possessed hypotensive action in animals. In addition, in a test with the multidrug-resistant K1 strain of *Plasmodium falciparum* cultured in human erythrocytes, pronounced antiplasmodial activity was exhibited by the methanol extract of the root bark of *A. macrophylla* with an IC_{50} value of 5.7 µg/ml. Subsequently, 13 indole alkaloids were isolated from the active extract. These alkaloids and a semisynthetic bisindole O-acetylmacralstonine were furthermore tested against the K1 strain of *P. falciparum*. Pronounced antiplasmodial activity was observed mainly among the bisindole alkaloids, particularly villalstonine and macrocarpamine with IC_{50} values of 0.27 and 0.36 µM, respectively. The potent alkaloids were also tested against T9-96, a chloroquine-sensitive strain of *P. falciparum*. It has been observed that the active alkaloids, in contrast to chloroquine, have significantly higher affinity to the K1 strain than to the T9-96 strain.

The same alkaloids have also been assessed for cytotoxic activity against two human lung cancer cell lines, MOR-P (adenocarcinoma) and COR-L23 (large cell carcinoma), using the SRB assay. Pronounced cytotoxic activity was exhibited by the bisindoles on both cell lines. This suggests that, in comparison with the corresponding monomeric indoles, at least part of both the ring systems present in the bisindoles is essential for cytotoxic activity. The potent alkaloids were additionally tested against a human normal cell line (breast fibroblasts) and other human cancer cell lines including StMI1 1a (melanoma), Caki-2 (renal cell carcinoma), MCF7 (breast adenocarcinoma), and LS174T (colon adenocarcinoma). The bisindoles

O-acetylmacralstonine, villalstonine and macrocarpamine were found to possess pronounced activity against cancer cell lines with IC_{50} values in the range of 2–10 μM, with no discernible cell-type selectivity. However, O-acetylmacralstonine displayed discernibly less toxicity against the normal breast fibroblasts.

A whole range of monoterpenoid, monomeric and bisindole and oxindole alkaloids have been isolated from several parts of *A. scholaris*, e.g. roots, root bark, stems and leaves. The derivatives belong to several structural types, derived from akummicine, akuammidine, echitamine, nareline, picralinaline, picrinine, strictamine, tetrahydroalstonine, angustilobine, tubotaiwine and lagunamine (= 19-hydroxytubotaiwine).

Several of these compounds display pharmacological activity; e.g. strictamine was found to be a mono-amino oxidase inhibitor in vitro. Echitaminechloride has been examined for its anticancer effects on methylcholanthrene induced fibrosarcoma. Echitaminechloride dissolved in saline (10 mg/kg body weight) and injected subcutaneously for 20 days in fibrosarcoma rats has exhibited significant regression in tumour growth. The altered activities of plasma and liver transaminases and γ-glutamyl transpeptidase and lipid peroxidation in fibrosarcoma have been corrected to near normal after this treatment. The decreased liver glutathione content and the lowered activities of glutathione peroxidase, superoxide dismutase and catalase have also been reversed to near normal after echitaminechloride treatment. Furthermore, the cytotoxic effect of echitaminechloride is enhanced by adding vitamin A. In addition, malignant tumours are known to exhibit high rates of glycolytic activity leading to high production of lactic acid. Hence, neoplastic cells have elevated activity of enzymes responsible for glycolysis. Therefore, the effect of echitamine chloride on energy metabolism of S-180 cells was investigated to gain a better understanding of its mode of action, including its effect on the mitochondrial and cellular respiration of S-180 cells, and the effects on glucose utilization, pyruvate utilization and lactate formation (studied in whole S-180 cells and S-180 cell-free homogenate). The levels of glycolytic enzymes such as hexokinase and lactate dehydrogenase were estimated, with particular emphasis placed on hexokinase which occurs both in cytosolic and particulate forms in neoplastic cells. In conclusion, echitamine chloride was found to affect both cellular and mitochondrial respiration, leading to reduction of the cellular energy pool and thereby resulting in the loss of viability of S-180 cells.

The hepatoprotective effect of *A. scholaris* on liver injuries induced by carbon tetrachloride (CCl_4), β-D-galactosamine, acetaminophen (paracetamol) and ethanol was investigated by means of serum-biochemical and histopathological examinations. Treatment with *A. scholaris* following induction reduced, dose-dependently, the elevation of serum transaminases levels and histopathological changes such as cell necrosis, inflammatory cell infiltration, which were e.g. caused by the single administration of 32 μl/kg CCl_4 or 600 mg/kg acetaminophen in mice. *A. scholaris* significantly lowered 288 mg/kg β-D-galactosamine induced serum transaminases elevation in rats. A tendency was also shown to inhibit cell necrosis and inflammatory cell infiltration caused by β-D-galactosamine upon histopathological examination of the animals.

Antifertility effects of an ethanolic leaf extract of *A. scholaris* were observed in male albino rats after oral administration (100 mg/kg/day per animal) for 21 days. The extract did not interfere with spermatogenesis but females mated by males treated with the extract showed significant luteolytic and anti-implantational effect. In addition, an ether extract from *A. scholaris* bark injected in immature female mice at a dose equivalent to 2 g of crude plant material for 5 days showed significant increase of mammary gland measured on whole mount preparation and simultaneous increase of utero-ovarian structure, suggesting that the active principles may be natural oestrogenic substances.

The effectiveness of *Alstonia* in the treatment of malaria is controversial. The antiplasmodial effect of echinatine, one of the major alkaloids, is very limited. However, despite the absence of antimalarial activity a dose-dependent improvement of the condition combined with delayed mortality was noticed amongst mice infected with *Plasmodium berghei* receiving a methanol extract of *A. scholaris* bark.

Finally, a crude extract of the bark of *A. spatulata* was found to contain the triterpene lupeol, as well as its benzoyl- and acetyl-derivatives. The latter 2 showed remarkable hypoglycaemic effects upon oral administration to glucose fed rabbits.

Description Shrubs or small to large, evergreen or deciduous, laticiferous trees up to 60 m tall; bole straight, generally coarsely fluted at the base and up to 200 cm in diameter; bark surface generally tessellated with small scales or shallowly fissured, appearing smooth at a distance, variable in colour, generally pale or purplish-black, outer bark granular, inner bark cream, soft, frequently conspicuously exuding sticky white latex; branches verticillate, mostly 4–5 together, distant. Leaves in verticils of 3–8, or sometimes opposite, simple, entire, with very variable shape (even in the same tree), from lanceolate to obovate and obtuse to acute or acuminate, glabrous or sometimes hairy, generally fleshy but papery when dry; venation pinnate, with many parallel secondary veins often linked near the margin by a hardly looped intramarginal vein; petiole generally short, with or without intrapetiolar stipules. Inflorescence terminal, cymose, compound, frequently in whorls or umbellate, few- to many-flowered, pedunculate. Flowers actinomorphic, bisexual, protandrous, generally small and fragrant; calyx 5-lobed, united at base into a short tube; corolla white, yellow or red, with 5 rotate, contorted, imbricate and spreading lobes, tube long, cylindrical, widening around the anthers, thickened at the throat, rather densely pubescent inside just below the stamens and on the lobes; stamens included, inserted on the corolla tube, filaments short but distinct, anthers basifixed, introrse, triangular to narrowly triangular, apices touching each other above the stigma in bud; disk annular, entire or lobed, free or adnate to the ovary, often indistinct; ovary superior, with 2 carpels, apocarpous or syncarpous, with 2 placentas per locule, ovules numerous, in 2–many rows, style 1, filiform to very short, glabrous, pistil head with minute, narrow or robust wide cleft stigmoid apex. Fruit composed of 2 follicles, free or connate at the base (sometimes united into a single capsule), woody, long and slender, dehiscent along an adaxial suture, inconspicuously striate outside, containing many seeds. Seed with endosperm, thin, flattened, minutely foveolate, glabrous or (often dorsally) pubescent, ciliate at both ends, sometimes winged. Seedling with epigeal germination; hypocotyl erect; cotyledons leaf-like, thin, oblong or ovate-oblong with an obtuse top and rounded base; leaves decussate, exstipulate.

Growth and development Seedlings are vigorous and hardy, and young trees demand full light in order to grow vigorously. Under favourable conditions they are undoubtedly fast growers, although no data are available on growth rates. Young trees of most species have a pagoda-like crown with a monopodial appearance (according to Prévost's architectural tree model). The growth of branches is intermittent. However, crowns of *A. angustifolia* and *A. macrophylla*, belonging to section *Monuraspermum* Monach., are of normal sympodial structure, even when young (Koriba's architectural tree model).
The trees are often deciduous at irregular intervals. They do not flower at every leaf-change, but only after marked periods of dry weather. The large branches of big trees provide favourable nesting sites for wild bees.
Pollination is by insects; when flowering, trees are often surrounded by butterflies and bees. The fruits open on the tree and the seeds, which have a tuft of silky hairs at each end, are dispersed by wind.

Other botanical information The genus *Alstonia* is divided into 5 sections, mainly on the basis of seed morphological characteristics. The sections *Alstonia* and *Monuraspermum* occur in Malesia. They mainly differ from each other by the number of secondary veins, direction of the contortion of the corolla lobes, shape of the seed and architecture. *Alstonia* trees often resemble jelutong (*Dyera costulata* (Miq.) Hook.f.) trees, but they can be distinguished by their usually tall buttresses and typically fluted stems. Within South-East Asia *Alstonia* can also be confused with the genera *Ochrosia*, *Rauvolfia* and *Tabernaemontana* which all have verticillate leaves, but *Alstonia* can be distinguished by its slender fruits and ciliate seeds. The name *Alstonia* R.Br. is conserved as a later homonym of *Alstonia* Scop. which is a synonym of *Pacouria* (*Apocynaceae*). Giant stomata have been observed in *A. macrophylla*.

Ecology *Alstonia* grows in both primary and secondary lowland evergreen to deciduous rain forest. They occur on humus-rich clayey soils but also on sandy or even limestone soils and in locations which are periodically inundated and carry swamp or peat-swamp forest, to comparatively dry areas with savanna woodlands. They occur from sea-level to up to about 3000 m altitude, in areas with 0–3 dry months per year.

Propagation and planting Seeds of *Alstonia* are difficult to collect, as the fruits open while still on the trees. The weight of 1000 seeds is about 1.5–2 g. The germination rate of fresh seeds is high, nearly 100%. Seeds can be stored in closed tins for 2 months, maintaining a germination rate of 90%. Seeds of *A. angustiloba* germinate in 2–8 weeks after sowing. In Indonesia, seedlings are planted into the field when they are 15–25 cm tall, with a spacing of 1 m × 2 m and interplanted with *Leucaena leucocephala* (Lamk) de Wit. In planting experiments in Peninsular Malaysia 3–4-month-old seedlings are used at spacings of 3 m × 3 m and 5 m × 2 m, respectively. Trials in secondary forest, denuded sites and open sites with top soil retained, showed similar early survival of about 75% after 23 months.

A. scholaris has been grafted. Cleft grafting and inverted T-grafting have been found to be most appropriate.

Husbandry There is hardly any experience with silviculture of *Alstonia*. Young *Alstonia* trees coppice well.

Harvesting The bark of *Alstonia* is simply removed in slices from the trunk and major branches, no mention is made of percentage of bark that needs to remain to guarantee survival of the tree. The latex is harvested by making incisions in the bark.

Yield Data on yield of *Alstonia* for pharmaceutical applications are scarce. The trunk and major branches of a 25-year-old *A. scholaris* tree yielded 19 kg of dry bark.

Handling after harvest The bark of *Alstonia* can be dried for storage and future use.

Genetic resources and breeding Most *Alstonia* are common and widely distributed, although they occur scattered, and do not seem immediately liable to genetic erosion, largely because they often invade severely disturbed locations. However, stands are heavily depleted locally as a result of deforestation caused by logging and shifting cultivation (e.g. in the Philippines) and the remaining stands need protection.

Prospects *Alstonia* contains a vast array of indole-alkaloids, of which several, as isolated compounds, display pharmacological activity. These are especially in the field of anti-plasmodial activity and cytotoxicity, both in vitro and in vivo. More research, however, will be needed to fully investigate their potential, when for instance in the case of a new anti-malarial lead, a generally low cytotoxicity has to be combined with a high anti-plasmodial activity.

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Selection of species

Alstonia angustifolia Wallich ex A.DC.

Prodr. 8: 409 (1844).

Synonyms *Alstonia latifolia* Ridley (1923), *Alstonia beccarii* (Benth.) Pichon (1947).

Vernacular names Indonesia: medang pasir (Bangka), pulai pipit (Palembang). Malaysia: itai setapoh, pulai (Peninsular), mergalang (Sarawak). Vietnam: s[uwx]a l[as] h[ej]p, l[aas]c.

Distribution Peninsular Malaysia, Singapore, Sumatra, Bangka and Borneo.

Uses In Malaysia, the leaves are externally applied to the spleen area to treat remittent fever. The bark is used for treating malaria. The wood is used as hard alstonia, but because the trees are small, it is often only locally used.

Observations A small to medium-sized tree up to 35(–45) m tall, bole fluted or with small or steep buttresses, up to 70 cm in diameter, outer bark smooth, fissured or scaly, inner bark yellowish, without latex; leaves usually in whorls of 3, oblanceolate, 4–18 cm × 1.5–7 cm, acuminate, with 10–20 pairs of secondary veins, petiole 8–30 mm long; inflorescence many-flowered, pedicel 0.5–2 mm long, calyx and corolla densely tomentose outside; follicles glabrous. *A. angustifolia* occurs in primary forest, seasonal peat swamps or hillsides, on sandy or granitic soils at 5–750(–1700) m altitude.

Selected sources 344, 454, 786, 950, 1083.

Alstonia angustiloba Miq.

Fl. Ind. Bat. 2: 438 (1856).

Synonyms *Alstonia calophylla* Miq. (1856), *Paladelpha angustiloba* (Miq.) Pichon (1947).

Vernacular names Brunei: pulai lilin (Malay). Indonesia: pulai hitam. Malaysia: pulai (Peninsular), pulai bukit (Sarawak). Thailand: tin pet lek (Songkhla).

Distribution Thailand, Peninsular Malaysia, Singapore, Sumatra, Java and Borneo.

Uses In Peninsular Malaysia, the leaves are externally applied to the spleen area to treat remittent fever. In Sarawak, the latex is used to heal boils and abscesses. An extract of the pounded bark is an ingredient of febrifuges and vermifuges. In Thailand, the latex is used to soothe toothache. The wood is used as pulai.

Observations A medium-sized to large tree up to 45 m tall, bole tall, straight, fluted, up to 100 cm in diameter, buttresses straight, up to 8 m tall and spreading out at the base for about 1.5 m, outer bark brown or grey to whitish, rough, fissured and peeling off in rectangular flakes, inner bark mottled, yellow-brown, with copious latex; leaves in whorls of 4–7(–9), elliptical to obovate, 4.5–22 cm × 2–7 cm, subacuminate or obtuse, with 30–60(–70) pairs of secondary veins, petiole 10–20(–30) mm long; inflorescence usually forming 2 umbels above each other, many-flowered, pedicel 1–3 mm long, calyx hirtellous, corolla glabrous outside; follicles brownish tomentose. *A. angustiloba* occurs on a wide variety of soils and is common in mixed dipterocarp forest on low hills and undulating land, and in freshwater swamp forest, up to 200 m altitude. It becomes abundant in secondary forest and is apparently a fast-growing light demander.

Selected sources 672, 786, 950, 1120.

Alstonia iwahigensis Elmer

Leafl. Philipp. Bot. 4: 1447 (1912).

Vernacular names Indonesia: pulai gunung, pelantan (East Kalimantan). Malaysia: tombalik (Bundu Tuhan, Sarawak), tambalait (Murut, Sabah).

Distribution The Philippines (Palawan, Sulu Archipelago), Brunei, Malaysia (northern Sarawak, Sabah), Indonesia (central and eastern Kalimantan).

Uses In Sabah, the diluted latex is drunk to cure fevers. A decoction of the roots is taken to treat diabetes and lumbago. The latex mixed with honey is taken as a tonic.

Observations A medium-sized to large tree up to 45(–70) m tall, bole tall, straight, fluted, up to 80 cm in diameter, buttresses straight, up to 6 m tall and spreading out at the base for about 2 m, outer bark greyish, yellowish or dark brown, smooth to slightly rough inner bark yellow or pale yellow, with copious latex; leaves in whorls of 4–7, elliptical to obovate, 3.5–10 cm × 1.5–4 cm, apex obtuse or rounded, with 25–40 pairs of secondary veins, petiole (5–)10–20(–28) mm long; inflorescence usually forming 2 bunches of dense and many-flowered clusters, pedicel 1–2 mm long, calyx variably pubescent, corolla glabrous outside except for the lobe margins; follicles glabrous. *A. iwahigensis* occurs on hillsides, both on sandy and loamy soils in primary and secondary forest at 20–500 m altitude. *A. iwahigensis* has been placed in the synonymy of *A. angustiloba* by many authors.

Selected sources 23.

Alstonia macrophylla Wallich ex G. Don

Gen. hist. 4: 87 (1837).

Synonyms *Alstonia batino* Blanco (1845), *Alstonia pangkorensis* King & Gamble (1907), *Alstonia brassii* Monach. (1949).

Vernacular names Hard alstonia, hard milkwood (En). Indonesia: pule batu (Ambon), kai riti (Seram), ai oi (Biak). Malaysia: pulai penipu bukit (Peninsular), pulai daun besar, sayongan (Sabah). Papua New Guinea: ai wawoi (Papua), andelagar (Enga), dero (Madang). Philippines: batino (Tagalog, Bikol, Pangasinan), kuyau-kuyau (Bikol), itang-itang (Panay Bisaya). Thailand: thungfa, kra thungfa hai, teen thian (peninsular). Vietnam: s[uwx]a l[as] l[ows]n, m[ows]p l[as] to.

Distribution From Sri Lanka and Nicobar Islands, Thailand, Cambodia, Vietnam to Peninsular Malaysia, Sumatra, Borneo (Sabah), the Philippines, the Moluccas and New Guinea. Cultivated in India and Africa.

Uses In the Philippines, the bark in the form of powder, decoction, infusion, tincture or wine preparation is used as a febrifuge, tonic, antiperiodic, antidysenteric, emmenagogue, anticholeric and a vulnerary. In Thailand, the bark is used as a tonic, antiamoebic, emmenagogue and antimalarial. In the Central Province (Papua New Guinea) a decoction of the young leaves is drunk to cure lung and ear congestions. In the Oro (Northern) Province (Papua New Guinea) the scraped bark is mixed with water and drunk, as well as used to wash the forehead, to relieve a headache. The wood is used as hard alstonia.

Observations A small to medium-sized tree up to 30(–50) m tall, bole straight, up to 100 cm in diameter, sometimes fluted at the base or with small buttresses, outer bark blackish-brown to grey, smooth or rough, minutely scaly, tuberculate, or fissured, inner bark cream, with broken, orange-yellow laminations, without latex; leaves in whorls of 3–4, obovate or narrowly obovate, sometimes elliptical to narrowly elliptical, 4.5–25(–32) cm × 1.5–10.5 cm, apex rounded to narrowly acuminate, with 12–25(–31) pairs of secondary veins, petiole 2–25 mm long; inflorescence many-flowered, pedicel 1–4 mm long, calyx laxly puberulous to glabrous, corolla glabrous outside; follicles glabrous. *A. macrophylla* grows in a wide range of vegetation types and soils in primary and disturbed forest ranging from flooded areas to montane forest, on soils ranging from sandy clay to limestone, from sea-level to about 2900 m altitude.

Selected sources 6, 68, 216, 427, 431, 520, 672, 786, 810, 834, 867, 950, 1078.

Alstonia scholaris (L.) R.Br.

Mem. Werner. Nat. Hist. Soc., Edinb. 1: 76 (1811).

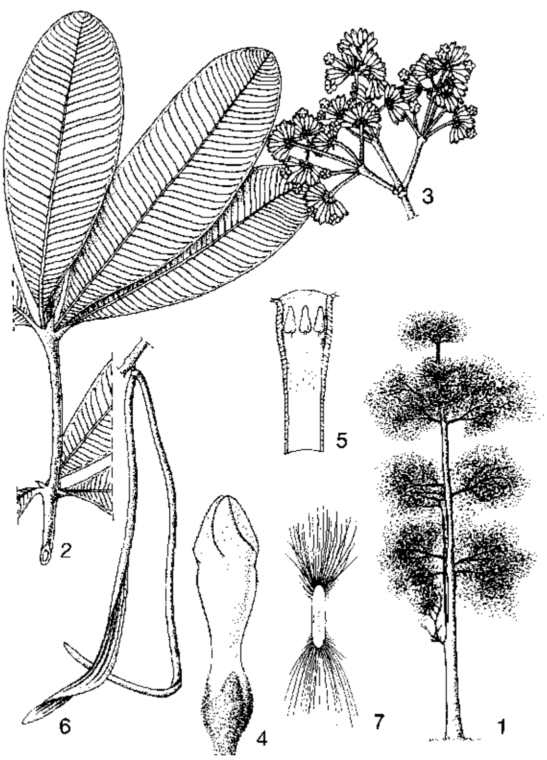
Synonyms *Echites scholaris* L. (1767), *Tabernaemontana alternifolia* Burm. (1768), *Echites pala* Ham. (1822).

Vernacular names White cheesewood, milkwood, blackboard tree (En). Shaitan (Fr). Brunei: pulai lilin. Indonesia: pulai (general), pule (Javanese), rite (Ambon). Malaysia: pulai (Peninsular), kacau gitik (Kiput, Sarawak). Papua New Guinea: katung (Buang, Morobe Province), kambuu (Kanganaman, Sepik Province), herina (Hisui, Central Province). Philippines: dita (Tagalog, Bikul, Sulu), dalipaoen (Iloko), tanitan (Bisaya). Burma (Myanmar): taung meok, lettok. Laos: tinpet. Thailand: sattaban, tin pet (central), hassaban (southwestern). Vietnam: m[of] cua, s[uwx]a.

Distribution *A. scholaris* is the most widely distributed *Alstonia* species, found from Sri Lanka and India through mainland South-East Asia and southern China, throughout Malesia, to northern Australia, the Bismarck Archipelago and the Solomon Islands. It has been planted elsewhere.

Uses In the Philippines, a decoction of the bark is used as a febrifuge and tonic, as an emmenagogue, anticholeric and vulnerary. The latex is applied to ulcers and for rheumatic pains. In Thailand, the bark is used as an antidysenteric, astringent, and a remedy for colds and bronchitis. In Indo-China, the bark is used as a strengthening tonic, a febrifuge, in the treatment of abdominal pains, irregular menstruation, dysentery, diarrhoea and arthritis. A decoction is applied as a wash for skin diseases, and as a gargle. It is believed to be a galactagogue, but this may well be an example of doctrine of signs. In Papua New Guinea, the leaves or bark are widely used as a febrifuge, to relieve stomach complaints, diarrhoea and dysentery. The latex is drunk in small amounts as a poison antidote. Mention is made of its use for coughs, asthma, pneumonia and lung cancer, gout, and hypertension. In New Britain, bark sap squeezed into water is occasionally drunk to combat anaemia. Bark sap, drunk three times daily, is said to induce abortion. Trobriand Island girls chew the leaves as an oral contraceptive. A poultice made from the leaves has been reported as a good remedy against skin diseases. *A. scholaris* is the most important source of pulai timber. The latex also provides a good-quality chewing gum. The tree is sometimes planted as an ornamental. In Java the wood was formerly used for school blackboards, hence the name 'scholaris'.

Observations A medium-sized to large tree 10–50(–60) m tall, bole cylindrical, in older trees massively fluted, up to 125 cm in diameter, with stout buttresses up to 10 m tall which spread out at the base for up to 4 m, outer bark brown or yellowish-white, smooth but coming off evenly in small papery flakes, with horizontally enlarged



Alstonia scholaris (L.) R.Br. – 1, habit of young tree; 2, sterile twig; 3, inflorescence; 4, flower bud; 5, dissected corolla tube; 6, fruits; 7, seed.

lenticels and hoops, inner bark yellow to brown, usually tinged yellowish, with copious white latex; leaves in whorls of 4–8(–9), narrowly elliptical to obovate, (5–)6–17(–22) cm × (1.5–)2.5–7.5(–8.5) cm, apex obtuse or rounded, with 25–45(–55) pairs of secondary veins, petiole 5–20(–25) mm long; inflorescence mostly formed of dense bunches of flowers, many-flowered, pedicel 0–2 mm long, calyx pubescent, corolla pubescent outside; follicles glabrous. *A. scholaris* is most abundant in monsoon areas, and it tolerates various soils and habitats, including secondary vegetation. It occurs from sea-level up to about 1250 m altitude. As an ornamental it has proved to be adaptable to the climates of southern Florida and California (United States).

Selected sources 118, 197, 216, 263, 334, 419, 425, 427, 431, 433, 503, 588, 672, 739, 786, 810, 867, 950, 1046.

Alstonia spatulata Bl.

Bijdr. fl. Ned. Ind.: 1037 (1826).

Synonyms *Alstonia cuneata* Wallich ex G. Don (1837).

Vernacular names Milkwood (En). Indonesia: gabusan (Sundanese), pulai gabus (Palembang, Bangka), lame (Kalimantan). Malaysia: pulai, pulai basong (Peninsular), pulai paya (Sarawak). Thailand: thia, sia, tinpet phru (peninsular). Vietnam: s[uwx]a l[as] b[af]ng, m[ows]p, m[of] cua n[uw][ows]c.

Distribution Burma (Myanmar), Thailand, Cambodia, Vietnam, Peninsular Malaysia, Singapore, Sumatra, Bangka, Java, Borneo and New Guinea.

Uses In Indonesia, an aqueous extract of the bark is used throughout West Sumatra as a natural remedy for diabetes mellitus. In Sarawak, the latex is applied to sores and skin diseases. An extract of the pounded bark is an ingredient of febrifuges and vermifuges. The wood is used as pulai. The wood of the roots is used for pith helmets, rafts, rafters for fishery and as a replacement for cork.

Observations A small to medium-sized tree up to 25(–30) m tall, bole at first cylindrical, becoming fluted and shortly buttressed at the base, up to 40(–75) cm in diameter, outer bark grey, smooth, coming off in small papery flakes, inner bark pale yellow, with copious latex; leaves in whorls of 3–4(–5), spathulate or obovate, 3–12 cm × 1.8–4.8 cm, apex rounded, with 20–35(–40) pairs of secondary veins, petiole 4–10(–15) mm long; inflorescence few-flowered, pedicel 4–9 mm long, calyx glabrous, corolla glabrous outside; follicles glabrous. *A. spatulata* occurs scattered on poorly drained, frequently flooded, clay-rich alluvium and on gley soils on undulating land, particularly near streams, usually below 300 m altitude. It is often abundant in secondary or shrub vegetation.

Selected sources 672, 786, 947, 950.

Alstonia spectabilis R.Br.

On Asclepiad.: 65 (1810).

Synonyms *Alstonia villosa* Bl. (1826), *Alstonia linearis* Benth. (1869), *Alstonia longissima* F. Muell. (1877).

Vernacular names Hard milkwood (En). Indonesia: legarang (Javanese), langkerang (Madurese), pole (Timor). Philippines: kuyau-kuyau. Papua New Guinea: tutu (Boku, Central Province), mirun (Kieta, North Solomons Province).

Distribution Indonesia (except Sumatra and Kalimantan), the Philippines, New Guinea, northern Australia and the Solomon Islands.

Uses In Central Province (Papua New Guinea), a decoction of the leaves and bark is used to treat a bad cough and sore throat. Leaves may also be chewed with betel nut (*Areca catechu* L.) and lime to ease the pain of constant coughing. On Yule Island, Central Province (Papua New Guinea), a decoction of the leaves is drunk to treat malarial fever. The same decoction taken daily is used to relieve asthma. The diluted stem sap is applied on tropical ulcers. In the Solomon Islands a decoction of the plant is the basis of a mixture used as an abortifacient. The wood is used as hard alstonia.

Observations A medium-sized to large tree up to 40 m tall, bole up to 90 cm in diameter, sometimes with small buttresses, outer bark brownish or dark brown, smooth scaly or longitudinally fissured, inner bark yellowish or straw-coloured, without latex; leaves in whorls of 3–4, linear to obovate, 3–32 cm × 1–12 cm, apex acute, obtuse or shortly abruptly acuminate with 10–30(–40) pairs of secondary veins, petiole (0–)5–27 mm; inflorescence usually in groups of 2–8, many-flowered, pedicel 1–3 mm long, calyx subequal, pubescent outside, corolla pubescent outside; follicles glabrous. *A. spectabilis* occurs on various soils in primary and secondary forest, up to 800 m altitude.

Selected sources 423, 431, 786, 950.

Stephen P. Teo

Alyxia R.Br.

Prodr.: 469 (1810).
APOCYNACEAE
$x = 18$; *A. ruscifolia*, *A. sinensis*: $2n = 36$

Major species *Alyxia reinwardtii* Blume.

Vernacular names Indonesia: pulasari (general), pulosari (Javanese), palasari (Sundanese). Thailand: nuut. Vietnam: ng[oo]n.

Origin and geographic distribution *Alyxia* comprises about 100 species from north-eastern India, southern China, continental South-East Asia, Malesia, Australia and the islands of the Pacific from the Marianas to New Caledonia and Norfolk Island, eastwards to Henderson Island and northwards to Hawaii. Many species are very localized, particularly in New Guinea, whilst others are common and widespread, such as *A. reinwardtii* and *A. ganophylla* Markgr. in western Malesia, *A. acuminata* K. Schum., *A. markgrafii* Tsiang and *A. subalpina* Markgr. in New Guinea, *A. sinensis* Champ. ex Benth. in China, *A. buxifolia* R.Br., *A. spicata* R.Br. and *A. ruscifolia* R.Br. in Australia, *A. concatenata* in the Philippines, and *A. stellata* (J.R. Forster & G. Forster) Roem. & Schult. in the Pacific.

Uses Some *Alyxia* species have fragrant bark and are sold in markets as white cinnamon. *A. reinwardtii* is widely used as an ingredient in medicines in Indonesia, accompanied by 'adas'(fennel, *Foeniculum vulgare* Miller), hence the name 'adas-pulasari'. It is frequently used in 'jamus', Javanese traditional medicine, to treat various illnesses and to impart flavour and a pleasant odour to the other ingredients. About 18 sorts of manufactured 'jamu' from Central Java contain 'adas-pulasari' as a principle ingredient. These are used as an antispasmodic and for treating stomach-ache, flatulence, colic, fever, dysentery, as a carminative and for sprue. The leaves and flowers taste spicy and rather bitter when still fresh and are sometimes used instead of the bark. *A. halmaheirae* Miq. is used in the same fashion. The bark, leaves and flowers can be taken as infusion to treat gonorrhoea. *A. reinwardtii* cooked together with *Amaranthus spinosus* L., *Usnea* sp. and the bark of *Cinnamomum cassia* J.S. Presl can be used to treat bronchitis. The bark of the same species pounded with onion, wrapped with leaves, cooked and then the juice extracted, is used to treat thrush. The bark can also be applied together with the leaves of *Polygonum flaccidum* Meisner and aniseed (*Pimpinella anisum* L.) as an emmenagogue, or in cosmetics and flavouring. In Indo-China, *A. reinwardtii*, under its various synonyms, is burnt and the smoke used to treat cephalalgia. The bitter sap is also applied as an emetic. *A. pullei* Markgr. is used to alleviate stomach-ache in New Guinea. In the Vogelkop peninsula the juice of *A. markgrafii* is drunk against cough.

Bundles of dried twigs of *A. reinwardtii* can be placed in cupboards to perfume them and the fragrant smell may last up to two years. Dried and finely powdered bark is used as an ingredient in the manufacture of incense in Java. Local wine industries sometimes use *Alyxia* to flavour their product with the coumarin substances found in the bark. *A. rostrata* (Markgr.) Markgr. can be used to make needles for sewing and also plays a role in religious ceremonies. *A. concatenata* (Blanco) Merr. is used to make perfumes.

Many species throughout the range of the genus are used in personal adornment and it is thought that the name *Alyxia* comes from the Greek 'halusis' meaning a chain, in reference to the making of leis in the Pacific. Leis are chains of leaves and the bark after it has been stripped off the wood. These are twisted around each other to form a decorative and scented chain for use on festive occasions.

Production and international trade Pulasari is sold as white cinnamon in some South-East Asian markets. *A. reinwardtii* is generally the principal ingredient of commercial pulasari, but in parts of Asia with more than one *Alyxia* species, pulasari may contain species other than the common *A. reinwardtii*. It is generally collected from the wild, so accurate production information is not available. The trade in pulasari for 'jamu' in Central Java is thought to be increasing by about 15% a year. In 1990 63 t were used and this will probably have risen to about 180 t in the year 2000. The local price of this material in Indonesia was expected to be about Rp 5000 per kg in the year 2000, local trade therefore generating more than Rp 900 million, about US $ 120 000.

Properties Responsible for the fragrant smell, typical of many species of *Alyxia*, including *A. buxifolia* from Australia and *A. luzoniensis* Merr. from the Philippines, is a mixture of isomeric coumarins which can be isolated from, for instance, the bark. Typical components, which are present in chloroform and petroleum extracts of dried stem parts of *A. reinwardtii* include 3-, 5- and 8-hydroxycoumarin, as well as their glycosides.

Further, the presence of iridoid substances is reported; pulosarioside (a bitter trimeric-iridoid diglycoside) from the bark, and 2 iridoid-lactones alyxialactone and 4-epi-alyxialactone from the leaves. Even though several reports on pharmacological activities of *A. reinwardtii* are available, most of them showed negative results except for antihistamine and antispasmodic activities.

Description Climbers, scramblers or shrubs with white latex; branches sometimes with large corky protuberances, branchlets mostly strongly or weakly angled when young, becoming mostly terete with age, lenticellate or not, pubescent or not. Leaves opposite or in whorls of 3–7, more or less equal in size within a whorl but often of extremely different size and shape on different parts of the plant, entire, colleters present in the axils, often with an intramarginal vein; petiole present; stipules absent. Inflorescences axillary and/or terminal, consisting of solitary flowers, of simple pleiochasia, or of compound pleiochasia and then sometimes forming large terminal panicles; peduncle very variable; bracts usually small, sometimes rather leafy, persistent or caducous; bracteoles absent, or one, two or several on the pedicel. Flowers actinomorphic, 5-merous (very rarely 4-merous); sepals normally erect, rarely somewhat fleshy and rarely of widely varying size, ovate to linear; corolla tube cylindrical, somewhat inflated around stamens, lobes erect, spreading or reflexed, overlapping to the left in bud; stamens inserted mostly in the upper half of the corolla tube, more rarely around or just beneath the middle, not exserted from corolla throat, filaments straight, short and thin, anthers ovate, free from pistil head; disk absent; ovary of two separate carpels united into a common style, glabrous, with tufts of hair between the two carpels, pubescent in a ring around the base of the ovary, or pubescent all over, style glabrous, pistil head small, pubescent, ovules several. Fruit a pair of drupes, very frequently with one aborted, consisting of one or more articles with one seed, when more than one then forming a moniliform chain; endocarp thin, papery, sometimes somewhat thicker to quite tough, mesocarp fleshy, often very thinly so, exocarp thin, coloured. Seeds ovoid, ruminate or with longitudinal ridges; embryo with flat to strongly undulate cotyledons.

Other botanical information *Alyxia* belongs to the subfamily *Rauvolfioideae*. It has been placed in various tribes by different authors. There are a large number of species in this genus, many of which are difficult to separate from each other, particularly those found in western Malesia. Many species are extremely variable, particularly *A. reinwardtii*, but also *A. sinensis* in China, *A. acuminata* in New Guinea, *A. stellata* in the Pacific Islands and *A. tisserantii* Montrouz. in New Caledonia. The name *A. stellata* has frequently and mistakenly been applied to *A. reinwardtii* and *A. halmaheirae*. In Polynesia, a decoction of the roots is used for blood in the stool. However, *A. stellata* does not occur in Asia or Malesia. Other often misapplied names include *A. laurina* Gaudich., found only on the island of Waigeo and neighbouring islands, for plants from the Moluccas and *A. pilosa* Miq. for plants from outside Sumatra. The status of the material quoted as *A. kurzii* by various authors is unclear. The centres of diversity of *Alyxia* are in Vietnam, Sulawesi, the Philippines, New Guinea and New Caledonia.

Ecology *Alyxia* comprises species that can be encountered in a variety of habitats, ranging from those that prefer drier conditions, such as *A. spicata* in Australia, New Guinea and the Lesser Sunda Islands, to those that grow in dense moist forest. Many species grow at low altitude whilst others are only found in high mountains, such as *A. royeniana* Markgr. in New Guinea. There is also a large variation in growth forms from species such as *A. linearis* Markgr. in the Philippines which is a small scrambler over rocks and branches, to species such as *A. acuminata* in New Guinea which can be a large forest liana growing up into the canopy.

Propagation and planting *Alyxia* propagates easily from vegetative parts and seed. Parts of the stem of *A. reinwardtii* will root when in contact with the ground. For vegetative propagation of *A. reinwardtii* cuttings of 0.5–0.8 cm diameter and 10–15 cm long are preferred. The cuttings are directly inserted to a depth of 2 cm in a medium of equal parts soil and compost. The cuttings should be screened from direct sunlight and regularly sprayed to maintain humidity. After 2 weeks roots of 1 cm length will have developed, and the first pair of leaves can be discerned after 3 weeks. The cuttings are ready for transplanting when 2–3 pairs of leaves have developed. Shade as well as frequency of watering can be gradually reduced. Seedlings are fairly common where the adult plants are found. In vitro propagation of *A. reinwardtii* produces good plantlets, when using enriched Murashige and Skoog medium with sucrose at 30 g/l, cytokinin and naphtalene acetic acid at 0.1 mg/l.

Harvesting *Alyxia* bark is usually collected from wild populations. Stems are cut and the bark scraped. The stem parts are then heated to facilitate removal of the bark.

Handling after harvest The removed and scraped bark of *Alyxia* can be dried in the sun.

Genetic resources and breeding *A. reinwardtii* is extremely variable and widespread, but may be liable to genetic erosion as a result of collection from the wild. No germplasm collections or breeding programmes are known to exist. It would be interesting to investigate the bioactive properties of the various forms from the entire range.

Prospects *A. reinwardtii* has potential in the medicinal and perfume industries, although more research is required. It should be possible to promote its cultivation rather than relying on wild sources. Anecdotal evidence of the medicinal and perfume uses of other *Alyxia* species should be further investigated.

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Selection of species

Alyxia concatenata (Blanco) Merr.

Sp. blancoan.: 310 (1918).

Synonyms *Alyxia monilifera* S. Vidal (1886), *Alyxia confertiflora* Merr. (1915), *Alyxia clusiacea* (Baill.) Pichon (1948).

Vernacular names Philippines: basikalang (Iloko), batikuling, malabatino (Tagalog).

Distribution The Philippines.

Uses The bark is used on swellings and is also an ingredient in perfumes.

Observations A scrambler to large forest climber; leaves in whorls of 3–4, elliptical, 2.2–12.5 cm × 0.9–5.7 cm, 1.4–4.3 times longer than wide, glabrous or puberulent on midrib only above; inflorescence axillary, 1.5–4 cm long, 5–11-flowered; corolla white, tube 7.6–12 mm long, lobes 2–3.2 mm × 1.2–2.7 mm; fruit with 1–4 articles in a string, globose, 4.5–8.8 mm × 4.3–6.8 mm, yellow or orange. *A. concatenata* is found in lowland primary or secondary forest, or lower montane, mossy or montane forest, from 200–2200 m altitude.

Selected sources 128, 649, 810.

Alyxia halmaheirae Miq.

Ann. Mus. Bot. Lugd.-Bat. 4: 140 (1869).

Distribution Sulawesi, Moluccas.

Uses *A. halmaheirae* is used in the same way as *A. reinwardtii*.

Observations A climber; leaves opposite or in whorls of 3–4, elliptical, 2.7–13.5 cm × 0.4–3 cm, 2.3–7 times longer than wide, apex acuminate, glabrous; inflorescence axillary or terminal, 1–2.2 cm long, 4–7-flowered; corolla tube 4.2–4.9 mm long, lobes elliptical or ovate, 2.1–2.4 mm × 1.2–1.6 mm, apex obtuse or acute, tube yellowish, lobes white; fruit with 1 article in each string, ellipsoid, globose or cylindrical, 9.3–14.5 mm × 7–10 mm, orange, turning black when mature. *A. halmaheirae* is found on porous nickel and thin sandstone soils, in open or dense primary or secondary forest, at 20–2000 m altitude.

Selected sources 649.

Alyxia pullei Markgr.

Nova Guinea 14(2): 281 (1926).

Vernacular names Indonesia: aidemot (Sougb, Papua), benggrai (Hatam, Papua).

Distribution New Guinea.

Uses The leaves are ingested for stomach disorders.

Observations A climber; leaves in whorls of 4–6, obovate or spathulate, 4.3–11.7 cm × 1.5–4.1 cm, 2.1–3.3 times longer than wide, apex emarginate, rounded, obtuse or cuspidate, base decurrent onto petiole; inflorescence axillary, 1.8–3.6 cm long, 4–10-flowered; corolla tube 6.3–6.9 mm long, lobes elliptical, ovate or orbicular, 2–3.5 mm × 1.7–2.6 mm, apex rounded to acute, tube pink, lobes white; fruit with 1–3 articles in each string, ellipsoid or globose, 8–13 mm × 6.2–8 mm, yellow turning black. *A. pullei* is found in forest on clay, at 1760–2600 m altitude.

Selected sources 649.

Alyxia reinwardtii Blume

Blume, Catalogus: 43 (1923).

Synonyms *Alyxia stellata* auct. non (J.R. Forster & G. Forster) Roem. & Schult., *Alyxia lucida* Wallich (1824), *Alyxia pumila* Hook.f. (1882), *Alyxia forbesii* King & Gamble (1908).

Vernacular names Indonesia: pulasari (general), pulosari (Javanese), palasari (Sundanese). Thailand: chalut (central, south-eastern), luut, nuut (peninsular). Vietnam: ng[oo]n d[aa]y v[as]t.

Distribution From southern China, through Burma (Myanmar), Thailand, Laos, Cambodia, Vietnam, southward to the Peninsular Malaysia, Sumatra, Java, Bali, Borneo and Palawan.

Uses *A. reinwardtii* is the most common source of pulasari for 'adas-pulasari', used in jamus, Javanese traditional medicine, to treat various illnesses. In Thailand, all parts are used as an antipyretic and cardiotonic.

Observations A ground creeper or climber; leaves opposite or in whorls of 3–5, elliptical, 1.1–17 cm × 0.3–6.1 cm, 1.5–5.1 times longer than wide, glabrous or puberulent; inflorescence axillary or terminal, 1–3.5 cm long, 3–12-flowered; corolla tube columnar, 4.8–14 mm long, lobes 1.2–3.8 mm × 1–3.1 mm, white, cream, yellow, pink, white with orange tube, or with a buff coloured tube and white lobes; fruit with 1–2 articles in each string, ellipsoid or globose, 6–20(–25.3) mm × 4.8–11.4 mm, maturing black. *A. reinwardtii* is found in a wide range of habitats from primary or secondary lowland to montane or peat swamp forest or in scrub or open ridges; on granitic, sandy, clay or ultrabasic soils, from sea-level to 3050 m. *A. reinwardtii* is extremely variable and widespread, but no satisfactory infraspecific classification can be established.

Selected sources 135, 252, 407, 672, 687, 786, 788, 853.

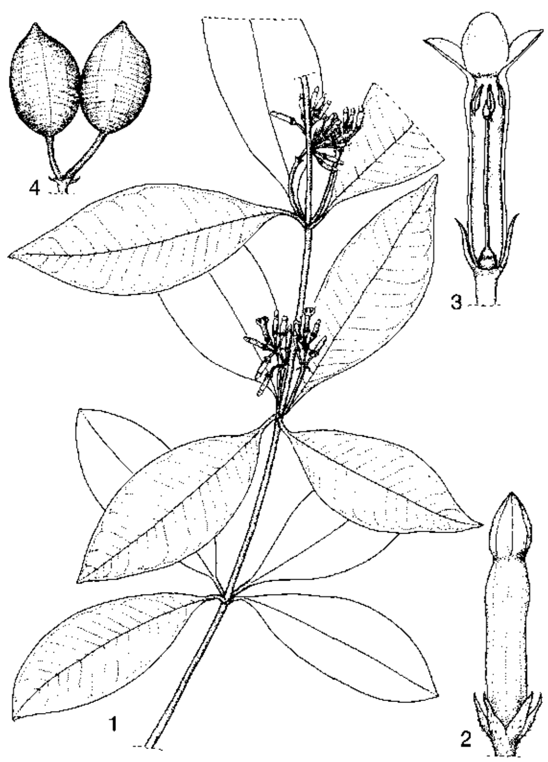
Alyxia rostrata (Markgr.) Markgr.

Blumea 23: 411 (1977).

Synonyms *Discalyxia rostrata* Markgr. (1926).

Vernacular names Indonesia: komunang (Yali, Papua), tu (Waigeo, Papua). Papua New Guinea: piumugasek (Washkuk, Sepik), kaw'iu (Plitty, Manus Province).

Distribution New Guinea.



Alyxia reinwardtii Blume – 1, flowering branchlet; 2, flower bud; 3, dissected flower; 4, fruit.

Uses The exudate of the inner bark is mixed with coconut bark and boiled together. The decoction is drunk to relieve backache and relax back muscles. The wood is used in rituals and to make sewing needles.

Observations A climber; leaves in whorls of 4–5, narrow to broad elliptical, obovate or oblong, 2–16 cm × 1.5–4.5 cm, 1.3–4 times longer than wide, apex long acuminate or caudate, glabrous; inflorescence a large lax axillary or terminal panicle, frequently branched, 4.3–16.5 cm long, consisting of more than 100 flowers; corolla tube 2.7–4 mm long, lobes oblong or ovate, 1–1.4 mm × 0.8 mm, apex rounded or obtuse, pubescent at base of lobes inside, stamens inserted in lower half of tube, tube white or pink, lobes white; fruit with 1–7 articles in a string, orange maturing black. *A. rostrata* is found in closed or open primary or secondary forest or scrub vegetation, at 1220–2100 m altitude.

Selected sources 649.

H.M. Sangat-Roemantyo & D.J. Middleton

Anamirta cocculus (L.) Wight & Arn.

Prodr. fl. Ind. orient. 1: 446 (1834).
MENISPERMACEAE
$2n = (22), 24, 26$

Synonyms *Menispermum cocculus* L. (1753), *Menispermum lacunosum* Lamk (1797), *Cocculus populifolius* DC. (1817), *Anamirta paniculata* Colebr. (1822).

Vernacular names Fish berry, poison berry (En). Indonesia: tuba biji (general), oyod peron (Javanese), bori (N. Halmahera, Ternate). Philippines: arai (Bagobo), lagtang (Bisaya, Manobo, Sulu, Tagalog), ligtang (Tagalog). Cambodia: seg dom. Thailand: khamin khruea (northern), om phanom (south-eastern), waai din (central). Vietnam: d[aa]y t[as]o, d[aa]y d[oo]ng c[aaf]u.

Origin and geographic distribution *A. cocculus* is the only species in the monotypic genus *Anamirta*. It occurs naturally from India, Sri Lanka, Andaman and Nicobar Islands, Thailand, Indo-China, through Sumatra, Java, Lesser Sunda Islands, the Moluccas, to the Philippines and New Guinea.

Uses In the Philippines, an infusion of the roots of *A. cocculus* is used to treat fevers, dyspepsia and menstrual problems. Extract of the stem is added to native wine and is drunk to make the blood strong. The leaves may be used as a poultice for headache, stomach-ache or delayed menstruation. The dried fruits constitute the drug known as 'cocculus' or 'cocculus indicus'. In Laos, the fruit is used in very small doses to treat eruptive fevers. The powdered fruit is used to treat acute barbiturate poisoning. In India, the fruits and seeds are made into an ointment for external application to treat skin diseases. The seeds are also externally applied to kill head lice. The juice of the fruits is applied externally to ulcers and scabies.

Fruits of *A. cocculus* are officially listed in the Pharmacopoeias of various countries. The fruit and especially the seed contain picrotoxin, a very strong poison. Picrotoxin has been used intravenously as an antidote against poisoning by barbiturates and morphine. However, the safe therapeutic dose range is very narrow. Picrotoxin has been used in very minute doses as a nervine tonic in schizophrenia and epilepsy and similar afflictions.

In South-East Asia the fruit of *A. cocculus* is used mainly as a fish poison and as an insecticide. For fish poison fresh or dry semi-ripe fruits with or without the fruit pulp are ground with shell-fish, shrimp or small crabs. The resulting paste is made into pellets used as fish bait. Upon ingestion of these pills the fish become stupefied and will float to the surface, after which the fish must be swiftly eviscerated. This is done in order to reuse the bait and avoid contamination of the fish with the poison. In the Philippines fruits are heated or roasted, crushed and powdered. The resulting powder is simply thrown in the water to stupefy the fish.

In the past the fruit was sometimes used fraudulently in the United Kingdom to flavour beers with its bitterness.

The bast-fibres are used for basketry rope and belt making.

Production and international trade Dried fruits of *A. cocculus* have since long been exported from India to the Near East and Europe. They were known to the physicians of the Arabic schools from the tenth century, and in the following centuries passed on to Europe, obtaining the name 'cocci orientalis'. Recent information on production and trade, however, is not available. The fruits are an ingredient of many homeopathic formulations.

Properties Fruits of *A. cocculus* contain about 1.5% picrotoxin, which is also known as cocculin. Picrotoxin is a crystalline equimolar mixture of 2 sesquiterpene dilactones, i.e. picrotoxinin and picrotin. Of the latter 2, only picrotoxinin is pharmacologically active.

The seed, when taken internally, is a powerful poison for all vertebrates affecting the central nervous system, stimulating the motor and inhibitory centres in the medulla, especially the respiratory and vagus centres, acting on the heart and respiration. It also irritates motor centres, either in the cerebrum or in the medulla and cord, producing in all vertebrates alternating epileptiform spasms, with periodic stoppage of the motions of the diaphragm and slowness of the pulse. The poisoning causes vomiting, purging, profuse sweating and intoxication, with extreme giddiness, dimness of vision and unconsciousness. Breathing and the pulse become weak. The poisoning also results in clonic convulsions; during spasms and intervals of relaxations the pupils correspondingly contract or dilate. Death occurs rapidly from respiration failure, or slowly from gastro-intestinal symptoms.

On a biochemical level, picrotoxin (or more precisely its active constituent, picrotoxinin) act as GABA (gamma-amino butyric acid) antagonists. It stimulates the central nervous system, particularly the medulla oblongata and respiratory centre.

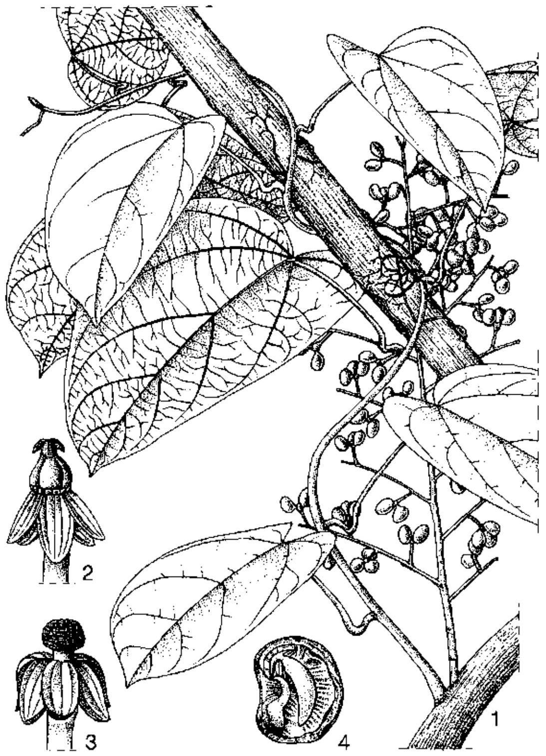
Administration of picrotoxin via the vertebral artery decreased sinus rate and increased circulating levels of vasopressin. On the other hand, infusion of picrotoxin into the internal carotid artery caused increases in sinus rate, blood pressure and plasma vasopressin. These data support the hypothesis that GABAergic mechanisms at different levels of the neuraxis exert opposite effects on cardiac vagal activity, and that GABAergic mechanisms in both the brainstem and forebrain inhibit the release of vasopressins into the systemic circulation.

At receptor level, the GABA receptor is a complex, membrane-bound glycoprotein, operating a chloride-ion channel. When the endogenous agonist GABA is released into the synaptic cleft, the receptor opens its ion channel, resulting in an influx of chloride ions and hyperpolarization of the membrane, thus being responsible for the resulting pharmacological effects. On the GABA receptor site, barbiturates bind close to the chloride channel and, at least in part, increase chloride-ion conductance mimicking GABA activation. On the other hand, picrotoxinin specifically binds to the same barbiturate site, but blocks the opening of the chloride channel. Therefore, picrotoxin can be used as a specific barbiturate poisoning antagonist, although its safety limits are very narrow.

Furthermore, the fruits contain the isoquinoline alkaloids menispermine, paramenispermine, magnoflorine, stephorine, berberine, palmatine and 1,8-oxotetrahydropalmatine. In addition, the stem and roots contain only small amounts (about 0.1%) of the alkaloids berberine, palmatine, magnoflorine, columbamine and 1,8-oxotetrahydropalmatine. The stem also contains oxypalmine and stepharine. In general, the alkaloids isolated from *A. cocculus* have antibacterial-, antimicrobial-, sympatholytical- (acetylcholine), and antifertility activities.

Adulterations and substitutes Picrotoxin is also isolated from *Tinomiscium petiolare* Hook.f. & Thomson (*Menispermaceae*). Several of the alkaloids recorded for *A. cocculus* occur in other *Menispermaceae*, e.g. berberine and palmitine in *Arcangelisia* spp., berberine, palmitine and magnoflorine in *Tinospora* spp., and magnoflorine in *Cyclea* spp.

Description A large, dioecious liana, up to 15 m long; stem twisting to the left, up to 10 cm in diameter, with stout, smooth branches, young stems and petioles pale straw-coloured when drying, striate, wood white or yellowish, exuding white milky sap when cut. Leaves alternate, simple,



Anamirta cocculus (L.) Wight & Arn. – 1, fruiting branch; 2, female flower; 3, male flower; 4, opened fruit showing cotyledons.

ovate to broadly ovate, 16–18 cm × 10–24 cm, base cordate to truncate, apex shortly acuminate, margin entire, palmately 3–5(–7)-veined at base with 4–5 pairs of lateral veins running parallel with the main pair of basal veins, lower surface with reticulum clearly visible and slightly raised, midrib very prominent, glabrous on both surfaces apart from hairy patches (domatia) in the axils of the secondary and main veins, thinly coriaceous; petiole 6–8(–26) cm long, glabrous, swollen at both ends, geniculate at base; stipules absent. Inflorescence a panicle, cauliflorous, spreading or pendulous, 16–40 cm long with lateral branches 2–5 cm long, glabrous, bracteoles about 0.5 mm long. Flowers shortly pedicellate, unisexual, petals absent, strongly fragrant; male flowers with glabrous pedicels up to 2–3 mm long, sepals white, yellow or pale green, outer sepals 2, scarcely 1 mm long, inner sepals 6, broadly elliptical, 2.5–3 mm × 2 mm, glabrous apart from often minutely papillose margin, stamens 30–35, filaments more or less connate, anthers in a stalked cluster; female flowers with pedicels and sepals as in male flower, staminodes 6, carpels 3(–4), curved-ellipsoid, 1.5–2 mm long, stigma thick, recurved. Infructescence with lateral branches up to 15 cm long, gynophore (3–)6–16 mm long, shortly branched below the drupes, continuous with pedicel, 8–20 mm long. Fruit a drupe, nearly spherical, 9–11 mm long, white turning red, finally dark purple, glabrous, smooth and hard when dry. Seed deeply cup-shaped, with endosperm; embryo with foliaceous, divaricate cotyledons.

Growth and development *A. cocculus* often bears flowers in abundance, the fragrant smell can be detected by man from 50 m distance. Pollination is probably effected by insects which are attracted by the scent of the flowers.

Other botanical information *A. cocculus* is very closely related to *Arcangelisia flava* (L.) Merr. with which it is sometimes confused. However, they can easily be distinguished. The domatia in the leaves of *A. cocculus* are hairy patches while in *Arcangelisia flava* they are hollow with the margin of the aperture hairy. Besides, *A. cocculus* has white wood while *Arcangelisia flava* has yellow wood.

Ecology *A. cocculus* occurs naturally in forest and forest fringes, in thickets, on river banks, near streams, in savanna, up to 400 m altitude, on volcanic basalt, limestone, calcareous rocks and sandy soils. It prefers a seasonal climate.

Propagation and planting Propagation of *A. cocculus* by seed seems the most appropriate means for any future plantings.

Harvesting Fruits, stem or roots of *A. cocculus* are collected from the wild when required.

Handling after harvest When used as a medicine the ripe fruits of *A. cocculus* are in general simply dried. For its use as a fish poison the same procedure can be followed or the fruits may be employed fresh.

Genetic resources and breeding In view of its large geographical distribution and its occurrence in a wide range of habitats it is unlikely that *A. cocculus* is seriously threatened by genetic erosion. Despite its longstanding use no reports of cultivation, let alone breeding efforts have been recorded.

Prospects Picrotoxin and picrotoxinin are substances with a distinct pharmacological profile, i.e. GABA antagonistic activity by interacting with the barbiturate binding site on the receptor. Due to this mechanism the compounds can, and have been used as antidotes in barbiturate poisonings. Due to their extremely narrow safety limits and variable outcome, however, they will never be used in general medical practice. On the other hand, in medicinal research, picrotoxinin is generally used as an experimental substance in the laboratory, and in laboratory animals. Therefore, *A. cocculus* will most probably stay of local importance.

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Other selected sources 135, 407, 486, 739, 861, 944.

N. Wulijarni-Soetjipto & J.L.C.H. van Valkenburg

Anisomeles R.Br.

Prodr.: 503 (1810).

LABIATAE

$x = 17$; *A. indica*: $2n = 34$, *A. malabarica*: $2n = 32$

Major species *Anisomeles indica* (L.) O. Kuntze, *A. malabarica* (L.) R.Br. ex Sims.

Vernacular names Catmint (En).

Origin and geographic distribution *Anisomeles* is a small genus of 3 species distributed through the Old World tropics, from Africa to Japan and southwards through Malesia to Australia. *A. indica* and *A. malabarica* are widely distributed but *A. salviifolia* R.Br. is restricted to Australia and New Guinea.

Uses Catmint is widely used as a medicinal plant in India, Sri Lanka and China, and on a smaller scale in Malesia. It has a strong camphor-like smell. The plant is an astringent, carminative, febrifuge and tonic. A decoction of the leaves is used as an antirheumatic and stomachic, and also to treat uterine infections, kidney gravel, swellings and hypertension. The juice of the leaves is given to children for colic, dyspepsia and fever caused by teething. In the Philippines, *A. indica* is used for gastric catarrh and intermittent fevers. Inhaling the vapour of the hot infusion induces copious perspiration. The essential oil distilled from the leaves is applied externally as an embrocation in rheumatic arthritis.

In India, Vietnam and China, the essential oil of *A. indica* is also used as a hair dressing, as a flavouring for sago cakes, and as a compound in perfumes and cosmetics. In Africa, the plant is burnt as a mosquito repellent. In Indonesia, sun-dried leaves are used as fodder; they are more palatable than fresh leaves, but contain less fibre and protein. *A. indica* is also cultivated as an ornamental, in the whole of its distribution area.

A. malabarica is used in India as a remedy against bites and stings, and also for catarrh, flatulence and arthritis.

Production and international trade *Anisomeles* is mainly collected from the wild for medicinal purposes, but is also cultivated on a small scale in China. The dried plants are stocked in Chinese pharmacies throughout Malesia. Cultivation as an ornamental or for essential oil extraction is widespread. Statistics on production and international trade however, are not available; in India cultivation for essential oil is important.

Properties The leaves of *A. indica* yield a volatile oil, which contains α-pinene, β-pinene (28%), δ-limonene, methyl-chavicol (9%), δ-α-thujone, citral (10%), borneol, 1,8-cineole (eucalyptol, 12%), nerol, α-terpineol, eugenol (25%), azulene and caryophyllene (15%). The essential oil shows antimicrobial activity against *Bacillus anthracis, Proteus vulgaris, Salmonella stanley, S. newport, Streptococcus agalactiae, Staphylococcus aureus, Escherichia coli, Aspergillus fumigatus* and *A. niger*.

Furthermore, several macrocyclic diterpenes which show pharmacological effects were isolated from the whole dried plant of *A. indica*. Ovatodiolide, 4,5-epoxyovatodiolide, anisomelic acid, 4,7-oxycycloanisomelic acid and 4-methylene-5-oxoanisomelic acid were found to inhibit the growth of KB cells in vitro. Ovatodiolide also inhibits the growth of Ehrlich carcinoma in mice, and 4-methylene-5-hydroxyovatodiolide possesses general cytotoxic effects. It also shows a transient hypotensive activity on the cardiovascular system in the anaesthetized dog, and inhibits myocardial contraction in the isolated frog heart. Furthermore, ovatodiolide, 4,7-oxycycloanisomelic acid, 4-methylene-5-hydroxyovatodiolide and 4-methylene-5-oxoanisomelic acid were found to possess an antagonistic effect on the Ca^{2+} current (calcium antagonistic activity), and the latter 3 compounds show inhibitory activity on the angiotensin converting enzyme. Ovatodiolide can also be isolated from the ethanolic extract of the roots of *A. indica*, as well as the flavonoid anisomelin (4′,5′-dihydroxy-3′,6,7-trimethoxyflavone).

Little is known about the biological activity of the compounds found in *A. malabarica*. Some diterpenes, anisomelic acid, anisomelol, anisomelide, anysomelyl acetate, 2-acetoxy melabaric acid and ovatodiolide were isolated from the aerial parts. Isolated sapogenins of β-amyrin C-28 carboxylic acid show spermicidal activity towards human semen in International Planned Parenthood Federation tests.

Application of the green leaves of *A. indica* to the soil reduces both pre- and post-emergence collar rot of chickpea caused by *Sclerotium rolfsii*.

Adulterations and substitutes Several components found in *Anisomeles* species are also found in *Mentha* (*Labiatae*), *Amomum* (*Zingiberaceae*) and in *Blumea* (*Compositae*).

Description Perennial, rhizomatic, strong smelling herbs or shrubs, stems and branches pubescent. Leaves simple, decussate, ovate, base broadly cordate to cuneate, apex acute, margins serrate to crenate, pubescent; petiole present; stipules absent. Inflorescence a loose terminal spike. Flowers in axillary whorls, numerous, subsessile, bisexual, irregular; calyx campanulate, 10-veined, 5-toothed, teeth equal, inside hairy; corolla 2-lipped, upper lip narrow, entire, lower lip 3-lobed, much longer than the upper lip, central lobe of the lower lip 2-winged; annulate rim within the corolla tube, fringed with simple hairs; stamens 4, slightly didynamous, filaments inserted on the corolla tube, exserted, but not exceeding the lower lip, the upper pair with 1-celled anthers, sterile, the lower pair with 2-celled anthers, fertile, the filaments hairy on the upper part; stigma bifid, subequal; disk nectariferous, 4-lobed. Fruit consisting of 4 dry 1-seeded schizocarpous nutlets enclosed in the persistent calyx, nutlet broadly ovoid, slightly compressed, smooth, with a rather prominent scar on the ventral surface. Seedling with epigeal germination.

Growth and development Growth starts from the rhizome after the rains have started, and the species flower for a long period. The flowers are nectariferous and are visited by insects as well as birds for nectar and pollen. The insects *Xylocopa* spp. (carpenter bees), *Amegilla* spp., *Apis florea* and *Megachile* spp., and sunbirds (*Nectarinia* spp.) are the principal pollinators of *A. indica*. *Nectarinia* spp., *Xylocopa* spp., *Amegilla* spp. and the wasp *Rhynchium metallicum* are the principal pollinators for *A. malabarica*. *Anisomeles* species are capable of producing seeds by self-pollination in the absence of cross-pollinators. The hairy rim probably forms a protection against ineffective pollinators and nutlet eaters, like ants. The nutlets are dispersed by water. The shiny pericarp may be attractive to seed-eating birds.

Other botanical information It is uncertain whether *Anisomeles* belongs to the subfamily *Lamioideae* or *Pogostemonoideae*, since it has characteristics of both groups. *A. indica* can hybridize with *A. malabarica*, forming hybrid segregates or local variants. Some of these hybrids have formerly been recognized at species level, but are nowadays incorporated in the parental species, or sometimes recognized at variety level.

Ecology *Anisomeles* species have a tendency to weediness and grow well on open, often waste places, in the lowlands and hills. The adaptation of *Anisomeles* to insect and bird pollination and to a flexible breeding system, safeguards their survival under changing environments.

Propagation and planting *Anisomeles* can be propagated by seed or by rhizome cuttings.

Harvesting *Anisomeles* is collected for medicinal purposes from the wild when the need arises.

Handling after harvest After collecting, *Anisomeles* plants are washed and used fresh, or dried and stored for later use.

Genetic resources and breeding Both major *Anisomeles* species are widespread, and do not seem to be at risk of genetic erosion. Hybridization between these species can be achieved through conventional breeding methods. There is a small germplasm collection of *A. indica* in the United Kingdom.

Prospects The diterpenes isolated from *A. indica* show interesting pharmacological effects. However, further research will be needed to fully evaluate their possible potential.

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Selection of species

Anisomeles indica (L.) O. Kuntze

Rev. gen. pl.: 512 (1891).

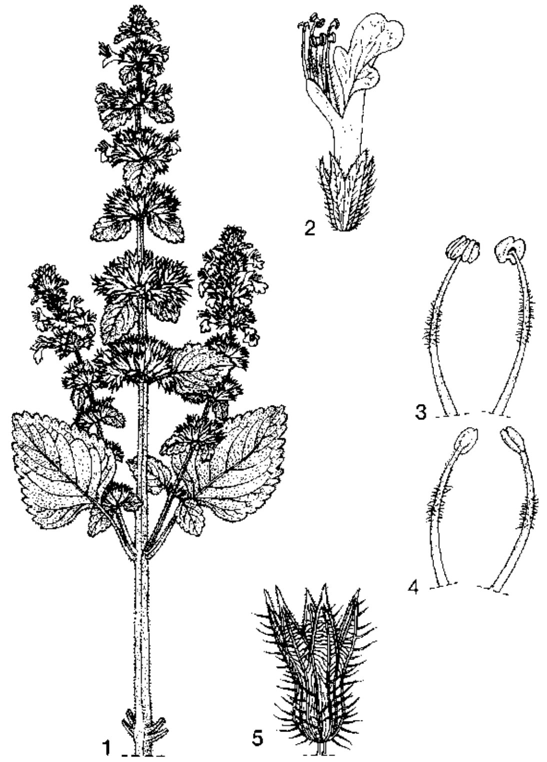
Synonyms *Nepeta indica* L. (1753), *Anisomeles ovata* R.Br. (1811), *Epimeredi indicus* (L.) Rothm. (1944).

Vernacular names Catmint (En). Indonesia: celangking (Javanese), ki hileud, patuk bangkong (Sundanese). Malaysia: babadotan, bandotan. Philippines: kabling-parang, kabling-lalake (Tagalog), lilitan (Iloko). Thailand: komko huai (northern), saapsuea (central), yaa farang (south-eastern). Laos: san nga (Louang-Prabang). Vietnam: thi[ees]n th[ar]o, ph[of]ng, phong th[ar]o.

Distribution *A. indica* is native of South-East Asia, and is nowadays widely distributed from Africa, though not common there, through India, China and Japan and southwards from Malesia to Australia.

Uses *A. indica* is a powerful astringent, carminative, febrifuge and tonic. The whole plant is used, but especially the leaves and the roots.

Observations A large herb up to 2 m tall, stems quadrangular, sparsely hairy to densely pubescent; leaves (broadly-)ovate, 5–12 cm × 2–7 cm, puberulent on both sides, hairs 5-celled, petiole 1.5–4 cm long, tomentose; inflorescence a terminal spike, accompanied by more than 2 lateral spikes, calyx 6 mm × 6.5 mm, longest teeth 1.7–2 mm long, in fruit 9–10 mm long, upper part of the tube and teeth hairy inside, corolla up to 11 mm long, lower lip about 8 mm × 3 mm, greenish to whitish, with dark red lines inside, sometimes purple or



Anisomeles indica (L.) O. Kuntze – 1, flowering stem; 2, flower; 3, lower pair of stamens with 2-celled anther; 4, upper pair of stamens with 1-celled anther; 5, fruiting calyx.

blue, filaments didymous, 5–6 mm long, style about 9 mm long; nutlets subglobular, 1.2 mm × 1 mm, shiny black. *A. indica* grows on sunny and open locations, grasslands, also in teak forests, and on wet soils along streams and irrigated rice fields, usually scattered, sometimes locally numerous, at 600–1800 m altitude. It flowers throughout the year, when enough water is available.

Selected sources 60, 74, 135, 145, 215, 235, 265, 739, 786, 810, 820, 897.

Anisomeles malabarica (L.) R.Br. ex Sims

Bot. Mag.: 46, t. 2071 (1819).

Synonyms *Nepeta malabarica* L. (1767), *Epimeredi candicans* (Benth.) Rothm. (1944).

Vernacular names Malabar catmint (En).

Distribution *A. malabarica* originates from South India and Sri Lanka, but is now also distributed in Thailand, Indo-China, Malesia and the Bismarck Archipelago. It has also been introduced into Mauritius.

Uses In Malesia and India, *A. malabarica* has the same uses as *A. indica*.

Observations A shrubby herb, 0.5–1.5 m tall, stems tetragonous, densely villous or woolly; leaves ovate to oblong, 3–8 cm × 1.5–3 cm, densely woolly beneath, sparsely hirsute above, hairs 4-celled, petiole 0.5–2.5 cm long, softly woolly; inflorescence a single terminal spike, calyx 8.5 mm × 6 mm, longest teeth 3–4 mm long, in fruit 8–10 mm long, teeth hairy inside, corolla up to 18 mm long, lower lip about 12 mm × 4 mm, lilac or pale blue, filaments almost at same level, about 8 mm long, style about 13 mm long; nutlets cylindrical, 1.3 mm × 0.9 mm. *A. malabarica* grows well in open, sandy waste locations, mostly under seasonal climatic conditions, at low altitude, flowering in the rainy season.

Selected sources 74, 135, 145, 215, 786, 810, 820.

L.T. Ng & S.K. Ling

Arctium lappa L.

Sp. pl. 2: 816 (1753).

COMPOSITAE

$2n = 36$

Synonyms *Lappa vulgaris* Hill (1762), *Lappa major* Gaertner (1791).

Vernacular names Great burdock, edible burdock, beggar's buttons (En). Bardane, gouteron, oreille de géant (Fr). Indonesia: gobo. Vietnam: ng[uw]u b[af]ng.

Origin and geographic distribution *A. lappa* is indigenous from Europe to China and Japan, and has been introduced into North America. It is cultivated mainly in Japan, but also in China, Vietnam, the Philippines, Indonesia, Hawaii, New Zealand and Europe.

Uses In China, Vietnam, India, and Europe *A. lappa* is well known as a medicinal plant. It possesses heart stimulant, stomachic, anodyne, antiscorbutic, antipyretic, laxative, diaphoretic, depurative, anti-inflammatory and diuretic properties. It is used for a great variety of diseases including furunculosis, suppurating abscesses, swellings, scrofulous gout, psoriasis, acne and prurigo, throat infections, pneumonia, chronic gastritis, scarlet fever, measles, small pox, rheumatism, vertigo, cancer, syphilis, and baldness. The tincture from the fresh roots is used to treat pulmonary catarrh, rheumatism and gout. The whole plant, or only the fruit, is employed as an ointment or liniment for burns, ulcers and other cutaneous diseases.

However, cases of contact dermatitis caused by *A. lappa* root plasters, applied for anti-inflammatory purposes, are known. In East Asia, the fruits are used as a cure against bites of poisonous insects and snakes, and against flatulence. They are exported to Indo-China and sold as a depurative, and are found in Chinese pharmacies in Peninsular Malaysia.

A decoction of the fruit of *A. lappa* and *Trichosanthes kirilowii* Maxim. is a cure for subclinical mastitis in calves of mastitis-positive cows. In India the plant is also used to treat scurf or skin diseases of animals and to prevent hair loss in humans and animals.

In Japan, *A. lappa*, called '(yama-)gobo', is a popular vegetable. The slightly fibrous mucilaginous roots have a sweetish taste and are consumed raw or cooked. The peeled tender petioles and young floral stalks are eaten less widely. North American Indians eat the young leaves as well as the fresh or dried roots. In Europe cows eat the leaves readily, but they may give milk a bitter flavour if eaten in large quantities.

Production and international trade No information is available on the production of *A. lappa* for medicinal purposes. Most *A. lappa* is cultivated in Japan for its edible roots. In Taiwan, Vietnam and New Zealand, *A. lappa* is produced for the Japanese market and for local Japanese people. The annual production of *A. lappa* roots for consumption in Taiwan rose from 16 t in 1990 to 25–30 t in 1993, while the cultivated area rose from 265 ha to 898 ha. In Japan, production in the early 1990s was estimated at 180 000 t/year from 14 000 ha, of which 140 000 t were purchased for consumption, 10 000 t were used for the chilled cut vegetable trade, 500 t were processed for dehydration, 200 t were frozen, and the remainder was used as stock feed.

Properties *A. lappa* has been investigated phytochemically quite well. As in many other *Compositae*, the roots of *A. lappa* contain 45–60% inulin, a fructose based polysaccharide. They also contain a volatile oil (0.06–0.18%) consisting of more than 60 compounds, e.g. phenylacetaldehyde, sesquiterpenes such as costusacid and costuslactone, several sulphur containing acetylenes and derivates, arctinone A and B, arctinone A acetate, arctinol A and B, arctinal, arctic acid, and lappaphen-A and -B. Non-sulphur containing acetylenes (0.001–0.002%) are also present, with (S)-12,13-epoxy-2,4,6,8,10-tridecapentayne, 1,3,11-tridecatriene-5,7,9-triyne and 1-tridecen-3,5,7,9,11-pentayne as the major components. The fresh roots contain up to 3.6% polyphenolics, together with chlorogenic-, caffeic- and caffeoylquinic-acid derivates. The unsaturated bitter sesquiterpene lactone arctiopicrine is present in all plant parts. Other constituents of the herb are the sesquiterpenes arctiol (= 8-hydroxyeudesmol), β-eudesmol, fukinone, the sesquiterpene lactones onopordopicrine and fukinanolide, and triterpenes such as α-amyrin, taraxasterolacetate and lupeolester.

Among the isolated compounds mentioned, the polyacetylenes (S)-12,13-epoxy-2,4,6,8,10-tridecapentayne and 1-tridecen-3,5,7,9,11-pentayne show good antibacterial and antifungal activity. The sesquiterpene lactone arctiopicrine is also an antibacterial principle, active against both gram positive and gram negative bacteria, although it is extremely sensitive to oxidation. Of the anti-oxidative quinic acid derivatives from the root, (1,3,5)-O-tricaffeoyl-4-O-succinylquinic acid showed the highest anti-oxidant activity.

Several tests were performed to evaluate the medicinal properties of *A. lappa* extracts. Subcutaneous administration of a crude extract of the roots significantly decreased carrageenan-induced rat paw oedema. Simultaneous administration of the extract with CCl_4, reduced CCl_4-induced acute liver damage. The IC_{50} of the extract on superoxide and hydroxyl radical scavenger activity was 2.1 mg/ml and 11.8 mg/ml, respectively. These results indicate that *A. lappa* possesses free radical scavenging activity, likely to cause the inhibitory effects on oedemas and hepatotoxicity. The plant was also tested in prevention and treatment of kidney stone formation using female Wistar rats. An evaluation of the main urolithiasis risk factors (citraturia, calciuria, phosphaturia, pH and diuresis) showed that the beneficial effects can be mainly attributed to some disinfectant action. *A. lappa* extract causes a sharp, long-lasting reduction of the blood-sugar level of rats, with an increase in carbohydrate tolerance, especially for diabetics. In a test for treatment of diabetes in normal and streptozotocin induced diabetic mice, however, *A. lappa* did not affect the parameters of glucose homeostasis examined in normal mice, but worsened the diabetic condition in the other mice. Crude extracts were tested in several cell lines for anti-HIV activity and cytotoxicity, but inhibition of HIV-1 replication could not be shown in all tests. The hot water extract showed RNA reverse transcriptase inhibiting activities. Methanol extracts were subjected to a screening test for larvicidal and antifeeding activity against two species of lepidopteran larvae, diamondback moth (*Plutella xylostella*) and tobacco cutworm (*Spodoptera litura*), using a leaf-dipping method. At 5000 ppm strong antifeeding activity against both larvae was observed.

The fruits of *A. lappa* are called 'bardanae fructus'. They are known to contain a broad spectrum of lignans. Arctiin, arctigenin and matairesinol are lignans containing 2 phenylpropane residues. Lappaol A–E contain 3 residues, and the dilignans lappaol F–H, neoarctin A and B, and diarctigenin (= bis-5′,5′-arctigenin) 4 residues. Other isolated lignans mentioned in literature are arctilignans A–E and trachelogenin, and other important compounds are chlorogenic acid and daucesterol (a phytosterol). Pharmacological activities attributed to these compounds include differentiation-induction of M1 (mouse myeloid leukaemia) cells by lignans and dilignans. Arctigenin was the most effective of all, inducing differentiation at 0.5 μM; in general, phagocytic activity of differentiated M1 cells was higher of lignans than that of dilignans. Trachelogenin produced a long-lasting anti-hypertensive effect through Ca^{2+} antagonist activity in rats, and arctiin and arctigenin showed strong cytotoxicity against HepG2 cells, but little toxicity against Chang liver cells. Chlorogenic acid did not affect the viability of these cells. Furthermore, the cytotoxicity of arctigenin against Chang liver cells, but not for HepG2 cells, was markedly potentiated by treatment with L-butathione-(S,R)-sulphoximine (BSO, a glutathione synthesis inhibitor). Extracts of *A. lappa* fruits were also tested for their inhibitory effect on the binding of platelet activating factor (PAF) to rabbit platelets, and were found to be significantly active. This activity is attributed to the presence of lignans.

A desmutagenic factor was isolated from *A. lappa*, which reduced the activity of a series of well known mutagens, including nitrobenzene derivatives (NDAB), ethium bromide, 2-aminoanthracene, Trp-P-1, and Trp-P-2. It is resistant to heat and proteolytic enzymes and sensitive to treatment with $MnCl_2$. The factor was shown to be a complex polymer with molecular weight of around 30000, possibly a lignin-like compound with 10% sugar content. In Canada the herbal drug 'Essiac', composed of *A. lappa*, *Rheum palmatum* L., *Rumex acetosella* L. and *Ulmus fulva* Michx., has been used for over 70 years in cancer therapies. There is some preliminary clinical evidence that 'Essiac' may be effective in treating breast cancer.

Rats first fed on a diet of *A. lappa* fibres with or without the inclusion of 8% mineral oil in a fat-free diet, showed a severe growth retardation without addition of the fibres. The *A. lappa* fibres, as well as cotton cellulose powder, inhibit mineral oil absorption from the intestinal lumen. In a test with the food colours amaranth, erythrosine, tartrazine, brilliant blue, new coccine and sunset yellow, all food colours caused severe growth retardation of weanling rats. When 5% fibre from the roots of *A. lappa* was added, growth was not retarded by any colour except for erythrosine.

Adulterations and substitutes Sarsaparilla (*Smilax* sp.) is an important anti-inflammatory and a remedy for venereal affections, and could be a substitute for *A. lappa*. Asparagus roots are eaten as a substitute for *A. lappa* roots.

Description A biennial, robust and much branched herb, 40–100(–210) cm tall when flowering; taproot up to 1.5 m long in the second year, brownish to weak yellowish-orange. Basal leaves arranged in a rosette, cauline leaves alternate, simple, heart-shaped, up to 40–50 cm × 15–20 cm, margin irregularly undulate, upper surface glabrous, underneath covered with white hairs; peti-

Arctium lappa L. – 1, flowering branch and basal leaf; 2, root; 3, achene.

oles (5–)20–30 cm long; stipules absent. Inflorescence a head, one or more together in a lax terminal or axillary corymbose cyme; peduncle 2.5–20 cm long, involucre hemispherical, involucral bracts herbaceous, bright green, margin in the lower half membranaceous, with few to many glandular hairs, the upper part slightly recurved, straight or (slightly) hooked, the head thus becoming a burr, heads rounded, 3–4.5 cm × 2–3 cm. Flowers all tubular, more than 40, lobes 5, corolla 9.5–14.5 mm long, mostly purplish; stamens 5; ovary inferior. Fruit an obovoid achene, 6–8 mm × 2.4–3.2 mm, angular, chestnut-brown. Seedling with epigeal germination; hypocotyl wrinkled and white, cotyledons large and rounded; epicotyl absent; first leaves alternate.

Growth and development In the first year, the average number of leaves of *A. lappa* is 20, with a leaf dry weight of about 60 g/plant. The taproot shows xylem thickening. In some cultivars a pith cavity starts developing during the 4th month after sowing and becomes quite large at harvest time, at the end of the 5th month after sowing. Early cultivars for root production mature in 120 days, late cultivars in 200 days.

Other botanical information *Arctium* belongs to the tribe *Cardueae*, and comprises 11 species (including part of the species formerly belonging to *Cousinia*) and 6 hybrids. *A. minus* (Hill) Bernh. (lesser burdock) is closely related to *A. lappa*, but differs from the latter by having hollow petioles and smaller flower heads. The natural hybrid between *A. lappa* and *A. minus*, *A.* ×*nothum* (Ruhm) Weiss, occurs occasionally throughout Western Europe, often among its parents. Its achenes are often abortive. A cultivar trial of *A. lappa* showed little difference among cultivars, but 'Ooura' showed a higher yield for all plant parts, and had a conspicuous pith cavity formation of the root.

Ecology *A. lappa* is found in ruderal, neglected locations, along roads and in fields as a weed, along streams and ditches, forest edges and marshlands. It tolerates a wide range of climates, and grows from sea-level up to 3200 m altitude. It grows in light to heavy, dry to moist soils, in full sunshine or in the shade.

Propagation and planting *A. lappa* is propagated by seed. Seeds germinate at 10–36°C, the optimum temperature being 21–30°C. Germination rate is around 90%. The optimum sowing depth is 2 cm, deeper than 4 cm reduces germination rate considerably. The seeds germinate 3–4 days after sowing. In New Zealand a plant density of 20 plants/m^2 is considered optimal for root production.

Husbandry In Japan, *A. lappa* is cultivated on a large scale and many operations are mechanized. Phosphorous fertilizer increases shoot dry weight and decreases mycorrhizal infection rate. Leaf N-uptake of *A. lappa* decreases when leaves begin to wither after attaining maximum growth in the 4th month. Root N-uptake increases after the leaves wither completely. Root hypertrophy, dry matter content and inulin content decreases when fertilizer application is further increased. Continuous cropping of *A. lappa* causes inhibition of germination and damping-off at seedling stage, while in the growth stage leaf width, plant height and root length become abnormal, and the roots are deformed and develop necrotic spots. Application of phenolic acids may improve crop growth, although plant growth is less than the first cropping.

In Taiwan *A. lappa* is mainly grown in the winter season and all the necessary fertilizer is applied in a single dose during land preparation.

Diseases and pests Several important diseases of *A. lappa* in Japan are caused by: *Aspergillus ochraceus*, *Fusarium oxysporum* f. *arctii*, *Erysiphe cichoracearum*, *Pythium irregulare*, *Scepticus uniformis*, *S. griseus*, *Sclerotinia sclerotiorum*, and *Sphaerotheca fuliginea*. *A. lappa* is a host for the following viruses: burdock mottle virus (also infecting *Chenopodium murale* L., *C. quinoa* L. and *Nicotiana rustica* L.), burdock mosaic virus, burdock yellow virus (a closterovirus), tobacco ringspot virus (TobRV), burdock stunt disease, and tomato spotted wilt tospovirus. Important insect pests found on *A. lappa* in Japan are: *Tebenna issikii*, *Pantomorus cervinus* (which feeds on the roots), and thrips.

Harvesting The roots are dug up the end of the first year's growth, when they are about 60–80 cm long and 2.5 cm in diameter, and the root dry weight is 70–80 g/plant.

Yield In New Zealand, yields of *A. lappa* roots are as high as 39 t/ha under experimental conditions. This is considerably higher than yields obtained in Japan, which are 13 t/ha. Under experimental conditions in Germany, a 1-year old crop yielded 6 t of roots per hectare, giving 450 kg of inulin, and 7.5 t of dry stems, yielding 3 t of good quality cellulose.

Handling after harvest In Taiwan the roots of *A. lappa* are washed and carefully dried, and then stored for 1–2 months at 0–5°C for the transformation of starch to saccharide. After 2 months of storage the content of saccharide increases from

50% to 75%, while that of starch reduces from 35% to 4%. The roots are then cut into 1.7 mm thick slices, which are dried for 15 minutes at 160°C. The farmers produce *A. lappa* under a guaranteed price-contract with dealers.

Genetic resources and breeding *A. lappa* is widely distributed and will not easily become endangered. Small germplasm collections are known to exist in Brazil, China, Germany, Poland and the United Kingdom. Breeding programmes on root production are being carried out in Japan.

Prospects Compounds from *A. lappa* show several interesting pharmacological activities, including antimicrobial, cytotoxic and anti-oxidant effects, which seem worthwhile for further research. Furthermore, the leaves of *A. lappa* are one of the best sources of pectinesterase and polygalacturonase for commercial clearing of fruit-juices. Air-dried, the enzymes retain a high activity for several months.

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G.H. Schmelzer & S.F.A.J. Horsten

Argemone mexicana L.

Sp. pl. 1: 508 (1753).
PAPAVERACEAE
$2n = 28$

Vernacular names Mexican poppy, prickly poppy, yellow thistle (En). Argémone, pavot épineux, pavot du Mexique (Fr). Indonesia: celangkringan, druju (Javanese). Malaysia: chelang keringan. Philippines: kachumba, kasubang-aso (Iloko), diluariu (Tagalog). Thailand: fin naam (Bangkok). Vietnam: gai cua, m[uf]i cua, c[af] gai hoa v[af]ng.

Origin and geographic distribution *Argemone* L. originates from tropical America and comprises 6–9 species. *A. mexicana* is native in Mexico and the West Indies, but has become pantropical as an ornamental and a weed. It is naturalized in many Asian countries, from India, Indo-China to Taiwan, and southwards through Peninsular Malaysia, Java, the Lesser Sunda Islands, Sulawesi, to the Moluccas and the Philippines.

Uses *A. mexicana* is not widely used in South-East Asia or Indo-China; the main users are people from India. In Vietnam though, the roots are sometimes used for rheumatism, while in the Philippines they are used as an abortifacient.

A. mexicana is highly esteemed as a medicinal plant throughout tropical America. The roots, leaves and seeds are registered officially in the Mexican pharmacopoeia. In tropical America, a decoction of the leaves is drunk for ailments of the spleen and liver, and for jaundice or whooping cough. An infusion of the young leaves or flowers is taken to relieve fever, cough and asthma. An infusion of the flowers is also taken before sleeping as a narcotic, to avoid insomnia, and given to teething children. In northern Venezuela, a decoction of the plant is employed as a sudorific, emmenagogue, vulnerary, depurative, emetic and treatment of epilepsy and cancer. In French Guyana, the root or stem is prescribed for vesicular calculus, as an eye-wash and a lotion for inflammations, as a mouth-wash for toothache and internally for gleet. In Mexico the seeds are considered an antidote to snake venom, whereas in French Guyana they are used as a cathartic and emetic.

In India, the root is used as an alterative, and an infusion is given to women to drink at the start of parturition, as well as being used against tapeworm. A decoction is also employed in chronic skin diseases. The latex is slightly corrosive and used to treat warts, but also for dropsy, jaundice and cutaneous infections. It is diuretic, relieves blisters, and heals ulcers and conjunctivitis. It is also rubbed on the body to relieve rheumatic pain. Mixed with milk it is given for leprosy. The seeds are laxative, emetic, nauseant, expectorant, and demulcent. They are useful in coughs and catarrhal affections of the throat and pulmonary mucous membrane, and in pertussis and asthma. Though they do not appear to possess any antispasmodic property, they have a distinct effect on asthma, apparently from their combined actions as nauseant, emetic, expectorant and demulcent. As their use is often accompanied by some degree of vomiting and nausea, as a laxative medicine they are more suited to some pulmonary affections than to other diseases. The seed oil is applied to herpes, indolent ulcers and externally for headaches. In West Africa, the plant is considered sedative, diuretic, cholagogue and anti-inflammatory.

The seed oil is toxic, causing intense pain all over the body, diarrhoea or constipation, and fever. The seeds have caused many fatalities in poultry, and the dried leaves are considered poisonous in fodder for cattle. In India, Mexico and the West Indies, the seed oil is sometimes used in the soap industry, or for illumination, whereas in Nigeria it is applied to preserve wood from termite attacks.

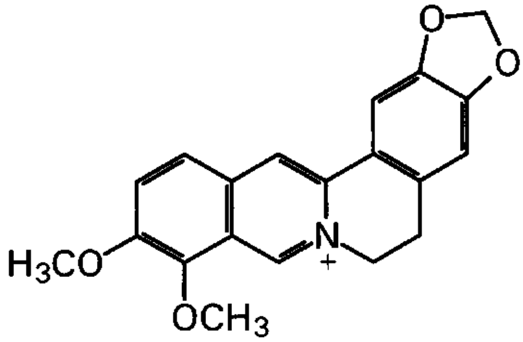
A. mexicana is sometimes cultivated as an ornamental.

Production and international trade *A. mexicana* is only used locally and is not traded internationally, at least not in continental Asia or South-East Asia.

Properties *A. mexicana* contains numerous alkaloids, biosynthetically derived from the amino acid phenylalanine, which belong to several alkaloid types e.g. the protopine type, the protoberberine type, the isoquinoline type, the benzyl(tetrahydro)isoquinoline type and the benzo[c]phenanthridine type. The total alkaloid fraction in the dried roots and stems is 0.25%, mainly consisting of protopine and berberine. Other alkaloids in the roots include coptisine, allocryptopine, chelerythrine and dihydro-chelerythrine. The stems and leaves also contain dihydro-palmatine, oxyhydrastinine, norsanguinarine, 6-acetonyl-dihydro-sanguinarin, 6-acetonyl-dihydro-chelerythrine, reticuline, thalifoline, acetyl-reframidine and muramine. The alkaloids argemonine (N-methylpavine), berberine, protopine, sanguinarine and dihydro-sanguinarine have been isolated from the seeds. In addition, the aerial parts also contain the aliphatic alcohols triacontan-11-ol and triacontane-6,11-diol.

The alkaloidal fraction from the seeds induced inhibition of spermatogenesis in dogs; isolated protopine induced inhibition of almost 100% when administered at 30 mg/kg for 70 days. Furthermore, the alkaloid fraction isolated from the roots led to a fall in blood pressure in anaesthetized dogs, and this action was not changed by atropine, antihistamines or adrenergic blocking agents. It also stimulated smooth muscles, antagonized the action of acetylcholine, histamine and serotonin. Its action on the uterus was similar to that of oxytocin. It showed a stimulating action on respiration, and antagonized barbiturate-induced respiratory depression. The methanol extract, a partially purified alkaloid fraction and some single compounds from the aerial parts were tested in a concentration-dependent assay to study morphine withdrawal (isolated guinea-pig ileum as a model). Both protopine and allocryptopine were found to reduce the morphine withdrawal significantly. The alkaloid fraction from the roots also showed anti-inflammatory activity in rabbits and rats.

Berberine, as a purified compound, has improving effects on the circulation in small doses, like a bitter. Overdose however, produces death by paralysis of the central nervous system. Other pharmacological effects of this compound, which can also be isolated from e.g. *Arcangelisia* and *Tinospora* species include spasmolytic, antibacterial and in some degree antifungal and antiprotozoal activity. Protopine and sanguinarine show molluscicidal properties in *Lymnacea acuminata*, causing a significant decrease in protein levels, free amino acid, DNA and RNA in the nervous tissue, and a simultaneous increase in the rate of lipid peroxidation. Sanguinarine also showed inhibition (60%) of the transport of D-glucose in everted sacs of the small intestines of rats, at a dose of 1 µM, and a dose-dependent inhibition of intestinal and hepatic enzyme Na^+,K^+-ATPase in a non-competitive manner.



berberine

The seeds of *A. mexicana* contain 36% of an orange-yellow oil, which was tested on hepatic xenobiotic metabolizing enzymes in albino rats in vivo. Following a single dose (10 ml/kg) or multiple intraparenteral doses (5 ml/kg) for 3 days, rats that had had a single dose exhibited a significant loss of hepatic cytochrome P-450 and cytochrome B5 contents and inhibition of aminopyrine-N-demethylase, aryl hydrocarbon hydroxylase and ethoxycoumarin-O-deethylase activities. The multiple dose treatment increased these effects, and caused a significant decrease in liver weight (40%). These results suggest that the oil causes auto-oxidative peroxidation of lipids.

The leaf extracts show some antifeedant activity against crop-eating and crop-sucking insects, including the cabbage webworm (*Crocidolomia binotalis*), the tobacco caterpillar (*Spodoptera litura*), the cotton aphid (*Aphis gossypii*) and also larvae of the mosquito *Culex quinquefasciatus*. The seed oil has a significant nematicidal effect on larvae of *Meloidogyne incognita* and *M. javanica*. An aqueous mixture of the oil (0.2%) applied to the soil or the leaves of okra (*Abelmoschus esculentus* (L.) Moench) significantly reduced nematode infection in terms of root galling, root protein content, 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. Dried plant extracts significantly reduced gall formation and hatching on seedlings of tomato and eggplant. Tomatoes treated with a leaf extract showed significantly less fruit rot caused by *Aspergillus niger*, in the presence of *Drosophila buschii*. A flower extract induced a high level of resistance to tomato virus X on the hypersensitive host *Chenopodium amaranticolor* (H.J. Coste & A. Reyn.) H.J. Coste & A. Reyn., for up to 96 days after leaf sprays. The petroleum and ethanol extracts also showed antibacterial activity in vitro against *Bacillus subtilis*, *Escherichia coli* and *Streptococcus faecalis*.

Aqueous leaf and flower leachates applied for 24 hours inhibit the germination and growth of many cultivated crops, such as tomato, cucumber, mustard, radish and pearl millet (*Pennisetum glaucum* (L.) R.Br.).

Adulterations and substitutes Ipecac (*Psychotria ipecacuanha* (Brot.) Stokes) is used as a substitute for the latex of *A. mexicana* in tropical America, because of its emetic properties. The seed oil of *A. mexicana* is an adulterant for mustard oil and sesame oil in India, but has been found to be the cause of epidemic oedema and glaucoma in humans.

Description An annual, erect, branched, thistle-like herb, 30–100 cm tall, glabrous, containing yellow latex, stem pithy, with scattered prickles, taproot firm. Lower leaves crowded as in a rosette, petiole short, higher ones alternate, semi-amplexicaul, sessile, very variable in shape, sinuate-pinnatifid, 5–22 cm × 3–7 cm, white variegated along the main veins, bluish green elsewhere, prickles scattered along the margin and on the veins below. Inflorescence terminal, flowers solitary, sessile. Flowers 3-merous, surrounded by 3 foliaceous bracts; sepals 3, valvate, vaulted, horn just below apex acute, terete, with few prickles, caducous in anthesis; petals 6, obovate, strongly plicate in bud, 1.7–3 cm long, bright yellow; stamens many, free, 7–12 mm long, anthers 2.5 mm long; ovary ovate, with long soft bristles, 8–10 mm long, style very short, stigma 3–6-lobed, dark red. Fruit an ovoid capsule, 2.5–4 cm long, with rounded ribs, valves 3–6, dehiscing from the apex to about 1/3, replum miter-shaped, prickles sharp. Seeds globular, 1.5 mm in diameter, fine reticulate, black-

Argemone mexicana L. – 1, flowering and fruiting stem; 2, flower-bud; 3, seed; 4, dehisced fruit.

brown, hilum prominent, pale. Seedling with epigeal germination; cotyledons long and narrow.

Growth and development *A. mexicana* flowers and fruits throughout the year. The flowers open early in the morning, and then last for 2–3 days. Small stingless bees are the main pollinators.

Other botanical information Several varieties of *A. mexicana* are recognized. In Australia, mostly var. *ochroleuca* (Sweet) Lindley occurs, which has pale yellow, stalked flowers, with a distinct style.

Ecology *A. mexicana* occurs mainly in regions with a pronounced dry season, on open waste ground, along roadsides, in fields as a weed and along railways, mostly at sea-level, but sometimes up to 3000 m altitude, locally abundant, but on the whole scattered.

Propagation and planting *A. mexicana* is propagated by seed. The seed is light, has a waxy coat and is pitted, so that air can be trapped. It is thus favoured by wind and water dispersal. Seed production can be up to 18 000 to even 36 000 seeds per plant. *A. mexicana* seeds germinate best in moist soil with low to moderate temperatures (up to 25°C), but in some regions that can germinate throughout the year.

In vitro production of active compounds Tissue culture of flowers, roots, stems, leaves or fruits of *A. mexicana* showed that most berberine was formed in the flowers, and that the precursor of berberine is tyrosine.

Diseases and pests In some areas *A. mexicana* is attacked by bacterial wilt, caused by *Xanthomonas papavericola*, which periodically hampers its distribution.

Harvesting The desired plant parts of *A. mexicana* are mostly harvested from wild-growing plants, but sometimes from cultivated ones as well.

Handling after harvest Harvested material of *A. mexicana* is used fresh or dried.

Genetic resources and breeding *A. mexicana* does not seem to be at risk of genetic erosion as it is a widely distributed weed. No breeding programmes for medicinal purposes are known to exist.

Prospects Several compounds of *A. mexicana* display interesting pharmacological effects as purified compounds, making further research is desirable. *A. mexicana* might be of interest as a natural source of berberine. The oil is unlikely to be used for medicinal purposes due to its toxic effects.

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Other selected sources 134, 135, 147, 215, 232, 261, 441, 527, 739, 786, 788, 935, 987, 1010, 1047.

Tran Cong Khanh

Artabotrys R.Br. ex Ker Gawl.

Bot. Reg.: t. 423 (1820).

ANNONACEAE

x = unknown; *Artabotrys hexapetalus*: $2n = 16, 18$

Major species *Artabotrys hexapetalus* (L.f.) Bhandari, *A. suaveolens* Blume.

Vernacular names Indonesia: pisang-pisang (used for most *Annonaceae*). Malaysia: mempisang (used for most *Annonaceae*). Vietnam: m[os]ng r[oof]ng.

Origin and geographic distribution *Artabotrys* comprises about 100 species and has a widespread distribution in the Old World tropics.

Uses In India, *A. hexapetalus* is used in traditional medicine for treatment of vomiting, biliousness, anti-fertility and diseases of blood and heart. As a Chinese folk medicine, the root and fruits of *A. hexapetalus* are applied to treat malaria and scrofula, respectively. In Indonesia and India a decoction or infusion of the leaves of *A. suaveolens* is used against cholera. In the Philippines, a decoction of the bark and roots of *A. suaveolens* is prescribed as an emmenagogue and for women after parturition.

Production and international trade Although medicine derived from *A. hexapetalus* originating from China is on the world market, no data are available on production and trade.

Properties From *A. suaveolens*, several aporphin type alkaloids have been isolated, e.g. the non-phenolic artabotrine (synonyms: isocorydine, luteanine), artabotrinine and the phenolic suaveoline. Purified artabotrine acts on the muscular system and stopped respiration in guinea-pigs. Furthermore, the methylderivative of artabotrine, i.e. methyl-isocorydine is reported to be a long lasting ganglion blocker with a sympathic/parasympathic activity ratio of 6/1.

Nine isoquinoline alkaloids have been isolated from the bark of *A. maingayi* Hook.f. & Thomson, from Peninsular Malaysia: four noraporphines (norstephalagine, 3-hydroxynornuciferine, anonaine and nornuciferine), one 7-hydroxyaporphine (ushinsunine), three oxoaporphines (atherospermidine, liriodenine and lysicamine), and one protoberberine. The effects of the main aporphine alkaloids, norstephalagine and atherospermidine, have been studied on the Ca-dependent contractile activity of smooth muscle preparation (uterus). Both norstephalagine and atherospermidine show relaxant activity on rat uterine contractions induced by KCl or rhythmic contractions induced by oxytocin in the presence of Ca^{2+}, but only atherospermidine can relax oxytocin- or vanadate-induced contractions in a Ca-free medium.

Furthermore, a wide range of isoquinoline alkaloids have also been isolated from the bark of *A. venustus* King, from Peninsular Malaysia: five noraporphines (nornuciferine, asimilobine, anonaine, norstephalagine, norushinsunine), two aporphines (nuciferine, lirinidine), (S)-reticuline, norcorydine, two berberines (discretamine, 10-O-demethyldiscretine) and the catecholic artavenustine.

In addition, besides some common flavonoids / organic acids (e.g. taxifolin, fumaric acid), 2 flavonol glycosides artabotryside A (synonym arapetaloside A; quercetin-3-O-α-L-rhamnopyranosyl(1->2)-α-arabinofuranoside) and artabotryside B (synonym arapetaloside B; kaempferol-3-O-α-L-rhamnopyranosyl(1->2)-α-L-arabinofuranoside are reported for the leaves of *A. hexapetalus*. Methanolic extracts of stem parts of *A. hexapetalus* showed significant in vitro activity against tissue culture cells of human KB, A-549 lung carcinoma and HCT-8 colon tumour, as well as murine P-388 and L-1210 lymphocytic leukaemia. The active fraction consists of alkaloids. The principal active components are 2 aporphine alkaloids: liriodenine and atherospermidine. Liriodenine demonstrated potent cytotoxicity against KB, A-549, HCT-8, P-388 and L-1210 cells with ED_{50} values of 1.00, 0.72, 0.70, 0.57 and 2.33 μg/ml, respectively. Atherospermidine posseses cytotoxic activity against KB cells at an ED_{50} value of 2.5 μg/ml.

The bark and roots of *A. hexapetalus* furthermore contain sesquiterpenes and alkaloids that possess antimalarial and antitumour activity respectively. The leaves contain cardiovascular principles. Also an alcoholic extract of the pericarp showed a positive inotropic and chronotropic effect on all types of experimental animals. The cardiac stimulant and uterine stimulant activity is attributed to the glycosides, whereas the relaxant action on the plain muscles and hypotensive effect, which could be partly cholinergic and partly resulting from vasodilatory activity, are probably due to the presence of the essential oil.

Ethanolic (90%) extracts of *A. hexapetalus* leaves, when administered orally at 250 mg/kg during early pregnancy, result in a 66% anti-implantation activity in albino rats. In addition, ethanolic (50%) and benzene (50%)leaf extracts of *A. hexapetalus* markedly increased ovarian weight and corpora lutea parameters of adult guinea-pigs. Antifertility activity of *A. hexapetalus* has been corroborated in rats. Ethanolic (50%) and benzene (50%) leaf extracts of *A. hexapetalus* have been shown to disrupt the normal oestrous cycle in rats and have also prolonged the duration of leucocytic stage of vaginal smear in the same species. Furthermore, both these extracts have been reported to possess significant anti-oestrogenic activity when tested in immature female bilaterally ovariectomized rats. In view of its antifertility and its anti-oestrogenic activity, oestrogen-dependent biochemical parameters in the uterine tissue of rats were assessed. Uterine glycogen levels were significantly reduced, perhaps due to the anti-oestrogenic effect. Total protein contents, non-protein nitrogen level and total solid matter were elevated, perhaps due to the anti-oestrogenic effect.

Arteflene (Ro 42-1611), which is a semi-synthetic derivative resembling Qinghaosu (artemisinin) was recently developed from biosynthetic intermediates isolated on guidance of activity from *A. hexapetalus*. The compoundw as evaluated extensively against various drug-sensitive and drug-resistant *Plasmodium falciparum* in vitro and *P. berghei* in mice. The potential therapeutic and prophylactic activities were compared with chloroquine, mefloquine, quinine as well as artemisinin and its derivatives artemether and artesunic acid. Experimentally arteflene proved to be a highly effective antimalarial drug. The suppressive and prophylactic properties were comparable to chloroquine and superior to artemisinin, artemether and artesunic acid. It was consistently rather more active against drug-resistant than against drug-sensitive strains of *P. falciparum*. Drug interactions in vitro and in vivo with chloroquine, mefloquine and quinine revealed an additive to synergistic effect with arteflene. Three different dose schedules (1500 mg twice a day for 24, 48 or 72 h, respectively) of arteflene were furthermore tested on patients in Brazil with confirmed *P. falciparum* malaria. All the doses were effective but only 2 of 16 patients (both on the highest dose regimen) achieved a radical cure.

In an open-labelled, randomized trial in children with uncomplicated *P. falciparum* malaria in Gabon, patients received single oral doses of either 25 mg/kg of arteflene suspension or 15 mg/kg of mefloquine tablets. High-grade (RII and RIII) resistance was observed in 8 of the 20 patients receiving the single dose of arteflene, but in none of the 21 mefloquine-treated patients. At day 28, only one patient in the arteflene group, compared with all 21 patients in the mefloquine group, was cured. Arteflene cleared fever slightly but not significantly faster than mefloquine and the 50% and 90% parasite clearance times were comparable in both treatment groups. In vitro results in the arteflene group suggest an increase in arteflene resistance when comparing sensitivity of paired parasite isolates before treatment and at recrudescence. Both treatment regimens were well tolerated. It is concluded that single dose mono-therapy with arteflene was not effective in curing children suffering from uncomplicated *P. falciparum* malaria in Gabon, whereas mefloquine proved to be highly effective for this purpose.

Leaf extracts of *A. hexapetalus* show strong inhibitory activity against the fungal plant pathogens *Xanthomonas campestris* pv. *campestris* and *Drechslera oryzae* (*Cochliobolus miyabeanus*) and several phytopathogenic bacteria. Leaf extracts of *A. hexapetalus* show a 100% inhibition of *Fusarium oxysporum* f. sp. *lentis*, which causes wilt disease in lentil, and *Ustilago maydis* and *U. nuda*, diseases of maize and barley. Leaf extracts strongly inhibit hatching of eggs of *Meloidogyne* nematodes.

Adulterations and substitutes Some of the compounds isolated from *Artabotrys* are also recorded for other plants, e.g. isocorydin (artabotrine) from *Corydalis*, or atherospermidine which is the main cytotoxic compound found in *Thalictrum sessile* Hayata.

Description Climbers or scandent shrubs. Leaves alternate, simple; petiolate. Flowers bisexual, solitary or in fascicles, leaf-opposed, borne on thickened, hooked peduncles; sepals 3, valvate, free or variably united at the base; petals 6, valvate in 2 whorls, the inner petals somewhat smaller, spoon-shaped, connivent about the reproductive organs; stamens numerous, closely arranged, connective with a truncate, dilated apex; carpels numerous, containing 2 basal ovules. Fruit a monocarp, cylindrical to ellipsoid, sessile, clustered on a toughened receptacle, indehiscent, 1–2-seeded. Seed oblong, aril absent.

Growth and development *Artabotrys* has cleistogamous flowers and seems to be completely autogamous; to date no pollinators have been observed. *A. hexapetalus* and *A. suaveolens* can be found flowering and fruiting throughout the year.

Other botanical information *Artabotrys* is badly in need of revision. According to a classification based on both flower and fruit characters of *Annonaceae* from all over the world, *Artabotrys* is placed in an informal group which also includes the Asian genera *Anaxagorea*, *Cyathocalyx*, *Drepananthus*, *Marsypopetalum*, *Meiogyne* and *Xylopia*.

Ecology *Artabotrys* can be found in dry thickets and secondary forest as well as moist primary forest in gaps.

Propagation and planting *A. hexapetalus* is propagated by seeds, cuttings or layering.

Husbandry *A. hexapetalus* thrives on all soil types, and preferably grows in damp, semi-shaded locations. As the plant is climbing with hooks, it may well be grown against walls, trellises and through thickets as a hedge plant.

Harvesting Leaves of *Artabotrys* are plucked whenever the need arises. Stems are cut and further divided into small pieces, with or without further removal of the bark. Roots are simply dug up.

Genetic resources and breeding The *Artabotrys* species treated here are either widely distributed or commonly cultivated. They may even occur in disturbed forest. All this indicates that they are not very liable to genetic erosion. *A. hexapetalus* although commonly cultivated, it appears to be becoming rare in natural habitats in its native area.

Prospects With the still growing, widespread resistance to the antimalarials commonly used in medicine, the search for new effective compounds is of the greatest interest. It is therefore only logical to attempt to exploit the massive potential found in nature. Since arteflene has shown biological activity in humans, there might be future potential for *Artabotrys* to serve as a biological source for medicine. The effects of the alkaloids, e.g. anti-tumour and anti-fertility, merit further research in order to fully evaluate their possibilities.

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Selection of species

Artabotrys hexapetalus (L.f.) Bhandari

Baileya 12(4): 149 (1965).

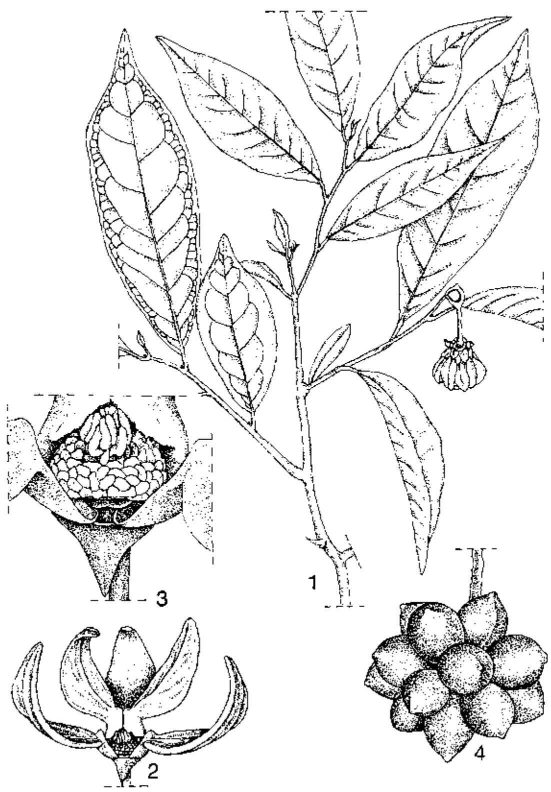
Synonyms *Annona hexapetala* L.f. (1781), *Artabotrys odoratissimus* R.Br. ex Ker Gawl. (1820), *Artabotrys uncinatus* (Lamk) Merr. (1912).

Vernacular names Climbing ylang-ylang (En). Malaysia: kenanga china, kenanga bolok. Thailand: kradangngaa cheen (central), sabanngaa cheen (northern). Vietnam: d[aa]y c[oo]ng ch[us]a, hoa m[os]ng r[oof]ng.

Distribution Indigenous in southern India and Sri Lanka, introduced throughout the Old World tropics. Commonly cultivated in southern China, Indo-China, the Philippines and also in Java.

Uses In the Philippines, a decoction of the leaves is used against cholera. The flowers are used to prepare a stimulating tea-like beverage. They also yield an essential oil, used in perfumery. *A. hexapetalus* is commonly cultivated in gardens for its very fragrant flowers, also used for screen-planting in large gardens.

Observations A climber or scandent shrub up to 8 m tall; young twigs densely appressed brown hairy, old twigs with many obtuse thorny branches (hooked peduncles) 1.5–6 cm long; leaves 5–25 cm × 2.5–8 cm, base cuneate, apex acute, short-acuminate, petiole 0.4–0.8 cm long; flower solitary or in pairs on a straight peduncle, later thickening and recurved, sepals ovate-triangular, about 5 mm long, pubescent outside, outer petals 3.7–4.5



Artabotrys hexapetalus (L.f.) Bhandari – 1, flowering twig; 2, flower with petals partly removed; 3, detail of stamens and pistil; 4, infructescence.

cm × 0.9–1.6 cm, inner petals 3.2–4.2 cm × 0.9–1.2 cm, green turning bright yellow, carpels 20–30; monocarp, obovoid, mucronate, 3.5–5 cm long, juicy, very fragrant, yellow. In South-East Asia in cultivation only.

Selected sources 74, 135, 216, 224, 359, 459, 522, 607, 662, 788, 838, 917, 924, 925, 1033.

Artabotrys suaveolens (Blume) Blume

Fl. Javae 28–29: 62, t. 30, t. 31d (1830).

Synonyms *Unona suaveolens* Blume (1825).

Vernacular names Malaysia: akar chenana, akar larak. Philippines: susong-kalabau, susong-damulag (Tagalog), bahai-balagan (Cebu Bisaya). Thailand : aa-kaa-kai (peninsular).

Distribution From north-eastern India, Burma (Myanmar), throughout the Malay Peninsula to Indonesia and the Philippines.

Uses In the Philippines, a decoction of the bark and roots is prescribed as an emmenagogue and for women after parturition. In Indonesia and India a decoction or infusion of the leaves is used against cholera. Plants are used as living fences in Bali (Indonesia), the young leaves are grazed by cattle.

Observations A scandent shrub or climber up to 25 m tall; young twigs with many fine appressed brown hairs; leaves elliptical, 5–18 cm × 2–6 cm, base cuneate, apex obtuse, long-acuminate, petiole very slender, 0.5–1 cm long; inflorescence many-flowered, consisting of up to 3–5-flowered fascicles on a recurved hook-like peduncle, sepals broadly ovate, united at base, petals 6, outer petals up to 1.5 cm long, inner petals shorter, all densely appressed hairy, creamy white or yellow, carpels 4–5; monocarp ellipsoid, obtuse, 2.5–3.5 cm long, yellow. *A. suaveolens* is found in dry thickets, secondary forest and primary forest from 100–800 m altitude.

Selected sources 74, 135, 216, 407, 522, 786, 810.

N.O. Aguilar

Asclepias curassavica L.

Sp. pl. 1: 215 (1753).

ASCLEPIADACEAE

$2n = 22$

Vernacular names Swallow wort, red milkweed (En), blood-flower (India). Asclepias de Curaçao (Fr). Malaysia: bunga mas. Philippines: bulak damo, kapul-kapul (Tagalog), anibung (Bontok). Laos: mak kha kay. Thailand: fai duean haa (northern), thian daeng (central), mai cheen (south-western). Vietnam: b[oo]ng tai, ng[oo] th[ij].

Origin and geographic distribution *A. curassavica* originates from South America and has now spread throughout the tropics and subtropics. In some locations it is now naturalized and has become a weed.

Uses Entire plants are considered extremely poisonous and are not generally used. In South America, Burma (Myanmar), China, Indo-China and the Philippines, but not in other parts of Malesia, a decoction of the powder from the roots is used as an emetic and purgative, and also as an astringent for dysentery. The leaf juice taken as a syrup is mentioned as a vermifuge and a sudorific. The pounded fresh or dry leaves and flowers are applied as a dressing for wounds and sores, and a decoction of the flowers is styptic. The flowers are considered more potent than the leaves. In Peninsular Malaysia, the flowers are crushed in cold water and used as a poultice for headache. In Thailand, roots, leaves or the whole plants are applied on abscesses and wounds. In South America, fresh or dried and powdered leaves are applied on cancerous sores, and are used in the treatment of dysentery, piles and gonorrhoea. In Mexico, it is used internally in to treat cancer of the stomach, intestines, uterus and kidneys, and externally on malignant tumours. In Brazil, an infusion of the roots, with a little sugar, is used against blennorrhagia and leucorrhoea. The latex is placed in carious teeth as an anodyne. It is also used as a remedy for bites of poisonous animals and for warts. The latex is considered cicatrizant in Madagascar. The follicles of *Asclepias* species contain a soft, fine floss, which is not of much value on account of its elasticity. It can however be used to stuff pillows. The fine bast fibre of *A. curassavica* may be applied in textiles in combination with cotton. It is also grown as an ornamental.

A. curassavica is suspected of cattle-poisoning, although cattle tend to avoid the plant, even when hungry and on overgrazed pastures during the dry season. Honey obtained from the plant is bitter, dark and thick.

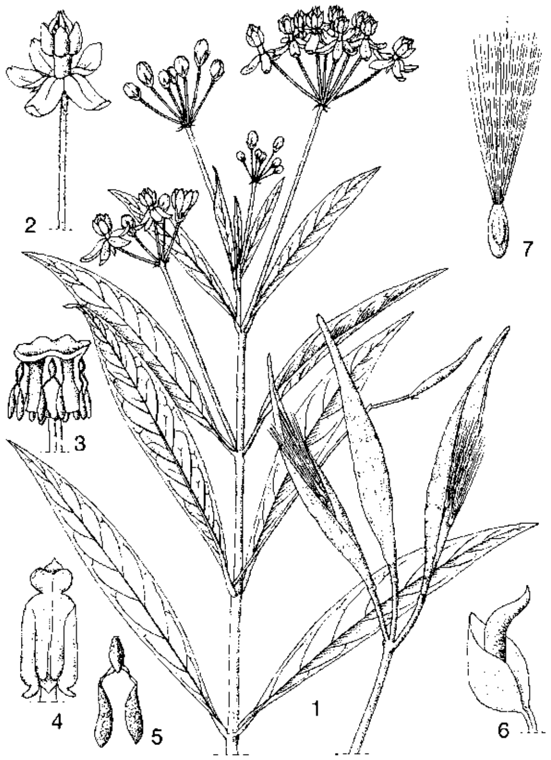
Production and international trade *A. curassavica* does not enter into international trade in Malesia, but bundles of the plant are sold in tropical American herb markets.

Properties The toxic principle of *A. curassavica* is a mixture of cardiac glycosides, of which the latex contains at least 50%. These cardiac glycosides are of the cardenolide type, and in a very small dose cause frogs to die in half an hour, the ventricles being arrested in systole. One of the isolated glycosides, asclepiadin, is extremely poisonous, causing paralysis of heart muscles and death, but in a dry state it decomposes fast into an inert component and a sugar. Its pharmacological effects after application include salivation, nausea, vomiting, diarrhoea, paralysis of the muscles, cramps, and death if the paralysis extends to the heart. Another cardenolide, asclepin, isolated from the aerial parts, also showed a marked positive inotopic effect in vitro on the isolated atrium and heart preparations of guinea-pigs, and in vivo on the anaesthetized cat. It was found to be more active than g-strophanthin, digoxin, digitoxin or digitoxigenin.

Other cardiac glycosides isolated from *A. curassavica* include 3′-epi-19-norafroside and 12β-hydroxycoroglaucigenin from the shoots, and curassavicin, calotroposide and vincetoxin from the roots. The latex is reported to inhibit the growth of *Candida albicans* by causing deformation of the fungal cell wall.

Adulterations and substitutes In the West Indies *A. curassavica* is used as a substitute for ipecacuanha (*Psychotria ipecacuanha* (Brot.) Stokes). It is considered a more potent emetic, but has considerable side effects.

Description An annual to perennial, erect herb, 40–150(–250) cm tall, usually unbranched but sometimes with several branches, woody at base, young stems hairy, latex copious, white. Leaves opposite, narrowly lanceolate, 6–15 cm × 1–3 cm, base and apex acute, lateral veins conspicuous, 10–15 pairs, slightly pubescent beneath; petiole 3–20 mm long; stipules absent. Inflorescence an axillary umbel, mostly solitary, sometimes several together on a common peduncle 3.5–6 cm long, 4–15-flowered. Flowers actinomorphic, 5-merous, pedicel 12–25 mm long, erect, accrescent in fruit, pubescent; calyx lobes lanceolate, 2–3 mm long, with 5–10 minute basal glands inside, reflexed at anthesis, green; corolla with short tube and 5 expanded or reflexed lanceolate lobes, 7–9 mm × 3.5–4.5 mm, red, rarely yellow or white; gynostegium composed of a staminal column 2–4 mm long, topped with 5 erect, hood-like, fleshy lobes (corona), 3.5–4 mm × 1.5 mm, golden yellow to orange, bearing inside at the base a slender incurved hornlike appendage and many nectar cells, anthers with an apical incurved membrane, pollinia 5, pollinium sacs 2, compressed, yellowish, united by 2 pendulous translator arms, connected by a slitted gland, dark brown; ovary superior, pistils 2, stigma head flattened, 5-lobed.



Asclepias curassavica L. – *1, flowering and fruiting branch; 2, flower; 3, stigma and pollinia; 4, stamen; 5, pollinium; 6, corona with hood and horn; 7, seed with coma.*

Fruit an aggregate of 2 dry follicles, each follicle fusiform, 5–8 cm × 0.8–1.5 cm, dehiscing along its ventral suture. Seeds numerous, broadly oval, flattened with a narrow wing, 5 mm long, with an apical tuft of silky hairs (coma), 2–3 cm long, white. Seedling with epigeal germination.

Growth and development In climates without a dry season, *A. curassavica* flowers throughout the year. *Asclepias* species are entomophilous, and pollination occurs exclusively through insects, especially wasps and bees, but also butterflies, which are attracted by the abundant nectar. The pollinia stick with the gland to the legs of the insects which are trapped in the narrow slit of the pollinium gland. When visiting other flowers of the same species, the burdened leg slips into the stigmatic chamber where the pollinium sac breaks from the translator arm. When hand-pollinated *A. curassavica* appears to be completely self-compatible.

In North and Central America, the monarch butterfly (*Danaus plexippus*) oviposits preferably on milkweed plants, because these produce oviposition stimulants, flavonol glycosides. Caterpillars of the monarch butterfly, as well as lygaeid bugs (*Oncopeltus cingulifer* and *Lygaeus reclivatus*) of Costa Rica and the oleander aphid (*Aphis nerii*) use cardenolides from *A. curassavica* as a chemical defence mechanism. They obtain these by eating the leaves.

Other botanical information *Asclepias* is a large genus, consisting of nearly 100 species of herbaceous plants. It has a mostly American distribution with a few African and West Indian representatives. There are no indigenous species in South-East Asia.

Ecology *A. curassavica* grows in sunny or slightly shaded habitats from sea-level up to 2400 m altitude, and has become naturalized in grassy and sandy areas, waste places, and coconut plantations, often in patches.

Propagation and planting *A. curassavica* propagates by seed.

In vitro production of active compounds Chromosome number and cardenolide production in *A. curassavica* plantlets grown in vitro from shoot tips and excised nodes were affected by the type and concentration of hormone used. Murashige and Skoog medium supplemented with kinetin + naphthalene acetic acid (NAA), kinetin + 2,4-D and indole acetic acid (IAA) produced cells with 2n = 33, 20 and 18 respectively, while the percentage of cardenolides ranged from 1.2–1.5, 1.5–2.3 and 1.6–2.8, respectively, after 60 days.

Diseases and pests In Ecuador, leaf yellowing and premature death of *A. curassavica* is caused by a mixed infection of the flagellate protozoa *Phytomonas* sp. and Rhabdovirus-like particles. *Phytomonas* sp. causes the serious Cedros wilt disease of coconut in South America. Caterpillars of the monarch butterfly and related species, as well as the oleander aphid and some other larvae of cardenolide-tolerant species feed specifically on *A. curassavica* plants.

Harvesting Plants of *A. curassavica* are harvested whenever the need arises.

Genetic resources and breeding *A. curassavica* is an exotic plant that is widely grown as an ornamental, and there is no danger of genetic erosion. No germplasm collections or breeding programmes are known to exist.

Prospects *A. curassavica* is considered extremely poisonous, due to the presence of toxic cardiac glycosides, which in in vivo experiments have shown to be more potent than well known cardenolides used in therapy, e.g. strophanthin and digoxin. Its toxicity will therefore strongly inhibit the use of the plant in medicine.

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R. Kiew

Ayapana triplinervis (Vahl) R.M. King & H. Robinson

Phytologia 20(3): 212 (1970).
COMPOSITAE
$2n = 51$ (triploid)

Synonyms *Eupatorium triplinerve* Vahl (1794), *Eupatorium ayapana* Vent. (1803).

Vernacular names White snakeroot, pool root (En). Ayapana (Fr). Indonesia: acerang (Malay), jukut prasman (Sundanese), rajapanah (Javanese). Philippines: apana, ayapana (Tagalog), impana (Iloko). Vietnam: b[ar] d[ooj]t, c[af] d[os]t.

Origin and geographic distribution *A. triplinervis* originated in the area from northern Brazil to Suriname, and was introduced, cultivated and naturalized long ago in some Caribbean islands, Africa, India, Indo-China, the Philippines, and Java, from where it was introduced into other parts of Indonesia.

Uses *A. triplinervis* plants smell strongly of coumarin, especially when crushed, and has a taste which is both bitter and aromatic. It is widely used as a tea in the whole of its distribution area, against chronic diarrhoea, as a stimulant, a sudorific and a tonic, and against badly infected wounds, thrush, lung diseases and as an antidote for snake bites. In small doses it is a stimulant and tonic, but when taken in larger quantities it is laxative. Because of its haemostatic properties it is used to regulate menstruation problems. A water extract of the dried leaves and shoots is used as a cardiac stimulant, increasing the force of the heart beat but diminishing its frequency. In Cambodia, it is recommended that young mothers inhale the scent of the leaves to gain strength and colour. In Brazil and the Caribbean, a gargle prepared from the leaves is used to relieve thrush, scurvy and angina. In Trinidad, a decoction is taken internally or used for bathing as a remedy for influenza, chest colds, pneumonia and constipation.

In Indonesia and Africa, *A. triplinervis* is also used as an excellent ground cover in tea and rubber plantations. In Suriname, the leaves are used for flavouring turtle meat. It is cultivated in Brazil for its essential oil, which is used in perfumes. In 19th century France, a leaf decoction was widely used as a substitute for tea, because of its spicy taste.

Properties The leaves of *A. triplinervis* contain ayapanine (7-methoxycoumarin) which has a distinct coumarin-like odour, and ayapine (6,7-methylenedioxycoumarin). Both compounds have excellent haemostatic properties, applied locally, as a tea or subcutaneously. Ayapanine and ayapine are generally non-toxic when administered locally or taken orally; moreover, they have no effect on respiration or on blood pressure. Further known constituents of the leaves include the terpenes phellandrene, borneol, β-selinene, the quinones thymoquinone and thymoquinone-dimethylether, carotene and vitamin C (0.025%).

Using the filter paper disk assay, the essential oil isolated from *A. triplinervis* was shown to inhibit the growth of certain fungi (*Curvularia* spp., *Rhizopus* spp., *Aspergillus* spp. and *Penicillium* spp.), but not that of *Aspergillus fumigatus* and *Penicillium decumbens*. Furthermore, the essential oil showed high activity against the bacteria *Escherichia coli* and *Proteus vulgaris*, and moderate activity against *Bacillus anthracis*, *Staphylococcus aureus* and some *Salmonella* spp.

A laboratory study showed strong feeding rejection by caterpillars of *Diacrisia obliqua*, *Philosamia ricini*, *Trabala vishnou* and *Pshissama transiens* on *Ricinus communis* L. leaves which had been sprayed with 7-methoxycoumarin. Also, a methanol extract of *A. triplinervis*, used as an insecticide against the paddy brown plant hopper (*Nilaparvata lugens*), caused about 42% mortality of adult female grass hoppers.

Description A perennial, tufted, glabrous, aromatic herb, 35–100(–150) cm tall; stem reddish, often partly decumbent, rooting at the lower nodes; young shoots often whitish, because of resinous exudate. Leaves opposite, on flowering stems partially alternate, simple, lanceolate to narrowly oblong, 3–12 cm × 0.5–2.5 cm, base gradually tapering, apex obtuse, margins entire, recurved, or with a few minute teeth, blade rather thick, lowermost opposite pair of lateral veins arising above the leaf-base, dark green or tinged purple to a varying extent; petiole 0–10 cm long; stipules absent. Inflorescence a head, many arranged together in a lax terminal corymb; involucre campanulate, bracts very acute, green with purple tips, finely pubescent, heads 6–7 mm long, 20(–50)-flowered. Flowers all tubular, corolla scarcely exerted from the involucre, narrowly funnel-shaped, 3.5–5 mm long, glabrous on inner surface, with glands on outer surface of lobes, reddish-violet, with a greenish-white base; anthers 5,

Ayapana triplinervis (Vahl) R.M. King & H. Robinson – 1, flowering stem.

very loosely cohering or finally free; ovary inferior; style base enlarged, glabrous, style branches filiform, appendages fimbriate. Fruit a narrowly oblong achene, 2 mm long, 5-angled and sparsely hairy on the angles; pappus 3 mm long, white.

Growth and development *A. triplinervis* forms large clumps of unbranched stems which grow throughout the year, but especially during the rainy season. It rarely flowers in Java, and when flower heads appear, achenes apparently never develop, probably because the species is triploid.

Other botanical information *Ayapana* is primarily a South American genus of 14 species, with a few widely distributed species such as *A. triplinervis*, which originates from northern Brazil to Suriname. *Ayapana* is one of the most natural groups in the tribe *Eupatorieae*, and is different from the other groups because of its fimbriate style appendages and the enlarged base of the fruit stalk. The red-flowered variety of *A. triplinervis* is medicinally most active.

Ecology *A. triplinervis* endures heavy shade, and has excellent ground-covering and soil retaining properties. It grows from sea-level up to 1600 m altitude. The flowering time in Brazil is from June to December.

Propagation and planting In Java, *A. triplinervis* is often planted in the hills, near local houses and remains long after these houses are gone. It is propagated through division.

Harvesting *A. triplinervis* leaves are picked from the gardens whenever the need arises.

Genetic resources and breeding As a result of vegetative propagation, the genetic variability within cultivated *A. triplinervis* seems to be rather small in Indonesia. No germplasm collections or breeding programmes are known to exist.

Prospects The coumarins and volatile oil constituents of *A. triplinervis* show interesting activity in the fields of haemostasis and plant protection (antifungal, insecticide), and merit further research.

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Other selected sources 74, 128, 134, 135, 275, 407, 410, 482, 670, 671, 735, 786, 810, 1094.

G.H. Schmelzer

Bacopa monnieri (L.) Pennell

Proc. Acad. Nat. Sci. Philad. 98: 94 (1946).
SCROPHULARIACEAE
$2n = 64$

Synonyms *Lysimachia monnieri* L. (1756), *Gratiola monnieri* (L.) L. (1759), *Herpestis monnieria* (L.) Kunth (1818), *Bacopa monnieria* (L.) Wettst. (1891).

Vernacular names Water hyssop (En). Malaysia: beremi. Philippines: ulasimang-aso (Tagalog). Cambodia: (smau) sna:ô. Laos: ph'ôm mi'. Thailand: phak mi, phrommi (central). Vietnam: rau (sam) d[aws]ng, ru[ooj]t g[af].

Origin and geographic distribution *B. monnieri* probably originates from tropical Asia, and is now widespread throughout the tropics and subtropics.

Uses In Peninsular Malaysia, a decoction of the leaves is taken to expel thread worms and also as an alterative. In the Philippines, a decoction of the whole plant is taken as a diuretic. In Indo-China, the whole plant is considered stimulant, diuretic and antispasmodic, and is administered as a kidney tonic, and also to treat scurvy, beri-beri, hoarseness and rheumatism. In Vietnam, the whole plant is furthermore taken as an appetitive and stomachic and used to treat dysentery. In China, it is mainly used for problems with the intestines, such as diarrhoea and colic.

In India, *B. monnieri* called 'Brahmi', has a reputation in Ayurvedic medicine as a brain tonic, and is said to improve the intellect and combat forgetfulness. It is considered astringent, bitter and cooling. The whole plant is used as a nerve tonic, and in combination with other plants or alone, used as a cure for epilepsy, hysteria and insanity, and also as a cardiac tonic. The powdered dry leaves have given satisfactory results in cases of weakness, nervous breakdown and similar conditions.

In Peninsular Malaysia and Vietnam, the plant is sometimes eaten as a vegetable despite its bitterness. It is also cultivated as an ornamental for borders of ponds and aquaria.

Production and international trade *B. monnieri* is cultivated in India as a medicinal plant. The dried herb, with standardized 50% bacosides (mainly bacosides A and B), is found in several Indian herbal nutritional supplements, called 'Smart Drugs', especially as a support for the brain, and helping with fatigue and forgetfulness. In 2000, prices for 60 capsules were between US$ 20–US$ 30. In South-East Asia, Chinese herbalists stock the dried plant in their pharmacies.

Properties The aerial parts contain the alkaloid herpestine, and the saponins monnierin (a tetrasaccharide of the sapogenin bacogenin A), hersaponin, and bacosides A, A_3, B and C, as well as pseudojujubogenin glycosides C and D. Jujubogenin was obtained following hydrolysis of bacoside A. Other constituents are the triterpene bacosine, D-mannitol, betulinic acid, heptacosane, octacosane, nonacosane, triacontane, hentriacontane, dotriacontane, nicotine, 3-formyl-4-hydroxy-α-pyran, luteolin and its 7-glucoside.

In a toxicity test, the LD_{50} of the plant extract was found to be more than 3000 mg/kg orally administered (p.o.) in mice and rats, and no sub-acute toxicity was found either in rodents or non-human primates. Bacoside A and B, which are the active components, were found to be non-toxic to chromosomes.

B. monnieri has been used since ancient times in India as a nerve tonic for improvement of memory. The administration of an alcoholic extract (40 mg/kg, p.o.) for three or more days improved the performance of rats in various learning situations, viz. a foot-shock motivated brightness discrimination response, active conditioned avoidance response and Sidman continuous avoidance response. Bacosides A and B are considered to be responsible for the facilitatory effect on learning schedules.

The anxiolytic (anxiety suppressing) activity of a standardized extract (bacoside A content about 25%) at doses of 5, 10 and 20 mg/kg p.o. was studied in rats, using the open-field, elevated plus-maze, social interaction, novelty-suppressed feeding latency and rotarod tests. The extract produced a dose-related anxiolytic activity, qualitatively comparable to that of benzodiazepine anxiolytic lorazepam, in all the test parameters, at doses of 10 and 20 mg/kg p.o. In addition, the advantage of the extract over lorazepam lies in the fact that it promotes cognition, unlike the amnesic action of the latter.

The effects of alcohol and hexane extracts as an antioxidant on $FeSo_4$- and cumene hydroperoxide-induced lipid peroxidation and hepatic glutathione content were studied in rat liver homogenates. The alcohol extract showed greater protection against lipid peroxidation with both inducers. The extract only slightly protected the auto-oxidation and $FeSO_4$-induced oxidation of reduced glutathione at doses of 100 µg/ml and below, but at higher concentrations it enhanced the rate of oxidation.

In a further study, the effect of the standardized extract in doses of 5 and 10 mg/kg p.o., was assessed on rat brain frontal cortical, striatal and hippocampal superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPX) activities, following administration for 7, 14 or 21 days. A dose-related increase in these enzyme activities were observed after 14 and 21 days in all the brain regions investigated. The results were compared with the effects induced by the monoamine oxidase-B inhibitor selegiline (= (–)deprenyl) at 2 mg/kg p.o., administered for the same time periods, and it was found that selegiline induced an increase in SOD, CAT and GPX activities in the frontal cortex and striatum, but not in the hippocampus.

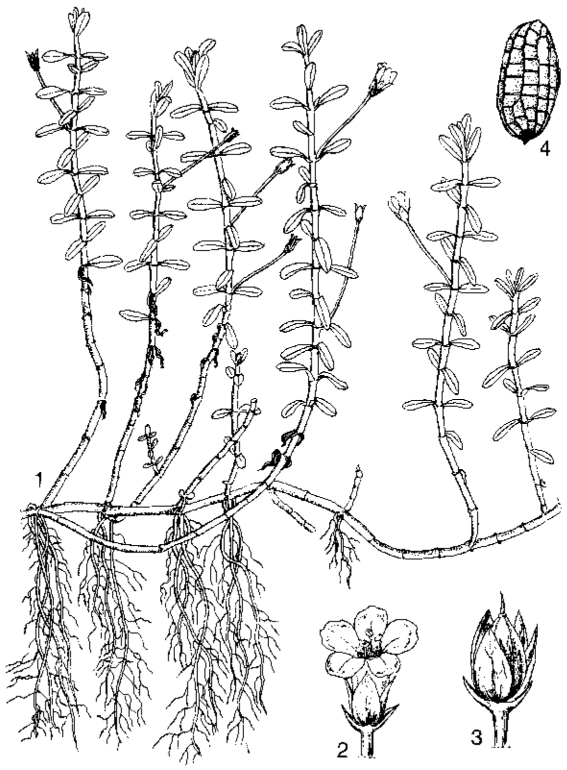
The saponin hersaponin is found to possess cardiotonic, sedative and spasmodic properties. It produced a mild inhibitory effect on the respiration of rat brain tissue which was partially reduced by LSD-25 and potentiated by 5-hydroxytryptamine (5-HT). The compound was also found, as in the case of reserpine, to deplete the noradrenalin and 5-HT content of the rat brain. An alcoholic extract of the plant, at a dose of 50 mg/kg, produced a tranquillizing effect on dogs and albino rats but the action was weaker than that produced by chlorpromazine.

In another test, different concentrations of the ethanolic extract were tested with Sarcoma-180 cell culture. The cell growth, viability and ^{3}H-thymidine incorporation into the DNA were assessed. Sarcoma-180 cell growth was significantly inhibited with increasing concentrations of the extract. The ^{3}H-thymidine uptake study suggested that the site of action of the drug may be at the DNA replication stage, when acting as an anticancer drug. The aqueous and alcoholic extracts were furthermore found to reduce the severity of seizures induced by drugs and electro-shock in rats, indicating that the extracts may have potential value in treating epilepsy.

Bacosine also exhibited moderate analgesic effects in mice and rats but was found to have no effect on barbiturate narcosis, haloperidol-induced catalepsy, spontaneous motor activity or conditioned avoidance response. The analgesic activity was furthermore found to be an opioid-like effect.

The bronchodilatory effect of the ethanol extract from plants collected in Pakistan, where they are used traditionally in the treatment of asthma, was examined using ring segments of pulmonary arteries (guinea-pig and rabbit), aorta (rabbit) and tracheal preparations (guinea-pig). The extract relaxed all tissues in a dose-dependent way. Pretreatment of the blood vessels with either atropine or propranolol did not alter the relaxant effect of the extract, while indomethacin reduced the extract-induced relaxation of all tissues. The effect of the extract on anaesthetized rats was reflected by a reduction in expiratory pressure which resembled a salbutamol-induced effect rather than that of isoprenaline. The action of the extract is probably mediated jointly by β-adrenoceptor-dependent and independent mechanisms. The extract antagonized the bronchoconstrictor action of carbachol. The mechanism of this action was later found to be the inhibition of calcium influx via both voltage and receptor operated calcium channels of the cell membrane.

Description A much branched, creeping herb, branches 5–40 cm long, somewhat fleshy, glabrous, rooting at the nodes. Leaves opposite, elliptical-ovate to spathulate, 6–15 mm × 4–9 mm, base tapering, apex obtuse, margins entire or obtusely serrate, midvein visible; petiole absent; stipules absent. Flowers axillary, solitary, slightly irregular, 5-merous, pedicel as long as or longer than the leaves; bracteoles 2, linear, calyx 4–5-parted, outer lobe broadly ovate, 5–6 mm long, the others lanceolate, apex acuminate; corolla tube cylindrical, 5–9 mm long, purplish at stamen insertion point, obscurely 2-lipped, upper lip 2-lobed, lower lip 3-lobed, 8–10 mm long, white to pale blue; stamens 4, in 2 pairs, inserted on the corolla tube, included, anthers 2-celled; style filiform, included, persistent. Fruit an ovoid capsule,



Bacopa monnieri (L.) Pennell — 1, plant habit; 2, flower; 3, fruit; 4, seed.

as long as calyx, valves 2–4, seeds numerous. Seed ovoid, 0.5–0.8 mm long, ribbed, pale brown. Seedling with epigeal germination; cotyledons small, elliptical, glabrous; first leaves 2, ovate, midvein present, glabrous.

Growth and development *B. monnieri* can be found flowering and fruiting throughout the year. The seeds are hydrochorous.

Other botanical information *Bacopa* consists of about 55 species from tropical and warm regions, and 3–4 are present in South-East Asia. *B. monniera* is an orthographic variant of *B. monnieria* (L.) Wettst.

There seems to be considerable confusion in the United States and Australia about whether the Ayurvedic medicine 'Brahmi' contains *B. monnieri* or *Centella asiatica* (L.) Urb. (synonym *Hydrocotyle asiatica* L. (*Umbelliferae*)), although the last species is known in India as 'gotu-kola'. In fact, both species have partly similar medicinal uses, and contain compounds which exhibit e.g. central nervous system-depressant activity, and are useful for learning and in memory disorders. The two species do not resemble each other botanically and identification should therefore not be a problem.

Ecology *B. monnieri* occurs in open wet localities, also rice fields, forming dense mats, mainly within the influence of salt and brackish water, on sandy soils along rivers, or on alkaline soils, from sea-level up to 300 m altitude.

Propagation and planting *B. monnieri* is propagated by seed and by rooted cuttings. Minimum temperature for germination is 16°C, maximum 28°C, while the optimum is at 20°C.
Reliable protocols for shoot regeneration and somatic embryogenesis have been developed. Node, internode and leaf explants were excised from shoots raised from axillary buds of nodal explants cultured on Murashige and Skoog (MS) basal medium. Leaf explants gave the largest number of shoot buds. Benzyladenine (BA) at 1.5–2 mg/l was best for inducing the highest number of shoot buds. MS + 0.1 mg BA + 0.2 mg indole acetic acid/l was the most suitable for shoot elongation. Elongated shoots were rooted on MS medium with or without 0.5–1 mg indole butyric acid or 0.5–1 mg naphthalene acetic acid/l. Rooted plants were successfully established in soil. Calluses derived from nodal explants cultured on MS medium containing 0.5 mg 2,4-D/l developed somatic embryos, which germinated either on the same media or on MS basal medium. The resulting plantlets were successfully transplanted to soil.

Husbandry *B. monnieri* needs to be planted in the full sun, on rather heavy soils with continuous water supply, in order to prevent the soil from drying out.

Diseases and pests The caterpillars of the white peacock butterfly (*Anartia jatrophae*) have a preference for *B. monnieri* as a feed plant. Under greenhouse conditions, the grasshopper *Spodoptera litura* can do much damage. *B. monnieri* is a host for several nematodes (*Meloidogyne* spp.).

Harvesting When *B. monnieri* is harvested from the wild, great care should be taken to harvest it from unpolluted sites, as it can take up considerable amounts of heavy metals. Marked seasonal changes in chemical constituents, especially the saponins, have been observed.

Handling after harvest The pretreatment of harvested shoots of *B. monnieri* to 80°C in an oven for 30 minutes before drying at 37°C helps to retain higher amounts of bacoside A in the dried plant material.

Genetic resources and breeding *B. monnieri* is widespread and common throughout South-East Asia, and therefore does not seem to be at risk of genetic erosion. In India, *B. monnieri* has been entered in a programme for micropropagation, breeding and germplasm conservation.

Prospects Extracts and purified compounds from *B. monnieri* show a range of interesting pharmacological activities both in vitro and in vivo animal models. Especially the positive results of *B. monnieri* preparations with learning schedules in rats, enhancing mental retention capacity and memory, and the effects as an anxiolytic look promising. Therefore, appropriate clinical evidence should be acquired with humans, in order to evaluate their future potential.

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Other selected sources 74, 112, 135, 215, 229, 311, 377, 739, 810, 921, 940, 1005, 1012.

N.O. Aguilar

Baeckea frutescens L.

Sp. pl. 1: 358 (1753).
MYRTACEAE
$2n$ = unknown

Synonyms *Baeckea chinensis* Gaertner (1788), *Baeckea cumingiana* Schauer (1843), *Baeckia cochinchinensis* Blume (1849).

Vernacular names Indonesia: junjung atap (Bangka), jung rabab (Javanese), jhung rahab (Madurese). Malaysia: chuchur atap, cucuran atap, hujong atap. Cambodia: moreck ansai. Thailand: son naa, son saai (peninsular), son hom (south-eastern). Vietnam: ch[oor]i xu[eer], ch[oor]i s[er], thanh hao.

Origin and geographic distribution *B. frutescens* is widespread from South-East Asia to Australia, including southern China, Thailand, Peninsular Malaysia, Sumatra, Borneo, Sulawesi and New Guinea. It is not known to occur in Java, the Lesser Sunda Islands or the Philippines.

Uses Throughout South-East Asia, the flowers and leaves of *B. frutescens* are made into a herbal tea. In Malaysia and Indonesia, it is traditionally associated with health drinks and powders used during childbirth. In Indonesia (Sumatra, Java) the leaves are used as an emmenagogue. In Vietnam all aerial parts are credited with antibacterial, antifebrile and haemostatic properties. It is indicated in the therapy of coryza, influenza, headache, measles, colic and jaundice, in the form of a fumigation of the dried plant or the inhalation of vapour from a boiling decoction of the fresh plant. It is also prescribed against epistaxis, impetigo, dyspepsia, dysentery and menstrual disorders. It is externally applied as an antiseptic in treating furunculosis and impetigo. The essential oil is used for massage in cases of rheumatism. In Indo-China leaves are occasionally put among clothing to keep insects away. In Hong Kong aerial parts are used to treat snakebite. The branches are used as brooms. The timber is hard, dark brown and very durable but of small dimensions.

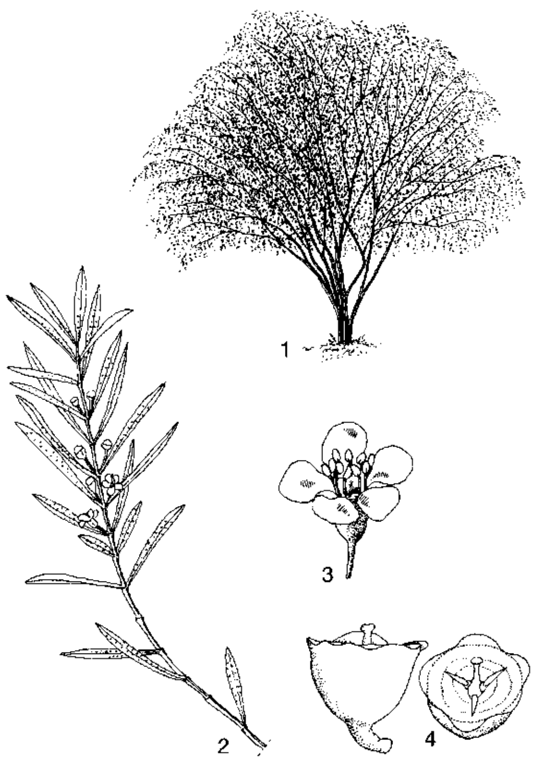
Production and international trade Dried parts of *B. frutescens* have been part of inter-island trade in Malaysia and Indonesia for centuries. The present day situation is unclear, but volumes are believed to be as high as 10–20 t per year.

Properties The aerial parts of *B. frutescens* contain an essential oil. The essential oil obtained by steam distillation of leaf material of *B. frutescens* obtained in 4 different sites in Malaysia showed considerable variation in composition and relevant percentage of its constituents. Three of the samples were dominated by pinenes (40–55.5%), the other sample was dominated by γ-terpinene (34%). 1,8-Cineole was prominent in three samples but absent in the fourth. Other compounds that were found as major components in most of the samples were p-cymene, limonene, linalool, α-terpineol, β-caryophyllen and α-humulene. Three sesquiterpenes have been isolated from the dichloromethane extract of the herb, 2 of them being also well known constituents of several essential oils; humulene epoxide, caryophyllene epoxide, and a new constituent clovane-2,9-diol. In a simple in vitro enzyme assay, the essential oil of *B. frutescens* showed strong inhibitory activity of more than 80% at 0.1 mg/ml against lipoxygenase. The essential oil at a dose of 435 mg/kg exhibited antihepatotoxic activity against artificially induced liver injury in mice.
Furthermore, from the leaves and aboveground parts, series of chromones, chromanones, as well as chromone-C-glycosides have been isolated. Chromones are structurally strongly related to the flavones: they lack the aromatic B-ring of the flavones, and in an analogue way, the chromanones are related to the flavanones. 5-Hydroxy-7-methoxy-2-isopropylchromone and 5-hydroxy-7-methoxy-2-isopropyl-8-methylchromone are examples of isolated chromones, 2,5-dihydroxy-7-methoxy-2-isopropylchromanone is the related chromanone.
In addition to the chromone derivatives, 3 flavanones (BF-4, BF-5, BF-6), and 2 phloroglucinols (BF-1 and BF-2) have also been isolated from the leaves. Compounds BF-2, BF-4 and BF-5 showed strong cytotoxic activity against leukaemia cells (L 1210) in tissue culture with an IC_{50} of 5, 0.25 and 0.25 μg/ml, respectively.

Adulterations and substitutes In trade the leaves of *B. frutescens* are sometimes used as a substitute for those of *Leptospermum* (*Myrtaceae*).

Description An evergreen, heather-like shrub or small tree up to 8 m tall; bark greyish brown, fissured and flaky; branches upright, then spreading and drooping, with wiry ends. Leaves opposite, seemingly in clusters at condensed nodes, needle-like, 6–15 mm × 0.4–0.8 mm, base narrowly cuneate, apex obtuse or acute, margin entire, resinous aromatic when crushed; petiole 0.5 mm long. Inflorescence axillary, 1-flowered; peduncle absent or very short; pedicel 0.8–1.7 mm long; bracteoles 2, early caducous. Flowers bisexual, 5-merous, hypanthium obconical to campanulate, 1.5–2.2 mm long, partly fused to the ovary; sepals semiorbicular, 0.4–0.9 mm × 0.6–1.1 mm; corolla up to 5 mm across, petals orbicular, 1.1–1.8 mm across, white, oil glands present; stamens 7–13 in groups of 1–3 opposite each hypanthium lobe, filament 0.5–0.8 mm long, anther about 0.3 mm long; ovary 2–3-locular, 12–18 ovules per locule, style terete, about 1.2 mm long. Fruit a hemispherical to campanulate capsule opening by 3–4 longitudinal slits. Seedling with epigeal germination; cotyledons small, green; hypocotyl elongated; leaves opposite, needle-like.

Growth and development Growing near the sea or in sheltered locations on mountains, *B. frutescens* becomes a small tree with switchy twigs, resembling *Casuarina* spp. On exposed peaty soils and rocky mountain tops, it grows as a



Baeckea frutescens L. – 1, habit; 2, flowering twig; 3, flower; 4, fruit.

dwarf shrub like a heather, with a gnarled woody stem and branches flattened against the soil surface.

Other botanical information The large genus *Baeckea* has recently been split up into five genera including *Babingtonia*, *Ochrosperma*, *Rinzia* and *Triplarina*; the latter three are endemic to Australia. *Baeckia* in the narrow sense comprises 14 species, 13 of which are confined to Australia. With the exception of *B. frutescens*, *Baeckia* species are of temperate climates.

Ecology *B. frutescens* grows on poor sandy and ultrabasic soils, in shrubland, often at high altitudes. It is also present in seasonally wet savanna and swamp forest.

Propagation and planting Seeds of *B. frutescens* germinate in 52–66 days.

Harvesting In Vietnam, the whole plant of *B. frutescens* except the roots is harvested during its flowering period in July–October.

Handling after harvest. The aboveground parts of *B. frutescens* are dried in the sun or artificially. The essential oil can be obtained by distillation.

Genetic resources and breeding *B. frutescens* is widespread and common throughout South-East Asia, and therefore not endangered.

Prospects Some information on the phytochemistry of *B. frutescens* is available which e.g. reveals the presence of chromone-derivatives, flavanones and phloroglucinols. The in vitro cytotoxic activity of the flavones might be of interest, and therefore these, and possible related compounds, merit further research.

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Other selected sources 135, 207, 252, 264, 407, 730, 739, 788, 1017, 1018, 1066, 1091.

Umi Kalsom Yusuf

Barleria L.

Sp. pl. 2: 636 (1753); Gen. pl. ed. 5: 283 (1754).

ACANTHACEAE

$x = 10, 20$; *B. cristata*: $2n = (34, 36, 38), 40$; *B. lupulina*: $2n = 40$; *B. prionitis*: $2n = 30, 40$

Major species *Barleria lupulina* Lindley, *B. prionitis* L.

Origin and geographic distribution *Barleria* is a large pantropical genus of herbs and shrubs, comprising at a conservative estimate some 300 species. Most species occur in Africa and Asia, only 1 species is native to Central America.

Uses The leaves, roots or sometimes the seeds of *Barleria* occurring in South-East Asia are chewed against toothache, and a poultice of the leaves is put onto snake bites. An infusion of the roots and leaves is applied to boils and sores to reduce swellings, and to soothe urticaria skin rash. In India, Indo-China and Malaysia, the bitter juice of the leaves or roots of *B. cristata* and *B. prionitis* is given with sugar as a diaphoretic and expectorant to children for catarrhal infections accompanied by fever and much phlegm. The leaves are chewed for aphthae, bleeding gums and whooping cough, and as a paste or infusion they are used to cure earache, backache and headache.

In Java, India and Vietnam, the leaves of *B. prionitis* are considered diuretic and chewed for intermittent fever, rheumatism, liver diseases, indigestion with constipation, jaundice and dropsy, asthma, urinary troubles and paralysis. They are also applied to cure cracking and laceration of the feet in the rainy season. The pulverized roots mixed with lemon juice are widely used as a poultice against ringworm. In India, the plant is used in mixtures against several forms of cancer. In Africa, a decoction of the root is taken as a mouth wash to relieve toothache. In Java, the young leaves and stems of *B. lupulina* are used as a poultice on wounds and rheumatism. In decoction, they are counter-indicated for pregnant women. In Thailand, the fresh leaves are applied to herpes simplex and herpes zoster, while the root is used as an anti-inflammatory for centipede bites.

Barleria species are widely cultivated for ornamental purposes due to their showy flowers. They are often planted as hedges, because of the spines.

Properties The ethanol extract of *B. cristata* contains flavonoids, malvidin-3,5-diglucoside and quercetin. The extract showed hypoglycaemic, antispasmodic and uterine stimulant activity.

The fresh aerial parts of *B. lupulina* contain the iridoid glycosides shanzhiside methylester, 6-O-acetyl-shanzhiside methylester, 8-O-acetyl-shanzhiside methylester (or barlerin) and 6,8-O-acetyl shanzhiside methylester (or acetyl-barlerin). These iridoid glycosides were tested for their anti-inflammatory effect in carrageenan-induced rat paw oedema and acetic acid-induced writhing in mice, and all were found to be active. Plant extracts also show an antagonistic activity on the effects of cobra-poison.

The aerial parts of *B. prionitis* contain the phenylpropanoid glycoside verbascoside (or acetoside), barlerin, 6-O-trans-p-coumaroyl-8-O-acetyl-shanzhiside methylester, its cis isomer and some flavonoids. The latter 2 compounds showed potent in vitro activity against the respiratory syncytial virus, antifungal activity against *Aspergillus flavus*, *Candida albicans*, *Microsporium gypseum* and *Trichophyton mentagrophytes*, and antibacterial activity against some gram-positive bacteria. Finally, from the flowers of *B. prionitis* the flavone glycosides scutellarein-7-neo-hesperidoside and scutellarein-7-rhamnosyl glucoside were isolated.

Description Armed or unarmed herbs or shrubs, with 2 axillary serial buds present, either forming spines or shoots. Leaves decussate, simple, normally entire, epidermal cells with double cystoliths; petiole short; stipules absent. Inflorescence simple or compound, composed of axillary or terminal cymes or spikes, or flowers solitary. Flowers normally subtended by 2 linear bracteoles; bracts foliaceous, often spiny, or reduced; calyx with 2 long and 2 shorter segments, the outer ones prominently veined, acuminate; corolla variable, tubular, sub-actinomorphic, zygomorphic or bilabiate, lobes 4–5, showy, yellow, white or blue-purple; androecium of 5, 4 or 2 epipetalous stamens, 2 median abaxial stamens fertile, filaments usually hairy at base, twisted through 180° near the base, anthers 2-celled, pollen spheroidal, deeply honeycombed; ovary superior, 2-locular, with 1–2 ovules per locule; stigma entire or 2-fid. Fruit a dry bilocular capsule, beak long or short. Seeds 2 or 4, usually discoid, flattened on one side, asymmetrical about the hilum, covered with hygroscopic hairs.

Growth and development *Barleria* tends to flower throughout the year, when sufficient water is available.

Other botanical information A satisfactory subdivision in *Barleria* has long been problematic, because of its largeness, but is now solved by the classification of the genus into 2 subgenera (*Barleria* and *Prionitis*) and 7 sections. There is a high degree of regional endemism, with only a few widespread species. *Barleria* is closely related to *Lepidagathis*.

Ecology Many *Barleria* species occur in dry regions on plains and in lower mountainous regions, in brushwood and thickets, and along roadsides. *B. prionitis* is considered a weed in Australia.

Propagation and planting *Barleria* is propagated by seed and stem cuttings. Seeds germinate readily within 7 days after sowing.

Diseases and pests *Barleria* is attacked by several leaf-spot fungi, including *Alternaria tenuis*, and also the leaf-spot bacterium *Pseudomonas cichorri*. It is also a host for the mycoplasma-like disease of *Santalum album* L. in India, which causes little-leaf disease.

Many *Barleria* pests are known in India, especially the larvae of the lepidopterous insects *Syngamia latimarginalis* and *Spilosoma obliqua* (synonym *Diacrisia obliqua*) and the *Barleria* lacebug (*Habrochila laeta*), but also the nematode *Aphelenchoides fragariae*, and leaf galls induced by *Ferrisia virgata* (Coccidae), causing abnormal rolling and twisting.

Harvesting Leaves or roots of *Barleria* are harvested mostly from garden plants, whenever the need arises, and mainly used fresh.

Genetic resources and breeding The Malesian *Barleria* species are not endangered because they are widespread as ornamentals. Breeding programmes only exist for ornamental purposes.

Prospects Not very much is known about the pharmacology of *Barleria*. In general, their flavonoids and iridoid glycosides show several interesting activities, which merit further research.

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Other selected sources 331, 868.

Selection of species

Barleria cristata L.

Sp. pl. 2: 636 (1753).

Synonyms *Barleria dichotoma* Roxb. (1832).

Vernacular names Bluebell, Philippine violet (En). Thailand: kaan chang, luem thao yai (northern), thong ra-aa (central). Vietnam: hoa ch[oo]ng.

Distribution Distributed from the Himalayas through India, eastwards to China, and also in the Philippines and northern Australia.

Uses The bitter juice of the leaves or roots is used as a diaphoretic and expectorant for serious catarrhal infections. An infusion of the roots and leaves is applied to boils and sores to reduce swellings.

Observations An erect, branched shrub, up to 1.5 m tall, unarmed, with appressed hairy twigs; leaves lanceolate to elliptical-oblong, 1–12 cm long, base attenuate, apex pointed, hairy, petiole 1–2 cm long; flowers 1–3 in each axil, bracts absent or lanceolate, 8–12 mm long, bristly on margins, bracteoles absent, calyx lobes acuminate, corolla tube 3.5 cm long, outside glandular, lobes 5, unequal, white, pink or purple, fertile stamens 4, filaments hairy; capsule ellipsoid, 2 cm long, 4-seeded. *B. cristata* occurs in waste places and along roadsides, and is sometimes weedy.

Selected sources 135, 250, 407, 725, 810, 968.

Barleria lupulina Lindley

Bot. Reg. 18: t. 1483 (1832).

Vernacular names Indonesia: landik, sujen trus (Javanese). Thailand: salet phangphong, phimsen ton (central). Vietnam: gai kim v[af]ng.

Distribution Native to Mauritius, now widely cultivated in the tropics as an ornamental.

Uses The leaves and roots are chewed against toothache, and a poultice of the leaves is put on bites of insects, snakes or dogs, as an anti-inflammatory.

Observations A glabrous, much branched shrub, up to 1.5 m tall, with axillary spines; leaves linear-oblong, 3–9.5 cm long, base cuneate, apex obtuse, midrib red above, petiole short, red; flowers in small terminal, hop-like spikes, up to 9 cm long, bracts broadly ovate, 1.2 cm long, ciliolate, purple tinged, on the back with cupular glands, bracteoles lanceolate, 4 mm long; calyx lobes broadly ovate; corolla tube 3 cm long, bent at base, expanded above, lobes 5, orange-yellow, stamens 4, didynamous, 2 exserted; capsule ovoid, 2-seeded. *B. lupulina* occurs in secondary bushland and thickets, when escaped from the gardens.

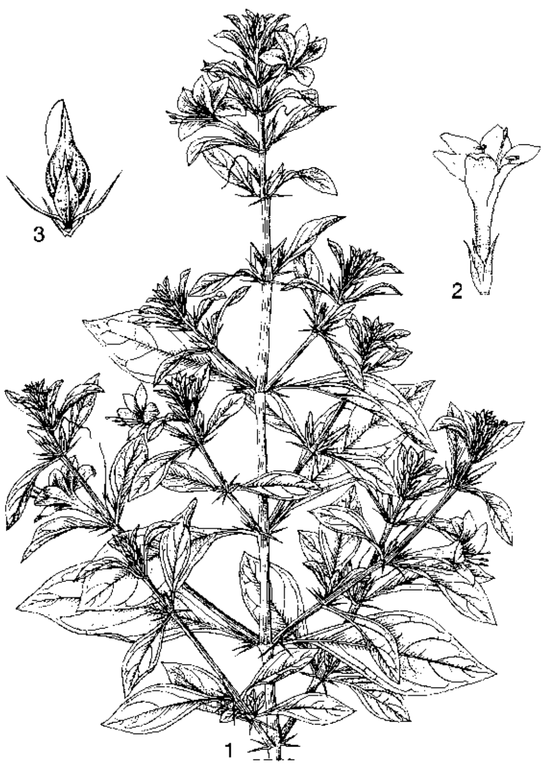
Selected sources 297, 838, 867, 868, 875.

Barleria prionitis L.

Sp. pl. 2: 636 (1753).

Synonyms *Prionitis hystrix* (L.) Miq. (1860).

Vernacular names Indonesia: jarong kembang landep (Sundanese), landep (Javanese, Madurese). Malaysia: bunga landak. Philippines: kolinta, kulanta, kokong-manok (Tagalog). Laos: dok



Barleria prionitis L. – 1, flowering stem; 2, flower; 3, fruit.

man khay. Thailand: khieo kaeo, angkaap nuu (central), mankai (northern). Vietnam: ch[oo]ng, gai kim hoang.

Distribution Throughout Africa, eastwards to South-East Asia through Arabia, India and Pakistan. Pantropical in cultivation as an ornamental.

Uses The leaves are diuretic and tonic and chewed for fever, rheumatism, liver diseases, indigestion with constipation, jaundice and urinary infections. An infusion of the roots and leaves is applied to boils and sores to reduce swellings, and also used for earache and headache.

Observations An erect, glabrescent, branched shrub, up to 1.7 m tall, with 2–4 axillary spines, 1–2 cm long; leaves ovate to elliptical, 2–12 cm long, base attenuate, apex pointed, petiole up to 1 cm long; flowers axillary, solitary, up to 7 cm long, upper ones in short spikes, bracts lanceolate, 1–2.5 cm long, spine-tipped, bracteoles linear, 1–2 cm long, spinescent, calyx lobes spine-tipped, corolla 2.5 cm across, tube 2.5 cm long, 4 lobes in the upper position, 1 in the lower, golden yellow or cream, fertile stamens 2, filaments exserted, staminodes 2, short; capsule ovoid-conical, 2 cm long, beaked, 2-seeded. *B. prionitis* occurs in the wild in thickets in waste places at low altitudes, and is sometimes becoming weedy.

Selected sources 135, 407, 725, 810.

N.O. Aguilar

Barringtonia J.R. Forster & J.G. Forster

Charact. gen. pl.: 75, t.38 (1776).

LECYTHIDACEAE

x = unknown; *B. acutangula*: $2n = 26$, *B. racemosa*: $2n = 52$

Major species *Barringtonia acutangula* (L.) Gaertner, *B. asiatica* (L.) Kurz, *B. racemosa* (L.) Spreng.

Vernacular names Barringtonia (En). Brunei: angas gimpalang, angas gimplang. Indonesia: butun (general), keben (Javanese). Malaysia: tampalang (Sabah). Philippines: botong, ulam (Tagalog). Burma (Myanmar): kyi-bin, kyi-gyi. Thailand: chik. Vietnam: l[ooj]c v[uwf]ng.

Origin and geographic distribution *Barringtonia* comprises about 50 species which occur from tropical and subtropical regions of East Africa (1 species) and Madagascar (2 species) to Afghanistan, Pakistan, India, Sri Lanka, Indo-China, southern China, Taiwan, the Ryukyu Islands, Thailand and the whole of the Malesian region towards northern Australia and the Pacific, and east to Samoa and the Society Islands (Tahiti). Malesia represents the centre of diversity of *Barringtonia* with 40 species occurring there. One species (*B. asiatica*) has been introduced into East Africa, Hawaii, the West Indies and St. Helena.

Uses Seed of most *Barringtonia* species contain saponins which are used as fish poison; the fruit, bark, wood or root is sometimes employed for the same purpose. The presence of the saponins in the bark explains the use in poulticing. In the Philippines, the fruits of *B. racemosa* are used to poison wild pigs and also for fish-net floats. In Peninsular Malaysia, the leaves of *B. racemosa* are consumed as a vegetable, against high blood pressure and as a depurative. Pounded leaves are said to cure chickenpox. Bark, leaves and fruits of *B. asiatica* are used for treating sores. In the Philippines, its leaves have been topically applied against rheumatism and the seeds as a vermifuge. An infusion of the leaves and bark of *B. calyptrata* (Miers) R.Br. ex F.M. Bailey has been used by aborigines in Australia to treat chest pains and fever.

Some of the uses mentioned for *B. acutangula* in the Philippines may well apply to *B. reticulata* (Blume) Miq. (synonyms *B. sumatrana* Miq., *B. gitingensis* Elmer, *B. lingaensis* Knuth). In Kalimantan, juice of the wood was formerly used to blacken teeth. Pounded seeds or bark of *B. scortechinii* King are applied as a fish poison in Malaysia. The fruit can be used as a flavouring in food.

Young leaves and shoots of some *Barringtonia* are eaten as a salad or in chutneys (e.g. *B. fusiformis* King). The bark of some species is locally used for tanning. In India, *B. acutangula* is an important 'bee plant' used for the production of honey. In Vanuatu and other Pacific Islands, *B. edulis* Seem., *B. novae-hiberniae* Laut. and *B. procera* (Miers) Knuth are cultivated for their edible seeds.

The wood of *Barringtonia* is used for local house building, general planking, flooring, boat building, mouldings, interior finish, household utensils, agricultural implements, boxes, crates and wooden pallets. The wood is suitable for veneer and plywood manufacturing. In the Nicobar Islands, New Guinea and Pacific islands, the bole is used to make canoes. In the Pacific region the wood has additionally been used for carving and turnery. The wood is sometimes used for fuel. Several species are planted as ornamentals. *B. asiatica* has also been planted as a windbreak and for shade.

Production and international trade The medicinal use of *Barringtonia* is of local importance only, and occasionally fruits are found in the market.

Properties The seeds of *B. asiatica* contain hydrocyanic acid, and triterpene acids (e.g. bartogenic acid). Triterpenoid glucosides, saponins (e.g. barringtosides A,B,C) and sapogenins (barringtogenol C) were isolated from the seeds of *B. acutangula*.

In addition to triterpenes like the barrigenols, neo-clerodane diterpenoids (nasimaluns A,B) are also present in the roots of *B. racemosa*. Some coumarins, ellagic acid, 3,3'-di-O-methyl ellagic acid and 3-O-methyl ellagic acid were isolated from the bark of *B. acutangula* and *B. racemosa*.

The ethanol extract of the leaves of *B. racemosa* displayed cytotoxicity against human cervical carcinoma (HeLa)-cell lines at a CD_{50} value of 10–30 μg/ml. Furthermore, field investigations in Iloilo Province (the Philippines) pointed to the use of *B. asiatica* seeds to induce regression of breast and ovarian tumours. In vitro tests with *B. asiatica* indicated a high antitumour potential of its active compounds.

In addition, an ethanolic extract of *B. macrostachya* leaves showed strong inhibitory activity towards Epstein-Barr virus activation in Raji cells. However, the extract was toxic to the Raji cells as well. Extracts of *B. asiatica* showed some in vitro antifungal activity.

Expressions from seeds of *B. asiatica* were studied for mutagenicity, clastogenicity and antimutagenic potential. The use of the rec assay revealed that there was no direct DNA damaging capacity. Mutagenicity before metabolic activation was not detected using the Ames pour plate method (*Salmonella typhimurium* strains TA 1535 and TA 1537); mutagenicity after metabolic activation was not observed using the host-mediated assay (*Salmonella typhimurium* His G46 as the indicator organism). Lack of chromosome breaking effects was indicated by the results of the micronucleus test. The test system, however, did exhibit antimutagenic effects against mitomycin C, metronidazole, safrole and cytoxan, which are all well-known muta-carcinogens. The latter was shown in the reduction of micronucleated polychromatic erythrocytes when expressions from seeds of *B. asiatica* were co-administered with the mentioned muta-carcinogens. A water extract of *B. acutangula* inhibited germination and growth of *Cuscuta reflexa* Roxb.

Description Evergreen shrubs or small to medium-sized or occasionally large trees up to 30(–47) m tall; bole branchless for up to 18 m, up to 60(–100) cm in diameter, sometimes with buttresses; bark surface slightly grooved and longitudinally fissured, cracked or scaly, thick, lenticels often distinctly diamond-shaped, brown, red-brown or grey, sometimes tinged with pink; inner bark finely, firmly fibrous, yellow-brown to pink or white with yellowish streaks (*B. asiatica*), without exudate. Leaves arranged spirally, crowded towards the ends of twigs, simple, obovate or obovate-oblong, dentate (except in *B. asiatica*), glabrous, with numerous lateral veins; petiole sometimes very short; stipules small, triangular, caducous. Inflorescence a many-flowered, terminal or axillary, or sometimes cauliflorous, erect or pendulous raceme or spike. Flowers white, pink or red, often very large, very fragrant, fluffy from the numerous stamens; calyx rupturing circumscissile or into 2–4(–5) segments or with 4(–5) free lobes, tube angular or winged; petals (3–)4(–5), free but connate to the filament tube; disk circular; ovary inferior, 2–4-locular with 2–6 ovules in each cell, style 1. Fruit a medium to large, 1-seeded berry, ovoid to fusiform, smooth, grooved or angled, crowned by the persistent calyx. Seedling with hypogeal germination; cotyledons absent (seed containing a swollen hypocotyl); shoot with scales at the first few nodes.

Growth and development Branching in *Barringtonia* is predominantly sympodial. Flowering takes place during the night with the corolla opening early in the evening and falling the next morning. In *B. asiatica* only 1 flower per inflorescence opens every night whereas in *B. racemosa* about half of the flowers in a single inflorescence bloom simultaneously. Most species flower throughout the year but full bloom is generally reached in May and August to September. Pollination of the fragrant flowers is generally by bats or insects (mainly moths), which are also attracted by the copious nectar. After shedding of the flowers, the inflorescences are often crowded with ants attracted by the nectar. A comparatively high percentage of the fruits is seedless. Seed dispersal is usually by squirrels and other animals that feed on the fruits. Fruits of *B. asiatica* and several other species are buoyant thanks to the thick layer of spongy, fibrous pericarp, and are dispersed by rivers and sea currents.

Other botanical information The family *Lecythidaceae* is sometimes split into three separate families, with *Barringtonia* being a member of the *Barringtoniaceae*. Species of *Barringtonia* are extremely variable in e.g. leaf shape, size and margin, position and shape of spikes, and fruit shape and size. Despite this polymorphism the species are generally easy to distinguish.

Ecology Most *Barringtonia* are quite common elements of the canopy layer in evergreen, primary or sometimes secondary, lowland rain forest. They often occur on river banks or in estuaries, or in permanently or seasonally swampy locations but some species prefer well-drained habitats. Most species are found below 600 m but a few grow in montane forest up to 1500(–2000) m altitude. *Barringtonia* species are present in areas subject to per-humid or seasonal conditions. *B. asiatica* is a very characteristic element of the coastal fringe forest (*Barringtonia* formation) and is associated with other trees like *Calophyllum inophyllum* L., *Casuarina equisetifolia* L., *Hibiscus tiliaceus* L. and pandans (*Pandanus* spp.). *B. racemosa* may form almost pure stands along tidal rivers or in upper mangrove swamps.

Propagation and planting *Barringtonia* can be propagated by seed or by cuttings. Seeds of *B. asiatica* show about 70% germination in about 35–65 days, compared with about 75% for *B. scortechinii* in 5–15 months. Sown fruits of *B. macrostachya* have a germination rate of about 40% in 9–22 months. Seeds of *B. acutangula* should be sown in full light, giving a germination rate of about 90%. *B. asiatica* can also be propagated by cuttings.

Diseases and pests The fungi *Phyllachora barringtoniicola* and *P. naqsii* may cause leaf spots in *Barringtonia* spp.

Harvesting Mature seeds of *Barringtonia* are simply collected from the ground underneath the trees.

Yield A mature *B. asiatica* tree yields about 500–2000 fruits per year.

Handling after harvest Seeds of *Barringtonia* are obtained by simply cutting the fruits open.

Genetic resources and breeding *Barringtonia* species of medicinal importance are widespread and common throughout South-East Asia, and therefore certainly not endangered. There are no records of *Barringtonia* in seed or germplasm banks.

Prospects Too little is known about the phytochemistry and pharmacology of *Barringtonia*. More research is therefore needed in these fields to fully evaluate a possible potential of this well-known fish poison.

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Selection of species

Barringtonia acutangula (L.) Gaertner

Fruct. 2: 97 (1791).

Synonyms *Barringtonia spicata* Blume (1826), *Barringtonia luzonensis* Vidal (1885), *Barringtonia edaphocarpa* Gagnep. (1920).

Vernacular names Indian putat (En). Indonesia: putat (Malay), alakang (South Sulawesi), kacuk (Merauke, Papua). Malaysia: jurai-jurai, pokok gajah beranak, putat nasi (Peninsular). Papua New Guinea: ko'o (Delena, Central Province). Philippines: apaling (Igorot), putat (Tagalog, Pampaya, Bikol), kalambuaia (Iloko). Burma (Myanmar): kyeni, kyi. Laos: ka dôn nam, ka dôn noy. Thailand: chik na (peninsular), kradon thung (north-eastern), tong (northern). Vietnam: m[uu]ng, l[ooj]c v[uwf]ng, chi[ees]c d[or].

Distribution From Afghanistan, Pakistan, India and Sri Lanka to Indo-China, southern China, Burma (Myanmar), Thailand, and throughout the Malesian area towards northern Australia.

Uses In Malaysia, the bark is used for poulticing ulcers in Perak, and bark, leaves and roots are applied for poulticing itch in Kedah. In the Philippines the bark is used as a fish poison. The bark in decoction is given as a stomachic; externally it is applied to wounds. In Burma (Myanmar), the root is considered aperient; the seed is used to treat ophthalmia, and the leaves to treat diarrhoea. In Central Province, Papua New Guinea, the scraped bark is squeezed with coconut meat and the juice is drunk daily for pneumonia, diarrhoea and asthma. In Indo-China, the bark is used as a remedy for diarrhoea, blennorrhoea, and malaria, externally a decoction is applied to sores. The liquid obtained by pounding the wood in water is considered haemostatic and given in menorrhagia. In Thailand, the roots are used as a laxative, the leaves are used for wound healing and against diarrhoea. In India, the bark, roots and seeds are employed as a fish poison. Powdered seeds in small doses are given to children as an expectorant and emetic. It is further used as an anthelmintic. In Thailand and Java, the young leaves are eaten as a vegetable.

Observations A shrub or small tree, 2–13(–25) m tall, trunk 20–90 cm in diameter, twigs 3–5 mm in diameter; leaves elliptical or obovate-oblong, (5–)6–16(–22) cm × 2–6(–8) cm, apex obtuse, acute or acuminate, finely serrate-crenulate, glabrous or hairy, petiole 4–10(–15) mm long; raceme terminal, pendulous, 20–45(–78) cm long, up to 75-flowered, sessile or with pedicel 3–7 mm long, opening buds 5 mm long, calyx tube about 0.5 mm long, not accrescent, sepals free, green, petals 4(–5), elliptical, convex, 0.6–1(–1.2) cm × 0.4–0.7 cm, usually red, white or pink, stamens in 3 whorls, 1–2 cm long, deep pink or dark red, ovary 2–3(–4)-celled, style 1–2 cm long, dark red; berry oblong, 2–6 cm × 1–3 cm, acutely angled to almost globular, 4- or 8-winged or slightly winged, tapering to apex, exocarp thin, fibrous and wrinkled, mesocarp parenchymatous with two layers of anastomosing fibres, endocarp a thin brown membrane covering the inside of the cell; seed ovoid, 1–4 cm × 0.5–1.5 cm, grooved. Based on flower and fruit characters, 2 subspecies are distinguished: ssp. *acutangula* and ssp. *spicata* (Blume) Payens. *B. acutangula* grows mostly along rivers, on plains regularly inundated or in swamps or freshwater mangroves from sea-level up to 750(–1600) m altitude.

Selected sources 128, 135, 164, 175, 217, 407, 634, 747, 786, 810.

Barringtonia asiatica (L.) Kurz

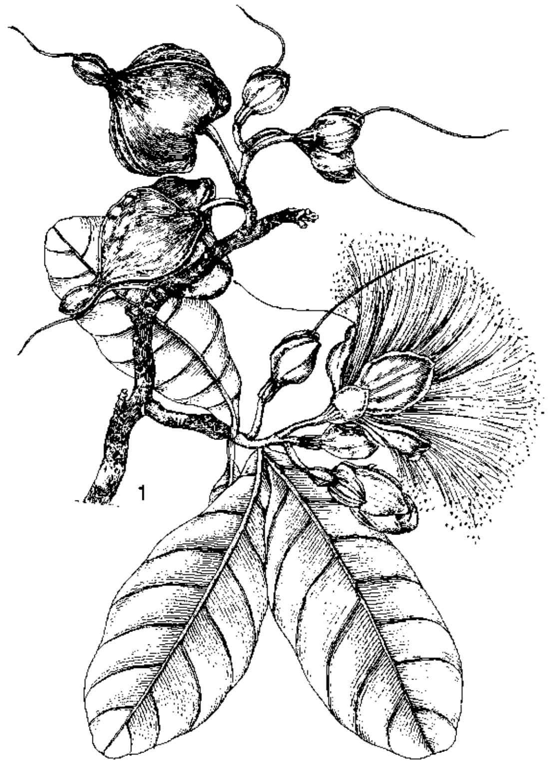
Prelim. rep. forest Pegu: App. A, 65, App. B, 52, in clavi (1875).

Synonym *Barringtonia speciosa* J.R. Forster & J.G. Forster (1776).

Vernacular names Sea putat (En). Indonesia: butun (Javanese, Sundanese), bitung (northern Sulawesi), keben-keben (Balinese). Malaysia: putat laut, butong, putat ayer (Peninsular). Papua New Guinea: maliou (Plitty, Manus Province). Philippines: botong (Tagalog, Bikol), boton (Tagalog), bitung (Bisaya). Burma (Myanmar): kyi-git. Thailand: chik ta lae, don ta lae (peninsular). Vietnam: b[af]ng qu[ar] vu[oo]ng.

Distribution From Madagascar to Sri Lanka, India, Burma (Myanmar), Indo-China, the Andaman Islands, Thailand, throughout the Malesian region towards northern Australia and into the Pacific, east to Samoa and the Society Islands (Tahiti); also planted within this region and introduced into East Africa, Hawaii, and the West Indies.

Uses In the Philippines, the leaves are heated and externally applied for stomach-ache. Fresh leaves are topically applied against rheumatism, and the seeds are employed as a vermifuge. In Indonesia, the Philippines and Indo-China, the fruit or seed is used as a fish poison. In the Bismarck Archipelago, the fresh nut is scraped and applied directly to a sore. The dried nut is ground, mixed with water and drunk to treat coughs, influenza, sore throat and bronchitis. Externally it is applied to wounds and a swollen spleen after an attack of malaria. In Fiji, a decoction of the leaves is used to treat hernia and a decoction of the bark to treat constipation and epilepsy. In Australia, the aborigines use the plant as a fish poison and sometimes to alleviate headache. In Indo-China the young fruits are consumed as a vegetable after



Barringtonia asiatica (L.) Kurz - 1, flowering and fruiting twig.

prolonged cooking. It is often planted as a shade tree along boulevards and avenues along the sea.

Observations A tree, 7-20(-30) m tall, trunk 25-100 cm in diameter, twigs 6-10 mm in diameter, with large leaf scars; leaves obovate or obovate-oblong, (15-)20-38(-52) cm × (7-)10-18(-21) cm, base cuneate, apex emarginate to mucronate, entire, marginal vein distinct, glabrous, petiole very short; raceme terminal, rarely axillary, erect, 2-15(-20) cm long, (3-)7(-20)-flowered, pedicel 4-8 cm long, opening buds 2-4 cm long, calyx tube about 3 mm long, not accrescent, rupturing in 2 unequal segments, green, petals 4, elliptical, convex, 5-9 cm × 2-5 cm, white, stamens in 6 whorls, (8-)12(-15) cm long, white at base, reddish at apex, ovary 4(-5)-celled, style 9-14 cm long, white at base, reddish at apex, accrescent to 15 cm; berry ovate, 8.5-11 cm × 8.5-10 cm, tapering to apex, sharply tetragonous to the emarginate base, exocarp thin with glandular dots and a shining cuticle, mesocarp 2-2.5 cm thick, spongy, endocarp a thick layer of longitudinal anastomosing fibres between 2 thin membranes; seed oblong, 4-5 cm × 2.5-4 cm, subtetragonous, tapering to the emarginate apex. *B. asiatica* is an almost exclusively littoral species, in some localities trees may grow further inland on calcareous hills or cliffs, generally growing on sandy beaches or coral-sand flats, along rivers or in mangrove swamp at sea-level, occasionally up to 350 m altitude.

Selected sources 135, 143, 164, 217, 368, 380, 407, 786, 810, 1008.

Barringtonia macrocarpa Hassk.

Flora 25, 2 (Beibl.): 36 (1842).

Synonyms *Barringtonia insignis* Miq. (1855), *Barringtonia serrata* Miq. (1855), *Barringtonia comosa* Gagnep. (1914).

Vernacular names Indonesia: songgom (Javanese, Sundanese), bulat, potet (Kalimantan). Thailand: chik nom yan. Vietnam: l[ooj]c v[uwf]ng qu[ar] to.

Distribution From Indo-China, southern Thailand, southern Burma (Myanmar) to Peninsular Malaysia, Sumatra, Java and Borneo.

Uses In Java and Borneo, the pounded roots or root bark are used as a fish poison. In Java, the young shoots are eaten raw as a salad.

Observations A shrub or small tree, 1.5-6(-13) m tall, trunk 5-16 cm in diameter, twigs (5-)7-15 mm in diameter; leaves obovate-lanceolate or linear-lanceolate, 30-60(-70) cm × 6-18 cm, base narrowly cuneate, apex cuspidate or obtuse, serrate-crenulate, glabrous, petiole 0.5-1(-2) cm long; raceme terminal, pendulous, (26-)40-75 (-112) cm long, up to 135-flowered, flowers not scented, pedicel 0.5-1.5 cm long, opening buds 0.5-0.7 cm long, calyx tube about 0.5-2 mm long, not accrescent, sepals 3-4, free, accrescent, purple or pink, petals 3-4, elliptical, convex, 2-3 cm × 1-1.5 cm, white, or pale pink, stamens in 3-4 whorls, 3-4 cm long, pink, ovary 3-4-celled, style 3.5-4.2 cm long; berry (immature) obovate to oblong, 6.5 cm × 2.5 cm, 3-4-gonous to 3-4-winged, pericarp about 2.5 mm thick, exocarp thin, mesocarp about 1 mm thick, fibrous, endocarp about 1 mm thick, fibrous; seed ovoid, 3.5 cm × 0.75 cm, fissured. *B. macrocarpa* occurs along rivers, in swampy forest and periodically inundated areas from sea-level up to 300 m altitude.

Selected sources 164, 407, 747.

Barringtonia macrostachya (Jack) Kurz

Prelim. rep. forest Pegu: App. A, 66, App. B, 52, in clavi (1875).

Synonyms *Barringtonia acuminata* Korth. (1846), *Barringtonia balabacensis* Merr. (1909), *Barringtonia cochinchinensis* (Blume) Merr. ex Gagnep. (1921).

Vernacular names Red putat (En). Indonesia: kayu putat, tuwah dotan (Sumatra), panga ha (Morotai). Malaysia: putat bukit putih, putat gajah (Peninsular), semuting (Sarawak). Philippines: apalang (Tagalog), karakauat (Negrito), ulam (Tagbanua). Burma (Myanmar): cây tam lang, thay nya oo. Thailand: chik nom (peninsular), chik nawn wan, chick. Vietnam: tam lang, chi[ees]c ch[uf]m to.

Distribution From southern China, Burma (Myanmar) and Indo-China to Thailand, Peninsular Malaysia, Singapore, Sumatra, Borneo, northern Sulawesi, the Moluccas, and the Philippines.

Uses In Peninsular Malaysia, the pulped root is used as an application to the skin for ringworm, and on sore eyes. A decoction of the leaves is drunk against stomach-ache. The seeds duly prepared, are considered edible in Indo-China.

Observations A shrub to medium-sized tree, 4–20(–30) m tall, trunk 3–35(–90) cm in diameter, twigs 5–10 mm in diameter; leaves obovate-oblong to oblong, (10–)15–25(–45) cm × (4–)6–8(–10) cm, base cuneate, apex cuspidate or caudate, shallowly serrate-crenulate, glabrous, petiole 2.5–10(–17) cm long; spike terminal or ramiflorous, pendulous, (10–)19–45(–75) cm long, up to 60-flowered or more, opening buds 0.7–0.9 cm long, calyx tube about 1–3 mm long, sepals free, red, purple, or magenta, petals 4, elliptical, convex, 2–2.5 cm × 1.5 cm, white, pink or red, stamens in 4(–5) whorls, 2.5–3 cm long, white, red or pink, ovary 4-celled, style 4–4.5 cm long, red or magenta; berry obovoid, 5.5–9 cm × 2–4 cm, tetragonous, pericarp 3–10 mm thick, exocarp 0.5–3 mm thick, mesocarp spongy and fibrous, 1–8 mm thick, endocarp fibrous, 0.5–2 mm thick; seed ovoid, 3–4.5 cm × 1–2.5 cm, quadrangular, ribbed. *B. macrostachya* is found in primary and secondary forest on hills, along rivers, or in periodically inundated or swampy areas, mostly on sand or loam, from sea-level up to 700(–1300) m altitude.

Selected sources 135, 164, 786.

Barringtonia racemosa (L.) Spreng.

Syst. veg. 3: 127 (1826).

Synonyms *Barringtonia stravadium* Blanco (1837), *Barringtonia pallida* (Miers) Koord. & Valeton (1900), *Barringtonia salomonensis* Rech. (1912).

Vernacular names Common putat (En). Brunei: putat aying. Indonesia: butun darat (Moluccas), penggung (Javanese, Sundanese), putat sungai (Bangka). Malaysia: putat ayam, putat kampong (Peninsular), putat ayer (Sabah). Papua New Guinea: paopao (Gunantuna, East New Britain), paniak (Plitty, Manus Province). Philippines: putat (Tagalog, Bikol, Samar-Leyte Bisaya, Panay Bisaya, Sulu, Magindanao), nuling, tuba-tuba (Cebu Bisaya). Burma (Myanmar): kye-bin, kyi. Laos: som pawng. Thailand: chick, chik ban, chik suan (central). Vietnam: tim lang, chi[ees]c hoa v[af]ng.

Distribution From eastern Africa and Madagascar to Sri Lanka, India, Burma (Myanmar), Indo-China, southern China, Taiwan, the Ryukyu Islands, Thailand, the Andaman and Nicobar Islands, throughout the Malesian region towards Micronesia, Polynesia (east to Fiji and Samoa) and northern Australia.

Uses In Indonesia, the pounded roots, fruits or bark are used as a fish poison. In the Philippines the bark is used as a fish poison. A decoction of the bark is externally applied as an antirheumatic. In Peninsular Malaysia and East New Britain, leaves, roots or bark are externally applied to treat chickenpox. In Peninsular Malaysia, a poultice is also applied for itch. In Papua New Guinea, a decoction of the scraped nut is drunk to relieve a cough, sinusitis or bronchitis. In Indo-China, the roots are employed as a febrifuge; an infusion is used for measles. The fruit is considered efficacious for coughs and asthma and the peeled seed mixed with flour and oil for diarrhoea. The seed is internally applied for colic and externally for ophthalmia. The seed is also used as a fish poison. In India, the fruit is used for poulticing sore throat and skin eruptions. The fresh or cooked leaves are eaten as a vegetable. It is occasionally planted as a roadside tree.

Observations A shrub or small to medium-sized tree, 2–20(–27) m tall, trunk 10–50 cm in diameter, twigs 3–6 mm in diameter; leaves tufted, obovate-oblong or obovate-lanceolate, 14–36(–42) cm × 4–14(–16) cm, base cuneate, acute to acuminate, petiole slightly winged; raceme or spike terminal, rarely ramiflorous, pendulous, 20–70(–100) cm long, (3–)7(–20)-flowered, pedicel up to 2.5 cm long, opening buds 0.5–1 cm long, calyx tube about 2–5 mm long, accrescent, rupturing in 2–4(–5) (un)-equal segments, red, petals 4, elliptical, convex, 1.5–2.5 cm × 0.5–1.5 cm, white (occasionally red), stamens in (5–)6 whorls, 2–4 cm long, white, pink, purple or red, ovary (2–)3–4-celled, style (2–)3–5.5 cm long, pink, purple, red or white; berry ovoid, 5–7(–9) cm × 2–4(–5.5) cm, subtetragonous, truncate, tapering at base, pericarp 3–12 mm thick, exocarp rather fleshy with dispersed fibres and a wrinkled, reticulate or fissured outer layer, endocarp a strong layer of longitudinal anastomosing fibres covered inside by a thin brown membrane; seed ovoid, 2–4 cm × 1–1.5 cm, subtetragonous, tapering towards the apex, rather flat at the base. *B. racemosa* is found in primary and secondary forest, mostly restricted to inundated flood plains on tidal river banks, or in swampy localities, also behind the mangrove or in the upper mangrove swamp. It grows well under slightly saline conditions or on beaches near high water level, with a preference for heavy clay, loam or rich volcanic soils, usually a little above sea-level and occasionally up to 500(–900) m altitude.

Selected sources 128, 135, 164, 217, 380, 407, 418, 786, 788, 810, 1008.

M.A. Yaplito

Basilicum polystachyon (L.) Moench

Suppl. Meth.: 143 (1802).

LABIATAE

$2n = 28$

Synonyms *Ocimum polystachyon* L. (1771), *Moschosma polystachyon* (L.) Benth. (1830).

Vernacular names Musk basil (En). Basilic musqué (Fr). Indonesia: sangketan (Javanese), surawung gunung (Sundanese). Malaysia: tapua jatten. Philippines: pansi-pansi (Tagalog), bauing (Magindanao), lodokong (Pangasinan). Vietnam: [es] gi[ar], [es] s[aj], m[ooj]c ma.

Origin and geographic distribution Musk basil is distributed as a weed from tropical Africa through India, the Mascarenes and Sri Lanka to South-East Asia and tropical Australia.

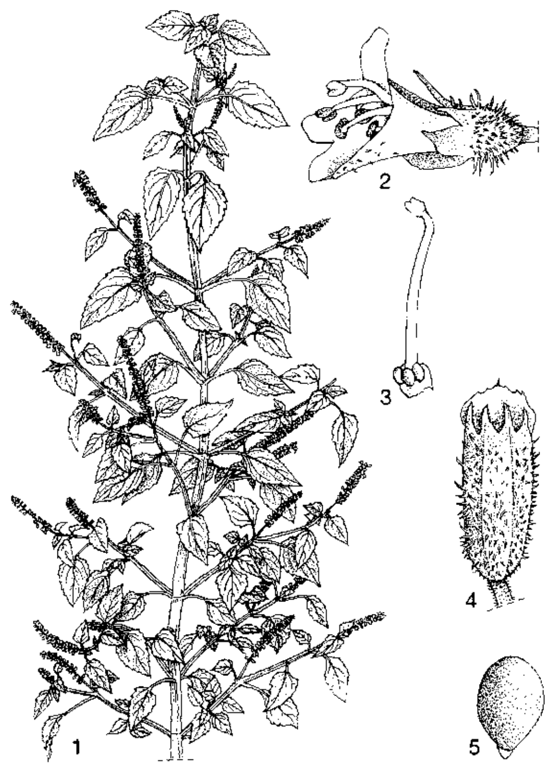
Uses Musk basil is used internally as a tea, and externally in decoction as a lotion. Some people lack tolerance for internal use, and develop sores in the mouth. The crushed leaves are used in Indonesia as a sedative, and to relieve painful sprains and limbs. Decoctions are used for epilepsy, palpitations of the heart, neuralgia, nervous headaches, nervousness after childbirth, rheumatism and convulsions. In East Africa, fresh roots are chewed against cough, or cooked with food to reduce flatulence. In Kenya, an infusion of the fruit is taken for parturition in the case of delayed birth. Nomads in Kenya burn the plant inside milking pots to give a pleasant smell to the milk. In East Africa, the plant is burnt indoors as a mosquito and snake repellent. In Nigeria, the leaves are used to flavour food and as a sedative. In Ghana, the leaf-sap is squeezed into the nostrils of children to cause sneezing, in order to cure headache.

Production and international trade Musk basil is not traded commercially, and is rarely found on local markets.

Properties Upon steam distillation, the leaves and flowers yield a pale yellow viscous essential oil, of which the main components are: methyleugenol (39%), methyl-isoeugenol (8%), limonene (7%), 1,8-cineole (eucalyptol, 5%), β-elemene (5%), β-caryophyllene (5%), β-selinene (4%), citronellal (3.5%), geranyl acetate (2.9%), α-humulene (2.4%), isobornyl acetate (2%) and δ-cadinene (2%). Eugenol is toxic in large amounts and can cause contact dermatitis.

Adulterations and substitutes Several components found in *B. polystachyon* are also found in *Mentha* (*Labiatae*) and in *Blumea* (*Compositae*).

Description An erect, annual to short-lived perennial, aromatic herb, 40–100 cm tall, stem much branched, prominently 4-angled, nearly glabrous. Leaves decussate, ovate to oblong-ovate, 2–6 cm × 1–3.5 cm, base acute or attenuate, apex



Basilicum polystachyon (L.) Moench – 1, flowering stem; 2, flower; 3, pistil; 4, fruiting calyx; 5, nutlet.

acuminate or caudate, margins irregularly serrate, thin-membranaceous, glabrous on both surfaces, or minutely gland-dotted underneath; petiole slender, 1–4 cm long; stipules absent. Inflorescence consisting of cymes, together resembling a terminal or axillary, slender raceme or panicle, 3–6 cm long, in fruit over 10 cm long; bracts minute, lanceolate, aristate, 1–2 mm long. Flowers small, bisexual; pedicel 1–1.5 mm long; calyx campanulate, 1.5–2 mm long, in fruit 3–3.5 mm long, slightly inflated at the base, 5-toothed, teeth short, the distal one broad, obtuse, abruptly acuminate, the other 4 much smaller, triangular, acute, pubescent; corolla funnel-shaped, 2–2.5 mm long, tube 1.8 mm long, 2-lipped, upper lip broad, entire, reflexed, lower lip 3-lobed, 2 lateral teeth cuspidate, a few short hairs outside, pale lilac, purple or flesh-coloured, sometimes white; stamens 4, didynamous, included, filaments inserted on the corolla tube, glabrous, anthers 1-celled; disk symmetrical; ovary superior, glabrous, style with short, 2-lobed stigma. Fruit consisting of 4 dry, 1-seeded schizocarpous nutlets, broadly ellipsoid, compressed, 0.5 mm long, smooth, dull brown. Seedling with epigeal germination; cotyledons petiolate, blade broadly ovate, base obtuse, apex emarginate, margin with sparse minute bristles; hypocotyl elongate, bristly in rows, epicotyl up to 1 mm long, 4-angular, bristly; first leaves opposite, ovate, base obtuse to cordate, apex rounded, margin dentate to crenate, with dense bristles; petiolate.

Growth and development Once established, seedlings of *B. polystachion* grow rapidly. When plants have reached a height of about 40 cm, branching starts. *B. polystachyon* is shallow rooted.

Other botanical information *Basilicum* belongs to the subfamily *Ocimoideae*, and is botanically close to *Ocimum* L., mainly differing in the length of the stamens and the presence of hairs on the filaments. *Basilicum* comprises one or a few species, but no recent taxonomical revision of this genus and related genera is available.

Ecology Musk basil grows as a weed in open waste places, usually in humid soils, such as fallow rice fields, along streams and swampy grasslands. It has a preference for seasonal climatic conditions, therefore in Java it is largely confined to the drier regions, from 0–600 m altitude, and it is scarce in most of Sumatra, Borneo and the Malaysian Peninsula. Musk basil is flowering throughout the year.

Propagation and planting Musk basil is propagated by seeds, which are dispersed by animals.

Diseases and pests Sometimes flowers of musk basil bear large red galls, caused by a gall midge. No other important diseases or pests are known to occur.

Harvesting Musk basil is collected from the wild whenever the need arises.

Genetic resources and breeding Musk basil has a large area of distribution in anthropogenic habitats and does not seem to be at risk of genetic erosion. Small germplasm collections are maintained in Italy and the United Kingdom. No breeding programmes are known to exist.

Prospects Very little is known about the phytochemistry or pharmacology of *B. polystachyon*. It will probably remain of minor importance in local medicine.

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Other selected sources 74, 135, 407, 786.

Marfu'ah Wardani

Biophytum DC.

Prodr. 1: 689 (1824).

OXALIDACEAE

$x = 9, 10$; *B. sensitivum*: $2n = 18$

Major species *Biophytum sensitivum* (L.) DC.

Vernacular names Malaysia: daun payong, payong ali. Indonesia: krambilan (Javanese). Philippines: damong-bingkalat (Tagalog).

Origin and geographic distribution *Biophytum* is a genus of about 70 species with a pantropical distribution; 7 species occur in Malesia, of which 2 are introduced.

Uses In Peninsular Malaysia, *B. adiantoides* and *B. sensitivum* are probably not distinguished from each other and are used in the same way. The whole pounded plant, or its ash mixed with some other plants, is made into a poultice to treat stomach-ache in small children. In Indonesia, the plant is roasted in a banana leaf and eaten with lime juice for stomach-ache, while children are given the roots to chew for this purpose. *B. sensitivum* is also widely applied in South-East Asia as an anti-inflammatory in the treatment of a sore throat, abscesses, chronic wounds, contusions and fevers. In Indonesia, Thailand and India, a decoction of the dried flowering plant is administered to treat chest illnesses including tuberculosis, asthma and feverish breathing. A decoction of the roots is taken against gall or bladder stones, and is also used to treat gonorrhoea. In India, the bruised plant is applied to burns. *B. sensitivum* is said to contain a plant-insulin, useful for treating diabetes, and is used as such in Thailand. Crushed with water, the plant is topically applied in Brazil against scorpion bites. The stem and leaves are used as an antihiccup. In India, a decoction of the whole plant of *B. reinwardtii* is applied against fevers, chicken pox and rashes. *B. sensitivum* is used in Malaysia and India as a magic plant, because of its sensitive leaves, which suggest modesty or youth, and the plant is taken to restore these qualities. In West Africa, it is taken for protection against snake-bites.

Biophytum is not medicinally used in Indo-China, but in Vietnam it is used as a condiment.

Production and international trade *Biophytum* is only used on a local scale.

Properties Several flavonoids were isolated from the whole plant of *B. sensitivum*, e.g. isoorientin-2'-O-rhamnoside, isoorientin-7-O-glucoside and isovitexin-2'-O-rhamnoside. The roots and stems contain the biflavonoid amentoflavone (13',II8-biapigenin), in concentrations of 0.35% and 0.26%, respectively. In vitro, the latter compound was also found to be a selective inhibitor of cyclo-oxygenase (COX-1), an enzyme which is part of the prostaglandin synthesis cascade, and thus involved e.g. in inflammatory reactions and pain. In the carrageenan-induced rat paw oedema test, an aqueous extract of the plant was found to be most active. The hypoglycaemic effect of an extract of the leaves was investigated in alloxan induced diabetic male rabbits, with different degrees of intensity: subdiabetic (alloxan recovered), mild diabetic and severely diabetic. Following single dose administration, there was a fall over 2.5 hours in fasting plasma glucose (FPG) of 27% in subdiabetic rabbits and 38% in mild diabetic rabbits, accompanied by a significant improvement in the oral glucose tolerance test. More significant improvements occurred following another week of treatment.

The alcohol extract of the whole plant of *B. sensitivum* was found to have significant antifungal and antibacterial activities in vitro.

Description Erect annual herbs or sympodially branched dwarf shrubs. Leaves in tufts (spirally arranged) at the end of the stem, paripinnate; petiolate; stipules setaceous; leaflets opposite, terminal pair mostly different from the others, distal half of base cuneate, proximal half rounded to truncate; subsessile, rachis prolonged into mucro. Inflorescence a terminal pseudo-umbel, peduncles many, bracteate; pedicel short, articulate at base. Flowers actinomorphic, 5-merous; sepals free, glabrous inside; petals contort, coherent above the claw, glabrous; stamens 10, filaments connate at base into a ring, shorter ones with callus at base, anthers dorsifixed, 2-celled, dehiscing extrorsely by longitudinal slits; disk absent; ovary superior, 5-celled; styles 5, terminal, hetero-, tri- or homostylous; ovules 3–6 per cell in 2 rows. Fruit an ellipsoid, 5-celled capsule, dry, dehiscent into a 5-rayed star or indehiscent; seeds 1–6 per cell. Seed with white aril, thin, at maturity ejaculatory. Seedling with epigeal germination.

Growth and development *B. sensitivum* flowers and fruits throughout the year.

Other botanical information The subdivision of *Biophytum* into several sections is unsatisfactory, but no complete revision of the genus exists at present. *Biophytum* is closely related to *Oxalis*, which differs from the first genus by the fewer, non-pinnate leaflets, and the valves of the capsule remaining attached to the central axis. In *B. adiantoides* and *B. reinwardtii* some reduced leaves may occur in the pseudo-umbel. The species referred to as *B. sensitivum* in African floras is a different one: *B. helenae* Busc. & Muschl. It is perennial, has a corolla 1.5–2 times as long as the calyx, has more pairs of leaflets, and the seeds have 2 longitudinal ridges, with transverse rows of small tubercles.

Ecology *B. reinwardtii* and *B. sensitivum* are weeds found in anthropogenic localities, while *B. adiantoides* is mainly found in open forest undergrowth.

Propagation and planting *Biophytum* is propagated by seed. In India, seeds of *B. sensitivum* show a dormancy period of 8.5–9 months when collected at the beginning of the dry period, and show a considerable decrease in germination rate after 11–12 months. The optimal temperature for germination is 30–40°C.

Diseases and pests In India, *Biophytum* is sometimes attacked by the leaf spot fungus *Pseudocercospora biophytiicola*.

Harvesting Mostly, whole *Biophytum* plants are pulled up, but sometimes only the leaves are harvested.

Handling after harvest Harvested plants of *Biophytum* are used fresh or are dried for storage.

Genetic resources and breeding *B. reinwardtii* and *B. sensitivum* are rather widespread, occurring in ruderal conditions, and therefore do not seem to be threatened by genetic erosion. *B. adiantoides*, however, is a forest dweller with a more restricted distribution and may therefore be more at risk when harvested from the wild in large quantities.

Prospects The antidiabetic effect of *B. sensitivum* is interesting, but since only limited information is available on its nature, further research is needed. Moreover, the activity of amentoflavone and possible other flavonoids on prostaglandin synthesis might be of interest as lead compounds in the development of future anti-inflammatory substances.

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Selection of species

Biophytum adiantoides Wight ex Edgew. & Hook.f.

Fl. Brit. India 1: 437 (1874).

Vernacular names Malaysia: daun payong, mayong, payong ali. Thailand: krathuep yop (northern). Vietnam: sinh di[eej]p r[as]ng.

Distribution Burma (Myanmar), southern Vietnam, Cambodia, Thailand and Peninsular Malaysia.

Uses In Peninsular Malaysia, the whole plant is given to small children against stomach troubles.

Observations A perennial shrublet, up to 30 cm tall, stem woody, branched; leaves 18–27-jugate, rachis 7–17 cm long, yellowish, terminal leaflets oblong to lanceolate, 9–22 mm × 3–8 mm, widest at or above the middle, other leaflets elliptical to oblong, base asymmetrical, midrib excentric at base, hairy; peduncle 5–20 cm long, up to 9-flowered, puberulous; pedicel 5–17 mm long, sepals lanceolate, 4.5–6 mm long, acute, in fruit 5–12-veined, 1.2–2 times as long as the fruit, sometimes with a few glandular hairs, petals lanceolate, 9–10 mm × 1–2.5 mm, apex rounded to truncate, white with yellow base, tristylous, styles in the middle form 2.5 mm long; capsule 3–4 mm × 2–3 mm, glabrous; seeds 2–3 per cell, 1 mm in diameter, with transverse, tuberculate ridges, puberulous. *B. adiantoides* occurs in crevices of limestone rocks along rivers and in open woodland, up to 300 m altitude.

Selected sources 135, 786.

Biophytum reinwardtii (Zucc.) Klotzsch

in Peters, Reise Mossamb. Bot. 1: 85 (1862).

Vernacular names Indonesia: biskucingan, krambilan (Javanese), ki payung (Sundanese). Malaysia: inya payung.

Distribution South-East Asia; in Malesia found in Peninsular Malaysia, Java, Sulawesi, and eastern New Guinea.

Uses In India, the whole plant is used against fever and rashes.

Observations An annual herb, up to 35 cm tall, stem simple, smooth; leaves 6–11(–14)-jugate, rachis 2.5–6(–9.5) cm long, terminal leaflets largest, obovate, 7–18 mm × 4–7 mm, asymmetrical, midrib excentric, curved, other leaflets elliptical, symmetrical, base truncate, hairy; peduncle up to 6.5(–12.5) cm long, up to 8-flowered; pedicel up to 7 mm long, strigose and glandular, sepals ovate-lanceolate, 2.5–4 mm long, acute, in fruit

3–8-nerved, as long as the fruit, petals elliptical to oblanceolate, 6–8 mm × 1–2 mm, apex rounded to emarginate, base yellow, above white to red to purple-veined, tristylous, styles in the middle form 0.5–0.8 mm long; capsule 2–3 mm × 2–2.5 mm, apically puberulous and minutely glandular on the ribs; seeds 1–3 per cell, 1 mm × 0.5 mm, with transverse, tuberculate ridges. *B. reinwardtii* occurs in shady locations, on waste land, river-banks and under humid thickets, up to 800 m altitude.

Selected sources 135.

Biophytum sensitivum (L.) DC.

Prodr. 1: 690 (1824).

Synonyms *Oxalis sensitiva* L. (1753).

Vernacular names Indonesia: daun kucingan (Sumatra), krambilan (Javanese), kurang-kurang (Moluccas). Philippines: damong-bingkalat (Tagalog), damon-huya (Bisaya), mahihiin (Iloko). Laos: dok han. Thailand: chi yop tontaan (northern), krathuep yop, khan rom. Vietnam: l[as] chue me, chua me l[as] me, ta lang.

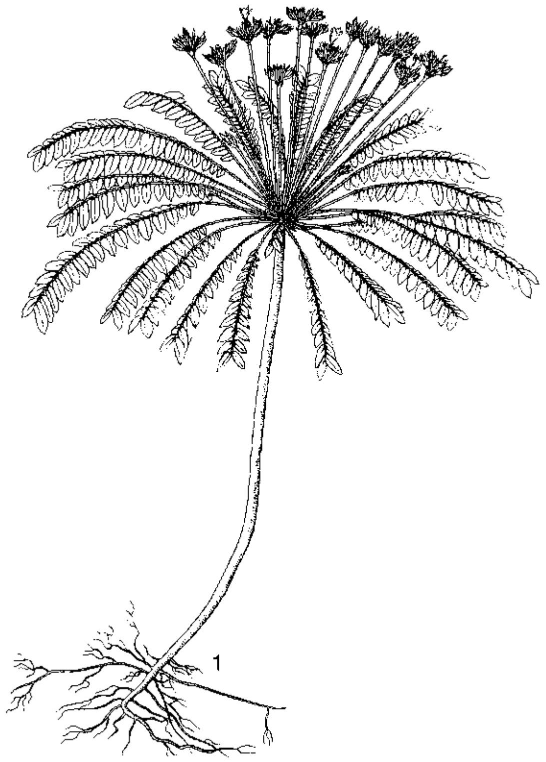
Distribution Widely distributed in the Indo-Malesian tropics, common throughout Malesia, but not yet recorded for New Guinea.

Uses The whole plant is used in Malesia and Thailand as an anti-inflammatory in the treatment of sore throat, abscesses, chronic wounds and fever.

Observations An annual herb, up to 35 cm tall, stem simple, smooth; leaves 7–12(–14)-jugate, rachis 5–10(–16.5) cm long, sensitive to touch, plying downwards, terminal leaflets falcate-obovate, 8–18 mm × 3–10 mm, asymmetrical, midrib excentric, other leaflets elliptical, symmetrical, base truncate, glabrous; peduncle up to 14 cm long, up to 10-flowered, glandular hairy; pedicel 1.5–3.5 mm long, sepals ovate-lanceolate, 4–7 mm long, acute, strigose and glandular-hairy, in fruit 5–9-nerved, 1.5–2 times as long as the fruit, petals lanceolate, 5–7 mm × 1–2 mm, truncate, yellow, sometimes with purplish lines, tristylous, styles in the middle form 0.5–1 mm long, often clasping the anthers of the longer filaments and tearing them off; capsule 3–4 mm × 2 mm, apically puberulous and minutely glandular-hairy on the ribs; seeds 0–3 per cell, 1 mm × 0.8 mm, transversely tubercled and ridged. *B. sensitivum* occurs in shady localities, in waste land, along riverbanks and under humid thickets, up to 250 m altitude.

Selected sources 135, 201, 739, 786.

R.C.K. Chung



Biophytum sensitivum (L.) DC. – 1, flowering plant habit.

Boerhavia L.

Sp. pl. 1: 3 (1753), Gen. pl. ed. 5: 4 (1754).

NYCTAGINACEAE

$x = 13, 26$; *B. chinensis*: $2n = 40, 42$; *B. diffusa*: $2n = 26$

Major species *Boerhavia diffusa* L.

Origin and geographic distribution *Boerhavia* is found in all warm or tropical countries, possibly originating from the Old World tropics. Three *Boerhavia* species occur widely in Malesia: *B. diffusa* and *B. erecta* are pantropical, occurring between 35°N and 40°S, while *B. chinensis* occurs only in the Old World tropics.

Uses In Malaysia, *B. diffusa* is used medicinally on a small scale, mainly as a diuretic. In India, the whole herb is a very popular medicine, called 'Punarnava' and the root has entered the Indian Pharmacopoeia. *B. diffusa* is 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, in large doses it produces vomiting. A decoction of the roots is also applied to corneal ulcers and to treat night blindness. Sometimes *B. chinensis* or *B. erecta* is substituted for *B. diffusa*. In Vietnam, the roots of a variety of *B. diffusa* with narrow leaves and axillary inflorescences (the former *B. repens* L.) are used to treat cough, liver complaints or hydrops. The uses of *B. diffusa* in West Africa and Central America are largely the same as in India. In Nigeria, an infusion of the whole plant is considered a mild laxative and febrifuge for children, also given for convulsions and to regulate menses. In Ivory Coast, the powdered leaves are made into a paste and are applied to the chest to relieve asthma in infants. Generally in West Africa, the roots are boiled and used on ulcers, abscesses and to assist in the extraction of Guinea worm. The roots and leaves are considered expectorant, and in large doses emetic. In East Africa, the plant is used against scabies, abscesses and boils. In Haiti and Uruguay, the leaves and roots are regarded as stimulant, tonic, sudorific, vermifugal and antispasmodic.

B. erecta is not used medicinally in South-East Asia, but it is thought to have similar properties as *B. diffusa*. In Tanzania, *B. erecta* plants that are reduced to ash, are mixed with oil and rubbed on for rheumatism and for scabies. The dried root is powdered and added to local beer as an aphrodisiac. Sap from the leaves is squeezed into the eye for conjunctivitis. In Mexico, a decoction of the whole plant is employed for bathing sores, and internally as an antispasmodic in epilepsy.

In Madura (Indonesia), the crushed leaves of *B. chinensis* are used for poulticing itch or scabies. Sometimes they are pounded with fragrant flowers and rice flour.

Boerhavia leaves are widely eaten by sheep and cattle, and in some parts of India and Africa, by humans as a vegetable. The roots of *B. diffusa* are traditionally eaten in times of scarcity in Australia and Fiji, and in Nigeria they are added to cakes. The seeds are added to cereals in Senegal and Mali. Fresh leaves of *B. erecta* are sold in the market in Mali, for the preparation of sauces. In Benin, *B. erecta* was found to be very palatable for breeding rabbits. *B. diffusa* and *B. erecta* are also considered notorious weeds in numerous annual crops.

Production and international trade *Boerhavia* is mainly used at a local scale, except in India where especially the roots enter in popular medicinal formulations.

Properties Several compounds were isolated from the roots of Indian *B. diffusa*, e.g. punarnavine, triacontanol hentriacontane, β-sitosterol, ursolic acid and 5,7-dihydroxy-6,8-dimethylflavone. The roots also contain the rotenoid boeravinones A1, B1, C2, D–F, as well as dihydro-isofurenoxanthin, boerhavine (a dihydro-isofuranoxanthone) and an antifibrinolytic compound, punarnavoside (a phenolic glycoside). Indian *B. diffusa* also contains boerhavic acid, punarnavine, tannins and phlobaphenes. Plants from Nigeria, however, have been shown to contain only traces of alkaloids and tannins, and no anthraquinones or saponins at all. These differences are probably regional as plants from several West African countries, including Nigeria, do show pharmacological activity. In India, *B. 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 produces diuresis in cases of oedema and ascites, especially in early liver and kidney conditions. The high amounts of potassium salts present in the whole plants increase the action of punarnavine. In India, an intravenous injection of punarnavine in cats produced a distinct and persistent rise of blood pressure and a marked diuresis. 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.

The alcoholic extract of Indian *B. diffusa* showed anti-inflammatory effects against carrageenan-induced paw oedema and increased urinary output in rats. The action can be compared with that of corticosteroids. The anti-nociceptive effect of a decoction of the leaves (DE) or the fresh juice (JE) was also tested in acetic acid writhing and hot-plate models of hyperalgesia in mice. Both DE and JE were found to produce a significant inhibition of the induced abdominal writhing in the acetic acid model, but in the hot-plate test, DE raised the pain threshold only during the first 30 minutes of observation while JE raised it for much longer. The extracts were also investigated for their anti-oedematogenic effect on carrageenan-induced oedema in mice, but neither DE nor JE inhibited this oedema.

The alkaloidal fraction of the roots of *B. diffusa* was studied for its effect on cellular and humoral function in mice. Oral administration of the fraction, at 25–100 mg/kg, significantly inhibited sheep red blood cells-induced delayed hypersensitivity reactions in mice, in a dose-related way. However, the inhibition was observed only during post-immunization drug treatment, while no effect during pre-immunization drug treatment was observed. The alkaloidal fraction also failed to show any blastogenic responsiveness of murine splenocytes to concanvalin A and lipopolysaccharide. Similarly, it did not display any mitogenic activity. Thus, the present study has shown the in vivo immunomodulatory activity of *B. diffusa* alkaloid fraction without an in vitro effect.

A methanol extract from the whole plant of *B. diffusa* was found to inhibit bone calcium resorption induced by parathyroid hormone in tissue cultures of neonatal mouse calvaria. The activity was found to be induced by 2 flavonoid glycosides, eupalitin-3-O-β-D-galactose and eupalitin-3-O-β-D-galactose-(1->2)-β-D-glucose.

The chloroform and methanol extracts of the whole plant of *B. diffusa* also exhibited hepatoprotective activity against carbontetrachloride intoxication in rats. The rotenoid, steroid and flavone exhibited a lowering of the serum enzyme GOT. The effect of season, thickness of roots and type of application (either aqueous or powder) were studied in thioacetamide intoxicated rats for their hepatoprotective action. The results showed that an aqueous extract (2 ml/kg) of roots of a diameter of 1–3 cm, collected in May (summer), exhibited marked protection of a majority of serum parameters, i.e. GOT, GPT, ACP and ALP, but not GLDH and bilirubin. Also, the studies proved that the aqueous form of drug (2 ml/kg) administration has more hepatoprotective activity than the powder form. This is probably due to the better absorption of the liquid form through the intestinal tract.

The water-soluble fraction of a methanol extract of the whole plant *B. diffusa* exhibited various pharmacological effects including anticonvulsant, hypotensive, myocardial depressant, skeleton and smooth muscle stimulant activity in rats. No teratogenic effects were detected in pregnant albino rats, after daily administration of the ethanol extract at a dose of 250 mg/kg, orally.

The root extract of *B. diffusa* showed noticeable reduction of the duration of menstrual flow, menstrual iron loss and activity of uterine tissue plasminogen activator in monkeys fited with an intrauterine contraceptive device. Two lignans, liriodendrin and syringaresinol mono-β-D-glucoside, have been isolated from the methanol extract of the roots of *B. diffusa*. The first compound exhibited a significant calcium channel antagonistic effect in the frog heart single cell assay, using the whole-cell voltage clamp method.

The root extract of *B. diffusa*, which was found to inhibit the infection of several plant viruses (tobacco mosaic virus, cucumber mosaic virus, cucumber green mottle virus and sun hemp rosette virus), was tested by the agar diffusion hole method for its action on RNA-containing bacterial viruses, and was found to cause only partial and not uniform plaque formation of the phages. *B. diffusa* seedlings, germinated in cattle dung, showed large inhibition zones for the fungi *Bacillus subtilis*, *Escherichia coli*, *Pseudomonas cichorii* and *Salmonella typhimurium*. Extracts of all parts of *B. diffusa* significantly reduced germination and growth of the notorious weed *Echinochloa colona* (L.) Link seedlings in petri dishes.

The antibacterial activity of the aqueous residue of the aerial parts of *B. erecta* was tested by the filter paper disk diffusion method and was found to be highly active against *Alkaligens viscolactis* and *Bacillus cereus*. *B. diffusa*, however, failed to show activity against any of the tested bacteria.

An extract of the aerial parts of *B. diffusa* significantly increased the growth and development of silkworms (*Bombyx mori*), silk gland weight and silk thread length.

Adulterations and substitutes In India, *Trianthema portulacastrum* L. (*Aizoaceae*) is used in the same way as *B. diffusa*, as a diuretic.

Description Annual to perennial herbs, erect, ascending or creeping, puberulous to glabrous, with sessile or stalked, club-shaped glands or hairs; stems often tinged red and swollen at the nodes. Leaves simple, opposite, subequal in each pair, pale green beneath, epidermis with irregular sculptures or reddish glands; petiole present; stipules absent. Inflorescence a 2–10-flowered (sub)-umbel, in axil of smallest leaf of a pair, or by reduction of leaves forming a large thyrsoid inflorescence, appearing terminal; bracts and bracteoles small, fimbriate, caducous. Flowers bisexual, actinomorphic, pedicel jointed with the flower, short; perianth tubular-campanulate, distinct constriction halfway, lower part obconical, 5–10-ribbed, upper part 5-lobed, plicate in bud, white or pink; stamens 1–4, exserted; ovary subsessile, smooth, style as long as the perianth or longer, stigma capitate. Fruit an anthocarp, closed at apex, 5–10-ribbed, glabrous or glandulously hairy, swelling and slimy in water. Seed with longitudinally folded embryo, cotyledons with recurved margin, surrounding the mealy endosperm. Seedling with epigeal germination; hypocotyl well developed, puberulous; cotyledons rounded, purplish beneath, midvein distinct; first leaves alternate, puberulous, purplish beneath.

Growth and development *Boerhavia* flowers and fruits throughout the year, when sufficient water is available.

Other botanical information Two major taxonomic problems are apparent in *Boerhavia*, one at the supra-specific level and the other being the large polymorphism within the species. The first problem is that in *Boerhavia* s.l. 4 groups of species can be recognized as separate genera: *Anulocaulis*, from Mexico and southern North America, with 10-ribbed fruits and a sticky band around the internodes, *Commicarpus*, from the Old World and partly pantropical, with faintly 10-ribbed fruits and relatively large, zygomorphic and tubular flowers, *Cyphomeris*, from Mexico, with asymmetric, glabrous fruits, and large, tubular flowers, and finally *Boerhavia* s.s., pantropical and in warm countries, with 3–5-ribbed, glabrous to glandular fruits and small, regular flowers. Here, the concept of *Boerhavia* s.l. is followed, and the segregate genera are regarded as subgenera. *Boerhavia* s.s. (orthographic variation '*Boerhaavia*') consists of 3–20 species, depending on the opinion of different authors. Especially *B. diffusa* is very variable, and some taxa, like *B. repens* and *B. coccinea* Mill., are often distinguished as separate species. This opinion is not shared here, as several differentiating characters vary with soil type, temperature and rainfall, and intermediate plants occur frequently.

Ecology *Boerhavia* is heliophilous, occurring on beaches and ruderal localities, preferring a slightly seasonal climate, indifferent to soil, from sea-level up to 1000 m altitude. They are often weeds in cultivated land. *B. erecta* prefers drier localities than *B. chinensis* or *B. diffusa*.

Propagation and planting *Boerhavia* is propagated by seed. The subepidermal slime coat of the anthocarp of *Boerhavia* shows a distinct sticky swelling when ripe, with which it clings to animals and birds.

In vitro production of active compounds In India, *B. diffusa* is propagated in vitro, using segments of the upper leaves. Roots were induced by culturing the segments on Murashige and Skoog medium, supplemented with sucrose and indole acetic acid (IAA). 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.

Diseases and pests In India, several host-specific diseases have been identified on *Boerhavia*, i.e. *Cercospora diffusa* causing chlorotic leaf spots, and *Colletotrichum boerhaavia* causing brown necrotic spots. In India, *B. diffusa* is recorded as a host for the virus causing aubergine mosaic disease, and in Costa Rica as a host of zucchini yellow mosaic potyvirus. In several countries, *Boerhavia* is an alternative host for insect pests in crops. In Cameroon, *B. diffusa* is an alternative host for the cotton aphid (*Aphis gossipii*), in India, for the groundnut leaf miner (*Aproaerema modicella*), and in Nigeria, caterpillars of *Aegocera rectilinea* and *Hippotion celerio* were found feeding almost solely on *B. diffusa*, and much less on food crops.

Harvesting All plant parts of *Boerhavia* are collected throughout the year for traditional medicinal use.

Handling after harvest The harvested parts of *Boerhavia* are often used fresh, except for the roots which are dried in the sun for later use.

Genetic resources and breeding All *Boerhavia* species treated here have a large area of distribution, often as weeds, and are not at risk of genetic erosion. There seems to be a large geographical variation in the composition of pharmacological compounds of *B. diffusa*, and more research is needed in order to evaluate the most promising populations. There are no known breeding programmes of *Boerhavia*.

Prospects Various extracts and purified compounds from *B. diffusa* show a range of interesting pharmacological effects (in vitro and in vivo), e.g. in the field of diuresis and fibrinolysis. No data, however, are available for humans, and therefore this merits further research in order to fully evaluate the potential for future medicine.

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Selection of species

Boerhavia chinensis (L.) Rottb.

Pl. hort. univ. rar. prog. descr.: 4 (1773).

Synonyms *Boerhavia repanda* Willd. (1797), *Boerhavia helenae* Schult. (1822), *Boerhavia chinensis* Asch. & Schweinf. (1867), *Commicarpus chinensis* Heimerl (1934).

Vernacular names Indonesia: karojep pager, ketek belangan (Madurese). Thailand: khee on khruea (northern, eastern). Vietnam: s[aa]m nam.

Distribution Throughout the Old World tropics; in Malesia only in Indonesia (eastern Java, Madura, Kangean Islands, Lesser Sunda Islands and Moluccas).

Uses In Madura, the leaves are crushed and applied to scabies and itching body parts.

Observations An erect or rambling, sometimes climbing herb, 1(–4) m tall, puberulous-glabrescent; leaves lanceolate to ovate, 2.5–4.5 cm × 1.5–4 cm, base obtuse to cordate, apex acute, margin deeply sinuate, petiole 1–3 cm long; umbel 0.5–2 cm × 0.3–3.3 cm, 3–8-flowered, peduncle 2–6 cm long; pedicel 2.5–14 mm long, each with caducous bracteole, perianth tubular-campanulate, 10–12 mm long, stamens 3–4, like style exserted for 4–5 mm; anthocarp elongate, 7–8 mm long, 10-ribbed, with conspicuous sessile to stalked glands in the upper half. *B. chinensis* occurs often in regions with a distinctly seasonal climate, in dry localities, hedges, brushwood, field margins and monsoon forest, on sandy clay and limestone soils, up to 700 m altitude.

Selected sources 74, 135, 407, 638, 745.

Boerhavia diffusa L.

Sp. pl. 1: 3 (1753).

Synonyms *Boerhavia repens* L. (1753), *Boerhavia coccinea* Mill. (1768), *Boerhavia paniculata* Rich. (1792), *Boerhavia adscendens* Willd. (1797).

Vernacular names Spreading hogweed (En). Papua New Guinea: mamauri (Yule Island, Central Province). Philippines: paanbalibis (Tagalog), katkatud, tabtabokol (Iloko). Burma (Myanmar): khomhin pak. Thailand: phak bia hin (northern), nang kuu sae (Karen, northern), phak khom hin (central). Vietnam: s[aa]m r[uwf]ng, s[aa]m d[aas]t, s[aa]m nam.

Distribution Pantropical, throughout Malesia, Australia and the Pacific.

Uses In Malaysia, a decoction of the aerial parts is widely used as a diuretic. The root is purgative, anthelmintic and a febrifuge. In Papua New Guinea, the scraped root is eaten raw or a decoction of the leaves is drunk to induce sterility in women. In Africa, the leaves are sometimes eaten as a vegetable.

Observations An annual or perennial, erect, ascending, creeping or climbing herb, 0.4–1(–2) m tall, puberulous to glabrescent, with club-shaped or stalked glands and glandular hairs, root fusiform, often woody; leaves ovate-lanceolate, 0.5–4 cm × 0.3–4 cm, base obtuse, cordate or truncate, apex acute to obtuse, beneath often white, some-

Boerhavia diffusa L. – 1, flowering and fruiting stem; 2, flower; 3, part of infructescence.

times with red marginal glands, petiole 1–3.5 cm long; flowers 1–12 together in cymose panicles, 0.5–7 cm × 1–6 cm, peduncle 2–5 cm long, 1–3 times branched; pedicel 0.3–2 mm long, bracteoles 1–3, perianth campanulate, 1.5–2.3 mm long, with a distinct constriction in the middle, white, red, pink or violet, stamens 1–3, like style barely exserted; anthocarp club-shaped, 2.5–3.3 mm long, 5-ribbed, with minute scattered, club-shaped, stalked or sessile glands. *B. diffusa* occurs in dry open localities, pastures, along railroads, roads, and in secondary forest, on rocks and sand, from sea-level up to 1000(–2000) m altitude.

Selected sources 70, 71, 74, 88, 89, 135, 154, 159, 198, 215, 293, 333, 580, 606, 676, 696, 707, 739, 745, 751, 787, 823, 913, 918, 930, 931, 1041.

Boerhavia erecta L.

Sp. pl. 1: 3 (1753).

Vernacular names Indonesia: bajam merah, cakaran, cakar ayam (Javanese). Thailand: phak khom hin (peninsular), yaa nuat (central). Vietnam: nam s[aa]m d[uws]ng.

Distribution A pantropical weed, native to tropical America, not recorded from Australia. In Malesia occurring in Singapore, Sumatra, Java, Lesser Sunda Islands and New Guinea.

Uses *B. erecta* is not known to be used medicinally in South-East Asia, but it is thought to have similar properties as *B. diffusa*, and therefore has potential in the region. It may become a serious weed in annual crops, such as groundnut, sorghum and cotton.

Observations An annual or sometimes perennial herb, erect or decumbent at the base, 20–80 cm tall, puberulous to glabrescent; leaves ovate, oblong or lanceolate, 1.7–3.5 cm × 1–2.3 cm, base rounded to truncate, apex acute, beneath white with sunken red glands, petiole 1.5–4 cm long; flowers 2–4 together in a cymose panicle, 1–2.5 cm × 1.5–3.5 cm, peduncle 1.5–2 cm long, 1–3 times branched; pedicel 0.5–5 mm long, with 1–2 bracteoles at top or lower, perianth tubular-campanulate, 1.7–2.5 mm long, with a distinct constriction in the middle, white, red or pink, stamens 2–3, like the style barely exserted; anthocarp obconical, 3–3.7 mm long, apex truncate, glabrous, faintly 5-ribbed, grooves between ribs slightly undulate. *B. erecta* occurs in open, sandy localities, along rail-roads, roads and in waste places, from sea-level up to 2000 m altitude.

Selected sources 74, 293, 441, 696, 745, 787.

Slamet Sutanti Budi Rahayu

Borreria G. Mey.

Prim. fl. esseq.: 79 (1818).

RUBIACEAE

x = 14, 28; *B. hispida*: $2n$ = 56, *B. laevis*: $2n$ = 24–28, *B. ocymoides*: $2n$ = (28), 40, 52–56, *B. verticillata*: $2n$ = 28

Major species *Borreria laevis* (Lamk) Griseb., *B. ocymoides* (Burm.f.) DC., *B. verticillata* (L.) G. Mey.

Vernacular name Button weed (En).

Origin and geographic distribution *Borreria* (including *Spermacoce*) comprises about 100–150 species, mainly from tropical and subtropical America, but many species have been introduced into the Old World as weeds. About 10 species occur in South-East Asia.

Uses In Peninsular Malaysia, the leaves of *B. hispida* or *B. ocymoides* are applied in poultices to treat headache, by cooling down the head, or mixed with other herbs applied to children with stomach-ache. The sap from the leaves of *B. hispida*, as well as those from *B. laevis* in South America, is applied to wounds and sores, to disinfect them. In Java, the stem and leaves of *B. hispida*, crushed with *Alyxia* R.Br., are used for diarrhoea. An infusion is taken for gallstones and kidney stones. In Papua New Guinea, the leaves of *B. laevis*, together with the scraped roots of *Desmodium sequax* Wallich and rhizomes of wild ginger, and mixed with ash, are made into a small bundle, which is squeezed empty into a tooth to relieve toothache. *B. verticillata* was formerly cultivated experimentally in Java, because of its stimulating action on the stomach, which in low doses resembles the action of *Psychotria ipecacuanha* (Brot.) Stokes (synonym *Cephaelis ipecacuanha* (Brot.) A. Rich.) and related species. In India it is used for intestinal parasites. Several *Borreria* species are stocked by Chinese herbalists in South-East Asia. In India, the seeds of *B. hispida* are used as a substitute for coffee and the leaves are eaten as a vegetable in times of scarcity.

Production and international trade *Borreria* is only used om a local scale.

Properties The aerial parts of *B. verticillata* contain an essential oil, which was shown to have antibacterial action on *Escherichia coli*, *Staphylococcus aureus* and *Vibrio cholerae* and gram-negative bacteria such as *Enterobacteria* and *Pseudomonas*. It also showed antifungal action by inhibiting conidial germination of *Drechslera oryzae*. The aerial parts also contain a mixture of borrerine, borreverine and isoborreverine together with spermacoceine, which are all indole alkaloids derived from the amino acid tryptophan. A series of iridoids was isolated from the root bark of *B. verticillata*, consisting of daphylloside, asperuloside, feretoside, methyl desacetylasperulosidate, desacetylasperuloside, asperulosidic acid and desacetylasperulosidic acid.

Pharmacological effects of *B. verticillata* extracts furthermore include schistosomicidal activity.

An infusion of the leaves of *B. hispida* showed a significant influence on solubility of kidney stones in vitro and artificial urethra stones in white rats. The methanol extract of *B. laevis* exhibited herbicidal activity against *Lepidium sativum* L., but also against seedlings of crops such as *Sesamum*. The extract also showed molluscicidal activity against *Biomphalaria glabrata* and *Pomacea canaliculata*.

Phytochemical screening of *B. ocimoides* revealed the presence of alkaloids and cardiac glycosides. Aqueous and alcoholic extracts inhibited the growth of *Candida albicans*, *E. coli*, *Klebsiella pneumoniae*, *Neisseria gonorrhoeae*, *Proteus mirabilis*, *Pseudomonas aeruginosa*, *S. aureus* and β-haemolytic streptococci.

Adulterations and substitutes 'Ipecacuanha' (mainly from *Psychotria ipecacuanha* is sometimes used in small doses as a substitute for *B. hispida* or *B. verticillata*, because of its stimulating action on the stomach.

Description Annual or perennial herbs. Leaves decussate, simple, entire; petiole short or almost absent; stipules interpetiolar, normally fringed. Inflorescence an axillary or terminal, sessile, few- to many-flowered fascicle. Flowers bisexual, actinomorphic, calyx 2- or 4-lobed, corolla campanulate, urceolate or funnel-shaped, 4-lobed, valvate in bud, stamens 4, inserted at base of tube, exserted, ovary inferior, 2-celled, 1-ovuled, style 2-lobed or 2-branched. Fruit a capsule, tipped with floral remnants, dehiscing with 2 valves, valves at base remaining attached to each other, septa detaching from the valves or not. Seed plano-convex, ventrally with a longitudinal groove. Seedling with epigeal germination.

Growth and development *Borreria* can be found flowering throughout the year when sufficient water is available. *Borreria* is pollinated by insects, mainly thrips, but also by (stingless) bees, searching for honey.

Other botanical information *Borreria* is the largest genus in the tribe *Spermacoceae*, and is very problematic with regard to both generic and infrageneric classification. Many authors include *Borreria* (often also *Dioida*) in *Spermacoce* s. l., but as the status of some species treated here is not clear, they are kept in *Borreria*. Other authors keep at least the American *Borreria* species separate, but include *Dioida* at the subgeneric level only. *B. articularis* (L.f.) F.N. Williams is considered here as a synonym of *B. hispida*. According to some authors they belong to different species, representing the extremes of a complex species. *B. hispida* is in this case an erect herb, with terete stem, long spreading hairs, flexuous leaves, campanulate flowers, large fruits and seeds, while *B. articularis* is prostrate, with sharply 4-angled stem, scabrid hairs, normally flat leaves, funnel-like flowers and small fruits and seeds.

Ecology *Borreria* grows mainly in regions with a short or long dry period, on many soil types, often in regularly disturbed localities, but also in grasslands and in secondary forest.

Propagation and planting *Borreria* is propagated by seed. The seeds show little dormancy. A single plant of *B. laevis* may produce about 22 000 seeds under favourable growing conditions, and a life cycle can be completed in 3 months. Seed weight is about 18 mg/100 seeds.

Diseases and pests *Borreria* is a host for several nematode species. Larvae of some hawkmoths use *B. verticillata* as primary feed plant. In India, *B. hispida* is an off-season host for the larvae of the groundnut leaf miner (*Aproaerema modicella*). Many *Borreria* species are weeds in annual and perennial crops throughout the world.

Harvesting *Borreria* is harvested throughout the season, when needed. Normally, whole plants are pulled up.

Handling after harvest *Borreria* is used fresh, or dried in the shade for later use.

Genetic resources and breeding All *Borreria* species treated here have a large area of distribution, because of their weedy nature, and do not seem to be at risk of genetic erosion. There are no known breeding programmes of *Borreria*.

Prospects In general ipecacuanha alkaloids (emetine, chephaëline) and resembling alkaloids display some schistosomicidal activity. In this respect the alkaloids found in *Borreria* deserve more research, in order to evaluate their possibilities.

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Selection of species

Borreria hispida (L.) K. Schum.

Engl. & Prantl, Nat. Pflanzenfam. 4(4): 144 (1891).

Synonyms *Spermacoce hispida* L. (1753), *Spermacoce articularis* L.f. (1781), *Borreria articularis* (L.f.) F.N. Williams (1905).

Vernacular names Shaggy button weed (En). Indonesia: bulu lutung (Sundanese), gempur watu, kertas watu (Javanese). Malaysia: rumput susur, rumput setawar, rumput sumpu. Philippines: landrina (Tagalog), ligad-ligad (Sulu). Vietnam: d[aa]y ru[ooj]t g[af], rau chi[ee]n l[oo]ng.

Distribution From India to southern China and Japan, throughout South-East Asia.

Uses In Peninsular Malaysia and China, the leaves are applied in poultices to treat headache, and also to wounds or sores. In the Philippines, a decoction of the leaves is considered an astringent and used to treat haemorrhoids. A decoction of the roots is used as a mouthwash for toothache. In Taiwan, the aerial parts are taken as a febrifuge. In Indo-China, the plant is considered emetic. In India, a decoction of the root is used as an alterative. The seeds are considered cooling and demulcent, and are given in diarrhoea and dysentery.

Observations An annual to perennial, variable, creeping to erect, branched, short hairy herb, up to 15 cm tall, branches quadrangular, greenish or purplish, taproot stout; leaves spatulate or elliptical, sometimes ovate, 1–4.5 cm × 0.5–1.5 cm, apex rounded or acute, margin undulate or not; fascicles axillary, 4–6-flowered; calyx 4-lobed, linear-lanceolate, 2–4 mm long, corolla funnel-shaped, 5–10 mm long, pale blue or white, a ring of hairs inside, just above base of tube, lobes lanceolate, outside hairy; capsule ovoid, 4–5 mm long, hairy; seed variable, oblong, up to 3 mm long, granulate. *B. hispida* occurs behind beaches, in dry gardens, teak forests, along steep roadsides, on sandy soils, locally abundant, from sea-level up to 500 m altitude.

Selected sources 74, 135, 335, 786, 810, 838.

Borreria laevis (Lamk) Griseb.

Goett. Abh. 7: 231 (1857).

Synonyms *Spermacoce tenuior* L. (1753), *Spermacoce laevis* Lamk (1791).

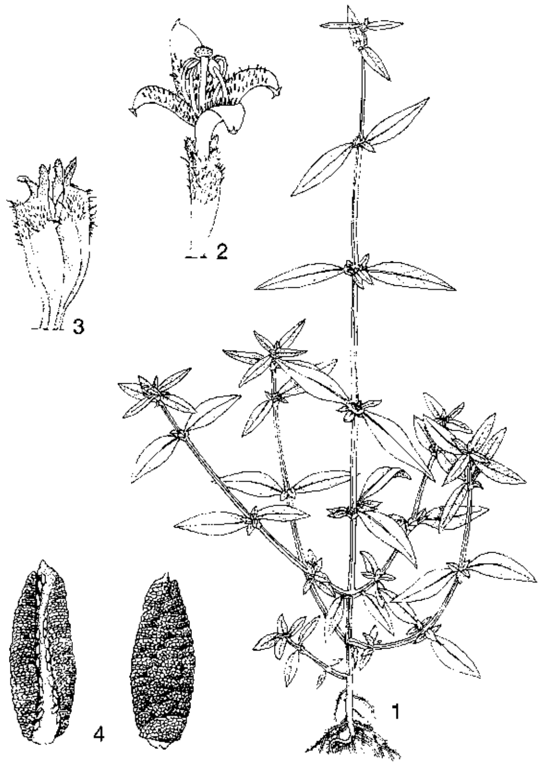
Vernacular names Indonesia: jugul, katumpang lemah (Sundanese). Papua New Guinea: kanan (Lalibu, Southern Highlands). Philippines: akupao. Vietnam: ru[ooj]t g[af] l[as] nh[awx]n.

Distribution Native to tropical America, nowadays almost pantropical, throughout South-East Asia, not recorded from Kalimantan.

Uses In Papua New Guinea, the leaves, mixed with the scraped roots of *Desmodium sequax*, rhizomes of wild ginger and ash, are applied for toothache. In the West Indies, a decoction of the plant is used for colds, and as an emmenagogue. The crushed plant is applied to cuts and burns.

Observations An erect, annual to perennial herb, mainly branched from the base, stems decumbent or ascending, 15–50 cm tall, normally conspicuously reddish-brown, slender, quadrangular or ribbed, taproot long, thin; leaves oblong-lanceolate, 2.5–6 cm × 0.8–2 cm, apex acuminate, glabrous, usually tinged dark purple, lateral veins conspicuous below; fascicles axillary, dense, filiform bracts between flowers visible, calyx narrowly obconical, sparsely hairy, 4-lobed, lobes narrow, 0.5–1 mm long, corolla funnel-shaped, about 3 mm long, white, tube glabrous inside, lobes ovate, often purplish-rimmed, inside sparsely hairy; capsule obconical, 2–3 mm long; seed oblong, 1.5–2 mm long, transversely wrinkled, brown. *B. laevis* occurs in regions with a short or pronounced rainy season, on sunny or lightly shaded localities, in grassland, along roadsides, in rice fields, often on hard soils, often abundant, from sea-level up to 1200(–2000) m altitude.

Selected sources 74, 696.



Borreria laevis (Lamk) Griseb. – 1, plant habit; 2, flower; 3, fruit; 4, seed, frontal and dorsal view.

Borreria ocymoides (Burm.f.) DC.

Prodr. 4: 544 (1830).

Synonyms *Spermacoce ocymoides* Burm.f. (1768).

Vernacular names Indonesia: katumpangan (Sundanese), balungan (Javanese), gofu sunyinga (Ternate). Malaysia: sajur babi. Philippines: siksik parang, landrina (Tagalog). Vietnam: ru[ooj]t g[af] d[aj]ng h[us]ng.

Distribution Tropical America, tropical Africa, India, Sri Lanka, continental Asia, South-East Asia and the Pacific Islands.

Uses The dried leaves smell strongly of coumarin. In Peninsular Malaysia, the leaves are applied in a poultice for headache. In Indonesia, the finely crushed leaves are applied to wounds. In Nigeria and Ivory Coast, the sap is used to treat eczema, worms and ringworm.

Observations An erect, annual herb, 25–60 cm tall, stems slender, quadrangular; leaves narrowly lanceolate or spathulate, 1–4 cm × 0.2–1.2 cm, base tapering, apex acute, veins prominent, rough beneath; fascicles axillary, 3–4-flowered, and terminal, 6–8-flowered; calyx (2–)4-lobed, 1.5 mm long, lobes obconical, slightly dented, apex acute, glabrous or slightly hairy, corolla campanulate, minute, up to 1.5 mm long, white or pink tinged, lobes oblong, inside tube slightly hairy, stamens almost sessile; capsule ovoid, 1.5–2 mm long, glabrous or sparsely pubescent; seed ovoid, 1.2 mm long, reticulate, dark brown. *B. ocymoides* occurs in waste places, disturbed soil, along canals and marshes, in grassy fields and along roads, from sea-level up to 650–1400 m altitude.

Selected sources 74, 134, 135, 137, 696, 786.

Borreria verticillata (L.) G. Mey.

Prim. fl. esseq.: 83 (1818).

Synonyms *Spermacoce verticillata* L. (1753), *Spermacoce globosa* Schum. & Thonn. (1827).

Distribution Native of tropical America, now also distributed in Africa, Indo-China, and rather rare in South-East Asia.

Uses In Java, it was formerly cultivated for its emetic and stomachic properties. In Africa and Mexico, the leaves are reputed to be used for treating skin problems such as lepra, furuncles and ulcers. In Ivory Coast and Central America, an infusion of the leaves is used for diarrhoea, but also as a purgative. They are diuretic and applied for schistosomiasis, kidney problems, fever and blennorrhagia.

Observations A perennial bushy herb or subshrub, 30–120 cm tall, sometimes sprawling, young stems quadrangular, tough, internodes long; leaves 2–4 together, narrowly lanceolate, 1–4.5 cm × 0.2–0.5 cm, acute at both ends, margins scabrous, midvein prominent, rough underneath; fascicle terminal and axillary, dense, head-like; calyx 2-lobed, cuspidate, 1–1.4 mm long, corolla campanulate, 1.5–2.5 mm long, inside pilose at base, white, sometimes tinged red; capsule obovoid, compressed, 1.5–2.5 mm long, wrinkled, shortly pubescent; seed oblong, with a longitudinal groove, brown. *B. verticillata* occurs in thickets, fields and waste places, often as a weed.

Selected sources 134, 135, 696, 838, 855.

L.M. Noriel

Breynia J.R. Forster & J.G. Forster

Char. Gen. Pl., ed. 1: 73 (1775).

EUPHORBIACEAE

x = unknown; *B. fruticosa*, *B. vitis-idaea*: $2n = 52$

Major species *Breynia discigera* Müll. Arg., *B. racemosa* (Blume) Müll. Arg., *B. vitis-idaea* (Burm.f.) C.E.C. Fischer.

Origin and geographic distribution About 30 species of *Breynia* are found in tropical Asia, Malesia, Australia, the western Pacific Islands, and New Caledonia. However, the genus has never been properly revised and the actual number of species may even be as many as 50.

Uses The main medicinal application of the various *Breynia* species is the use of the leaves as a poultice to relieve various pains and illnesses. The leaves of *B. discigera* are applied as a poultice in combination with either *Justicia gendarussa* Burm.f. leaves or cumin seeds (*Cuminum cyminum* L.) over the kidneys to relieve kidney disorders. In Peninsular Malaysia a poultice of *B. racemosa* leaves, sometimes with turmeric (*Curcuma longa* L.) added, is used to treat headache, mumps, swellings in general, various skin diseases and as a febrifuge in children. Pickled in vinegar the leaves are applied for blotches on hands and feet. The sap of the leaves and roots is credited with antiseptic properties. In the Philippines the bark of *B. vitis-idaea* is used as an astringent to arrest haemorrhages. In India, the dried leaves are smoked like tobacco for tonsilitis. In Papua New Guinea, the squeezed leaves of *B. vestita* Warb. are rubbed over the body to relieve malarial and other fevers. A decoction of the bark of *B. pubescens* Merr. from the Moluccas is drunk to relieve stomach complaints. Some mention is made of *B. coronata* Hook.f. from Peninsular Malaysia and Borneo being used in traditional medicine in Borneo. In India *B. vitis-idaea* is reported as a good hedge plant. The young leaves of various species are sometimes eaten as a vegetable. The wood is used for general construction purposes and utensils.

Production and international trade Freshly collected *Breynia* material is most likely to be for home consumption or traded in local markets only.

Properties Very little is known about the phytochemistry and pharmacology of *Breynia*. In an in vitro screening assay using a human lymphoblastoid cell line harbouring the Epstein-Barr virus genome, extracts of *B. coronata* Hook.f. showed tumour-promoting activity at a concentration of 0.2–1.2 μg/ml.

Description Shrubs or small trees, sometimes scramblers, monoecious; indumentum of simple hairs. Leaves simple, distichous, usually glabrous, drying blackish, especially above; petiole short; stipules present. Inflorescence an axillary fascicle. Flowers small; calyx 6-lobed; petals and disk absent. Staminate flowers urceolate to bell-shaped; calyx lobes small, on inside with small scales closing flower when immature; stamens 3, united into a column, anthers along the column; pistillode absent. Pistillate flowers flatter, more dish-like, 3-locular, styles often absent, seldom united, stigmas when without style in an apical depression, erect, split. Fruit a small fleshy capsule, up to 5 mm wide, red, tardily dehiscent into 6 parts, in some species calyx enlarged, apical depression often showing as a corona, styles and or stigmas persistent. Seed triangular in transverse section, blackish, covered by a thin aril.

Other botanical information An overall revision of *Breynia* for South-East Asia is needed to clarify the status of some of the names in use.

Ecology *Breynia* is found in a variety of vegetation types, from the understorey of evergreen forest to swamp forest and mangrove to deciduous scrubs and savanna, often in secondary growth and along rivers and roads. The species are found in per-humid conditions and in areas with a seasonal dry period, from sea-level up to 2500 m altitude. The soils are usually sand, sandstone or alluvial soils.

Propagation and planting As a rule only material from wild plants of *Breynia* is collected for medicinal purposes, but its occurrence along roads may be due to some selective planting or sowing.

Harvesting The leaves, which are most often collected, are available throughout the year and they are collected from wild specimens, which may be locally very common. The quality of the leaves may be lower during the dry season.

Handling after harvest The leaves of *Breynia* are used fresh.

Genetic resources and breeding The *Breynia* species of medicinal importance are relatively widespread and also found in disturbed habitats. Therefore the risk of genetic erosion appears to be limited. No germplasm collections or breeding programmes are known to exist.

Prospects At present the use of *Breynia* is very limited. The effectiveness of its applications has never been properly tested.

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Selection of species

Breynia cernua (Poiret) Müll. Arg.

in DC., Prod. 15(2): 439 (1866).

Synonyms *Phyllanthus cernuus* Poiret (1804), *Melanthesa rubra* Blume (1825), *Breynia rubra* (Blume) Müll. Arg. (1866).

Vernacular names Indonesia: gembiran (general), imer (Javanese), gamer (Sundanese). Papua New Guinea: pilpil (Raluana, East New Britain), pipul (Vunapope, East New Britain), giligili (Losuia, Trobriand Islands). Philippines: matangulang (Tagalog), bagbagotot (Iloko), tintug (Sulu).

Distribution The Philippines, Java eastward to New Guinea including the Aru Islands, northern Australia and the Solomon Islands.

Uses In Java the pounded leaves are applied to swollen legs. In New Guinea the leaves are heated in salt water and mixed with lime and then rubbed on sores and ulcers. A poultice of hot leaves is applied to relieve body pains. Leaf sap is drunk to soothe coughs. An infusion of the bark is used to cure dysentery. Patients with malaria and diarrhoeal complications are washed with a hot solution of boiled leaves of a mixture of plants including *B. cernua*, to induce sweating, thereby reducing malarial symptoms.

Observations A shrub or treelet, up to 2(–7) m tall, glabrous; leaves ovate, 1.7–6.5 cm × 1.2–3.7 cm, length width ratio 1.3–2.1, base attenuate to cuneate, apex obtuse to bluntly acute, margin entire, flat, papery, light green above, tinged glaucous underneath, petiole 1.5–4 mm long, stipules 1.5–2.5 mm long; staminate flowers 1–1.5 mm in diameter, pedicel 2.5–4 mm long, calyx about 1–1.5 mm long, very thick, green, lobes rim-like, androphore 0.7–1 mm high, anthers about 0.7 mm long; pistillate flowers about 3.5 mm in diameter, pedicel about 1.7 mm long, calyx about 2.8 mm long, flat, accrescent in fruit up to 11 mm in diameter, red, lobes about 1.7 mm wide, ovary with stigmas very short, undivided; fruit about 3.5–4 mm × 6–7 mm, red turning black when mature; seed 2.5 mm × 3.3 mm × 2 mm. *B. cernua* is a very variable species, the most typical characters being the accrescent pistillate calyx and ovate leaves. It is usually encountered in very disturbed, anthropogenic habitats, and also in coastal vegetation, often on limestone, up to 450 m altitude.

Selected sources 33, 36, 407, 418, 425, 671, 786.

Breynia discigera Müll. Arg.

in DC., Prodr. 15(2): 440 (1866).

Synonyms *Breynia rhamnoides* (Blume) Müll. Arg. var. *pubescens* (Müll. Arg.) Müll. Arg. (1866).

Vernacular names Malaysia: katut selayer, saga monyit, semelit jekok.

Distribution Peninsular Thailand southwards to Singapore and Sumatra.

Uses In Pahang, Peninsular Malaysia, leaves are used in poultices to relieve kidney disorders.

Observations A shrub or treelet, up to 2 m tall, tomentose all over; leaves ovate to elliptical, 1.3–3.8 cm × 0.8–2 cm, length width ratio 1.6–1.9, base acute, apex acute, margin recurved, coriaceous, dark green above, very light pale green beneath, petiole 1–2 mm long, stipules 1.5–2 mm long; staminate flowers about 1.5 mm in diameter, pedicel about 0.5 mm long, calyx dull pinkish-white, about 1.7 mm × 1.5 mm, very thick, lobes about 0.3–0.4 mm long, androphore about 1 mm high, anthers about 0.8 mm long; pistillate flowers 4–5 mm in diameter, pedicel about 1.5 mm long, calyx 2.1–2.8 mm long, dull pinkish-white, lobes 1.5–2.2 mm wide, only hairy outside, ovary about 1 mm × 1.3 mm in diameter, apically lobed, stigmas about 0.2 mm long, not united, not split, pointing towards each other; fruit about 7 mm × 6.5 mm, with small apical crown, red; seed about 4 mm × 2 mm × 2 mm, orange. *B. discigera* is found in open thickets and margins of secondary forest at 30–300 m altitude.

Selected sources 31, 135, 786.

Breynia fruticosa (L.) Hook.f.

Fl. Brit. India 5: 331 (in obs.) (1887).

Synonyms *Melanthesa chinensis* Blume (1825), *Melanthesopsis lucens* (Poiret) Müll. Arg. (1863), *Melanthesopsis fruticosa* (L.) Müll. Arg. (1866).

Vernacular names Vietnam: b[oof] cu v[ex], d[or] d[oj]t.

Distribution From China southward to Indo-China and Thailand, possibly Malaysia.

Uses In Indo-China a decoction of the leaves is used as an antiseptic wash to clean cuts and sores.

It is used in a similar way in southern China.

Observations A shrub or tree up to 5 m tall, glabrous; leaves ovate, 2.2–7.7 cm × 1.2–3.3 cm, length width ratio about 2.3, base broadly cuneate, apex long acute to acuminate, margin often recurved, coriaceous, petiole 2–3 mm long, stipules 1.2–2.2 mm long; staminate flowers 2.6–3 mm in diameter, pedicel 3.5–4.4 mm long, calyx 2.6–3.2 mm × 2.6–3 mm, yellowish to orange, lobes 0.3–0.4 mm long, androphore 2–2.2 mm high, anthers 1.2–1.4 mm long; pistillate flowers few together, 3–4 mm in diameter, pedicel 0.8–1.7 mm long, calyx 2.2–3.7 mm long, greenish, lobes 1.3–2.4 mm wide, overlapping, ovary cylindrical, 1.2–1.7 mm × 0.9–1 mm, apically often lobed, stigmas 1–1.2 mm long, free, reflexed in older flowers, often split apically; fruit flattened globose, 5–7.5 mm × 6.2–8 mm, yellowish with a narrow apical crown; seed 4.6–5 mm × 3 mm × 3 mm, red. *B. fruticosa* is found in the understorey of mixed evergreen or deciduous forest, scrub vegetation, forest margins, roadsides and along rivers on various soils, from 300–1300 m altitude.

Selected sources 31, 739, 786, 788.

Breynia racemosa (Blume) Müll. Arg.

in DC., Prod. 15, 2: 441 (1866).

Synonyms *Breynia rhamnoides* (Blume) Müll. Arg. var. *hypoleuca* (Müll. Arg.) Müll. Arg. (1866), *Breynia acuminata* (Müll. Arg.) Müll. Arg. (1866), *Breynia reclinata* (Roxb.) Hook.f. (1887).

Vernacular names Papua New Guinea: mus-mus (Taskul, New Hanover). Philippines: matang-ulang (Tagalog), karmai (Iloko). Thailand: kangpla.

Distribution Thailand, Peninsular Malaysia, Sumatra, Java, Sumbawa, Timor, Borneo, the Philippines and New Guinea.

Uses In Peninsular Malaysia the leaves are used extensively for poulticing. The sap of crushed leaves and roots is added to water and used as a mouthwash for children. In Papua New Guinea, a cooled decoction of the leaves is used as a skin wash to treat rashes and skin eruptions. Leaves are sometimes added to drinking water of cage birds as a sort of tonic.

Observations A scandent shrub or tree up to 9 m tall, glabrous; leaves ovate, 1.9–2.9 cm × 1.2–1.7 cm, length width ratio 1.6–1.7, base rounded, apex obtuse, mucronulate, margin recurved, coriaceous, petiole 1.5–2 mm long, stipules about 1.3 mm long; staminate flowers unknown; pistillate flowers 1.7–3.5 mm in diameter, pedicel 0.5–1.8 mm long, calyx 1–1.8 mm long, lobes 0.7–1 mm wide, ovary obconical, about 1.3 mm in diameter, apically lobed, stigmas about 0.2 mm long, not united, not split, pointing towards each other; fruit flattened globose, about 5 mm × 5.8 mm, sometimes a bit spiny, with narrow apical crown, red; seed about 4 mm × 2.3 mm × 2.3 mm, orange. The New Guinea plants (var. *aromatica* Airy Shaw) usually have larger leaves. *B. racemosa* is found in scrub, forest edges and along paths near beach forest, from sea-level up to 2500 m altitude.

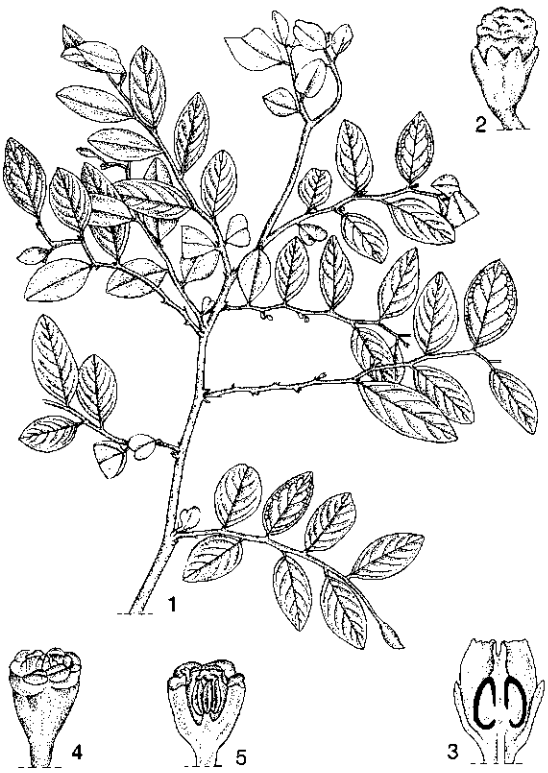
Selected sources 31, 32, 33, 36, 135, 671.

Breynia vitis-idaea (Burm.f.) C.E.C. Fischer

Kew Bull.: 65 (1932).

Synonyms *Breynia rhamnoides* (Willd.) Müll. Arg. (1866), *Breynia officinalis* Hemsley (1894), *Breynia microcalyx* Ridley (1920).

Vernacular names Malaysia: hujan panas, semomah, seruyan. Philippines: matang-ulang (Tagalog), sungut-olang (Bisaya), santing (Sulu). Thailand: kaangplaa thale, phak wan tua phu. Vietnam: c[uf] d[eef].



Breynia vitis-idaea (Burm. f.) C.E.C. Fischer – 1, twig; 2, female flower; 3, female flower in longitudinal section; 4, male flower; 5, male flower with calyx partly removed.

Distribution From India eastward to the Philippines and southward to Peninsular Malaysia.

Uses In the Philippines the bark is used as an astringent to arrest haemorrhages. In Pahang, Peninsular Malaysia, the leaf juice is given after childbirth.

Observations A shrub or treelet up to 3 m tall, glabrous; leaves ovate, 2.3–5.5 cm × 1.3–3.1 cm, length width ratio 1.8–2, base obtuse, apex obtuse, mucronulate, margin flat, papery, petiole 2–4 mm long, stipules about 2 mm long; staminate flowers 1.3–1.8 mm in diameter, pedicel 3.5–5 mm long, calyx 1.5–2 mm × 1.3–1.8 mm, relatively thin, greenish, lobes about 0.3 mm long, androphore 1 mm high, anthers 0.8 mm long; pistillate flowers 1.6–5.3 mm in diameter, pedicel 2.5–4 mm long, calyx 1.3–2.8 mm long, greenish, lobes 0.4–2.2 mm wide, ovary cylindrical, about 2 mm × 1 mm, apically lobed, stigmas about 0.2 mm long, not united, not split, pointing towards each other; fruit ovoid to globose, 4.6–6.3 mm × 4.6–6.7 mm, sometimes a bit spiny, with narrow apical crown, red; seed 3–4.5 mm × 1.8–2.5 mm × 1.7–2.5 mm. *B. vitis-idaea* is usually found scattered, in forest edges and clearings in evergreen forest, mangrove, swamp forest, bamboo thickets, along rivers and roads and near the beach, from sea-level up to 800 m altitude.

Selected sources 31, 36, 128, 135, 671, 810.

P.C. van Welzen

Caesalpinia L.

Sp. pl. 1: 380 (1753); Gen. pl. ed. 5: 178 (1754) ('Caesalpina').

LEGUMINOSAE

$x = 11, 12, 14$; *C. coriaria*, *C. crista*, *C. sappan*: $2n = 24$; *C. decapetala*: $2n = 22, 24$; *C. pulcherrima*: $2n = 24, 28$

Major species *Caesalpinia bonduc* (L.) Roxb., *C. sappan* L.

Origin and geographic distribution *Caesalpinia* comprises about 100 species and is pantropical. There are 18 species indigenous in Malesia, and 1 species indigenous in the Solomon Islands (*C. solomonensis* Hattink). Three species have been introduced in South-East Asia and are now widespread (*C. coriaria*, *C. pulcherrima*, *C. sappan*) and 2 are occasionally cultivated (*C. spicara* Dalz., *C. spinosa* (Molina) Kuntze).

Uses The traditional medicinal uses of *Caesalpinia* species vary considerably. In general, various plant parts of numerous species are used as a tonic, anthelmintic, antipyretic and for their astringent properties; some are used as emmenagogue.

A decoction of the leaves of *C. latisiliqua* (Cav.) Hattink (synonym *Mezoneuron latisiliquum* (Cav.) Merr.) is given for relief of asthma in the Philippines. In Vietnamese folk medicine, the roots and leaves of *C. minax* Hance are considered analgesic and sedative, and prescribed for insomnia, various pains, and also used as a gargle for toothache.

Production and international trade *Caesalpinia* products are primarily traded in local markets. Statistics on international trade are not available.

Properties The effects of a leaf extract of *C. bonduc* on calcium metabolism and cholinergic receptors were studied on isolated pregnant rat myometrium preparations. The effects were comparable to those obtained with acetylcholine. Isometric contractions were recorded, and the contractile force in the isolated strips increased with the concentration of the extract. Further pharmacological experiments suggest the existence of cholinergic receptors sensitive to the extract (constituents), which could influence the influx of calcium (phasic contraction) and mobilization of calcium from cellular stores (tonic contraction). Both of these are responsible for the increase of contractile activity and development of the contraction of uterine smooth muscle.

Hypoglycaemic, antihyperglycaemic and hypolipidaemic activities of the aqueous and 50% ethanolic extracts of *C. bonduc* seeds were studied in normal and streptozotocin-diabetic rats. In normal rats, both extracts exhibited hypoglycaemic activity as early as 4 hours after administration of a dose of 100 mg/kg. The hypoglycaemia produced by the aqueous extract was of prolonged duration when compared to the hydro-ethanolic extract. In diabetic rats, both extracts produced a significant antihyperglycaemic effect from day 5 onwards. The aqueous extract also exhibited antihypercholesterolemic and antihypertriglyceridemic effects in streptozotocin-diabetic rats. An isoflavonoid bonducellin and several diterpenes, including bonducellpin, bonducin, caesaldekarin, caesalpin, caesalpinin, were isolated.

Seed of *C. coriaria* yield 9.1% of a fixed oil, containing 4.9% cyclopropenoid fatty acids, which have known co-carcinogenic properties. Oven-dried fruits of *C. coriaria* at 2500 ppm were 100% effective in controlling the snails *Lymnaea luteola* and *Gyraulus convexiusculus* within 24–72 h. Methanolic herbal extracts showed algicidal activity when tested in ponds: precipitation of algal proteins due to hydrolysable and condensed tannins may be involved.

A 50 mg/kg dose of *C. crista* seed powder, its equivalent of a methanolic extract, or piperazine (200 mg/kg) were found equally effective in treating ascarid infection in poultry. The crudes eed powder appears to be more potent and safer than its methanol extract on the basis of the side effects observed. A single oral dose of powdered *C. crista* seeds (4 g/kg body weight) reduced faecal egg counts in buffalo calves naturally infected with *Neoascaris vitulorum* by 91% after 10 days and 100% after 15 days, without adverse effects.

The sterol mixture from the heartwood of *C. sappan* (campesterol 11.2%, stigmasterol 18.9% and β-sitosterol 69.9%), and some further isolated compounds (e.g. brazilin, brazilein and protosappanin E) showed a strong anticomplementary activity in vitro. Of the latter, the pharmacological effects of the phenolic compound (catechol derivative) brazilin ((6aS-cis)-7,11b-dihydobenz[b]indeno[1,2-d]pyran-3,6a,9,10(6H)-tetrol) were studied in more detail.

Based on the fact that immunomodulation during the initial stage of autoimmune diseases is an effective wau of preventing or controling these diseases, the effects of brazilin on the altered immune functions in the early phase of halothane intoxication of C57BL/6 mice were investigated. Treatment of halothane-caused hepatitis by an autoimmune-mediated process, and significantly increased the delayed type hypersensitivity (DTH)response, and mitogen (ConA, LPS)induced proliferation of splenocytes, while suppressor cell activity and mixed lymphocyte reaction were decreased, and IgM plaque forming cell titers (PFCs) were not significantly changed. Upon treatment with brazilin, all these parameters tested were changed to normal, although brazilin also significantly increased IgM PFCs to a higher than normal level. At the cellular level (e.g. T cells), brazilin decreased splenic cellularity and IL-2 production which had been augmented in mice treated with halothane for 4 consecutive days, whereas the reduced expression of IL-2 receptors by ConA or standard IL-2 was increased by this compound.

Brazilin was found to have a hypoglycaemic action and increase glucose metabolism in experimental diabetic animals. In order to investigate the mechanism of the hypoglycaemic action, its effects on glucose transport, insulin receptor autophosphorylation, and protein kinase C(PKC) activity in 3T3-L1 cells were studied. Brazilin increased basal glucose transport in 3T3-L1 fibroblasts and adipocytes, although insulin-stimulated glucose transport was not influenced. Autophosphorylation of the partially purified insulin receptor was not affected by brazilin treatment in 3T3-L1 fibroblasts, but the compound decreased PKC activity in 3T3-L1 fibroblasts and adipocytes. The hypothesis that brazilin might require Ca^{2+} for its glucose transport-stimulating action was also investigated by the use of calcium modulators such as nifedipine, verampamil and A23187. From these experiments it was suggested that calmodulin and the maintenance of the intracellular Ca^{2+} concentration, rather than an increase in it, may be essential for the stimulatory action of brazilin on glucose transport.

Other pharmacological effects of extracts of *C. sappan* include antibiotic activity against *Staphylococcus* 209P, *Salmonella typhi*, *Shigella flexneri*, *Shigella dysenteriae* and *Bacillus subtilis* of a decoction of the wood. A *C. sappan* extract was found to be a potent agent for inactivating human sperm in vitro. Exposure of sperm from healthy donors to this agent showed remarkably reduced sperm motility. The antimotility effect of *C. sappan* is concentration-dependent and about 2.5 mg/ml is required to reduce motility to 50% of that of the control medium (EC_{50}).

The ethanolic extract of the aerial parts of *C. decapetala* administered orally on days 1–8 post-coitum at 500 mg/kg dose exhibited significant contraceptive activity in female hamsters, but was devoid of any oestrogenic activity. On fractionation, the activity was found to be localized in the butanol and aqueous fractions. Caesaljapin, a cassane triterpenoid isolated from the roots of *C. decapetala* showed inhibitory activity against the anaphylactic contraction in taenia coli of guinea-pigs sensitized by anti-egg albumin rabbit IgE.

Water extracts of *C. digyna* leaves demonstrated antifungal activity against *Trichophyton tonsurans*, *T. rubrum*, *T. simii*, *Trichosporon beigelii*, *Microsporum fulvum* and *M. gypseum*.

Several cassane-type furanoditerpenes, called caesaldekarins have been isolated from the roots of *C. major*; caesaldekarin A inhibited mitogen responses of mouse spleen cells and interleukin-1 production. Pulcherrimins A and B (diterpene dibenzoates), as well as cassane-type furanoditerpenes, isolated from the roots of *C. pulcherrima*, were active against the DNA repair-deficient mutant of the yeast *Saccharomyces cerevisiae*.

Lectins isolated from the seeds of *C. pulcherrima* showed in vivo antitumour activity against EAC or S-180 in mice, and the ethanol extract of the flowers is reported to have molluscicidal activity.

Description Small to medium-sized trees, shrubs, lianas or scramblers, usually armed with spines or prickles. Leaves alternate, usually paripinnate, rachis often prickly, leaflets opposite or alternate, sessile or petiolate. Inflorescence an axillary, supra-axillary or terminal panicle or raceme. Flowers unisexual or bisexual, 5-merous; sepals free, imbricate, usually unequal, the lowest one hood-shaped; petals free, unequal, the upper one different in shape and size; stamens 10, free, equal or alternately unequal, filaments hairy at base; pistil sessile or shortly stalked; ovary pubescent or glabrous, 1–10-ovulate, style slender, stigma funnel-shaped or bilobed. Fruit a pod, dehiscent or indehiscent, thin or thick, winged or wingless, sometimes spiny or twisted or furrowed. Seed orbicular, ellipsoid or reniform. Seedling with epigeal germination, cotyledons rounded, thick.

Growth and development *Caesalpinia* species flower and fruit throughout the year. Peak flowering may occur in the rainy season. Flowers and fruits can be present simultaneously. Growth performance varies greatly in *Caesalpinia*. *C. sappan* may start producing flowers after 1 year, whereas *C. coriaria* only starts flowering 5–7 years after sowing.

Other botanical information *C. bonduc*, *C. crista* and *C. major*, mentioned in the literature are often misapplied names, partly for their close resemblance and for nomenclature reasons. Whereas *C. bonduc* and *C. major* are sometimes difficult to tell apart, *C. crista* is very different.

Ecology *Caesalpinia* is mostly found in scrub vegetation, sometimes in coastal habitats and rarely in primary forest. Most species prefer a seasonally dry climate, but some are also found in per-humid conditions. They are found on a wide range of soils from sea-level up to 1700(–2000) m altitude. Seeds of *C. bonduc* can float and retain their viability in water for extended periods.

Propagation and planting *Caesalpinia* species are usually propagated by seed. Mechanical scarification or sulphuric acid treatment is necessary to overcome the seed coat imposed dormancy of the often very hard seeds of *Caesalpinia*, e.g. *C. decapetala* and *C. digyna*. Fresh seed of *C. pulcherrima* germinates readily in 2 weeks, without pretreatment. *C. pulcherrima* is also propagated by in vitro techniques. Shoot formation of nodal explants from trunk sprouts is most successful in Murashige and Skoog (MS) media containing naphthalene acetic acid (NAA) and cytokinin, whereas root formation is most prolific in MS media containing indole acetic acid (IAA) and cytokinin.

Husbandry *Caesalpinia* used for its wood is usually managed as coppice. The climbing, thorny *Caesalpinia* species in particular are often cultivated in hedges.

Diseases and pests No serious diseases or pests are recorded. Some fungi are known to attack *C. coriaria*: *Fomes lucidus*, *Micropeltis domingensis* and *Zignoella caesalpinia*. *Auricularia auricula-judae* and *Meliola caesalpinia* have been observed in *C. sappan*.

Harvesting *C. sappan* managed as coppice is usually harvested every 6–8 years, whereby a stump of 1 m height is maintained. Mature pods of other *Caesalpinia* can be collected from the plant or picked up after they have dropped from the tree.

Handling after harvest Wood of *Caesalpinia* is cut in pieces of about 6 cm length and split to facilitate drying. Seeds are simply dried and stored for later use.

Genetic resources and breeding Most of the medicinally important *Caesalpinia* species have large areas of distribution and are often found in disturbed habitats. In addition, several species are commonly cultivated for their ornamental value, so the risk of genetic erosion appears rather limited. Germplasm collections and breeding programmes are not known to exist.

Prospects Several extracts of *Caesalpinia* show very interesting pharmacological effects, e.g. modulation cholinergic receptors, hypoglycaemic and antihyperglycaemic activity, complement inhibition and contraceptive and sperm motility reducing activity, which all merit further research. The effects of brazilin, isolated from the wood of *C. sappan*, are quite well studied. More research is needed to fully evaluate its potential as a lead compound in future medicine.

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Carthy, P.M. (Editor): Flora of Australia. Vol. 12. Mimosaceae (excl. Acacia), Caesalpiniaceae. Australian Government Publishing Service, Canberra, Australia. pp. 59–66. |4| Oh, S.R., Kim, D.S., Lee, I.S., Jung, K.Y., Lee, J.J. & Lee, H.K., 1998. Anticomplementary activity of constituents from the heartwood of Caesalpinia sappan. Planta Medica 64(5): 456–458. |5| Sharma, S.R., Dwivedi, S.K. & Swarup, D., 1997. Hypoglycaemic, antihyperglycaemic and hypolipidemic activities of Caesalpinia bonducella seeds in rats. Journal of Ethnopharmacology 58(1): 39–44. |6| Shih, I.M., Chiang, H.S., Yang, L.L. & Wang, T.L., 1990. Antimotility effects of Chinese herbal medicines on human sperm. Journal of the Formosa Medical Association 89(6): 466–469.

Selection of species

Caesalpinia bonduc (L.) Roxb.

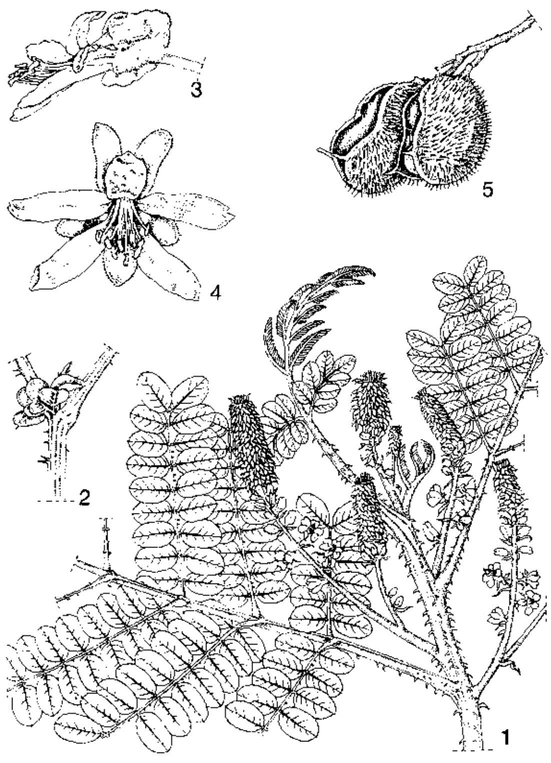
Fl. ind. (Carey ed.), 2: 362 (1832), p.p. excl. pl. descr.

Synonyms *Guilandina bonduc* L. (1753), *Caesalpinia bonducella* (L.) Fleming (1810).

Vernacular names Bonduc nut, fever nut (En). Indonesia: kemrunggi (Javanese), areuy mata hiyang (Sundanese), kate-kate (Ternate). Papua New Guinea: kurere (Garara, Oro Province). Philippines: kalumbibit (Tagalog), sabinit (Bikol), singor (Iloko). Thailand: waat (peninsular). Vietnam: m[os]c m[ef]o, vu[oos]t h[uf]m.

Distribution *C. bonduc* is a pantropical species. It is found throughout Malesia, although it is noticeably scarce in the rain forest areas of Sumatra, Borneo, the Philippines and western New Guinea.

Uses In the Philippines, the seeds are used to soothe stomach disorders and as a mild purgative. Administered in powder form they are considered a febrifuge and tonic. In Thailand, the leaves are considered carminative, and are used in the treatment of abnormal urination. The leaves are also an ingredient of a famous cough formula. In Indonesia, the leaves or pounded seeds are employed as an anthelmintic. In Papua New Guinea, a decoction of the leaves is prescribed as an antidepressant for mentally disturbed persons. In large doses the plant is believed to be poisonous. In Fiji, the young leaves are also employed as an anthelmintic for children. A decoction of the leaves is used to treat sinusitis, and of the roots for fatigue. In India, the leaves and bark are considered emmenagogue, febrifuge and anthelmintic. The seed has a reputation as a tonic and antipyretic.



Caesalpinia bonduc (L.) Roxb. – 1, flowering twig; 2, node with pinnate stipules; 3, male flower side view; 4, male flower frontal view; 5, part of infructescence.

Observations A liana up to 15 m long, branchlets usually armed; leaves paripinnate, rachis 15–80 cm long, with 6–11 pairs of pinnae, pinna 8–20 cm long, stipules pinnately or 3–5-lobed, up to 20 mm long, subpersistent, leaflets opposite to subopposite, 6–9(–12) pairs per pinna, base rounded, apex rounded to acute; raceme or panicle supra-axillary or terminal, 30–60 cm long, flowers unisexual, sepals 7–10 mm × 2–3 mm, petals 7–10 mm × 2–3 mm, clawed, ovary with 2 ovules; pod 6.5–9 cm × 3.5–4.5 cm, covered with long hairy spines, 1–2 seeded, dehiscent; seed ovoid, smooth, grey. *C. bonduc* can be found in a variety of coastal habitats, including back mangal, especially in disturbed sites, but also occurs inland chiefly in secondary forest up to 800 m altitude. *C. bonduc* and *C. major* are often confused or misidentified.

Selected sources 135, 143, 256, 407, 585, 637, 789, 790, 810, 867, 1008, 1038.

Caesalpinia coriaria (Jacq.) Willd.

Sp. pl. ed. 4, 2: 532 (1799).

Vernacular names Divi divi (En). Indonesia: dewi. Thailand: tanyong (Bangkok).

Distribution *C. coriaria* originates from Central and South America and was introduced and is now cultivated in South-East Asia.

Uses The pods and bark are said to be antiperiodic. A decoction of the pods is used in the treatment of haemorrhoids, and an infusion for dressing sores. In Thailand, the roots are used as an antipyretic and for the treatment of abscesses and chronic wounds. The bark or pods are employed dressing wounds.

Observations A shrub or small tree up to 10 m tall, unarmed; leaves often imparipinnate, with 4–8 pairs of pinnae, stipules minute, subulate, leaflets 15–28 pairs per pinna, base obliquely subcordate, apex rounded to truncate; raceme axillary or terminal, short, condensed, almost sessile, 2–6 cm long; flowers bisexual, fragrant, sepals 3–4 mm long, petals 3–6 mm long, yellow or cream; pod 3–6 cm × 1.5–3 cm, inflated, often twisted, 1–10-seeded.

Selected sources 72, 81, 135, 215, 256, 407, 585, 602, 1038.

Caesalpinia crista L.

Sp. pl. 1: 380 (1753) p.p.

Synonyms *Caesalpinia nuga* (L.) W.T. Aiton (1811).

Vernacular names Indonesia: kemrunggi, rembete (Javanese), mata hiyang (Sundanese). Papua New Guinea: kait (Gunantuna, East New Britain). Philippines: bakaig (Tagalog), binit (Bikol). Thailand: thephee (peninsular)(for *C. nuga*), sawaat (central), waat (peninsular) (for *C. crista*). Vietnam: chi[ee]ng chi[ees]ng.

Distribution *C. crista* can be found in coastal areas from India and Sri Lanka, eastward to the Ryukyu Islands, throughout South-East Asia to Queensland and New Caledonia. In Malesia it is not found in East Sumatra and East Borneo.

Uses In the Philippines, a decoction of crushed seeds is used as an emetic and credited with antidysenteric properties. In Papua New Guinea, the fruits are externally applied in the treatment of rash. In Indonesia, the roots are used in the treatment of kidney stones. In India, the root is considered a diuretic, a tonic and useful in the treatment of bladder stones.

Observations A liana up to 15 m long, branchlets variably armed; leaves paripinnate, rachis 10–30 cm long, with 2–4(–5) pairs of pinnae, pinna 2.5–8(–12) cm long, stipules triangular, minute, caducous, leaflets opposite, 1–3(–5) pairs per pinna, base acute, margin curved, apex acute to obtuse; panicle axillary or terminal, 20–40 cm long; flowers bisexual, sepals 6–8 mm × 2–4 mm, petals 5–10 mm × 4–5 mm, clawed, ovary with 1–2(–3) ovules; pod stipitate, 4–7 cm × 2.5–3.5 cm, unarmed, 1(–2)-seeded, indehiscent; seed ovoid, black. *C. crista* is found on river banks, sandy beaches, in and behind the sandy parts of mangroves, on chalk and limestone, generally at low altitudes, rarely up to 350 m.

Selected sources 39, 135, 215, 256, 407, 418, 485, 585, 810, 1008, 1038.

Caesalpinia decapetala (Roth) Alston

Handb. fl. Ceylon, 6 (suppl.): 89 (1931).

Synonyms *Caesalpinia sepiaria* Roxb. (1832), *Caesalpinia japonica* Siebold & Zucc. (1845).

Vernacular names Mysore thorn (En). Indonesia: areuy mata hiyang gunung, secang lembut (Sundanese). Philippines: puto (Igorot). Thailand: krachaai (central). Vietnam: vu[oos]t h[uf]m, m[os]c di[eef]u.

Distribution *C. decapetala* is found in temperate and tropical regions from the Himalayas southward and eastward to Sri Lanka and South-East Asia, and northward and eastward to China, Korea and Japan. In Malesia it is not recorded for Borneo, the Moluccas or New Guinea; sometimes naturalized where it has been introduced.

Uses In Indo-China, the roots are employed as a purgative. In India, the bruised leaves are applied to burns. In China, the seeds are credited with astringent, anthelmintic, analgesic, antipyretic, and antimalarial properties. In Japan, the roots are used to treat neuralgia. Seeds and roots are also applied as insecticide.

Observations A shrub or liana up to 25 m tall, branchlets armed; leaves paripinnate, rachis 7–38 cm long, with 3–10 pairs of pinnae, pinna 2.5–7 cm long, stipules obliquely ovate-semicordate, leaflets opposite, 5–12 pairs per pinna, base rounded, apex truncate to retuse; raceme axillary or terminal, 15–32 cm long, flowers bisexual, sepals 6–10 mm × 3–4 mm, petals 6.5–13 mm × 4–8 mm, ovary with 8–10 ovules; pod 6.5–11 cm × 2.5–3 cm, 4–9 seeded, dehiscent; seed ellipsoid, black. *C. decapetala* is found in open grasslands, scrubland and forest fringes at 1000–1700(–2000) m altitude; sometimes cultivated at lower altitudes and then often running wild.

Selected sources 135, 256, 521, 585, 602, 720, 748, 810.

Caesalpinia digyna Rottler

Ges. Naturf. Freunde Berlin Neue Schrift. 4: 200, tab. 3 (1803).

Synonyms *Caesalpinia oleosperma* Roxb. (1832).

Vernacular names Teri pods (En). Cambodia: khvaw bânla. Laos: kachaay. Thailand: kamchaai (northern), khee raet (central), ngaai (peninsular). Vietnam: m[os]c m[ef]o xanh, vang xanh.

Distribution *C. digyna* is found in temperate and tropical regions from the Himalayas southward and eastward to Sri Lanka and South-East Asia, and northward and eastward to China. In Malesia, it is found in Peninsular Malaysia, Sumatra, Java and the Lesser Sunda Islands.

Uses In Indo-China, the pounded bark is used as a fish poison. In India, the root being astringent is given internally in phthisis, scrofula and diabetes.

Observations A liana, scandent shrub or small tree up to 10 m tall, branchlets armed; leaves paripinnate, rachis 17–23 cm long, with 8–13 pairs of pinnae, pinna 4–5 cm long, unarmed, stipules minute, subulate, caducous, leaflets opposite, 7–12 pairs per pinna, base oblique-truncate, apex truncate; panicle axillary or terminal, 30–40 cm long; flowers bisexual, sepals 3–8 mm × 2–5 mm, petals 5–8 mm × 3–8 mm, clawed, ovary with 2–4 ovules; pod 3–5 cm × 1.5–2 cm, constricted between the seeds, 1–3(–4)-seeded, indehiscent; seed subglobose, dark brown. *C. digyna* can be found in rather dry open habitats up to 250 m altitude in Malesia.

Selected sources 135, 215, 256, 274, 585, 602.

Caesalpinia major (Medik.) Dandy ex Exell

Journ. Bot. 76: 180 (1938).

Synonyms *Caesalpinia bonduc* auct. non (L.) Roxb., *Caesalpinia jayabo* Maza (1890).

Vernacular names Indonesia: kemrunggi (Javanese), areuy mata hiyang (Sundanese), katekate (Ternate). Cambodia: kouat (kampot). Thailand: waat (peninsular). Vietnam: vang l[as] l[ows]n.

Distribution *C. major* is found in the Caribbean and fringing parts of the Americas, Madagascar, from India eastward to the Ryukyu Islands, throughout the Pacific Islands,South-East Asia and Queensland (Australia). In Malesia it is not found in the rain forest areas of Sumatra, Borneo, the Philippines, Sulawesi or New Guinea.

Uses In Indonesia, a decoction of the roots is used as a tonic and as an anthelmintic, as well as to treat rheumatism and backache. In Fiji, the root is likewise used as a tonic. In Cambodia, the roasted and ground seeds are drunk as a kind of coffee to cure respiratory illnesses.

Observations A liana up to 15 m long, branchlets armed; leaves paripinnate, rachis up to 75 cm long, with 3–8 pairs of pinnae, pinna 10–30 cm long, stipules subulate, minute, leaflets opposite to subopposite, 3–7 pairs per pinna, base acute to rounded, apex acute to acuminate; raceme or panicle supra-axillary, 10–50 cm long; flowers unisexual, sepals almost equal, 7 mm × 2 mm, petals 4–7 mm × 2–3 mm, clawed, ovary with 4 ovules; pod 5–13 cm × 4–6 cm, hairy, covered with variably densely hairy bristles, 2–4-seeded; seed sub-globular, yellow. *C. major* can be found in a variety of coastal habitats, thickets, disturbed places as well as primary forest up to 1000(–1400) m altitude.

Selected sources 135, 143, 256, 407, 541, 585, 1008, 1038.

Caesalpinia pulcherrima (L.) Swartz

Observ. bot.: 66 (1791).

Synonyms *Poinciana pulcherrima* L. (1753).

Vernacular names Peacock flower (En). Indonesia: bunga merak, kembang merak, kembang patra. Philippines: bulaklak ng paraiso (Tagalog), caballero (Tagalog, Sp). Cambodia: dok fang, kan gok meas, fang ham. Thailand: khwaang yoi (eastern), som pho (northern), haang nokyuung thai (central). Vietnam: di[eej]p ta, di[eej]p c[us]ng, kim ph[uw][owj]ng.

Distribution *C. pulcherrima* originates in tropical America, and is now found throughout the tropics. Cultivated throughout South-East Asia and naturalized in some regions.

Uses In general a decoction or infusion of roots, bark, leaves or flowers is used as a purgative and emmenagogue. According to the dosage it may be used as a mouthwash for teeth or gums, a remedy for colds and fevers, or even as a strong abortifacient. In Papua New Guinea, the roots are used as an abortifacient, whereas the leaves are taken to relieve constipation. In Vietnam, the roots are used as an emmenagogue in folk medicine. *C. pulcherrima* is a popular ornamental throughout the tropics.

Observations A shrub or small tree up to 5 m tall, branches unarmed or with a few straight prickles; leaves paripinnate, rachis 10–40 cm long, with 5–9 pairs of pinnae, stipules subulate, minute, caducous, leaflets opposite, 6–12 pairs per pinna, base unequal, rounded, apex rounded to retuse; raceme or panicle axillary and terminal, 20–50 cm long; flowers bisexual, sepals 10–15 mm

× 5–7 mm, petals 10–25 mm × 6–8 mm, stamens very far exserted, ovary with 8–12 ovules; pod 6–12 cm × 1.5–2 cm, 8–10-seeded; seed slightly rectangular, brown or black. *C. pulcherrima* is locally naturalized in Malesia.

Selected sources 135, 241, 256, 407, 418, 585, 739, 778, 810, 818, 1038, 1069.

Caesalpinia sappan L.

Sp. pl. 1: 381 (1753).

Synonyms *Biancaea sappan* (L.) Todaro (1876).

Vernacular names Sappanwood, Indian redwood (En). Sappan, brésillet des Indes (Fr). Indonesia: kayu secang, soga jawa (Javanese), secang (Sundanese). Malaysia: sapang (Murut, Sabah). Philippines: sapang (Tagalog, Bisaya, Ilokano), sibukau (Tagalog, Bisaya, Sulu). Cambodia: sbeng. Thailand: ngaai (south-western), faang (general). Vietnam: vang, vang nhu[ooj]m, t[oo] m[ooj]c.

Distribution The origin of *C. sappan* is unknown. It is cultivated and naturalized in many parts of South-East Asia, as well as Africa and the Americas.

Uses A decoction or infusion of the wood is generally considered a strong emmenagogue and astringent. It is used to cure tuberculosis, diarrhoea and dysentery, and also used as a vulnerary. The seeds serve as sedative. In Thailand, the wood is used as a blood tonic, in the treatment of pulmonary diseases, as an expectorant and emmenagogue. A few drops of wood extract in drinking water is considered refreshing, due to the fragrance and colour it imparts. In Vietnam, it is considered an emmenagogue, haemostatic, and is prescribed in haemoptysis and post-partum haemorrhages. In Sabah, a decoction of the bark is drunk as a tea to treat tuberculosis and lumbago. The red dye extracted from the heartwood is used for colouring cotton, silk, wool and matting. In some countries it is used as a colouring agent for food.

Observations A shrub or small tree up to 10 m tall; branchlets usually armed with recurved prickles; leaves paripinnate, rachis 25–40 cm long, with 9–14 pairs of pinnae, pinna 6–15 cm long, stipules 3–4 mm long, caducous, leaflets opposite, 10–20 pairs per pinna, base obliquely truncate, apex retuse or rounded; panicle supra-axillary or terminal, 10–40 cm long; flowers bisexual, sepals 7–10 mm × 4 mm, petals 9–12 mm × 6–10 mm, the upper one smaller, ovary with 3–6 ovules; pod flat oblongoid-obovoid, 6–10 cm × 3–4 cm, 2–5-seeded, dehiscent, glabrous; seed ellipsoid, brown or black.

Selected sources 135, 196, 256, 264, 407, 418, 528, 538, 585, 602, 810, 867, 1038.

Caesalpinia sumatrana Roxb.

Fl. ind. (Carey ed.), 2: 366 (1832).

Synonyms *Mezoneuron sumatranum* (Roxb.) Wight & Arnott ex Miq. (1855).

Vernacular names Malaysia: darah belut, kelichi rimba (Peninsular). Philippines: siit.

Distribution *C. sumatrana* is found in the Peninsular Malaysia, Sumatra, Borneo, Java, New Guinea and the Solomon Islands.

Uses In Peninsular Malaysia, a decoction of the leaves is used as a vermifuge, and for intestinal complaints in general. It is also given after childbirth.

Observations A liana up to 20 m long, branchlets sometimes armed with up to 5 mm long prickles; leaves paripinnate, rachis 30–50 cm long, with 4–8 pairs of pinnae, stipules early caducous, leaflets alternate, 7–12 pairs per pinna, base cuneate to truncate, apex retuse or rounded; panicle supra-axillary or terminal, 30–80(–100) cm long; flowers bisexual, calyx tube 6–15 mm × 4–8 mm, red, lobes 2–10 mm long, petals 12–32 mm × 8–12 mm, pink, ovary with 2–4(–8) ovules; pod 10–17 cm × 3–6 mm, winged, 1–8-seeded; seed ellipsoidal, brown. *C. sumatrana* occurs in lowland forest and forest fringes up to 1000 m altitude.

Selected sources 135, 256, 810, 1038.

B. Ibnu Utomo

Callicarpa L.

Sp. pl. 1: 111 (1753); Gen pl. ed. 5: 127 (1754).

VERBENACEAE

$x = 8, 9$; *C. japonica*: $2n = 32, 36$, *C. longifolia*: $2n = 36$, *C. macrophylla*: $2n = 34$

Major species *Callicarpa candicans* (Burm.f.) Hochr., *C. formosana* Rolfe, *C. longifolia* Lamk.

Vernacular names Beauty berry (En).

Origin and geographic distribution *Callicarpa* comprises some 150 species which are mainly distributed in East and South-East Asia, followed by tropical and temperate America, tropical Australia and some Pacific Islands. It is not found in Africa or Europe, except under cultivation. In the New World there are fewer native species, of which about 20 occur in Cuba. The highest concentration of species is in the Philippines and on Cuba.

Uses Throughout South-East Asia numerous *Callicarpa* are used externally for poulticing or internally for various afflictions. Sometimes external and internal applications are combined in e.g. the treatment of an upset stomach. Several species are used as a fish poison e.g. *C. erioclona* Schauer in the Philippines. This species is also mentioned as a cure for itch. *C. arborea* Roxb. (synonym *C. tomentosa* auct. non (L.) Murray) is primarily used for its timber. In Peninsular Malaysia, its pounded leaves are used to poultice sores, and the juice is drunk to relieve stomachache. *C. macrophylla* Vahl is applied in Indian folk medicine for the treatment of stomach disorders and malarial fever, and heated leaves are applied on rheumatic joints to relieve pain. *C. macrophylla*, indigenous in the region, and *C. japonica* Thunb. from temperate Asia, are primarily grown as ornamentals in South-East Asia.

Production and international trade *Callicarpa* is only used on a local scale.

Properties The leaves of *C. candicans* contain callicarpone, a component 10 times as toxic to fish as a rotenone reference. It is assumed that callicarpone, which is an abietane-type diterpene, will act in a similar way as an insecticidal agent as does rotenone, an isoflavone derivative from *Derris elliptica* (Wallich) Benth. Structure-activity relationships of callicarpone were examined by synthesizing a series of simple analogues bearing certain of its structural features. Compounds were tested for insecticidal and antimicrobial activities. Examples include piperitone oxide which showed approximately 1/100th the activity of rotenone against *Daphnia magna*, 1 (α-hydroxyisopropyl)-3-oxocyclohexene oxide which showed fungicidal activity against *Mycobacterium*, while 2,3,4, 6,7,8-hexahydronaphthalene-1,4-dione showed inhibitory activity against *Mycobacterium* and 2 yeasts. This indicates that at least the epoxide and ketone functions of the callicarpone are involved in its biological activities.

A 1% benzene extract from *C. japonica* shows strong in-vitro antifeedant activity towards the third-instar larvae of *Spodoptera litura* using the leaf disk method. In addition, a flavone, 5,6, 7-trimethoxyflavone, isolated from *C. japonica*, was subjected to antiviral assays. The compound exhibited relatively high inhibitory effects on herpes simplex virus type 1 (HSV-1), human cytomegalovirus and poliovirus. The anti-HSV-1 action was not due to the inhibition of virus adsorption, entry or viral protein synthesis, but might involve, at least in part, a virucidal activity, which results in a suppression of viral binding to host cells at an early replication stage. The flavone and acyclovir were synergic in their anti-HSV activities at levels below the 50% inhibitory concentrations for antiviral activity. Furthermore, a modified syncytia formation inhibition assay using recombinant virus vPE 16 and $CD4^+$ HeLa cell revealed that extracts of *C. japonica* contain anti-HIV compounds.

Ether, ethanol and chloroform extracts of the leaves of *C. formosana* showed strong in vitro inhibition of *Bacillus subtilis* using the disk agar diffusion method. The presence of triterpenes (ursolic acid derivatives) and phytosterols is reported.

Description Small trees, shrubs or undershrubs, evergreen or deciduous; stem and branches almost cylindrical, variously hairy. Leaves decussate, simple, reticulate-veined; petiolate; stipules absent. Inflorescence axillary or supra-axillary, cymose, in the axils of the upper leaves; pedunculate. Flowers usually bisexual, usually 4-merous, actinomorphic, bracteate; calyx tubular to campanulate, persistent; corolla campanulate to tubular, spreading; stamens 4(–5), inserted at base of corolla tube, alternating with the corolla lobes; ovary superior, 4-locular, 4-seeded. Fruit a small globose drupe, variously coloured, endocarp consisting of 4 undivided pyrenes. Seed exalbuminous. Seedling with epigeal germination; cotyledons emergent; hypocotyl elongated.

Growth and development In South-East Asia *Callicarpa* flowers and fruits throughout the year. The fruits of most species are said to be devoured extensively by birds and seed dispersal is thus effected.

Other botanical information The Malesian *Callicarpa* species are poorly known botanically and in need of a thorough taxonomic revision. Traditionally *Callicarpa* has been included in the *Verbenaceae* subfamily *Viticoideae*, as is done so here. However, current research suggests that those genera within *Viticoideae* characterized by their cymose inflorescences, should now be included within the *Labiatae*. Some of the uses attributed to one of the closely resembling species *C. candicans*, *C. longifolia* and *C. macrophylla* may equally apply to all of them.

Ecology *Callicarpa* can be found from sea-level on isolated islands to high alpine habitats in the Himalayas. Within South-East Asia, *Callicarpa* occurs scattered in rain forest, up to 2300 m altitude. Several species are also found in secondary forest or as understorey trees.

Propagation and planting Probably most, if not all *Callicarpa* species can be grown from cuttings.

Harvesting Shoots, leaves and roots of *Callicarpa* are collected whenever needed.

Handling after harvest Usually *Callicarpa* is used fresh, however, leaves can be dried for future use.

Genetic resources and breeding As *Callicarpa* is botanically poorly known, it is difficult at present to assess the conservation of its genetic resources. There are no records of ex-situ conservation.

Prospects The anti-insecticidal properties of callicarpone, and the antiviral activities of 5,6,7-trimethoxyflavone are interesting, and merit further research in order to fully evaluate their future possibilities.

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Selection of species

Callicarpa candicans (Burm.f.) Hochr.

Candollea 5: 190 (1934).

Synonyms *Callicarpa cana* L. (1771).

Vernacular names Indonesia: apu-apu (Sundanese), meniran kebo, (Javanese), sesepo (Lampung). Malaysia: tampang besi, tampang besi merah. Philippines: tigau (Bisaya, Bikol, Tagalog), palis (Tagalog), anuyup (Ibanag, Iloko). Cambodia: sroul kraham. Laos: dok pha nok. Vietnam: n[af]ng n[af]ng, tr[uws]ng [ees]ch, pha t[oos]p.

Distribution From southern China westward to eastern India and southward throughout South-East Asia to tropical parts of Australia and the Pacific.

Uses In Peninsular Malaysia, a decoction of the young leaves is drunk to relieve abdominal troubles and amenorrhoea. In Java, the leaves are used for poulticing wounds to prevent swelling and on boils. An infusion is used as an emmenagogue. In the Philippines, the leaves are pounded and used as a fish poison. The leaves are smoked to relieve asthma. The leaves are externally applied as a plaster for gastralgia. In Vietnamese folk medicine, a decoction of roots and leaves is prescribed to women after parturition to restore appetite. Externally a decoction is employed as a wash for ulcers and boils.

Observations An evergreen shrub or small tree, 1–4(–6) m tall, stem and branches greyish-brown tomentose; leaves very variable, elliptical-oblong, lanceolate or ovate-rotundate, (7–)10–20 cm × (2.5–)4–9(–11) cm, base cuneate, apex shortly acuminate, margin serrate-dentate, glandular and densely stellate tomentose beneath, stellate pubescent above when young, petiole 0.6–3(–4) cm long, stellate tomentose; cyme stellate tomentose, primary peduncle shorter than the petiole, 0.5–1

Callicarpa candicans (Burm. f.) Hochr. – 1, flowering and fruiting twig; 2, detail of inflorescence; 3, flower; 4, opened flower.

cm long; flowers subsessile, calyx minutely 4-toothed, 1–1.5 mm long, glandular and stellate hairy outside, corolla mauve or violet, tube 2 mm long, lobes broadly ovate, 3–3.5 mm long, with a few glands, stamens exserted, ovary globose, glabrous, glandular all over, style exserted, 5–6 mm long; drupe depressed globular, 2 mm in diameter, almost succulent, glabrous, glandular, mauve, purple or deep red. *C. candicans* is found in grasslands, brushwood, thickets, village groves and secondary forest, from sea-level up to 1000 m altitude.

Selected sources 74, 135, 207, 407, 739, 788, 810.

Callicarpa caudata Maxim.

Bull. Acad. Imp. Sci. Saint-Pétersbourg 31: 76 (1887).

Vernacular names Papua New Guinea: mamen (Mt. Hagen, Western Highlands). Philippines: anayop (Igorot, Bontok), haray-hai (Negrito), kabatit (Bagobo).

Distribution From the Philippines southward to the Moluccas, New Guinea, Solomon Islands and Australia (Queensland); its range possibly extends to China, Sulawesi and Timor.

Uses In the Philippines, a decoction of fresh or dried leaves is used as a cure for stomach trouble. In Mt. Hagen, Papua New Guinea, the leaves are externally applied to relieve earache.

Observations An evergreen shrub up to 4 m tall, stem and branches glandular, densely clothed with whitish-yellow or feruginous tomentum of simple septate hairs; leaves narrowly lanceolate, 8.5–20.5 cm × (2–)3–5(–6) cm, base rounded, truncate or cordulate, apex long-tapering caudate, margin dentate, reddish-yellow glands on both surfaces, densely tomentose beneath with ferruginous stellate-dendriform hairs, pubescent above with simple septate hairs, petiole 0.3–1.5 cm long, floccose tomentose with ferruginous simple hairs; cyme ferruginous tomentose, primary peduncle longer than the petiole, 0.5–2(–2.5) cm long; flowers pedicellate, calyx minutely 4-toothed, 1–1.5 mm long, glandular and with long simple hairs outside, corolla mauve, tube 2 mm long, lobes broadly ovate, 1 mm long, glabrous all over, stamens exserted, ovary globose, glabrous, glandular all over, style exserted, 4 mm long; drupe globular, 2 mm in diameter, glabrous, glandular, pink. *C. caudata* is closely related to *C. pilosissima* Maxim. from Taiwan. In the Philippines *C. caudata* is found on steep open slopes, in thickets and in stream depressions from 1200–2000 m altitude.

Selected sources 418, 810.

Callicarpa formosana Rolfe

Journ. Bot. 20: 358 (1882).

Synonyms *Callicarpa blancoi* auct. non Rolfe.

Vernacular names Philippines: palis (Tagalog), tigau (Bisaya, Bikol, Tagalog), anuyup (Ibanag, Iloko). Vietnam: n[af]ng n[af]ng d[af]i loan.

Distribution From southern China, Japan, Taiwan and Vietnam to the Philippines.

Uses In the Philippines, the leaves are locally used to relieve difficulty in breathing. They are rolled into cigarettes which are considered to have a sedative effect on asthma. Fresh and crushed the leaves are also used to stupefy fish, shrimp and eels. In Taiwan, crushed flower and leaf buds are applied as a styptic to wounds. The root is employed as remedy for gonorrhoea and as an emmenagogue, the whole plant to treat hepatitis.

Observations A deciduous or evergreen shrub up to 4 m tall, stem and branches densely clothed with brownish or greyish tomentum of stellate or dendriform hairs; leaves variable, elliptical, ovate to rhomboid, 7–18 cm × 3–11 cm, base cuneate, obtuse or rounded, apex acute to acuminate, margin serrulate to dentate, sparsely glandular, and loosely to subdensely pubescent with stellate and dendriform hairs above, densely glandular, and densely tomentose beneath with stellate hairs, petiole 1–2 cm long, densely dendriform hairy; cyme tomentose, primary peduncle as long as the petiole, 1–2 cm long; flowers subsessile, calyx shallowly 4-toothed, about 1 mm long, glandular and densely stellate hairy outside, corolla purplish pink or rarely white, tube 2 mm long, lobes obtuse to rounded, stamens exserted, ovary globose, glabrous or with a few hairs at the top, glandular all over, style exserted; drupe globose to ellipsoid up to 4 mm in diameter, glabrous, glandular, purple. *C. formosana* is found in thickets, roadsides and secondary forest from sea-level up to 2300 m altitude.

Selected sources 188, 190, 380, 786, 810.

Callicarpa longifolia Lamk

Encycl.1(2): 563 (1785).

Synonyms *Callicarpa albida* Blume (1826), *Callicarpa blumei* Zoll. & Mor. (1846).

Vernacular names Indonesia: katumpang (Sundanese), meniran sapi (Javanese), dama besoi (Aceh). Malaysia: tampang besi, tampang besi puteh. Papua New Guinea: topapimanua, vuti mata (Gunantuna, East New Britain). Vietnam: t[uwr] ch[aa]u tr[aws]ng, t[uwr]ch[aa]u l[as] d[af]i.

Distribution From India eastward throughout South-East Asia to Australia (Queensland); its range possibly extends to Indo-China, China, Bhutan, and Peru.

Uses In Peninsular Malaysia, the leaves are widely used for poulticing and for rubbing over the body in fever, and are also applied to swellings. A decoction of the leaves is drunk in colic, after parturition and for fever. An infusion of the roots is mentioned as a remedy for syphilis. Various parts, prepared in different ways, are prescribed as a remedy for sprue. In Indonesia, a decoction of the roots is mentioned as a cure for diarrhoea and colic. Pounded leaves are an ingredient for a poultice to mature boils and ulcers. An infusion of the leaves is drunk as a depurative after parturition. Pounded leaves are used to stupefy fish. In East New Britain, the leaves are externally applied on wounds to an ulcerated mouth and to reduce fever, swellings and bruises. The leaves or roots are internally applied to treat diarrhoea.

Observations An evergreen shrub or small tree, 2–4(–6) m tall, stem and branches densely stellate hairy, glabrescent; leaves elliptical-oblong, lanceolate or oblong, 7–18 cm × 2.5–6.5 cm, base cuneate, apex with a long point, margin serrate, glandular and tomentose beneath, often slightly brownish-rusty, almost glabrous or sprinkled with very short hairs above, petiole 0.7–2(–2.5) cm long, stellate hairy; cyme densely stellate hairy, glabrescent, primary peduncle shorter than the petiole, 0.3–1.3(–1.7) cm long; flowers subsessile, calyx minutely 4-toothed, 1–1.5 mm long, densely glandular and floccose outside, corolla white, tube 1.5 mm long, lobes broadly ovate, 0.5–1 mm long, with a few glands, pubescent, stamens exserted, ovary globose, with a few hairs at the top, glandular all over, style exserted, 4–6 mm long; drupe globular, 1.5–3 mm in diameter, almost succulent, with a few hairs at the top, glandular, white. *C. longifolia* is an extremely variable and polymorphic species often confused with other *Callicarpa*. It is found in brushwood, thickets, village groves and secondary forest from sea-level up to 1700 m altitude.

Selected sources 67, 74, 135, 207, 407, 418.

Callicarpa pedunculata R.Br.

Prodr.: 513 (1810).

Synonyms *Callicarpa cuspidata* Roxb. (1820).

Vernacular names Indonesia: meniran (Javanese), ringan-ringan (Balinese), memeniran (Moluccas).

Distribution From Indo-China, Malaysia and throughout Indonesia and Papua New Guinea to tropical parts of Australia; its range possibly extends to eastern India and southern China.

Uses In the Moluccas, the roots are credited as an antidote for poisonous fish, crabs and toadstools. A decoction of the roots is an ingredient of a poultice used to mature boils and ulcers. An infusion of the leaves, together with leaves of *Ocimum basilicum* L., is drunk after parturition and as an emmenagogue.

Observations An evergreen shrub or small tree, (2–)3–4(–6) m tall, stem and branches densely tomentose with yellowish-brown or ferruginous stellate-dendriform hairs; leaves ovate, ovate-lanceolate or oblong-ovate, (5–)6–18 cm × 3–6(–8) cm, base rounded, truncate or subcordate, apex long-acuminate, margin serrate-dentate, glandular and densely brownish tomentose beneath with stellate-dendriform hairs, sparsely pubescent with simple hairs above, petiole 0.5–0.8(–1.5) cm long, densely dendriform tomentose; cyme rather lax, densely tomentose, primary peduncle longer than the petiole, 0.8–1.8(–2.7) cm long; flowers subsessile, calyx minutely 4-toothed, 1–1.5 mm long, densely glandular and stellate-dendriform outside, corolla purple or mauve, tube (2–)2.5–3 mm long, lobes almost orbicular, 1 mm long, stamens exserted, ovary globose, glabrous, glandular especially at the top, style exserted 5–8 mm long; drupe globular, 2–3.5(–4) mm in diameter, almost succulent, glandular chiefly at the top, pale mauve or violet-purple. *C. pedunculata* is found in forest margins and grasslands, from sea-level up to 2000 m altitude.

Selected sources 407, 688.

J.L.C.H. van Valkenburg & N. Bunyapraphatsara

Calotropis R.Br.

Asclepiadeae 28 (1810); Mem. Wern. Nat. Hist. Soc. 1: 39 (1811).

ASCLEPIADACEAE

$x = 11$; *C. gigantea*, *C. procera*: $2n = 22$

Major species *Calotropis gigantea* (L.) Aiton f., *C. procera* (Aiton) Aiton f.

Vernacular names Giant milkweed, swallow wort (En). Arbre à soie (Fr).

Origin and geographic distribution *Calotropis* is a small genus of 3 species, distributed throughout the Old World tropics. Two species occur from tropical Africa to Malesia, the third, *C. acia* F. Ham., is restricted to India, Bangladesh and Nepal. Both *C. gigantea* and *C. procera* are now pantropical, initially cultivated but often escaped, particularly in arid locations.

Uses *Calotropis* species generally have similar uses. Many uses originate from India, and have spread to Africa, South-East Asia and South America. The whole plant is used for skin diseases, boils and sores and as a tonic and purgative in small doses, and as an emetic in larger doses. The powdered root bark is used to cure dysentery, elephantiasis, and leprosy. The stem bark is diaphoretic and expectorant, and is used for dysentery, spleen complaints, convulsions, osteomyelitis, lumbago, scabies, ringworm, pneumonia, and protracted labour. The latex is used on stings, toothache, caries, ringworm, leprosy, syphilis, rheumatism and tumours, and also as an antiseptic, vermifuge, emetic and purgative, as well as for poisoning arrows. The powdered flowers are given for coughs, colds and asthma. The leaves are applied on burns, headaches and rheumatic pains, and as a tincture for intermittent fever. In Vietnam, leaves are taken as a cardiotonic, and a decoction of leaves is used in asthma, with a delayed effect of 2–3 days, or sometimes up to 7–8 days. Secondary effects are tiredness, diarrhoea and vomiting. In Ambon, treatments for snake bites include chewing the root of *C. gigantea*, swallowing the juice, and applying the mashed root to the bite. In Java, the powdered roots mixed with rice are rubbed on tired feet, and the smoke from burning leaves is inhaled for catarrh. In Thailand, the flowers are applied to skin diseases. In Curaçao and the Bahamas, the fresh leaves of *C. procera* are bound to the head to relieve headache, and to the feet for sprains and swellings. Crushed leaves are heated and smeared on rheumatic or stiff limbs.

In the past both *C. gigantea* (Madar fibre) and *C. procera* (French cotton or Akund) were cultivated and used as a source of a strong fibre, and their seed floss was used for packing, as it was too short and too light for spinning. They have also been tested for use in the paper pulp fabrication, and as a source of methane, through anaerobic fermentation. *Calotropis* species are not often used as fuel wood, as they are of poor quality. In Indo-China, charcoal from the wood was used in gun powder and fireworks. *Calotropis* produces many leaves, which can be used for mulching, green manuring of rice fields and for binding sandy soil. In Vietnam, *C. gigantea* is planted as a hedge plant. In Africa, the wood is also used as a toothbrush. The gynostegium is used by the Chinese in Indonesia in sweetmeats. In the Philippines, *C. gigantea* is not medicinally used, but the flowers are strung into rosaries. In Thailand, the flowers are used in wedding ceremonies, due to the name 'rak', which means love.

Production and international trade *Calotropis* is not traded internationally in South-East Asia but is readily available for local use, as it is commonly grown in the villages. The leaves are widely sold in local markets.

Properties All parts of *C. gigantea* are toxic, due to the presence of several cardiac glycosides (cardenolides). The latex contains the cardenolides calotropin, calotoxin and uscharin (which has been patented), as well as the proteolytic enzyme calotropain. The cardiac glycosides calotroposide A and B have been identified in the root bark, together with the resinols β-calotropeol and giganteol. Giganteol, α- and β-calotropeol were also isolated from the stem, as well as β-calotropeol from the flowers. In addition, the leaves contain the cardenolides calotropine and gigantine, and the roots calotropine, frugoside and 4'-O-β-D-glucopyranosylfrugoside.

Cardiac glycosides are also the toxic components of *C. procera*. The latex contains cardenolides such as calotropin, calotroposide, calactin, calotoxin, uscharin, uscharidin, voruscharin and proceroside, and the proteolytic enzyme calotropain. The plant also contains the aglycone proceragenin, which has antibacterial properties.

Calotropin is a quick acting heart stimulant, and is known to be 15–20 times more poisonous than strychnine: minute amounts can cause death. In the cat, the cardiotonic actions of calotroposide, calotoxoside and uscharin are 83%, 76% and 58% of the action of ouabain, respectively. The lethal dose for calotropin is 0.12 mg/kg. In addition to cardiac glycosides, several triterpenes, cyclosadol, cycloart-23-ene-3β-25-diol, α-lactucerol and lupeol have been isolated.

Most phytochemical tests have been done with *C. procera*. Aqueous and alcoholic extracts of the root of *C. procera* initially produce a light depression, followed by a stimulation of the rate and force of myocardial contractions in isolated frog and rabbit hearts. They also produce marked vasoconstriction in frog and rat and a persistent rise in blood pressure in dog, which cannot be altered by sympathetic drugs. In goats, latex administered orally at doses of 1 ml/kg, or 0.005 ml/kg intravenously or intraperitoneally, caused death between 4 minutes and 4 days. The small doses given orally or intramuscularly, caused no death. Main features in the goats were nervous signs, frequent urination, frothing at the mouth, dyspnoea and diarrhoea. Lameness was observed in goats given latex via the intramuscular route. At the site of the injection haemorrhagic myositis occurred, and in general, haemorrhages, pulmonary cyanosis, enterohepatonephropathy and peritonitis were observed, as well as increased concentrations of cholesterol, urea and creatinine, and a decrease in the level of general protein. The toxicity of the latex was also tested in the black rat (*Rattus rattus*), which was fed bait, with a latex concentration of 5, 7.5 or 10% for a period of up to 10 days. It produced sedation, dyspnoea, weakness, weight reduction, anorexia, diarrhoea, bleeding from nose, eyes and anus, mild tetanic convulsions, collapse and death. The latex of both *Calotropis* species exhibits uterine stimulation in albino rats which may result in abortion.

Some literature reported that, in the case of *Calotropis* poisoning, demulcent and mucilaginous drinks like milk or rice-gruel should be given, and morphine and atropine administered to relieve pain. *Calotropis* is also known to cause allergic contact dermatitis, and the latex causes keratoconjunctivitis.

Further pharmacological activities of *C. procera* extracts include significant anti-ulcer activity against aspirin, indomethacin, ethanol, indomethacin + ethanol, or stress-induced ulcerations in rats, by the chloroform fraction of the root extract. Significant inhibition of gastric secretory volume and total acidity in pylorus ligated rats was also observed, as well as inhibition of the arachidonic acid metabolism induced by soya bean lipoxygenase, suggesting that the anti-ulcer activity might be attributable to the inhibition of 5-lipoxygenase.

An aqueous suspension of the dried latex was significantly effective as an anti-inflammatory in a carrageenin- and formalin-induced rat paw oedema model, as was the chloroform-soluble fraction from the roots in rats using the models of carrageenin-induced pedal oedema, cotton pellet granuloma and formaldehyde-induced arthritis. In addition, a significant analgesic potential was demonstrated using acetic acid-induced writhing in mice. The ethanol extract of the aerial parts was also tested in guinea-pig for its antipyretic, analgesic, anti-inflammatory, antibacterial, purgative and muscle relaxant activities, and showed significant antipyretic, analgesic and neuromuscular blocking activity. However, no significant anti-inflammatory or antibacterial activity was shown. Furthermore, an aqueous extract of the leaves and stem bark had significant cough-suppressing activities upon bronchial irritation by ammoniac in guinea-pigs, and a chloroform extract of the chloroform-soluble fraction from the roots caused a significant reduction in experimentally induced acute and chronic liver injury by carbon tetrachloride in rats. The alcoholic extract of the leaves of both *C. procera* and *C. gigantea* exhibited anticancer activity against human epidermal carcinoma of the nasopharynx in tissue culture, as did an ethanol extract of *C. procera* flowers on cultivated tumour-cells. Finally, the enzyme calotropain is said to be more active than papain, bromalein or ficin.

An extract of the leaves applied on rice had a marked molluscicidal activity against the golden apple snail in the Philippines, as well as against other snails elsewhere; this is caused by uscharin. The petroleum ether and acetone extract of the aerial parts show a marked effect on the mortality of late 3rd instar larvae of the mosquito *Culex quinquefasciatus*, and also in last instar larvae of the groundnut pest *Spodoptera litura*. The ethanol extract of the leaves shows the highest toxicity of all solvents used, against all life stages of the flesh fly (*Sarcophaga haemorrhoidalis*). The powder of the leaves showed mortality of the bruchid *Callosobruchus chinensis* feeding on stored seeds of cowpea (*Vigna unguiculata* (L.) Walp.), although the damage to the seeds was 7.6%, compared to malathion at 2.2%. The leaf extract showed high antifeedant activity against 3rd instar larvae of the teak skeletonizer (*Eutectona machaeralis*).

Several extracts of the leaves revealed strong antimicrobial activity in vitro against *Clostridium perfringens*, *Klebsiella ozaenae*, *Pseudomonas aeruginosa*, *Salmonella typhi* and *Streptococcus faecalis*, as well as other species. The latex showed similar activity against *Candida albicans*, *Escherichia coli*, *Klebsiella pneumoniae*, *Proteus vulgaris*, *Pseudomonas aeruginosa*, *Salmonella gallinarum* and *Staphylococcus aureus*. The ethanolic extract of the flowers significantly inhibited the growth of both gram-positive and gram-negative bacteria.

The latex, the aqueous or ethanol extract of the flowers or leaves, or chopped plant parts mixed in the soil, show strong nematicidal effects against *Helicotylenchus dihystera*, *Meloidogyne* spp., *Tylenchorhynchus brassicae* and other nematodes, as well as their egg masses. The latex inhibited activity in vitro and inhibited infection of tobacco mosaic virus, when sprayed on the leaf surface of tobacco before and after inoculation. It also inhibited 2 strains of watermelon mosaic virus. Apart from plant viruses, the leaf extract is also active against the herpes simplex type-1 and vesicular stomatitis viruses in humans. The leaf extract and latex are also active in vitro against several plant pathogens, including *Alternaria brassicicola*, *Colletotrichum capsici*, *Fusarium oxysporum*, *Rhizoctonia solani* and *Sclerotinia sclerotiorum*.

Adulterations and substitutes In Asia *C. gigantea* is used as a substitute for ipecacuanha (*Psychotria ipecacuanha* (Brot.) Stokes), from tropical America, as an effective cure for amoebic dysentery, but it has a stronger tendency to produce vomiting and depression. In Africa, lemon juice is sometimes used as a substitute for the latex of *C. procera* as a coagulant for making soft white cheese.

Description Erect, much-branched shrubs or small trees with abundant milky latex, covered with woolly hairs when young. Leaves opposite, thick, fleshy and broad, underneath with woolly tomentum, glands at leaf basis; petiole absent or short; stipules absent. Inflorescence composed of many-flowered, erect, axillary umbellate cymes, 1 per axil; peduncle present; pedicel present. Flowers 5-merous; calyx 5-lobed with many glands at the base on the inside; corolla broadly campanulate, deeply divided into 5 lobes, fleshy; staminal corona of gynostegium with 5 fleshy lobes enlarged at base into an upturned horn and auricles, stamens with filaments joined in a tube, anthers short, pollinia 5, pollinium sacs 2, united by 2 pendulous translator arms 2 mm long; stigma head flattened, 5-lobed. Fruit an aggregate of 2 dry follicles, each ovoid-oblong, curved on the outside, with a very oblique base and pointed tip, fleshy. Seeds many, flattened, ovoid, with an apical tuft of white silky hairs (coma), 2–3 cm long. Seedling with epigeal germination.

Growth and development *Calotropis* is fast growing, and flowers throughout the year, but especially during the hot season. It is primarily pollinated by bees, butterflies and wasps.

Other botanical information *Calotropis* belongs to the tribe *Asclepiadeae* of the subfamily *Asclepiadoideae*, and was known to contain 6 species, 3 of which are now considered a synonym of *C. procera*. The tribe is characterized by anthers with membranaceous tips and pollinaria with pendulous pollinia. Genetic variation is expressed in white-flowered forms of *C. gigantea*, and larger leaves of African *C. procera* plants than those from Asia.

Ecology *Calotropis* grows especially on littoral sandy soils and dry uncultivated land, with periodic dry periods.

Propagation and planting *Calotropis* can be grown from seed or stem cuttings. The seeds are spread by wind and water. Callus cultures of *C. procera* on Murashige and Skoog medium showed a marked increase in laticifer differentiation (10–30%) with increasing age of the cultures or when supplied with 1% of its own latex, or with the auxin indole acetic acid (IAA).

Husbandry In Thailand, a trial on plant spacing of *C. gigantea* for medicinal purposes showed that a spacing of 0.5 m × 0.5 m gave higher plants, whereas at 2 m × 2 m plants were wider, although the number of main branches did not differ significantly.

Diseases and pests The leaf hopper *Poecilocerus pictus* (*Orthoptera*) is a pest of *Calotropis* plants. The oleander aphid (*Aphis nerii*) and the caterpillars of the tiger butterfly (*Danaus chrysippus*) feed on *Calotropis*, using the cardenolides as a chemical defence mechanism. The nematodes *Meloidogyne incognita* and *M. javanica* are found on the roots of *Calotropis* in India, although the leaf extract kills them.

Harvesting The leaves of *Calotropis* are harvested throughout the year.

Yield At a spacing of 0.5 m × 0.5 m, *C. gigantea* reaches a maximum height of 166 cm in 1 year, producing 7.3 t fresh leaves (1.1 t dry leaves) and 56 kg latex per hectare.

Handling after harvest The leaves of *Calotropis* are cleaned with a cloth to remove the hairs, before being used fresh or dried in the sun.

Genetic resources and breeding The ease of growing *Calotropis* and its widespread occurrence in villages, in sandy areas and on seashores means that it is in no danger of genetic erosion. Small germplasm collections of *C. procera* exist in Wakehurst Place in the United Kingdom and in Maracay in Venezuela.

Prospects *Calotropis* species are considered very poisonous, due to the presence of cardiac glycosides. This toxicity will strongly limit its potential use in local medicine. Also, the patenting of the cardenolide uscharine has not led to its use as a medicine. Extracts of *Calotropis* species, however, display a range of interesting pharmacological activities, e.g. anti-ulcer and anti-inflammatory, which merit further research. In Thailand, the flowers of *C. gigantea* have economic potential as ornamentals used in ceremonies.

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Selection of species

Calotropis gigantea (L.) Aiton f.

Hort. kew. 2, 2: 78 (1810).

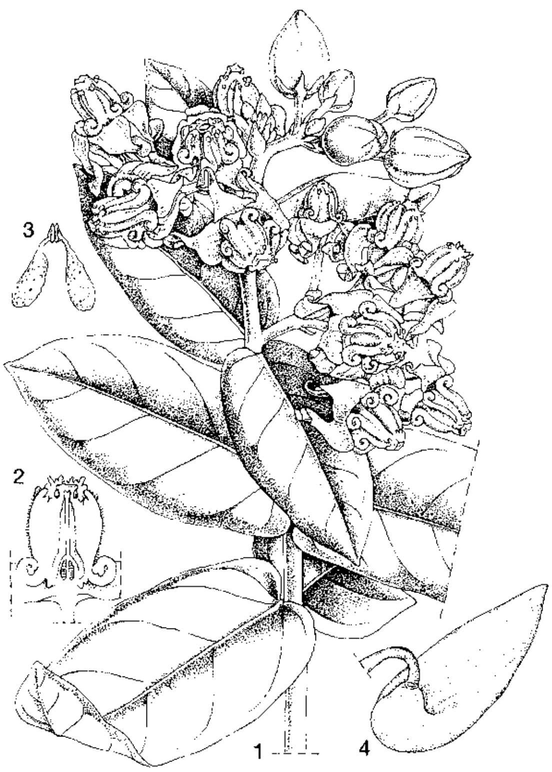
Synonyms *Asclepias gigantea* L. (1753).

Vernacular names Crown flower, giant Indian milkweed (En). Faux arbre de soie, mercure végétal (Fr). Indonesia: bidhuri (Sundanese, Madurese), sidaguri (Javanese), rubik (Aceh). Malaysia: remiga, rembega, kemengu. Philippines: kapal-kapal (Tagalog). Laos: kok may, dok kap, dok hak. Thailand: po thuean, paan thuean (northern), rak (central). Vietnam: b[oof]ng b[oof]ng, l[as] hen, nam t[if] b[af].

Distribution From India and Sri Lanka to Thailand and southern China, naturalized in Malesia and Hawaii in coastal areas, and planted in villages.

Uses The French name 'mercure végétal' refers to its use as an alternative to mercury in the treatment of syphilis. Immigrants from India in South-East Asia use it widely, and the uses have thus spread. The leaves are applied as a poultice for sores, and the juice is dropped into deaf ears and sore eyes. The smoke of the burnt leaves is inhaled to treat ulcerations of the nose. The latex is dropped into teeth with caries, and is applied to boils.

Observations A large shrub or small tree, 3–4(–10) m tall, stems erect, up to 20 cm in diameter; leaves broadly elliptical to oblong-obovate, 9–20 cm × 6–12.5 cm, subsessile; cymes 5–12.5 cm in diameter, peduncle 5–12 cm long, pedicel 2.5–4 cm long, calyx lobes broadly ovate, 4–6 mm × 2–3 mm, corolla 2.5–4 cm in diameter, lobes broadly triangular, 10–15 mm × 5–8 mm, pale lilac, cream coloured towards the tips, corona with 5 narrow scales, fleshy, laterally compressed, 5–8 mm long, adnate to and shorter than the staminal column, forming an upturned horn with 2 obtuse auricles on either side, cream coloured or lilac to purple, with a dense longitudinal dorsal row of short white hairs; follicles mostly in pairs, ovoid, boat-shaped, inflated, 6.5–10 cm × 3–5 cm. *C. gigantea* is a common weed in open waste ground, roadsides and railway lines, as well as village surroundings. It is found in semi-cultivated state throughout Indo-China.



Calotropis gigantea (L.) Aiton f. – 1, flowering branch; 2, gynostegium in longitudinal section; 3, pollinium; 4, follicle.

Selected sources 44, 135, 263, 407, 739, 788, 810, 826, 990.

Calotropis procera (Aiton) Aiton f.

Hort. kew. 2, 2: 78 (1810).

Synonyms *Asclepias procera* Aiton (1789).

Vernacular names Apple of Sodom, rubber-bush, calotropis (En). Calotrope (Fr). Laos: kok may, dok kap, dok hak. Vietnam: b[oof]ng b[oof]ng, l[as] nh[or].

Distribution From tropical and subtropical Africa, through Saudi-Arabia and the Middle East to the Indian subcontinent, Indo-China and Thailand, and introduced in drier areas of Australia, Central and South America and the Mascarene Islands. Probably also introduced or spread to South-East Asia.

Uses In Africa and India, the latex is used as a rubefacient and to extract guinea worms. The dried root bark is used in a soup to treat colic and as a stomachic. The burnt root is made into an ointment for skin eruptions and ulcers.

Observations A large erect shrub up to 4 m tall, stems much branched at the base; leaves oblong-obovate to broadly obovate, 9–15 cm × 5–10 cm, sessile; cymes 4–10 cm in diameter, peduncle 5–8.5 cm long, pedicel 1.5–4 cm long, calyx lobes ovate-lanceolate, 5–6 mm × 3–4 mm, corolla 2.5 cm in diameter, lobes ovate-lanceolate, 6–8 mm × 4–5 mm, cream or greenish-white at the base and purple-violet towards the tip of the lobes, corona with 5 broad scales, adnate to and equalling or longer than the staminal column, basal horn incurved, bifid, without auricles, cream coloured, glabrous; follicles often in pairs, subglobose to obliquely ovoid, inflated, 6–12.5 cm × 3–7 cm. *C. procera* is common in semi-arid conditions on sandy soils, and a weed in cropped land.

Selected sources 38, 66, 92, 185, 249, 255, 532, 572, 683, 696, 760, 788, 891, 973.

R. Kiew

Capparis L.

Sp. pl. 503 (1753); Gen. pl. ed. 5: 222 (1754).

CAPPARACEAE

$x = 20, 22$; *C. zeylanica*: $2n = 40, 44$; *C. sepiaria*: $2n = 40$

Major species *Capparis micracantha* DC., *C. zeylanica* L.

Origin and geographic distribution *Capparis* comprises about 250 species and is found throughout the tropics and subtropics, especially in America and Africa. Another centre of diversity, with about 40 species, is found in Burma (Myanmar) and Indo-China, while in Malesia 23 species are recognized.

Uses *Capparis* is used in traditional medicine in many countries. In general, the root, stem, leaves and fruit are used for the treatment of chronic infected skin diseases, swellings, boils and haemorrhoids. In the Philippines, the whole plant of *C. micracantha* is used for asthma and chest pain. A decoction of the roots is taken to treat stomach-ache, and also as a post-partum tonic. Sap from the petiole is dropped into the eye to treat ophthalmia. In Indo-China and Thailand, a decoction of the leaves or the root grated with water, is drunk as a diuretic to treat quotidian fever, and it is also considered as carminative. The leaves are also used to treat muscular cramps, as a decoction or bath, while the roasted seeds are employed as a cough remedy. In Cambodia, the smoke of the powdered stem is inhaled for bronchitis and nose ulcers. Infusions of the wood of *C. micracantha* or *C. pyrifolia* are used to treat biliousness, stomach-ache and dizziness. *C. pyrifolia* leaves are also used as a remedy for headache. In the Philippines, *C. sepiaria* is considered as febrifugal, alterative and tonic. In India, Burma (Myanmar) and the Philippines, the leaves or bitter root bark of *C. zeylanica* are employed as a counter-irritant, to reduce perspiration and to improve the appetite. In Burma (Myanmar), the bark is used to treat cholera. It is also recommended as an antiscorbutic, and for the treatment of gastritis. In the Philippines, the leaves, rubbed with salt and sometimes pounded, are placed on the forehead and/or temples as a remedy for headache. In India, a decoction of the leaves is used for syphilis.

C. decidua (Forssk.) Edgew. (synonym *C. aphylla* Hayne ex Roth.) is well known from Africa, Iran, Saudi Arabia and India, where the bitter and pungent root is used to treat intermittent fevers, boils, arthritis, gout and rheumatism. The fruit is astringent and useful for cardiac troubles and biliousness. In India, the stems are used to stupefy fish. The fruits and flower-buds are commonly pickled and used as a condiment, like those of the well-known Mediterranean *C. spinosa* L. var. *mariana* (Jacq.) K. Schum., the caperbush. *C. decidua* is also used in traditional medicine, though not in South-East Asia. In India, infusions or decoctions from the root bark are used for the treatment of dropsy, anaemia, and arthritis, and are recommended as tonic, diuretic, anthelminthic, emmenagogue and analgesic. The fruit of *C. pyrifolia* is sweet and edible, but that of *C. zeylanica* has a poor flavour.

Many *Capparis* species are considered a good source of fodder for cattle and wild animals in the dry season.

Production and international trade *Capparis* is only used on a local scale in South-East Asia.

Properties Most research on biological activity in *Capparis* has been carried out with *C. decidua*. Pharmacological effects of *C. decidua* extracts include a strong antibacterial activity of an ethanolic extract of the flowers, fruit-husks and seeds against *Bacillus subtilis*, *B. megaterium*, *Escherichia coli*, *Proteus vulgaris*, *Staphylococcus aureus* and *Vibrio cholerae*. In addition, a sulphur-containing compound (without further structural elucidation) isolated from the seeds showed both high antibacterial and antifungal action against the fungi *Aspergillus flavus*, *Candida albicans* and *Penicillium echyogenum* and the bacterium *Vibrio cholerae*, at a dilution of 50 µg/ml. An aqueous extract of the flowers, fruit pulp and root bark has been found to have anthelmintic properties against earthworms.

The powdered aerial parts of *C. decidua* showed marked activity against oxidative stress in isolated tissues from alloxan-induced diabetic rats. In the animals, this extract also increased the urine volume, but not the excretion of electrolytes, thus displaying an aquaretic activity.

p-Methoxy benzoic acid, isolated from the aqueous extract of *C. spinosa* var. *mariana*, was found to possess significant antihepatotoxic activity against carbontetrachloride and paracetamol induced hepatotoxicity in vivo, and thiocetamide and galactosamine induced hepatotoxicity in isolated rat hepatocytes in vitro. The alcoholic extract of the aerial parts of *C. decidua* and *C. spinosa* var. *mariana* also showed anti-inflammatory activity and inhibition of carrageenan-induced paw oedema in rats.

An alcoholic extract of the aerial parts of *C. sepiaria* showed some antibacterial activity on non-specified bacteria. The alkaloids L-stachydrine and 3-hydroxy-L-stachydrine have been isolated from the leaves of *C. zeylanica*. An aqueous alcoholic extract of the aerial parts showed antispasmodic activity against acetylcholine and histamine.

Adulterations and substitutes Mustards and horseradish (*Cruciferae*) are substitutes for *Capparis* because they also have a sharp taste and a similar effect as a digestive stimulant.

Description Erect to climbing shrubs, occasionally small trees, branches often overhanging. Leaves spirally arranged, simple; petiole short; mostly with 2 stipular thorns. Inflorescence consisting of pedicelled flowers arranged in serial, supra-axillary rows, rarely solitary, or in subumbellate racemes, sometimes becoming paniculate; bracts mostly early caducous. Flowers 4-merous, somewhat zygomorphic, bisexual; sepals biseriate, outer pair mostly concave, inner pair flattish; petals variously imbricate, not unguiculate, bases of the 2 posterior ones (upper pair) cohering and surrounding a small disk; stamens (8–)numerous, about twice as long as the petals; ovary on a long gynophore, occasionally abortive; placenta 2–4. Fruit a 1-locular, globular, leathery berry. Seeds normally numerous, rarely 1, obliquely reniform, embedded in pulp.

Growth and development The flowers of *Capparis* are often scented and showy, although the nectar is concealed, and visiting insects are rarely seen. Some species are known to be noctiflorous though, so perhaps those flowers are visited by nightly insects. In Java, *C. micracantha* flowers mostly from March to December, *C. pyrifolia* flowers from July–September and fruits from July–February. *C. sepiaria* flowers from March till December, and when in fruit, often most of the leaves are shed.

Other botanical information In the taxonomic literature the family name is either *Capparaceae* or *Capparidaceae*, but the name *Capparaceae* has been conserved. *Capparaceae* are closely allied to the *Cruciferae*, but can be distinguished by the nontetradynamous stamens, the 1-loculed ovary and the usually zygomorphic flower. A complete revision of *Capparis* in the Old World does not exist at present.

Ecology *Capparis* is most frequently found in sunny, warm and dry habitats with seasonal climatic conditions, such as coastal vegetation, savannas, hedges, light forest, thickets, and forest borders, in lowland and hills up to 1700 m altitude.

Propagation and planting *Capparis* is propagated by seed. The coloured and often sweetish fruits of *Capparis* are likely to be eaten by birds and other animals and in this way seed is dispersed.

Diseases and pests *Capparis* is attacked by several leaf-spot diseases. The sooty mould *Asterostomella horrida* occurs on *C. micracantha* in the Philippines.

Harvesting *Capparis* plants are harvested from the wild whenever needed.

Genetic resources and breeding *Capparis* is fairly common in secondary forest and brush land and is therefore not very likely to become liable to genetic erosion. No germplasm collections or breeding programmes are known to exist for the South-East Asian species.

Prospects Little information is available on active constituents and pharmacological activity of *Capparis*, but most species seem to have some antibacterial activity. The fruits of several species might also serve as a local source of vitamin C.

Literature |1| Gadgoli, C. & Mishra, S.H., 1999. Antihepatotoxic activity of p-methoxy benzoic acid from Capparis spinosa. Journal of Ethnopharmacology 66(2): 187–192. |2| Jacobs, M., 1960. Capparis. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Series 1, Vol. 6. Wolters-Noordhoff Publishing, Groningen, the Netherlands. pp. 69–93. |3| Nyein, M.M., Maung, C. & Bwin, M., 1996. Investigation of antibacterial activity on three traditional medicine formulations. Myanmar Health Sciences Research Journal 8(1): 20–24. |4| Perry, L.M., 1980. Medicinal plants of East and Southeast Asia. Attributed properties and uses. MIT Press, Cambridge, Massachusetts, United States & London, United Kingdom. pp. 68–69. |5| Quisumbing, E., 1978. Medicinal plants of the Philippines. Katha Publishing Co., Quezon City, the Philippines. pp. 338–340. |6| Yadav, P., Sarkar, S. & Bhatnagar, D., 1997. Action of Capparis decidua against alloxan-induced oxidative stress and diabetes in rat tissues. Pharmacological Research 36(3): 221–228.

Selection of species

Capparis micracantha DC.

Prodr. 1: 247 (1824).

Synonyms *Capparis odorata* Blanco (1837), *Capparis myrioneura* Hallier f. (1906).

Vernacular names Indonesia: balung, kledung (Javanese), sanek (Madurese). Malaysia: kaju tuju. Philippines: salimbagat (Tagalog), tarabtab (Iloko), salimomo (Bisaya). Cambodia: kanchoen bai dach. Laos: say sou. Thailand: chingchee (central), kradaat khaao (central), nuat maeo daeng (northern). Vietnam: b[uf]ng ch[ef], c[as]p gai nh[or].

Distribution From Burma (Myanmar), Indo-China, Thailand and Peninsular Malaysia, to Indonesia and the Philippines.

Uses In the Philippines, a decoction of the roots is used in stomach-ache and as a uterine tonic after childbirth. In Indonesia, the plant has the same use as *C. pyrifolia*. The stem is crushed with water and applied topically to relieve pain and swellings. The pulp of the round, red to purple fruit has a sweet aromatic flavour, but is unsafe to eat when unripe.

Observations A half-erect shrub or small tree with drooping branches, 1–6 m tall, rarely a vine 2–4 m tall, young branches zigzag, glabrous; leaves oval to oblong-lanceolate, 9.5–20 cm × 3–11 cm, base rounded, apex variable, rarely acuminate, coriaceous, shining, petiole 0.7–1.5 cm long, thorns patent, straight or slightly curved, 2–7 mm long, on flowering branches often absent; flowers 2–6 in a row, pedicel about 1 cm long; sepals ovate, 5.5–13 mm long, petals oblong or elliptical, 10–26 mm long, thin, white with yellow base, later turning dark red, stamens 20–45, filaments 2.5–3 cm long, white, gynophore 15–35 mm long, ovary and gynophore sometimes abortive; berry globular or ellipsoid, 2–6 cm in diameter, with 4 longitudinal sutures, yellow, orange or red and strongly smelling when ripe; seeds numerous, in whitish, slimy, sweet pulp. *C. micracantha* is found in brushwood, hedges and open forest, also along the seashore and in sandy locations, mostly below 500 m altitude.

Selected sources 74, 135, 201, 215, 237, 407, 788.

Capparis pyrifolia Lamk

Encycl. Bot. 1: 606 (1785).

Synonyms *Capparis acuminata* Willd. (1799).

Vernacular names Indonesia: sanek (Sundanese), gagahan (Javanese), kaloang-kaloangan (Kangean). Malaysia: kaju tujuh. Thailand: maengso (peninsular), kinkhee (central), naam haang nokkaling (northern). Vietnam: c[as]p c[os] m[ur]i, ta cha.

Distribution Distributed in Thailand, Indo-China, Indonesia (Java, Lesser Sunda Islands) and the Philippines.

Uses The wood is used in Indonesia and the Philippines for biliousness, stomach-ache and giddiness.

Observations A shrub, sometimes climbing, 1–4 m tall, all lateral branches with their leaves in the same plane, young parts stellately hairy; leaves oblong or ovate-oblong, 4–14 cm × 2–6.5 cm, base acute, obtuse, rounded or cordate, apex acuminate with blunt tip, herbaceous, petiole 0.5 cm long, thorns patent, straight or slightly curved upwards, 1–3 mm long; flowers 2–4 in a row, pedicel slender, 1–2 cm long, densely hairy, sepals 4–5 mm long, petals very thin, 6–9 mm long, pubescent on both surfaces, white, tinged pale yellow or green, violet when older (honey-guide), stamens about 20, filaments white, 1.5–2.5 cm long, gynophore 1.5–2.5 cm long; berry globular, 10–13 mm in diameter, shiny black; seeds 2–6. *C. pyrifolia* occurs in the lowlands and hills in dry locations, living fences, brushwood, and teak forest, from sea-level to 700 m altitude.

Selected sources 74, 135, 407.

Capparis sepiaria L.

Syst. Nat. ed. 10, 2: 1071 (1759).

Vernacular names Indonesia: poka(n) (Madurese). Philippines: tarabtab, keme-keming (Tagalog), arayat (Iloko). Thailand: phee waidaat (peninsular), wua sang (north-eastern), naam kieo kai (central). Vietnam: c[as]p h[af]ng r[af]o.

Distribution From India and Sri Lanka to southern China, southwards through Peninsular Malaysia, Indonesia (eastern Java, Madura, Lesser Sunda Islands, Sulawesi, the Moluccas), the Philippines, southern New Guinea and northern Australia.

Uses In the Philippines, the plant is said to possess febrifugal properties, and is considered alterative and tonic.

Observations A woody vine or much-branched shrub, 1–3 m tall, with stout, marked zigzag twigs, young shoots greyish; leaves oval to oblong-lanceolate, 3–8 cm × 1.2–3.5 cm, apex rounded, notched, midrib flattened above, firmly herbaceous, upper surface often with scattered minute warts, petiole 2–4(–7) mm long, hairy, thorns short, recurved, strong, 3–5 mm long; subumbels mostly axillary, 3–25-flowered, pedicel slender, 4–25 mm long, sepals 4–6 mm long, petals 7–9 mm long, in lower half densely hairy, white, stamens 30–45, filaments 10–16 mm long, white, gynophore 8–14 mm; berry globose or transversely oval, 1–1.5 cm in diameter, ivory-white or pale fleshy-coloured to dark violet; seeds 1–2. *C. sepiaria* is found in dry localities, brushwood, hedges, teak forest, in the lowlands, often near the seaside, solitary or in groups.

Selected sources 74, 215.

Capparis zeylanica L.

Sp. pl. ed. 2: 720 (1762).

Synonyms *Capparis horrida* L.f. (1781).

Vernacular names Indonesia: melada (general). Philippines: halubagat-baging (Tagalog), tarabtab (Ilokano), baralauik (Ibanag). Burma (Myanmar): nah-ma-nee-tanyet. Cambodia: rôôk sââ. Thailand: sa ae (south-western), yieo kai (eastern), thao lang maakkep (northern). Vietnam: c[as]p t[is]ch lan, gai den.

Distribution From India to Indo-China, Peninsular Malaysia, Indonesia (Java, Sulawesi, Lesser Sunda Islands), and the Philippines.

Uses In Burma (Myanmar) and the Philippines, leaves are employed as a counter-irritant, and made into a poultice for boils and swellings. They are also used to reduce perspiration and to improve the appetite. The fruit has an edible pulp of poor flavour, but is found pickled in India.

Capparis zeylanica L. – 1, flowering twig, leaves still young; 2, flower; 3, fruiting branch with opened fruit.

Observations A climbing shrub, 2–5(–10) m tall with zigzag branches, pubescence tawny to brownish red; leaves ovate to elliptical, 4–10(–18) cm × 3–6(–9) cm, base acute or obtuse, tip acute, leathery, petiole 0.5–1.5 cm long, thorns 3–6 mm long, recurved; flowers 2–5 in a row, rarely solitary, before the leaves on young twigs, pedicel stout, 1–2 cm long, sepals concave, 1 cm long, hairy, petals 0.9–1.6 cm long, thin, white to pinkish, inner side later darker, pinkish to red; stamens 30–50, filaments 2.5–3.5 cm long, pink, later turning dark purple; gynophore 2.5–4.5 cm, pubescent only towards the base; berry globular to ellipsoid, up to 5 cm × 4 cm; seeds numerous. *C. zeylanica* occurs in hedges, brushwood, savannas, forest borders, at low and medium altitudes, under seasonal climatic conditions.

Selected sources 74, 106, 215, 245.

F.I. Windadri

Cassytha filiformis L.

Sp. pl. 1: 35 (1753).

CASSYTHACEAE

$2n = 48$

Vernacular names Dodder laurel, seashore dodder, woe vine (En). Liane sans tête, liane sans fin, liane ficelle (Fr). Brunei: akar janjang (Sengkurong). Indonesia: tali puteri (Javanese), sangga langit (Sundanese), akar pengalasan (Bangka). Malaysia: chemar batu. Philippines: kaduadkawaran (Tagalog), barutbarut (Iloko), malabohok (Tagalog, Bikol, Bisaya). Thailand: khiang kham (eastern), khueang kham khok (north-eastern), chong naang khlee (peninsular). Vietnam: d[aa]y t[ow] xanh, t[ow] h[oof]ng xanh.

Origin and geographic distribution *C. filiformis* is widespread in the tropics of both hemispheres; in the Old World it is distributed from Africa to Asia, central and southern China, Japan, through South-East Asia and northern Australia.

Uses Throughout its distribution area, *C. filiformis* is considered astringent and diuretic. In India, Vietnam, China and also in Central America, an infusion of the stems is taken as a tonic, for biliousness, piles, diarrhoea and spermatorrhoea. Externally, the stems are used for cleaning ulcers and an infusion as an eyewash. In Indonesia, the pounded stems are given as a vermifuge and for other intestinal troubles. In Java, the stems are also used for headache, malaria, fever, nephritis, oedema, hepatitis, and urinary problems. In Brunei, a decoction of the stems is drunk or applied to the skin to relieve itch and eczema. In the Philippines, a decoction of the plant is taken to hasten parturition, and to prevent haemoptysis. In Fiji, a drink made with crushed stems in water is drunk to treat indigestion, difficult parturition and to reduce fever. It is also taken for haemorrhoids, to treat sinusitis and to promote menstruation. In Peninsular Malaysia and India, the stems are dried, powdered and mixed with sesame oil to make a mucilaginous hair tonic, but this use may be attributed to the luxuriant hair-like appearance of the stems. In several African countries, the whole plant is used for treating venereal discharges, urethritis, diarrhoea, gonorrhoea and syphilis. It also has a widespread reputation for use against parasitic conditions of the skin and scalp. In southern Nigeria, a decoction is taken by women to suppress lactation after a stillbirth.

In East Africa, the pounded stems of *C. filiformis* are used to prepare a brown dye.

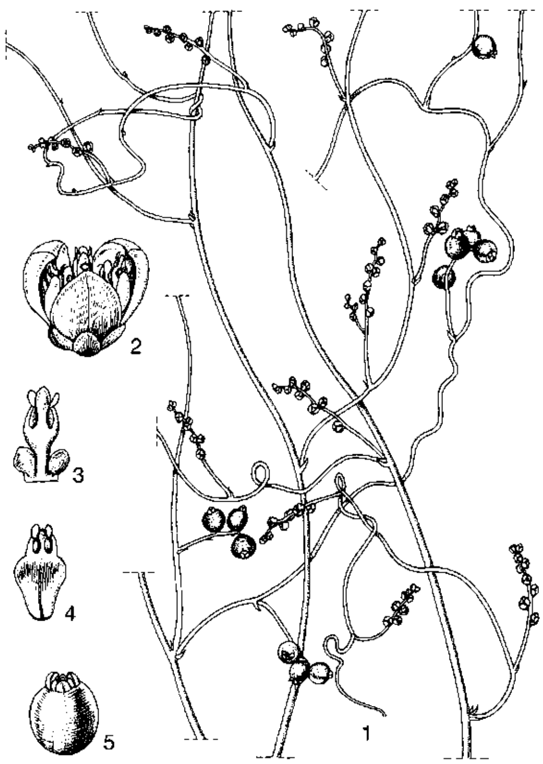
Production and international trade *C. filiformis* is only traded on a local scale.

Properties *C. filiformis* (especially the stem) contains a series of alkaloids belonging to the aporphine type, biosynthetically derived from the amino acid phenylalanine. These include: actinodaphnine, N-methylactinodaphnine, cassameridine, cassamedine, cathafiline, cathaformine, cassyformine, cassyfiline, cassythidine, filiformine (oxyaporphine type), isoboldine, laurotetanin, lysicamine, ocoteine and predicentrine. Further phytochemical investigations also revealed the presence of the lignan (+)-diasyringaresinol, together with positive reactions for tannins, saponins and leucanthocyanins.

Several of these isolated alkaloids show pharmacological activities, e.g. laurotetanin is a tetanizing drug which produces cramps, and in high doses, death. Cathafiline, cathaformine, actinodaphnine, N-methylactinodaphnine, predicentrine, and ocoteine exhibited significant inhibitory activity of rabbit platelet aggregation induced by adenosine diphosphate, arachidonic acid, collagen and platelet-activating factor (PAF) in vitro. In addition, actinodaphnine and N-methylactinodaphnine also exhibited strong inhibition of the contraction of aortic preparations in vitro, induced by K^+ and norepinephrine, and ocoteine was found to be a selective α-1-adrenoceptor blocking agent by using the rat thoracic aorta preparation (competitive antagonism of phenylephrine-induced vasoconstriction) in vitro. Methanolic and aqueous extracts had marked uterotonic effects both in vitro and in vivo which could be compared to that of oxytocin.

Finally, an ethanol extract exhibited molluscicidal activity at a dose of 100 ppm, and a methanol extract exhibited anti-trypanosomal activity against *Trypanosoma vivax*, when administered intraperitoneally to mice.

Description A perennial, twining parasitic or hemiparasitic plant, stems filiform, 3–8 m long, much branched, often matted together, glabrous or pubescent, dark green, brown, yellow or orange; haustoria small. Leaves reduced to tiny scales, spirally arranged, early caducous. Inflorescence an axillary, short, lax spike, 1.5–4 cm long, rachis rather thick. Flowers small, bisexual, sessile, protogynous, bracts 3, small, ciliate, perianth persistent; sepals 3, triangular-ovate, about 2 mm large, apex obtuse, not fleshy; petals 3, ovate-oblong, about 3 mm × 2 mm, concave, valvate, somewhat fleshy, white or yellowish; stamens in 4 whorls of 3, fertile stamens 9, anthers basifixed, 2-celled, dehiscent by uplifting valves, white, filaments lat-



Cassytha filiformis L. – 1, plant habit; 2, flower; 3, glandular stamen; 4, eglandular stamen; 5, fruit.

erally expanded, 2 outer whorls almost equal, eglandular, anthers introrse, third whorl with 2 glands at base, anthers extrorse, fourth whorl staminodal, small, yellow; ovary superior, hairy, style short, erect, stigma capitate or slightly 3-parted. Fruit a globose drupe, 6–9 mm in diameter, surrounded by fleshy perianth, slimy, black when ripe, narrow orifice at apex. Seed 1, with hard seed coat; endosperm absent, embryo well differentiated, straight.

Growth and development *C. filiformis* is a hemiparasite when the stems contain chlorophyll, the green colour often being more pronounced on young stems. It becomes a holoparasite when the chlorophyll disappears, and the stems turn yellow or orange. It attaches itself by means of its haustoria indiscriminately to various herbs and shrubs, often forming dense mats that can kill the host. In India 42 species of host plants have been determined, in the Philippines 36 species from 25 families and in the Bahamas 81 host species from 45 families. In Java, *C. filiformis* is found flowering and fruiting throughout the year.

Other botanical information *Cassytha* comprises about 17–20 species, distributed throughout the tropics of the Old World. In Australia, 15 species are found, of which 13 are endemic. *C. filiformis* is rather often confounded with *Cuscuta* (*Convolvulaceae*), which is similar in habit, but has 5-merous flowers, with a tubular corolla and fruit which is an ovoid or globose capsule. *Cassytha* is often treated as an aberrant genus of *Lauraceae*, but cladistics confirm its status as a separate family.

Ecology *C. filiformis* occurs especially on the seashore and areas immediately behind the shore, often forming a dense blanket over thickets. Occasionally, it is found in the interior, but not higher than 600 m altitude. It is found both in moist and dry regions.

Propagation and planting *C. filiformis* is propagated by seed. The seeds have dormancy, and germinate only after softening by microbial action. The fruits are dispersed by sea currents and by birds.

Diseases and pests As *C. filiformis* is a parasite on many plant species, it is considered a weed, and e.g. in young coconut plantations it can do considerable damage by extracting plant sap from the host and by covering the host with a dense mat of stems. *C. filiformis* is a host for citrus mosaic virus and citrus yellow corky vein, and has been found to transmit the virus from one *Citrus* species to another. A mycoplasma-like organism causing root wilt in coconut, and normally transferred by a lace bug (*Stephanitis typicus*), may also be transmitted through *C. filiformis* to *Catharanthus roseus* (L.) G. Don. The larvae of the lepidopteran *Zetona delospila* from Australia feed specifically on *Cassytha*.

Harvesting *C. filiformis* is harvested from the wild, when needed.

Handling after harvest *C. filiformis* is normally used fresh, but can also be dried for later use.

Genetic resources and breeding Because *C. filiformis* is a widespread species, growing on a wide range of hosts, it is not likely to be threatened by genetic erosion.

Prospects Several alkaloids from *C. filiformis* (actinodaphnine, ocoteine and laurotetanin) display interesting pharmacological activities, which could be of use especially in experimental pharmacological research. In order to evaluate their possible potential as lead compounds in the future development of new clinically active substances, more information is required, for instance on their toxicology.

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Other selected sources 74, 135, 142, 152, 407, 685, 696, 757, 872, 1069.

Trimurti Hesti Wardini

Cayratia A.H.L. Juss.

Dict. Sci. Nat. 10: 103 (1818).

VITACEAE

x = 20, 40; *C. japonica*: $2n$ = 40, 60, *C. mollissima*: $2n$ = 40, *C. trifolia*: 2n = 40, 80, about 96

Major species *Cayratia japonica* (Thunb.) Gagnep., *C. trifolia* (L.) Domin.

Vernacular names Sorrel vine (En).

Origin and geographic distribution *Cayratia* consists of about 50–65 species, mostly distributed in the tropics and subtropics of Africa, Asia, Australia and many Pacific Islands.

Uses In South-East Asia, different plant parts of *Cayratia* are commonly applied for fever. In Peninsular Malaysia, the leaves of *C. japonica*, boiled with an onion and lime, are applied to the head to cure violent headaches. The dried and powdered flowers are employed for fever. In Sumatra, all aerial parts are applied for fevers, including malaria. In the Solomon Islands, the leaves are rubbed on the stomach to relieve constipation. In China, the aerial parts or the roots are widely used for fever, and also to resolve toxins in mumps, jaundice and dysentery and disperse swellings in rheumatism. The mucilaginous roots are also employed to treat cancerous affections, and also act as a diuretic to treat haematuria. In decoction, the roots are applied for mastitis. Pounded leaves are put on scorpion stings and centipede bites.

In Peninsular Malaysia and East New Britain, the leaves of *C. trifolia* are commonly used for poulticing ulcers of the nose. The leaves or roots also act as a rubefacient, drawing blood to the surface. The leaves or roots in decoction are used as a fomentation for high fever, resulting in perspiration. The juice from the leaves and stems may also be drunk, diluted in water, for the same purpose. In Java, the juice of the leaves, together with the juice of young pineapple, may be used on the head for itch and dandruff. In Thailand, the leaves and roots are used for fever and as an astringent, the stem as an expectorant, carminative and blood purifier. The stem is applied to relieve vertigo, fainting, internal bruises, boils and nose ulcers. In the Philippines and Thailand, a decoction of the leaves or the juice of the fresh leaves is considered antiscorbutic. In India, the ground root, together with black pepper (*Piper nigrum* L.), is applied to boils, as an astringent and disinfectant. In Vietnam, the sap from the cut stem is drunk, but no use is given.

In Peninsular Malaysia, a decoction of the leaves of *C. novemfolia* (Wallich) Burkill is used as a cooling lotion in fevers, and the leaves may be oiled, heated and applied to boils or for dropsy.

Production and international trade *Cayratia* is only used on a local scale.

Properties The stem, leaves and root of *C. trifolia* contain cyanic acid, and traces of it were also found in the flowers. The leaves of *C. trifolia*, *C. mollissima* and *C. japonica* contain several flavonoids including cyanidin, delphinidin, kaempferol, myricetin and quercetin. Furthermore, the aerial parts of *C. trifolia* contain the triterpene epifriedelanol. This compound demonstrated antitumour activity in a potato disk bioassay against crown gall tumours caused by *Agrobacterium tumefaciens*.

Description Perennial, evergreen or deciduous, climbing or scrambling lianas, climbing by leaf-opposed tendrils, often branched several times, branches subtended by a bract; roots sometimes tuberous. Leaves alternate, pinnate or pedate, 3–12-foliolate, margins serrate; petiole present; stipules 2, often triangular, caducous. Inflorescence axillary, pseudo-axillary or leaf-opposed, pedunculate, carried above the leaves, multi-flowered in irregular corymbose cymes, often loose; peduncle and pedicel subtended by bracts. Flowers bisexual, small, 4-merous, buds often swollen; calyx usually cup-shaped; corolla with 4 lobes, free, cohering in bud by the interlocked epidermis cells; stamens 4, inserted on the receptacle at the base of the disk, opposite the petals, filaments erect, often flattened, anthers dorsifixed, opening by longitudinal slits, introrse; disk cupular, adnate to and entirely surrounded by ovary, lobes 4, rounded; ovary superior, 2-locular, 2 ovules per locule; style conical, stigma minute, accrescent. Fruit a fleshy berry, 1–4-seeded, on the ventral side with 2 grooves. Seed triangular to ovoid, shape depending on number of seeds in berry, flattened, with 1–2 furrows or pits on the ventral surface; endosperm in transverse section U- or T-shaped. Seedling with epigeal germination.

Growth and development *C. trifolia* starts flowering at the beginning of the rainy season, while *C. japonica* can be found flowering and fruiting throughout the year.

In Japan, nectar secretion in *C. japonica* lasts for 2 days, and nectar volume peaks at 11 a.m. and 3 p.m. each day, with a sugar concentration of 60%. The commonest visitors were the ant *Lasius niger* and the wasp *Vespa xanthoptera*.

Other botanical information *Cayratia* may be distinguished from the closely related *Cissus* by its compound leaves, ratio central petiolule to lateral petiolule rarely less than 2, dichotomous cymes, 2–4-seeded berries and endosperm in transverse section U- or T-shaped. *Cissus* has simple leaves (except for some Australian species), umbellate or paniculate cymes and usually 1-seeded berries.

In *Cayratia*, leaf-size, margin indentation and degree of pubescence varies considerably intraspecifically, but number of leaflets, shape and relative size, position of hairs, nature of tendrils and seed characteristics are useful diagnostic characters.

Ecology *Cayratia* is found on all soil types in thickets and along forest margins, usually at low altitudes, often carpet- or curtain-forming.

Propagation and planting *Cayratia* is propagated by seed and root suckers. Unpollinated ovary explants of *C. japonica* can be cultured on modified Murashige & Skoog medium supplemented with different concentrations of 2,4-D, or in combination with thidiazuron for the induction of embryogenic callus. For the induction of embryogenic callus and somatic embryogenesis, both cytokinin and auxin are required in the medium.

Diseases and pests *Cayratia* is a host of the grape Cristulariella leaf spot (*Cristulariella moricola*), which causes severe damage on the grape (*Vitis vinifera* L.), and *C. japonica* is a host of *Pseudomonas cissicola*, the causal agent of bacterial leaf spot on grape and related genera. *Cayratia* is resistant to the fungus causing grape downy mildew (*Plasmopara viticola*).

Cayratia is also an alternative host for the cotton aphid (*Aphis gossypii*). *C. japonica* is an alternative host for the Lepidopteran *Scrobigera amatrix*, which feeds on the leaves of grapes.

Harvesting *Cayratia* is harvested from the wild whenever the need arises.

Handling after harvest All plant parts of *Cayratia* are normally used fresh. The flowers are sometimes dried for future use.

Genetic resources and breeding The *Cayratia* species treated here are widespread and common throughout South-East Asia, and do not seem to be at risk of genetic erosion. There are no known breeding programmes of *Cayratia*.

Prospects Little information is available on the phytochemistry and phytopharmacology of *Cayratia*. More research will be needed for a proper evaluation of its future potential, e.g. as a febrifuge.

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Selection of species

Cayratia japonica (Thunb.) Gagnep.

Notul. Syst. (Paris) 1: 349 (1911).

Synonyms *Vitis japonica* Thunb. (1784), *Cissus japonica* Willd. (1797), *Cissus obovata* Lawson (1875).

Vernacular names Sorrel vine (En). Indonesia:

dudugan (Siberut). Malaysia: lakum, charek merah, pokok riang hutan. Vietnam: v[as]c nh[aaj]t.

Distribution From Japan and southern China to Indo-China, Malesia and Australia; common in Peninsular Malaysia. Recently occurring as an adventive in Texas (United States).

Uses In Peninsular Malaysia, the boiled leaves, together with onion and lime, are applied to the head for violent headaches. The dried and powdered flowers might be employed for fever. In Sumatra (Indonesia), the aerial parts are applied for fever and malaria. In India, the stem bark is used as an antidote. The long stems can be used for tying purposes.

Observations A rather small, usually evergreen climber, 2–4 m long, stem ridged, often reddish when young, hairy mainly at nodes, tendrils 2–3-fid, usually glabrous, tuber small or absent, root system large; leaves pedate, usually 5-foliolate, petiole 4–8 cm long, central leaflet broadly lanceolate to ovate, 6–10 cm × 3–5.5 cm, lateral leaflets ovate, 3–7(–11) cm × 2–3.5 cm, margins serrate, both surfaces pubescent; inflorescence axillary, cymose corymbiform, primary branches 3, 6–12 cm × 3–4 cm, peduncle 4–8 cm long, flowers small, greenish-white to yellowish; berry subglobose, up to 1 cm in diameter, purplish-blue to black, sometimes white, 2–4-seeded. *C. japonica* is a variable hairy species, and occurs usually along rainforest margins, brushwood and village margins, from sea-level up to 1500 m altitude.

Selected sources 135, 563, 586, 786.

Cayratia japonica (Thunb.) Gagnep. – 1, flowering branch; 2, flower and bud; 3, part of infructescence.

Cayratia mollissima (Wallich) Gagnep.

Notul. Syst. (Paris) 1: 345 (1911).

Synonyms *Vitis mollissima* Wallich (1824).

Vernacular names Malaysia: lakom gajah, kesakitan burong, akar sebenkak. Vietnam: v[as]c l[oo]ng m[eef]m.

Distribution Thailand, Indo-China, Malaysia and the Philippines.

Uses In Peninsular Malaysia, the fruits are used to poultice swellings and aches; they are also rubbed on the belly, for pain in labour. An infusion of the leaves is applied as a cooling lotion.

Observations An evergreen climber, 2–10 m long, stem long stiffly hairy; leaves 3-foliolate, petiole up to 5 cm long, hairy, leaflets elliptical to obliquely ovate, margins serrate, both surfaces softly hairy; corymb axillary, wide-spreading, up to 7.5 cm in diameter, peduncle up to 5 cm long, flowers small, dull bluish-green; berry ovoid, up to 2.5 cm in diameter, white to pinkish, with crystals. *C. mollissima* occurs commonly along forest margins.

Selected sources 135, 586, 786.

Cayratia trifolia (L.) Domin

Biblioth. Bot. 89: 370 (1927).

Synonyms *Vitis trifolia* L. (1753), *Cissus trifolia* (L.) K. Schum. (1889), *Cayratia carnosa* (Lamk) Gagnep. (1911).

Vernacular names Indonesia: galing (Javanese), gumburu rogbo-robo (Ternate), ai lau salak (Ambonese). Malaysia: lakum, daun kapialun, galing-galing. Papua New Guinea: vualai, vaulai (Gunantuna, East New Britain). Philippines: kalit-kalit (Tagalog), alangingi (Bisaya), arinat (Iloko). Laos: ta det. Thailand: thao kan khaao (central). Vietnam: s[af]n s[aj]t, d[aa]y v[as]c.

Distribution From India to southern China, Indo-China, through Malesia and the Pacific Islands; not common in Peninsular Malaysia.

Uses In Peninsular Malaysia, the leaves and roots are commonly used for poulticing ulcers of the nose. A decoction of the leaves and roots or the fresh juice of the leaves and stem are also used for

high fever. In Java, the juice of the leaves, together with the juice of young pineapple is used on the head for itch and dandruff. In Thailand, the leaves and roots are used for fever and as an astringent, the stem as an expectorant, carminative and blood purifier. Heated leaves are applied to boils to relieve inflammation. In the Philippines, a decoction of the leaves or the juice of the fresh leaves is considered antiscorbutic.
In the Moluccas (Indonesia), the young leaves are eaten as a vegetable, after boiling them with salt to remove the irritant properties.

Observations A usually deciduous climber, 2–20 m long, stems angular, pubescent when young, tendrils 4–5-fid, ending in adhesive disks, roots tuberous; leaves 3-foliolate, petiole 2–4 cm long, leaflets ovate to oblong-ovate, 2–8 cm × 1.5–5 cm, margins coarsely toothed, lateral leaflets often lobed, both surfaces pubescent, often becoming sparsely so when old; inflorescence axillary, cymose corymbiform, primary branches 3–4, about 6–9 cm × 3–6 cm, peduncle long, flowers small, greenish-white; berry compressed globose, about 1 cm in diameter, dark purple or black, 2–4-seeded. *C. trifolia* occurs in thickets and open forest, from sea-level up to 400 m altitude.

Selected sources 74, 135, 201, 586, 786.

Slamet Sutanti Budi Rahayu

Celastrus paniculatus Willd.

Sp. pl. 1: 1125 (1797).
CELASTRACEAE
$2n = 46$

Synonyms *Celastrus multiflorus* Roxb. (1814), *Celastrus australis* Harv. & F. Muell. ex F. Muell. (1855).

Vernacular names Indonesia: sila (Javanese). Philippines: bilogo (Tagalog). Thailand: kra thong laai. Vietnam: d[aa]y s[aw]ng m[as]u.

Origin and geographic distribution *C. paniculatus* is widely distributed from India, Burma (Myanmar) to southern China, Taiwan and throughout South-East Asia (except Borneo) to Australia and New Caledonia.

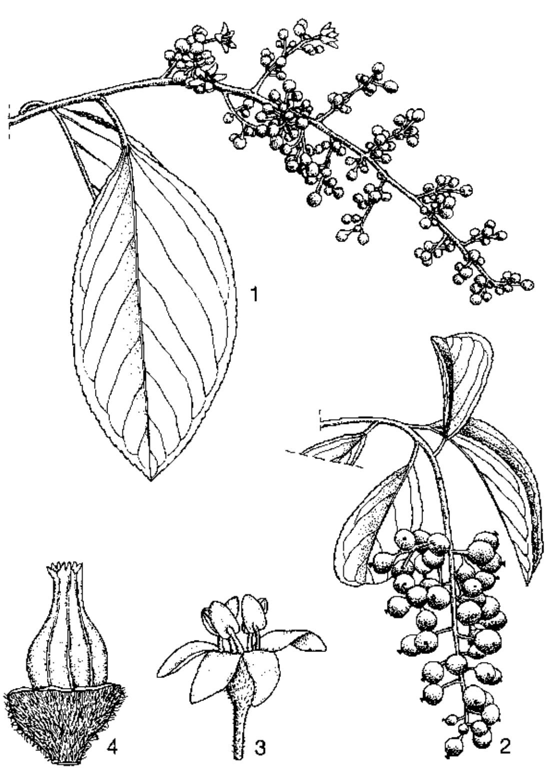
Uses In Java, the leaves of *C. paniculatus* can be an ingredient together with 'adas-pulasari' (*Alyxia reinwardtii* Blume and *Foeniculum vulgare* Miller) of a prescription against dysentery. In traditional Thai medicine, the root is used as an antimalarial and antipyretic, the wood is used in the treatment of tuberculosis, the stem bark as an antidysenteric and a decoction of the stem as a diuretic in the treatment of kidney disorders. The fruits are considered antiflatulent, a blood tonic and a relief for fainting, and the leaves are considered antidysenteric. In India and the Philippines, the crushed seeds, a decoction of the seeds or the fixed oil from the seed are applied as a poultice, or taken internally. Credited with stimulant and diaphoretic properties, they are applied to relieve fevers, joint and muscular pains, and paralysis. The leaf sap has been used as an antidote for opium poisoning.
The seed oil of *C. paniculatus* in combination with *Bacopa monnieri* (L.) Pennell is traded as a cognitive booster under the name Smart Oil™. The seed oil is a major component in various products to relieve rheumatic and muscular pains. *C. paniculatus* oil is an ingredient of many more herbal medicines, claiming to enhance the nervous and mental system.

Production and international trade In South-East Asia *C. paniculatus* is only used locally. India and China export seed and seed oil but no trade statistics are available. In the United States 1 kg of seed fetches US$ 195 wholesale price, 100 cc seed oil fetches US$ 50 wholesale price.

Properties For a detailed GLC analysis of the fatty acid composition of the seed oil of *C. paniculatus*, the oil was fractionated into 4 lipid fractions: normal triglycerides (20.2%), polar triglycerides (44.4%), polar nonglyceridic esters (23.5%) and nonpolar nonglyceridic esters (11.9%). In general, the percentage contents of the major fatty acids in these fractions were determined as palmitic, 25.1, 42.0, 12.7, 58.2; stearic, 6.7, 4.5, 0, 15.8; oleic, 46.1, 24.8, 4.7, 14.2; linoleic, 15.4, 14.7, 10.7, 0; and linolenic, 3.0, 13.1, 43.0, 0, respectively. Furthermore, the main components of the normal triglyceride fraction included palmito-oleopalmitin (6.8%), palmito-oleostearin (5.6%), palmito-diolein (14.7%), palmito-oleolinolein (7.0%), stearo-diolein (6.1%), triolein (8.0%) and dioleolinolein (7.6%). In addition, lipolysis of the polar triglyceride fraction indicated that 59.6% of saturated acids were linked to the 2-position of glycerol.
Reputed as a pharmaceutical aid for learning and memory the seed oil of *C. paniculatus* has been tested in various animal models. In a navigational memory task model (the Morris water maze model), using young adult rats, chronic administration of the seed oil selectively reversed the impairment in spatial memory produced by acute central muscarinic receptor blockade using scopolamine. This

supports the possibility that one or more constituents of the oil may offer cognitive enhancing properties. Furthermore, in a two compartment passive avoidance task model in albino rats, *Celastrus*-oil treated rats showed significant improvement in retention ability. On a biochemical level, *Celastrus* oil was also shown to cause an overall decrease in turnover of three central monoamines (norepinephrine, dopamine, serotin) involved in the learning and memory process.
Pharmacological studies in cats and dogs have shown that the seed oil has sedative and tranquillizing properties. Seed extracts increased the total lipid and phospholipid content of the brain of rats treated for 30 days.
In order to study possible toxic effects of polar and semipolar compounds isolated from the fractionated seed oil, these compounds were injected into rats. Although fatty degeneration in the liver and proximal tubular damage in the kidney were observed, these harmful effects appeared to be transient. In addition, an oily seed extract given to rats showed strong antispermatogenic action, thereby pointing to useful antifertility effects of the seed oil.
Other pharmacological effects include a methanolic extract of the flowers of *C. paniculatus* showing oral analgesic and anti-inflammatory activities in the hot water tail-immersion test in mice, and the carrageenan-induced pedal oedema in rats. An ethanol extract of dried stems of *C. hindsii* Benth., collected in Taiwan, showed potent cytotoxicity against HEPA-2B (hepatoma), HELA (cervix carcinoma), COLO-25 (colon carcinoma) and KB (nasopharynx carcinoma) cells, as well as HIV replication inhibitory activity in H9 lymphocytes in vitro. Activity can be ascribed to the triterpenoid compounds present in the extract: maytenfolone-A demonstrated cytotoxicity against hepatoma at an ED_{50} of 2.3 μg/ml and nasopharynx carcinoma at an ED_{50} of 3.8 μg/ml; celasdin-B exhibited anti HIV-replication activity in H9 lymphocyte cells with an EC_{50} of 0.8 μg/ml.
Finally, various β-dihydroagarofuran sesquiterpene polyesters isolated from members of the *Celastraceae* have been found to have insecticidal and/or insect antifeedant activities.

Description A scandent, deciduous, usually dioecious shrub up to 10 m tall; stem up to 25 cm in diameter, branchlets terete, pubescent. Leaves spirally arranged, simple, elliptical to suborbicular to oblong, 5–15 cm × 2.5–6 cm, base cuneate, obtuse or rounded, apex acute, acuminate, obtuse, rarely emarginate, margin remotely crenulate, midrib elevated, glabrous; petiole 0.5–1.5 cm long; stipules small. Inflorescence an axillary or terminal panicle, usually thrice to multi-compound, spreading, (2–)5–10(–20) cm long, peduncle 0.6–1 cm long. Flowers unisexual, 5-merous, pale greenish, pedicel 1.5–3.5 mm long, accrescent to 3–6 mm, articulated at base; calyx campanulate, persistent, lobes semi-orbicular, short-ciliate, about 1 mm × 1.5 mm; petals oblong to obovate-oblong, obtuse, entire, 2.5–3 mm × 1–1.5 mm; disk cupular, obscurely 5-lobed; in male flower stamens about 3 mm long, pistil columnar, about 1 mm long; in female flowers staminodes about 1 mm long, pistil 2–2.5 mm long, ovary superior, globose, (in)completely 3-celled, ovules 1–2 per cell, style columnar, stigma 3-lobed. Fruit a subglobose capsule, loculicidally 3-valved, valves broad-elliptical, 5–10 mm × 5–8 mm, 3–6-seeded. Seed ellipsoid, 3.5–5 mm × 2–3 mm, enveloped by a fleshy orange to crimson aril, yellowish to reddish brown, smooth or with obscure areoles; albumen copious, cotyledons thin and broadly spathulate. Seedling with epigeal germination.



Celastrus paniculatus Willd. - 1, male inflorescence; 2, infructescence; 3, male flower; 4, female flower detail of pistil.

Growth and development In Java, *C. paniculatus* flowers and fruits, from October–December. The presence of a nectariferous disk in the flower may well point to insect-pollination. The bright-coloured fleshy aril of the fruits is a great attraction to birds, which are the likely means of dispersal.

Other botanical information *Celastrus* comprises about 32 species, in tropical and subtropical areas, widely distributed chiefly in eastern Asia, with 5 species present in Malesia. The leaves of *C. monospermoides* Loes. (synonym *C. malayensis* Ridley) occurring in Malaysia and Indonesia, are used in Peninsular Malaysia for poulticing the head in fevers. Recently, *C. hindsii* Benth. a species from thickets at 1000–1800 m altitude, has been the subject of pharmacological screening. It is found from India eastward to southern China and Taiwan and is indigenous to Indonesia but has no traditional medicinal use. In China *C. angulatus* Maxim. is used as an insecticide.

Ecology *C. paniculatus* is mainly found in thickets at 200–1800 m altitude.

Propagation and planting *C. paniculatus* can be propagated by seed. The aril has to be removed to facilitate germination. The aril protects the seed from desiccation. Germination can be further enhanced by chemical scarification of the hard seed coat. It can be alternatively propagated by cutting, layering or air-layering. Plants should be grown in a sheltered position in sun or partial shade on moderately fertile, well-drained neutral to acid soils.

Husbandry In the absence of natural support for *C. paniculatus* trellis or another sort of framework is essential.

Harvesting Roots, stems and leaves of *C. paniculatus* are collected whenever the need arises. Seed is collected when ripe.

Handling after harvest Root and stem portions of *C. paniculatus* are cut into smaller pieces and dried for future use. Leaves can be dried and stored to be used later on. Drying of seed prior to oil extraction is preferably done under vacuum at low temperatures, to retain its quality.

Genetic resources and breeding *C. paniculatus* is widespread throughout South-East Asia, and common in thickets and secondary growth. It therefore does not appear to be endangered. There are no known breeding programmes of *C. paniculatus*.

Prospects Especially the seed oil of *C. paniculatus* shows a range of interesting pharmacological effects, e.g. a claimed improvement of the learning and memory activity, together with sedative and tranquillizing properties. The compounds or fractions responsible for these effects, together with a full investigation of their toxicology involved, are still missing, however, and therefore there is a need for further research. Also the cytotoxic triterpenes merit further investigations to evaluate their possibilities.

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Other selected sources 201, 215, 455, 730, 739, 786, 810, 862, 895.

H.C. Ong

Centipeda minima (L.) A. Br. & Asch.

Ind. sem. hort. Berol.(1867), App. 6 (1868).
COMPOSITAE
$2n = 20$

Synonyms *Artemisia minima* L. (1753), *Centipeda orbicularis* Lour. (1790).

Vernacular names Sneezeweed, sneezewort (En). Indonesia: mbakoan (Javanese). Philippines: harangan (Tagalog), pisik (Bisaya). Thailand: krataai chan (central), yaa krachaam (peninsular), mueat lot (eastern). Vietnam: c[us]c m[awr]n, c[os]c m[awr]n, c[or] the.

Origin and geographic distribution *C. minima* occurs from Africa through Afghanistan and

India to China and Japan, and southwards through South-East Asia to Australia and the Pacific Islands.

Uses *C. minima* is used in general against eye and sinus infections and nose polyps. The leaves, when squeezed between the fingers and inhaled, make the eyes water, clear the head and provoke sneezing. In Indo-China and Thailand, the plant is also used against cough, common cold and bronchitis. In China, it is considered a hot and dry medicine which is useful as a decoction in paralysis and pain in the joints, and also against malaria, hepatitis, diabetes mellitus, eczema, insect or snake bites, and opium poisoning. Taken with wine, it is a remedy for internal injuries. The seed or dried aerial parts are used as a vermifuge and amoebicide.

In India, the herb is boiled to a paste and applied to the cheeks for toothache, and also used for other swellings and inflammations. In Taiwan, a decoction is suggested as a remedy for rickets and children's sores, and for diseases of the digestive system. It is considered a stimulant, like *Arnica* spp. (*Compositae*).

C. minima is said to have caused poisoning of livestock in northern Australia.

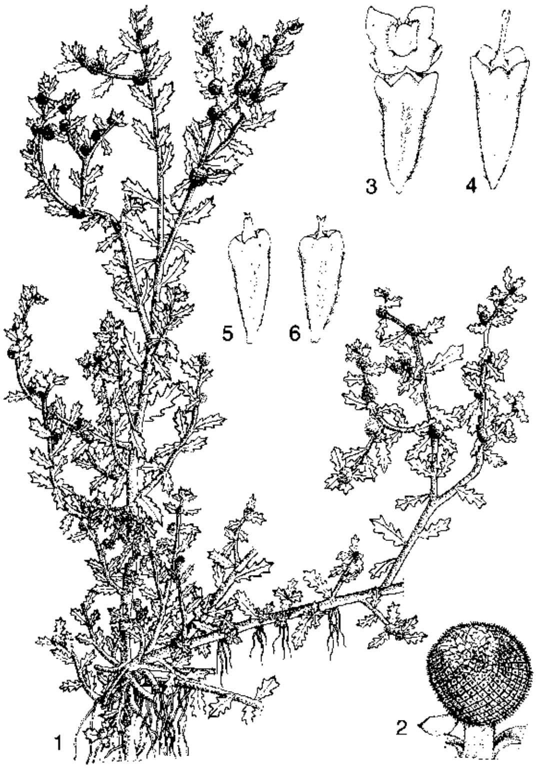
Production and international trade *C. minima* is only locally used as a medicinal plant and is not traded on the international market.

Properties The essential oil of *C. minima* contains bitter compounds such as myriogynic acid and myriogynin, several flavonoids including quercetin, quercetin-3-methylether and kaempferol-7-rhamnoside, and pentacyclic triterpenes such as arnidiol, taraxasterol, taraxerol, 3α,21β,22α,28-tetrahydroxyolean-12-ene and 3α,16α,21β,22α,28-pentahydroxyolean-12-en-28-O-β-D-xylopyranoside. Other compounds include 6-hydroxy-hexacos-trans-8-en-3-on, 3,5,4'-trimethoxy-trans-stilbene, and several sesquiterpene lactones. The sesquiterpene lactones 6-O-methylacrylylplenolin, 6-O-angeloylplenolin and 6-O-isobutyroylplenolin showed antibacterial activity against *Bacillus subtilis* and *Staphylococcus aureus* in vitro, the latter compound being the most active. An aqueous extract of the above-ground plant parts showed in vitro activity against *Entamoeba histolytica*, *Giardia intestinalis* and *Plasmodium falciparum*. Activity was found to be caused by the sesquiterpene lactone brevilin A. Furthermore, an aqueous extract showed significant inhibitory activity on the binding of platelet activating factor to rabbit platelets. 6-O-angeloylplenolin and 6-O-senecioylplenolin were identified as the most potent compounds in the extract. Ether, methanol and aqueous extracts showed significant anti-allergy activity in the passive cutaneous anaphylaxis test. 6-O-isobutyroylplenolin, 6-O-senecioylplenolin and some flavonoids inhibited induced histamine release from mast cells. A methanolic extract of dried aerial parts showed significant activity against herpes simplex virus, polio virus and sindbis virus.

An infusion of dried plants exhibited antitussive activity in mice at 0.5 g/kg, and the aqueous extract showed antispasmodic activity against acetylcholine- and histamine-induced spasms of guinea-pig ileum. The ether extract showed anaphylactic activity when administered antiperitoneally to rats. *C. minima* extracts also show moderate antimutagenic activity against benzo [a]pyrene.

A weak cytotoxic activity of methanol and aqueous extracts was shown in culture of mammary microalveolar cells. The ethyl acetate extract, however, revealed strong cytotoxic activity on HeLaS3 cells, with a IC_{50} value less than 10 μg/ml, and the LD_{50} of the ethanol extract, injected intraperitoneally in mice, at 500–750 mg/kg.

Description A small annual, aromatic herb, 8–20(–30) cm tall, often much branched, often prostrate; stems filiform, ribbed, internodes 2–10 mm long, 1 mm large, sparsely to densely covered with fine white, cobwebby hairs. Leaves alternate, simple, narrowly spatulate, 5–20 mm × 1–7 mm, base attenuate, apex obtuse and mucronulate, sometimes 3-lobed at the apex and entire at the lower part, margins pinnatilobed or dentate (lobes or teeth mucronulate), sparsely pilose on both sides; petiole absent; stipules absent. Inflorescence an axillary head, 2–4 mm in diameter, opposed to a leaf; peduncle absent, involucral bracts 2-seriate, oblong, about 1 mm long, margins membranous, subdentate, with long, cotton-like hairs, apex rounded. Flowers all tubular, marginal flowers numerous, female, corolla 0.2 mm long, pilose, whitish, disk flowers few, bisexual, corolla 0.5 mm long, campanulate, deeply 4-lobed, yellow or tinged with violet; anthers 4, 0.4 mm long, apically thickened; ovary obconical, 4-angled; style filiform, short, bifid. Fruit an oblong and curved achene, 1 mm long, 4-angled, angles with appressed hairs 1 mm long, white, pistil more or less persistent; pappus absent. Seedling with epigeal germination, hypocotyl 2 mm long, cotyledons subsessile, elliptical, 1.8 mm × 0.9 mm, base attenuate, apex rounded, glabrous, epicotyl absent, first leaves opposite, subsessile, elliptical, 1.7–2 mm × 1.1–1.3 mm, midvein distinct, base attenuate, margin entire, apex apiculate, glabrous.



Centipeda minima (L.) A. Br. & Asch. – 1, plant habit; 2, flower head; 3, disk flower; 4, achene of disk flower; 5, marginal flower; 6, achene of marginal flower.

Growth and development *C. minima* is a minor weed because it does not root deeply, and it stays small. The flowering period in Java is March–October.

Other botanical information *Centipeda* comprises 6 species, which are predominantly distributed over the Old World tropics. *C. minima* is at present placed in the tribe *Anthemideae*, but on the basis of the pollen grain structure it is probably better placed in the *Astereae*.

Ecology *C. minima* is common in humid open locations, on thinly grassed patches in savanna, on banks of permanent waterholes, and on muddy banks of rivers. In Indo-China, it is common in fallow rice-fields and waste land. It occurs from sea-level up to 30 m in Java, but up to 1200–2400 m altitude elsewhere.

Propagation and planting *C. minima* propagates through achenes, which are zoo- and hydrochorous.

Diseases and pests No diseases and pests are known to attack *C. minima*. It is resistant to root-knot nematodes.

Harvesting *C. minima* is harvested either when the flower heads are just opening or are in full bloom.

Handling after harvest *C. minima* is cleaned of sand and dried after harvesting.

Genetic resources and breeding *C. minima* is a widespread weed, which does not seem to be in danger of genetic erosion. No germplasm collections or breeding programmes are known to exist.

Prospects Little information is available about phytochemical and pharmacological properties of *C. minima*. The bactericidal activity of the sesquiterpene lactones merits further research.

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Other selected sources 74, 108, 134, 135, 215, 329, 355, 559, 595, 604, 739, 786, 788, 793, 810, 876, 981, 993, 994.

Wongsatit Chuakul, Noppamas Soonthornchareonnon & Orawan Ruangsomboon

Cerbera L.

Sp. pl. 1: 208 (1753); Gen. pl. ed. 5: 98 (1754).
APOCYNACEAE

$x = 20$; *C. manghas*: $2n = 40$, *C. odollam*: $2n = 40$

Major species *Cerbera manghas* L., *C. odollam* Gaertner.

Vernacular names Grey milkwood (En, trade name). Indonesia: bintaro (Java). Malaysia: pong-pong (Peninsular). Papua New Guinea: cerbera (general). Burma (Myanmar): kalwa. Cambodia: krapur. Thailand: teenpet (central). Vietnam: m[uw][ows]p x[as]t, m[aaj]t s[as]t.

Origin and geographic distribution *Cerbera* comprises 6 species and is found from Tanzania (Pemba), Madagascar and islands in the Indian Ocean to India, Burma (Myanmar), Indo-China, Taiwan, southern Japan and Thailand, throughout the Malesian region towards Melanesia and north-eastern Australia.

Uses Several *Cerbera* species are applied medicinally against itch and sores. *C. manghas* and *C. odollam* are well known for their poisonous seeds, which are for various purposes in the Philippines and Thailand including for stupefying fish. In areas where both species occur, they are apparently used indiscriminately. An excellent purgative can also be prepared from their root and bark. The seeds contain an oil which has been used for making candles. In Thailand, the bark is used as a laxative, antipyretic and in the treatment of dysuria. The wood is used in paralysis, and the outer bark in the treatment of ringworm. The leaves are also externally applied to treat ringworm. The oil from the seeds is externally used to treat scabies and as a hair tonic. The flowers are applied to treat haemorrhoids. In Vietnam, a liniment of the seed oil is used to treat scabies and itch, and applied to the hair to kill head lice. The bark and leaves are occasionally used with caution as a purgative. In the Solomon Islands, heated leaves of *C. floribunda* K. Schum. are rubbed on the skin to relieve aches and sores. Likewise the exudate is placed on sores. In New Ireland, Papua New Guinea, the scraped bark mixed with leaves of wild ginger is squeezed into water and taken as a remedy for malaria, black water fever and hepatitis.

C. manghas and *C. odollam* are also planted as ornamentals. The wood of *Cerbera* is used for non-durable or indoor applications. The wood of both *C. manghas* and *C. odollam* yields a good charcoal.

Production and international trade *Cerbera* is only locally used medicinally and is not traded on the international market.

Properties Both *Cerbera* species are known to contain a series of cardiac glycosides of the cardenolide type. The seeds contain cardenolides derived from the aglycones tanghinigenin and digitoxigenin, such as cerberin, neriifolin, thevetin B and 2'-O-acetyl-thevetin B. The principal cardenolides contained in the bark and root are gentiobiosyl-thevetoside and glucosyl thevetoside along with other thevetosides derived from tanghinigenin and 17βH-tanghinigenin as their aglycone. Cardenolides in the leaves are: 17βH-neriifolin, neriifolin, 17βH-deacetyltanghinin and deacetyltanghinin.

Besides the cardiac glycosides, phytochemical investigations of both species revealed the presence of a series of lignans, derived from olivil (the cerberalignans D–I, from the stems), and the monoterpenoids cerberidol, epoxycerberidol and cyclocerberidol together with their respective D-allopyranosides.

The purified cardenolide cerberin acts on plain muscle preparations as definite stimulant both with regard to its tone and peristaltic movements. As such it behaves as a parasympatomimetic poison. When administered subcutaneously to animals in dilute solutions it produces vomiting, diarrhoea and sometimes unconsciousness.

In moderate doses cerberin has positive inotropic properties. It acts both on the rhythm and amplitude of the heart. In toxic doses, it produces a negative inotropic and chronotropic effect. This is in correspondence with the administration of graded doses of an alcoholic extract of the seeds in anaesthetized cats and dogs, which resulted in first degree heart block, atrial and ventricular fibrillation and death. Furthermore, the immediate and delayed toxicity of *C. odollam* leaf extract was studied in mice. The leaves appeared to be relatively devoid of the marked toxicity found in seeds. At doses smaller than the maximal dose was never lethal (14.5 g/kg intra peritoneally), the leaf extract decreased spontaneous motor activity in mice significantly, increased the reaction time to a thermal stimulus, reduced the duration of pentylenetetrazole-induced tonic seizures and mortality, and potentiated sodium pentobarbital-generated hypnotic effects.

Other pharmacological effects of *Cerbera* extract include activity in a DPPH free radical scavenging assay; the lignans olivil, (–)-carinol, and (+)-cycloolivil were identified as active principles. In addition, ethanolic extracts of *C. manghas* have shown selective activity against vesicular stomatis viruses (VSV) at a minimum inhibitory concentration (MIC) of 0.005–0.1 mg/ml and cytotoxic activity was observed in HeLa cells at a median curative dose (CD_{50}) of 0.001–0.1 mg/ml.

Cerbera yields a lightweight to medium-weight timber. Shrinkage upon seasoning is moderate; the wood seasons readily and well. It works easily.

The wood is non-durable and resistant to preservative treatment under pressure.

Adulterations and substitutes Cardiac glycosides are present in several other genera of the *Apocynaceae* family, e.g. *Thevetia* (structurally very similar to *Cerbera*) and *Strophanthus*.

Description Evergreen shrubs or small to medium-sized trees up to 30 m tall; bole up to 90 cm in diameter, not buttressed; bark surface irregularly scaly or warty, peeling off in small flakes, exuding abundant white latex. Leaves arranged spirally, clustered at the apices of twigs, glabrous, entire or sinuate with a decurrent base. Inflorescence terminal, cymose, glabrous. Flowers actinomorphic, 5-merous; calyx deeply divided or the sepals free; corolla hypocrateriform, white or light red, strongly scented, lobes overlapping to the left in bud; disk absent; anthers lanceolate, contiguous to the style head and with filiform appendages; carpels 2, free, with 4 ovules in each carpel, style-head composed of 2 annular swellings, surmounted by 2 thick appendages. Fruit consisting of 2 (or by abortion 1) drupaceous mericarps, exocarp fleshy, endocarp woody, seeds 1 or 2. Seed compressed, not winged. Seedling with hypogeal germination; hypocotyl not elongated.

Growth and development *C. manghas* develops according to Koriba's architectural tree model, characterized by orthotropic axes which branch to produce initially equivalent modules, but where one of these subsequently becomes dominant, constituting one unit of the sympodial trunk. In Vietnam, *Cerbera* spp. flower from February to October and bear ripe fruits from August to April. In Australia *C. manghas* flowers and fruits throughout the year. The flowers are pollinated by insects. The fruits of *C. manghas* and *C. odollam* are dispersed by water and are quite commonly washed up on the shores.

Other botanical information There used to be considerable confusion about the correct names for *C. manghas* and *C. odollam*. As a result, it is often not possible to allot given information to one of these species. Furthermore, open flowers, or else mature or almost mature buds are indispensable for determination. Fruiting specimens can only exceptionally be named, often only on the basis of mutual exclusion by the natural distribution of the species involved.

Ecology *Cerbera* species are generally associated with water and occur along rivers or streams, in swamp forest and behind mangroves, but may also be found in shrubby savanna or in secondary forest edges. Some species, like *C. manghas* and *C. odollam*, are common elements of mangrove swamps and tidal river banks and may root in muddy locations but also in sandy coastal soils. Most *Cerbera* species occur at low altitude in primary lowland rain forest, but some may ascend up to 2000 m. Where species distributions overlap, they have different biotopes.

Propagation and planting *Cerbera* is usually propagated by seed but can also be propagated by ripewood cuttings. *Cerbera* should preferably be grown in full light in a fertile moist but well-drained loam with additional leaf mould.

Harvesting Fruits of *Cerbera* are harvested when ripe.

Handling after harvest The pulp of the ripe fruits of *Cerbera* is removed to obtain the seeds. Alternatively, the fruits are dried first, and then cracked to liberate the seeds. Seeds are pressed to extract the oil.

Genetic resources and breeding The *Cerbera* species of medicinal importance have a widespread natural distribution. They are locally common and sometimes planted. The risk of genetic erosion seems therefore rather limited.

Prospects At present in medicine, cardiac glycosides are only applied in specific cases. The drug of choice is generally digoxin from *Digitalis lanatae* Ehrh. or in acute situations the strophanthins (e.g. ouabain) from *Strophanthus*. Therefore the cardenolides from *Cerbera* are unlikely to play an important role in future medicine; in certain cases they may, however, be of some local importance.

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nal plants of Vietnam, Cambodia and Laos. Mekong Printing, Santa Ana, California, United States. pp. 57–58.

Selection of species

Cerbera manghas L.

Sp. pl. 1: 208 (1753).

Synonyms *Cerbera linnaei* Montrouz. (1860), *Cerbera odollam* auct. non Gaertner.

Vernacular names Sea-mango (En). Indonesia: bintaro (Java), bintan (Manado), mangga brabu (Moluccas). Malaysia: bentan, bintaru (Peninsular). Philippines: baraibai (Tagalog). Burma (Myanmar): kalwa salat. Thailand: teenpet lek (central), teenpet sai (peninsular), rak khao (south-eastern). Vietnam: m[uw][ows]p s[as]t h[uw][owf]ng, m[uw][ows]p x[as]c h[uw][owf]ng.

Distribution From the Seychelles towards Indo-China, Taiwan, Thailand, throughout the Malesian area to north-eastern Australia and Melanesia.

Uses In Thailand, the leaves and bark are used as a laxative and emetic. In Fiji, the leaves and fruits are used as an emetic, and the root and bark as a purgative. The scraped root is used to treat liver disorders. A decoction of the inner bark is drunk with cold water as an abortifacient.

Observations A shrub or tree up to 25 m tall, bole up to 70 cm in diameter; leaves narrowly obovate to elliptical, 5–31 cm × 1–7(–8) cm, length-width ratio (1.7–)2.4–7, base cuneate, apex acuminate, apiculate or rounded, with 15–40 pairs of secondary veins; inflorescence few- to many-flowered, up to 30 cm long, usually only one flower open at a time, sepals very variable in shape and size, length-width ratio 1.2–12, corolla tube narrowly infundibuliform, 17–55 mm long, with 5 lanate scales just below the mouth, lobes 15–50 mm long, usually white, but locally tinged pink or yellow at the base, stamens inserted just beneath the mouth, covered by the lanate scales; fruit consisting of 2 mericarps, ellipsoid, 5–12 cm × 3–7 cm × 3–5.5 cm, purplish-red or pale green.

Selected sources 215, 263, 407, 459, 672, 786, 810, 1008.

Cerbera odollam Gaertner

Fruct. sem. pl. 2: 193 (1791).

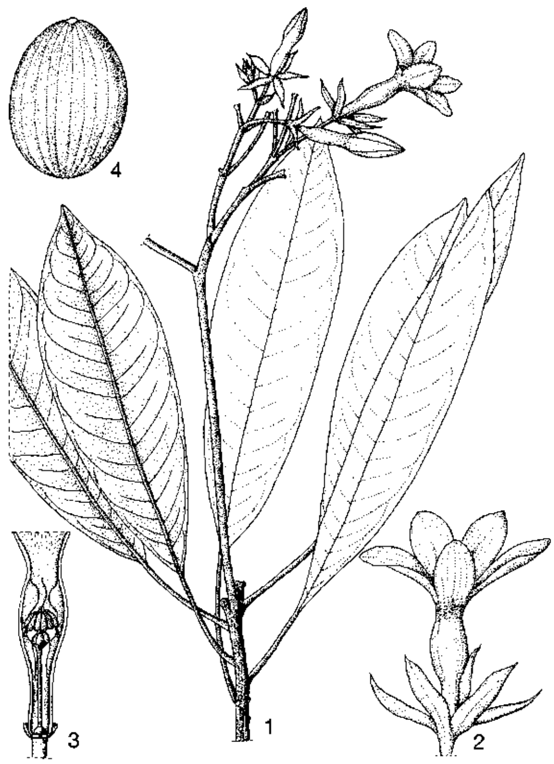
Synonyms *Cerbera lactaria* Buch.-Ham. ex Spreng. (1825), *Cerbera manghas* auct. non L.

Vernacular names Brunei: pong pong (Sengkurong). Malaysia: bintan (Peninsular). Thailand: sang la (peninsular), teenpet nam, teenpet thale (central). Vietnam: m[uw][ows]p s[as]t v[af]ng, m[uw][ows]p x[as]c v[af]ng.

Distribution From Sri Lanka and India towards Burma (Myanmar), Indo-China and Thailand; in Malesia recorded in Peninsular Malaysia, Sumatra, Java, western Sulawesi, Borneo and the Philippines (Luzon); in the Pacific recorded in the Mariana Islands and Guam.

Uses In Brunei, a leaf decoction is added to an aromatic bath after childbirth. In India and Thailand, the bark, leaves and latex are considered emetic and purgative. The seed, and in particular the seed oil, is toxic and strongly purgative.

Observations A shrub or tree up to 15 m tall; bole up to 20 cm in diameter; leaves obovate, 9–26 cm × 2–5.5 cm, length-width ratio 2.5–5, base cuneate, apex acuminate or apiculate, with 15–25 pairs of secondary veins; inflorescence few- to many-flowered, up to 35 cm long, usually only one flower open at a time, sepals very variable in shape and size, length-width ratio 2–6, corolla tube bulging in the middle, 15–25 mm long, lobes 12–38 mm long, usually white, sometimes yellow



Cerbera odollam Gaertner – 1, flowering twig; 2, flower; 3, dissected flower; 4, fruit.

or orange in the mouth, stamens inserted around the middle of the corolla tube; fruit consisting of 2 mericarps, subglobose to broadly ellipsoid, 8–11 cm × 7.5–11 cm × 6.5–10 cm, pale yellow-green or red.

Selected sources 201, 215, 407, 672, 786, 810, 1008.

Tran Cong Khanh

Cissus L.

Sp. pl. 1: 117 (1753), Gen. pl. ed. 5: 53 (1754).

VITACEAE

$x = 12$; *C. adnata*: $2n = 48$, *C. javana*: $2n = 24$, *C. quadrangularis*: $2n = 24$, (45), *C. repens*: $2n = 96$, *C. verticillata*: $2n = 48$

Major species *Cissus quadrangularis* L.

Origin and geographic distribution *Cissus* occurs throughout the tropical and warm regions of the world and consists of about 350 species.

Uses In South-East Asia, several *Cissus* species are used as an anti-inflammatory, antidiarrhoeal and against headache.

In Java, Thailand, India and southern Africa, the leaves of *C. quadrangularis* are applied on boils, burns and wounds while the crushed leaves or the juice from the stem, which has a pungent smell and taste when crushed, are applied for rheumatism and to ease the pain of broken bones and hasten recovery. In India, the powdered root is also used in the treatment of fractured bones, as well as for indigestion, and the juice of the plant is applied for scurvy, asthma, ear problems or nosebleed, and used as an alterative for amenorrhoea. An infusion of the plant is considered purgative. In Thailand, the fresh stem is used in the treatment of haemorrhoids, by swallowing thin slices, covered in banana pulp, without chewing, to prevent irritation in the mouth. In southern Africa, the juice from the stem is dripped into the ear for earache, and a decoction of the root is used for swellings and muscle pain.

In Java, a cold infusion of the pounded root of *C. adnata* is taken for cough, and the juice from the stem is taken for cough and diarrhoea. Externally, the leaves are applied for maturation of boils, cuts and fractures, just like those of *C. compressa* Backer (synonym *Vitis compressa* Blume). A poultice of the roots of *C. diffusa* (Miq.) Amshoff (synonym *Vitis diffusa* Miq.) from Borneo, Peninsular Malaysia and Sulawesi, is applied for headache. A paste of the fresh leaves of *C. nodosa* Blume is spread over the abdomen for intestinal problems. The fruits cause inflammation in the mouth when eaten, but externally they are applied for skin ailments. The roots of *C. rostrata* (Miq.) Planch. (synonym *Vitis furcata* Lawson) are boiled to make a poultice for rheumatism. In Indonesia, the leaves of *C. javana* DC. (synonym *Cissus discolor* Blume) are taken for stomach-ache, and the leaves and shoots of *C. repens* Lamk are poulticed on swellings and for fever. In Peninsular Malaysia, the pounded leaves of *C. hastata* are used to poultice boils, or are boiled and put on the abdomen for ague.

The fruits of *C. modeccoides* Planch. (synonym *Cissus triloba* Merr.) from China and Indo-China, are widely used for arthritis and rheumatism and the roots are applied for headache. In China, *C. assamica* (Laws.) Craib is used to treat snakebites. In West Africa, a decoction of the stem of *C. populnea* Guill. & Perr. is applied to sores of cattle suffering from foot-and-mouth disease. In Nigeria, a gum, 'Okoho gum', which is extracted from the root can serve as a binder in lactose-based tablets, or may be useful in prolonged release tablet formulations.

The young shoots and leaves of several *Cissus* species, e.g. *C. javana*, *C. quadrangularis* and *C. repens*, are pleasantly acid in taste and eaten as a vegetable, often mixed with other vegetables.

The stems of *Cissus* are often used for making strong ropes; others are cultivated as ornamentals, and also as pot plants in the temperate regions.

Production and international trade *Cissus* is used on a local scale only.

Properties Phytochemical analysis of several parts of *C. quadrangularis* has revealed the presence of a variety of compounds. The aerial parts contain tartaric acid and calcium oxalate in the form of crystals. Especially the latter may be held responsible for the irritating action on the skin and in the mouth. Furthermore, the triterpenoids/steroids onocer-7-ene-3α,21β-diol and onocer-7-ene-3β,21α-diol were isolated from the stems, as well as β-sitosterol, δ-amyrin and δ-amyrone, resveratrol, piceatannol, pallidol, parthenocissine A, taraxeryl acetate, friedelan-3-one, taraxerol and an asymmetrical tetracyclic triterpenoid, 7-oxoonocer-8-ene-3β,21α-diol. In addition, extraction was performed on the aerial parts using ethanol followed by hexane and other solvents. From the hexane fraction the following alkanes were isolated: 4-hydroxy- 2-methyl- tricos- 2-en-22-one, 9-methyl-octadec-9-ene, heptadecyl octadecanoate, icosanyl icosanoate, 31-methyltritriacontan-1-ol, 7-hydroxy-20-oxo-docosanyl cyclohexane, 31-methyltritriacontanoic acid and isopentacosanoic acid. Stilbene derivatives from *C. quadrangularis* mentioned in the literature include quadrangularins A, B, and C. Quercitin, quercetrin and isoquercetrin were isolated from the stem of *C. quadrangularis*, while cyanidin, delphinidin, kaempferol, myricetin were found in the leaves of *C. hastata*.

In an in vitro assay, an ethanol extract of the aerial parts acted upon the isolated intestines and the uterus of rabbits and albino rats and on the tracheal and intestinal muscles of the dog in a manner comparable to that of acetylcholine. The overall LD_{50} of this extract was found to be 15.5 mg/kg in guinea-pigs. Furthermore, in dogs a fraction containing glycosides produced a dose-dependent hypotension. The negative chronotropic effects on the myocardium could be overcome by applying calcium, which is thought to inhibit the passage through the cell membrane. Intramuscular administration of an extract to rats and local use as an ointment in dogs showed a reduction of the convalescence time of experimental cortisone-treated fractures by 33%. Cortisone has an anti-anabolic action and thus delays consolidation.

In another test, the effects of a methanolic extract of the stems of *C. quadrangularis* (CQ) on the healing process of experimentally fractured radius-ulna of the dog was evaluated. Radiological and histopathological examination revealed faster initiation of the healing process in CQ treated animals than the control animals. The treated group also revealed a greater decrease in serum calcium level than the control group. Healing was almost complete 3 weeks after fracturing in the treated animals and remained incomplete in the control animals, and no significant alteration of serum calcium level was observed. *C. quadrangularis* was also screened for its genotoxic effects on Swiss mice. Salted, sun-dried and oil fried stems induced moderate mutagenic effects including chromosomal aberrations, sperm head abnormalities and micronuclei production, which were comparable to the effect of 20-methylcholanthrene.

Furthermore, the consumption of *C. quadrangularis* is suspected of causing significant loss of livestock in the Sudan. Nubian goats, 3–6 months old, and desert sheep, 6–9 months old, were given dried stems finely ground in a water suspension at 0, 0.25, 0.5, 1, 5 or 10 g/kg body weight daily by stomach tube until death or slaughter. Signs of poisoning included decreased appetite, staggering, dyspnoea, diarrhoea and loss of condition. Pathological changes included haemorrhaging in kidney, lung, heart and intestine, focal catarrhal enteritis and atrophy of cardiac fat, hydroperitoneum and hydropericardium.

In India, a stem extract of *C. quadrangularis* was found to inhibit rice tungro virus infection when dilute macerates were sprayed on rice seedlings before inoculation by means of viruliferous *Nephotettix virescens*. In another test, a 5% aqueous leaf extract was sprayed on chillies 30 days after transplanting, which caused a reduction of the yellow mite (*Polyphagotarsonemus latus*) populations, at 5 and 10 days after treatment.

From the fruits of the South American *C. verticillata* (L.) Nicolson & C.E. Jarvis (synonym *C. sicyoides* L.), which is naturalized in Java, delphinidin-3-rhamnoside, delphinidin-3-rutinoside and cyanidin-3-rhamnosyl-arabinoside, were extracted. The anthocyanin content of the fruit juice was about 120 mg/100 ml. The effect of the aqueous extract of *C. verticillata* on isolated guinea-pig aortic rings was studied in vitro. The extract was found to contract the smooth muscle of the aorta in a dose-responsive relation. The extract also potentiated the norepinephrine-induced contraction in normal calcium and in solutions without calcium. Lanthanum ions were found to inhibit the contraction induced by the extract. Also, the vasoconstrictor effect of the extract was increased in solutions without calcium or with low calcium, thus showing an inverse calcium-dependent contraction. Prolonged exposure to calcium-free solution did not abolish the induced contraction. Caffeine reduced contractile response induced by the extract in normal calcium, as well as in solutions without calcium. These results support the idea that the aqueous extract of *C. verticillata* acts at the membrane level, increasing the calcium entry through the membrane as well as acting on the internal calcium deposits, possibly on the sarcoplasmic reticulum.

Anti-inflammatory effects of aqueous extracts from *C. verticillata* have been investigated in vivo, by using the carrageenan-induced rat paw oedema (systemic model) and the mice ear oedema test (topical model) using tetradecanoylphorbol acetate as inflammatory agent. Dry extracts from a stem decoction were administered in oral doses of 500 mg/kg in the systemic model, and in doses of 3 and 5 mg/mouse ear in the topical model. In the systemic anti-inflammation assay, the oral administration produced a significant anti-inflammatory effect. In the topical model, the administration produced similar inhibitions of the oedema, with a

reduction of approximately 50% in comparison with the control group. In homogenated tissue samples from the inflamed areas, a distinct decrease in the level of myeloperoxidase enzyme was noted. Furthermore, it was reported that LD_{50} values after intraperitoneal administration were quite high.
In another in vitro screening assay, a *C. verticillata* extract showed a moderate cytostatic activity against HEp-2 cells.
Powdered root of *C. populnea* is used in parts of Eastern Nigeria as seasoning, added to soup, and mean daily intake is around 3–15 g/person. In an in vivo model, Sprague-Dawley rats were given diets with and without *C. populnea* during 10 days. Results suggest a goitrogenic effect, resembling a mild effect of thiocyanate. Slight dietary deficiency and the goitrogens in unfermented smoked cassava and in *C. populnea* may act together to cause the goitre that is endemic to some parts of Eastern Nigeria.

Description Perennial, evergreen or deciduous, climbing or scrambling lianas, variably hairy, hairs uni- or multicellular, then often uniseriate, climbing by leaf-opposed tendrils, branched or unbranched, branches subtended by a bract; roots sometimes tuberous. Leaves alternate, simple or pinnate, 3–5(–7)-foliolate, margins entire or indented, sometimes with domatia; petiole present; stipules 2, caducous. Inflorescence leaf-opposed, pedunculate, multi-flowered in umbellate cymes, or paniculate with terminal umbels, often loose; peduncle and pedicel subtended by bracts. Flowers bisexual, small, usually 4-merous; calyx cup-shaped, entire or shallowly lobed; corolla with 4 lobes, free, cohering in bud by the interlocked epidermis cells, cucullate at apex, reflexed after anthesis, soon caducous; stamens 4, inserted on the receptacle at the base of the disk, opposite the petals, filaments erect, often flattened, anthers dorsifixed, opening by longitudinal slits, introrse; disk adnate to and entirely surrounding the ovary, margins sometimes slightly lobed; ovary superior, 2-locular, 2 ovules per locule; style cylindrical or conical, stigma minute, accrescent. Fruit a fleshy berry, with 1(–4) seeds. Seed ovoid, pyriform or rarely elongate, shape depending on number of seeds in berry, flattened, with 1–2 furrows or pits on the ventral surface; albumen on transverse section ruminate, not U- or T-shaped. Seedling with epigeal germination; cotyledons similar or dissimilar.

Growth and development Many *Cissus* start flowering at the beginning of the rainy period, and fruiting at the beginning of the dry season; others can be found flowering and fruiting throughout the year. *Cissus* is pollinated by insects. *C. quadrangularis* shows Crassulacean Acid Metabolism (CAM), a physiological adaptation to drought typical of many succulent plants, in which CO_2 is fixed in the dark.

Other botanical information *Cissus* may be distinguished from the closely related *Cayratia* by its usually leaf-opposed umbellate cymes and its usually simple leaves. If the leaves are compound though, they are palmately 3–5–7-foliolate and the petiolules are absent, or, if present then the central petiolule is less than twice as long as the lateral, rarely longer, and if so the fruit is 1-seeded with 2 ventral furrows.
In *Cissus*, leaf-size and degree of pubescence vary considerably intraspecifically, as in *Cayratia*, but shape and relative size of leaves, nature and position of hairs, nature of tendrils, nature of stipules and seed characteristics are useful diagnostic characters.
C. adnata, *C. assamica* (Laws.) Craib and the not locally used *C. aristata* Blume are distinct and easily recognized by the nature and distribution of their trichomes although they have been frequently confused in the literature with respect to their circumscription and synonymy. *C. adnata*, from India to Australia, has both multicellular, uniseriate and unicellular 2-armed trichomes on the abaxial leaf surface, glabrous stipules and a pubescent ovary; *C. assamica*, from India to New Guinea, has unicellar, 2-armed hairs, sparsely distributed, glabrous stipules and ovary; *C. aristata* extending, from Burma (Myanmar)to Papua New Guinea, has scattered unicellar, 2-armed hairs, pubescent stipules and a glabrous ovary.

Ecology *Cissus* occurs in thickets, open forest, along forest borders and on river banks, at low and medium altitudes.

Propagation and planting *Cissus* is propagated by seed, although some species can be multiplied by stem cuttings.

Diseases and pests Larvae of the grape vine Sphinx (*Hippotion celerio*), a minor pest of grape vine (*Vitis vinifera* L.), also feed on *C. quadrangularis* in India.

Harvesting *Cissus* stems and roots can be harvested throughout the year. As some species are deciduous, leaves can only be harvested in the season.

Handling after harvest The parts of *Cissus* harvested are often used fresh. Roots are mainly dried and powdered for future use.

Genetic resources and breeding The *Cissus* species treated here have a large area of distribution, either naturally or as a result of cultivation, and do not seem to be at risk of genetic erosion. There are no known breeding programmes of *Cissus*.

Prospects Several pharmacological effects of fractions of a number of *Cissus* species, e.g. in the fields of anti-spasmodics and anti-inflammatories, may be of interest for future developments. On the other hand, *Cissus* species are also suspected to have adverse effects, for instance causing significant loss of livestock, or causing goitre. Therefore, more research will be needed to fully evaluate their possibilities.

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Selection of species

Cissus adnata Roxb.

Fl. ind. 1: 405 (1820).

Synonyms *Vitis adnata* Wight & Arnott (1834).

Vernacular names Indonesia: areuy beungbeurutan (Sundanese), bantengan, galing kebo (Javanese). Malaysia: akar gamik, sambangan, seketan. Philippines: ayong-kabayo (Tagalog), bolakau (Kuyonon), linga-an (Bagobo). Thailand: hun (eastern). Vietnam: d[aa]y n[oo]i, d[aa]y cu[oos]n.

Distribution From India and Sri Lanka to Indo-China, Thailand, throughout South-East Asia into tropical Australia.

Uses In Java, a cold infusion of the pounded root is taken for cough. The juice from the stem is taken for cough and diarrhoea. Externally the leaves are applied for maturation of boils. In India, a decoction of the dried tuberous roots is taken as an alterative, diuretic and blood purifier. The powdered root is heated and applied to cuts and fractures. In Bangladesh, a leaf poultice is applied to boils.

In India, the leaves are cooked and eaten as a vegetable. The stem is commonly used for cordage.

Observations A deciduous, slender climber, 5–15 m long, bark often reddish, flaky, pubescent when young, hairs multicellular, uniseriate and unicellular 2-armed, tendrils usually unbranched; leaves simple, orbicular to broadly ovate, 8–18 cm × 10–19 cm, base cordate to reniform, apex acuminate to cuspidate, membranaceous, veins prominent, secondary veins terminating in hair-like projections which extend beyond the margin, hairs on lower surface 2-armed, petiole 3–8 cm long, stipules rounded-triangular, 3.5 mm long, glabrous; inflorescence umbellate, loose, 2.5–7 cm long, 3–5 primary branches, pubescent, corolla 1–1.5 mm long, often papillose, pale green to white; berry pyriform, 4.5–7 mm long, dark brown to black, 1-seeded; seed ovoid, 4–6 mm long, lower end beaked, endosperm in transverse section twice divided by the thin endotesta, cotyledons similar. *C. adnata* occurs in semi-deciduous thickets close to beaches, monsoon forest and open forest, usually on well-drained soils. Soils are variable but usually sandy to sandy loam, sometimes lateritic, sometimes calcareous.

Selected sources 74, 215, 407, 479, 810.

Cissus hastata Miq.

Fl. Ind. Bat., Suppl.: 517 (1860).

Synonyms *Vitis hastata* (Miq.) Miq. (1863).

Vernacular names Malaysia: akar asam riang, akar iang-iang, akar kerayong. Thailand: thao som op, som khaao (peninsular), som sandaan (south-eastern). Vietnam: h[oof] d[awf]ng m[ux]i gi[os]o.

Distribution From India to Indo-China, Thailand, throughout South-East Asia to the east coast of Australia.

Uses In Peninsular Malaysia, the pounded leaves are used to poultice boils, or are boiled and put on the abdomen for ague. In Thailand, leaves stems, or fruits are used for coughs, as an expectorant and as an anti-emetic.

Observations An evergreen climber with quadrangular stems, margins winged, glaucous, hairy when young, hairs unicellular, 2-armed, tendrils unbranched or bifid; leaves simple, ovate to broadly ovate, 7–11.5 cm × 5.5–10.5 cm, often reddish on the lower surface when young, base cordate, apex acute to acuminate, margins serrulate, petiole 1.5–4 cm long, stipules triangular, up to 2.5 mm long, borne at right angles to the stem; inflorescence umbellate, 2–3.5 cm long, 3 primary branches, pubescent, peduncle 0.5–1.2 cm long, hairs both 2-armed and uniseriate; pedicel straight or curved, corolla 1.5–2 mm long, white to yellowish; berry ovoid, 6–7 mm × 4–6 mm, black, 1-seeded; seed pyriform, 4–4.5 mm long, endosperm in transverse section appearing almost twice divided by the endotesta; cotyledons dissimilar. *C. hastata* occurs along forest margins, usually cascading over trees, from sea-level up to 700 m altitude, on most soil types.

Selected sources 74, 491, 586, 841.

Cissus quadrangularis L.

Syst. nat. ed. 12(2): 124 (1767).

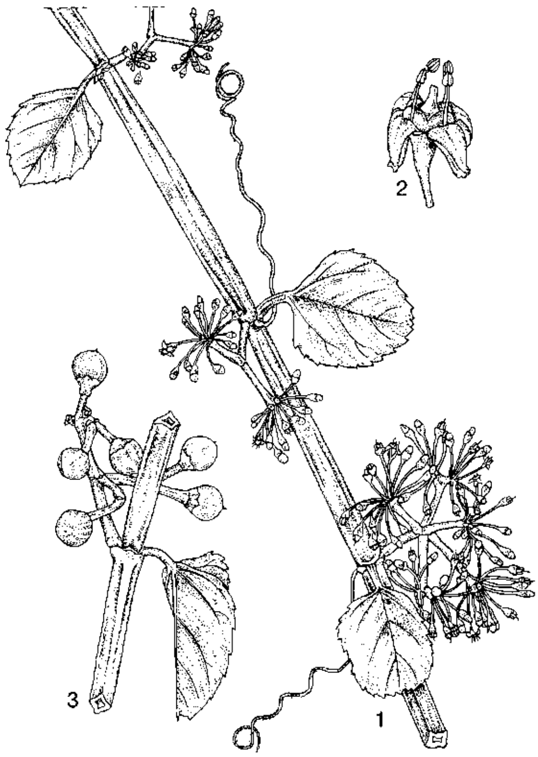
Synonyms *Vitis quadrangularis* (L.) Wight & Arnott (1834).

Vernacular names Climbing cactus, edible-stemmed vine, kangaroo vine (En). Indonesia: patah tulang (Malay), tikel balung (Javanese). Philippines: sugpon-sugpon (Bisaya), sulpa-sulpa (Cebu Bisaya). Thailand: khankho (south-western), phet sangkhaat, san cha khuat (Bangkok). Vietnam: h[oof] d[awf]ng b[oos]n c[aj]nh, d[aa]y xanh vu[oo]ng.

Distribution Tropical Africa and Arabia, Madagascar, Mascarenes, India and Sri Lanka; naturalized in Thailand, Vietnam, Java, the Moluccas and the Philippines.

Uses In Java, the leaves or young stems are applied for maturation of boils, and to cure wounds and burns, also for saddle sores on horses. The crushed leaves or the juice from the stem are applied for rheumatism and to broken bones, to ease the pain. In India, the pulped stem is given in asthma, and the powdered root is considered to be a specific in the treatment of fractured bones. The powdered dry roots are used for indigestion. In the Philippines, the stems are applied as an alterative for amenorrhoea. In Thailand, the fresh stem is used in the treatment of haemorrhoids.
In southern India and Sri Lanka, the green stems are edible if fried or curried. The ash of the plant is used as a substitute for baking powder.

Observations A deciduous, glabrous climber, 1–2(–8) m long, with stout, succulent, quadrangular, almost winged stems, 1–1.5 cm wide, constricted at the nodes, tendrils simple, minute bract in upper half; leaves variable, broadly ovate or triangular-reniform, 4–6 cm long, somewhat fleshy, base truncate, apex rounded, margins distantly serrate, petiole 5–11 mm long, stipules ovate, up to 5 mm long; cymes leaf-opposed, sub-umbellate, more or less asymmetrical, 2–3 cm × 5–6 cm, peduncle 7–15 mm long, 2–5 primary branches, one sometimes further branched; flowers crowded, sweetly-scented, petals about 2.5 mm long, recurved at anthesis, quickly caducous, pinkish inside, green and red outside; berry subglobose, fleshy, about 7 mm in diameter, reddish to blackish, calyx and style persistent, 1-seeded. Seed obovoid, 5 mm long, endosperm in transverse section M-shaped. *C. quadrangularis* occurs in arid and semi-arid conditions, especially near the coast, up to 300 m altitude, but is also planted as a hedge.



Cissus quadrangularis L. – 1, flowering stem; 2, flower; 3, infructescence.

Selected sources 74, 77, 215, 407, 491, 760, 810, 838, 889, 914.

N.O. Aguilar

Clausena Burm.f.

Fl. indica: 87 (1786).

RUTACEAE

$x = 9$; *C. anisata*: $2n = 18$, 36, *C. excavata*: $2n = 36$, *C. heptaphylla*: $2n = 36$, *C. lansium*: $2n = 18$

Major species *Clausena anisata* (Willd.) Hook.f. ex Benth., *C. excavata* Burm.f.

Origin and geographic distribution *Clausena* is a relatively small genus, comprising 15 species, distributed over 4 sections. *Clausena* occurs primarily in continental Asia and South-East Asia, extending to north-eastern Australia (Queensland). *C. anisata* extends its distribution area to India and Sri Lanka and is the only representative in tropical Africa.

Uses Many *Clausena* species are important medicinal plants in their original area of distribution, but some of them have been widely planted for their edible fruit as well. The juice or a decoction of the roots or leaves of several *Clausena*, e.g. *C. anisata*, *C. excavata*, *C. lansium* and *C. anisum-olens* (Blanco) Merr. (synonym *C. sanki* (Perr.) J.F. Molino), is widely used for treating colds, sinusitis, fever and stomach problems such as constipation and diarrhoea.

The leaves and fruits of *C. anisata* are very aromatic when crushed. The essential oil is comparable to that of *C. anisum-olens*. In Vietnam, a decoction of the leaves and roots is used for treating colds, rheumatism and arthritis. In Java the roots of *C. excavata* are used likewise. Externally, the roots of *C. anisata* are poulticed for sprain, contusion and fractures. In Africa the crushed leaves are considered antiseptic and analgesic and applied on wounds and burns.

In Java the juice from the leaves of *C. excavata* is taken for worms. Pounded leaves may be applied to the head for headache. In Java and Peninsular Malaysia, ulcerations of the nose may be treated by applying a poultice of the leaves or by fumigating with burning leaves and bark. A decoction of the flowers and leaves may also be taken for colic. In China a poultice of the leaves is applied to treat paralysis. In Indo-China the leaves are considered laxative, stomachic and expectorant and are prescribed in dyspepsia, stomach-ache and cough.

C. lansium is used in traditional medicine in Malaysia and China to treat coughs, asthma, viral hepatitis and dermatological and gastro-intestinal diseases including ulcers and dysentery. The dried unripe fruits and dried sliced roots are used as a remedy for bronchitis. Ripe fruits are said to have stomachic and cooling effects and to act as a vermifuge. A decoction of the leaves, such as those of *C. lenis* Drake (synonym *C. kerrii* Craib) from northern Indo-China and Taiwan, is used for dandruff and to preserve the hair colour. The immature fruits of *C. lenis* are dried and taken for bronchitis, while the roots, stem and leaves are applied on persistent furuncles.

C. anisum-olens is restricted to the Philippines and var. *calciphila* (Stone) Molino to Borneo. Its essential oil is a potential substitute for anise oil. Medicinally, a decoction of the roots and fruits is taken for cough with fever, that of the leaves to treat nausea during pregnancy. The leaves are also added to baths to treat rheumatism, or stuffed into pillows, as they have a soporific effect.

Production and international trade *Clausena* is of local importance only and is not traded internationally.

Properties The leaves and fruits of *Clausena* contain essential oils.

For example, leaf samples of the Philippine essential-oil plant *C. anisum-olens* var. *anisum-olens* showed the existence of 3 chemovariants: 'pure anethole' oil, 'pure methyl chavicol' oil, and 'mixed' oil (about 90% (E)-anethole and 10% methyl chavicol).

In the essential oils of the leaves of *C. anisata* from different sources, 3 chemovariants can also be distinguished: (E)-anethole (75–95%) containing oils (Indonesia, Ghana), methyl chavicol (80–100%) containing oils (Benin, Ghana, Nigeria) and an oil containing a large number of constituents varying in concentration from 0.2% to 20%. Examples of the latter include a leaf oil from Zimbabwe with sabinene (33%), germacrene D (17%), Z-β-ocimene (6%), germacrene B (5.5%), (E)-β-ocimene (5%) and terpinen-4-ol (4.7%) and from Cameroon, with (Z)-tagetenone (26.8%), (E)-tagetenone (19.2%), (E)-nerolidol (11.5%) and germacrene D (9.2%). Essential oils from the seeds differ in composition, without a clear distinction in chemovars: from Benin it consisted of methyl chavicol (40.8%), myrcene (22.2%), (E)-anethole (16.3%) and limonene (13.4%), and from Cameroon it contained (Z)-tagetenone (15.3%), (E)-tagetonene (14.8%), (E)-nerolidol (10.3%), myrcene (7.4%), β-caryophyllene (7.4%), 3-carene (3.9%) and α-humulene (3.5%).

Dried plants of *C. anisata* are used in Africa and elsewhere to repel mosquitoes. In tests, the leaf essential oil proved toxic to the 3rd nymphal instar of the grasshopper *Zonocerus variegata*. Its major component was identified as estragol, which proved 1.5 times more toxic than the oil itself. Re-

sults of other bioassays showed that the essential oil was also very effective against stored-product insect pests, *Sitophilus zeamais* and other species, including *Tenebrio molitor* and *Rhizopertha dominica*. It caused 99.3% mortality and completely inhibited the reproduction of *Tribolium castaneum* when used for fumigation at a dosage of 20 mg/litre, or mixed with wheat flour at a concentration of 0.2% by weight.
Furthermore, using the hole-plate diffusion method for antibacterial testing, the essential oil from the leaves originating from Zimbabwe exhibited significant activity against *Alcaligenes faecalis*, *Bacillus subtilis*, *Enterococcus faecalis* (synonym *Streptococcus faecalis*), *Flavobacterium suaveolens*, *Leuconostoc cremoris* and *Serratia marcescens*. The mycelium growth inhibition method was used to test for antifungal activity. The oil exhibited significant activity against *Alternaria alternata*, *Aspergillus parasiticus*, *Candida albicans*, *Geotrichum candidum* and *Penicillium citrinum*.
The fruits, aerial parts and stem bark of *C. anisata* contain series of coumarins belonging to the furanocoumarin type (e.g. imperatorin, isoimperatorin, oxypeucedanine, bergaptene, xanthotoxin, xanthotoxol and chalepin), geranylcoumarin (e.g. anisocoumarin A–I), or furanocoumarin-lactone type (indicolactone, anisolactone). Several of these constituents show biological activities. Imperatorin is mentioned as an anticonvulsant agent. In addition, of imperatorin, oxypeucedanine and chalepin, only chalepin is found to have anticoagulant activity when administered to rats in a single dose. Aniline hydroxylase activity was appreciably depressed by each of the substances. Ethylmorphine demethylase, hepatic DNA, reduced glutathione and glucose-6-phosphatase were unaffected by these compounds when administered at a dose of 50 mg/kg for 3 days prior to slaughter. Under similar conditions only chalepin treatment resulted in α-1-globulin increase and a decrease in β-globulin content of the serum. Only intraperitoneal treatment with chalepin (100 mg/kg) for 2 days resulted in the death of 40% of the rats used within 48h of treatment. Livers of dead rats showed generalized necrosis of hepatocytes. Rats surviving after 8 weeks showed no changes in hepatic enzyme activity, reduced glutathione and DNA concentrations. However, chalepin and imperatorin induced alterations in the serum protein pattern within this period. Liver lesions were observed in chalepin-treated animals and were characterized by very mild necrosis of hepatocytes. No lesions were observed in the livers of rats treated with imperatorin or oxypeucedanine.
Additionally, methanolic root extracts showed molluscicidal activity in a bioassay with *Bulinus globosus*, the intermediate snail host in schistosomiasis. The LC_{50} and LC_{90} were 60 and 80 ppm, respectively. The powdered crude drug resulted in 60% mortality at 100 ppm. Two coumarin derivatives, heliettin and imperatorin, isolated from the methanolic extract, were more toxic to the test snail than other simple coumarins used in the bioassay, both giving 100% kill at 8 ppm.
Furthermore, *C. anisata* stem bark contains several quinolone/carbazole type alkaloids, including clausenol, clausenine, clausamines A–G, 1-methyl-3,4-dimethoxy-2-quinolone and 3-formyl-1-hydroxycarbazole. The latter two can also be isolated from the roots. Clausamines D–G act as inhibitors of Epstein-Barr virus early antigen activation induced by 12-O-tetradecanoylphorbol-13-acetate in Raji cells. In addition clausenol was found to be active against Gram-positive and Gram-negative bacteria and fungi.
The essential oil of *C. excavata* from Vietnam contains more than 50 components, of which the main ones are β-caryophyllene (25.3%), germacrene B (11.8%) and β-phellandrene (9.2%). In addition, coumarins and alkaloids are also mentioned. For example, the binary carbazole alkaloid clausenamine-A, and a carbazole-pyranocoumarin dimer, carbazomarin-A, were isolated from the stem- and root bark. Other (series of) carbazole alkaloids include clausemine A, clausenaquinone-A, clauszoline A–L, clausines A–V and clausevatine D-G. Furthermore, typical furano-coumarins are the clauslactones A–J, N–Q, together with claucavatin-A, -B, clausarin, umbelliferone, scopoletin and xanthoxyletin.
Of the isolated constituents, the alkaloid clausenaquinone-A shows potent cytotoxicity in HCT-8, RPMI-7951, and TE671 tumour cells, as did clausemine-A against a variety of human cancer cell lines in vitro.
In addition, the extract from the stem bark showed significant inhibition of rabbit platelet aggregation and caused vasocontraction. The crude methanol extract, partitioned layers and chromatographic fractions revealed the presence of promotive and inhibitive constituents simultaneously. Other research revealed some more information on active constituents: clausine-D inhibited arachidonic acid- and collagen-induced aggregation of rabbit platelets in a dose-dependent manner (IC_{50} values of 9 and 59 μM, respectively). In human citrated platelet-rich plasma, clau-

sine-D inhibited the secondary phase, but not the primary phase, of aggregation induced by epinephrine and ADP. Therefore, it was concluded that the antiplatelet effect of clausine-D is due to the inhibition of thromboxane A2 formation. Also safrole, isolated from the leaves, showed significant anti-platelet aggregative activity: 70% at 20 μg/ml, after rabbit platelet aggregation was induced by 100 μM arachidonic acid, and 48% at 50 μg/ml, after aggregation was induced by 10 μg/ml collagen. Clausenaquinone is active in the same assay as well.

The volatile oil obtained from the fruits of *C. lansium* contained some 40 compounds. Monoterpene hydrocarbons represented 60% of the total volatiles, while β-phellandrene (40.5%) was dominant. Among the sesquiterpenoids found, α-santalal was the most abundant. Other compounds are carbazole type alkaloids (e.g. murrayanine, glycozoline, indizoline, 3-formyl-6-methoxycarbazole, methyl 6-methoxycarbazole-3-carboxylate and 3-formyl-1,6-dimethoxycarbazole), and (furo-)coumarins, of which chalepensin, chalepin, lansiumarin A–C, wampetin, dehydroindicolactone and clausenacoumarin are examples. The latter coumarin can lower blood glucose levels in normal- and alloxan diabetic mice at a dose of 200 mg/kg for three days when given orally. It also antagonized the elevation of blood glucose caused by injecting adrenaline in normal mice. However, no effect on blood lactic acid content was observed.

Further characteristic constituents from *C. lansium* include a series of amides: clausenamide, neoclausenamide, cycloclausenamide, clausamide-I, -II, lansamide 1–4, and lansiumamide A–C. As isolated compounds, several showed distinct biological activities. Lansamide 2–4 were found to have a marked spasmolytic activity on the isolated guinea-pig ileum in vitro. Furthermore, the hepatoprotective activity of clausenamide, neo-clausenamide, cylcoclausenamide and some related derivatives was studied. Except for demethyl-secoclausenamide, at a dose of 250 mg/kg, they significantly depressed the elevated serum transaminase levels in mice intoxicated with CCl_4. Further studies on seco-clausenamide and clausenamide demonstrated that they decreased the hepatotoxicity of thioacetamide and acetaminophen in mice as well. Clausenamide was additionally shown to significantly inhibit CCl_4-induced lipid peroxidation of liver microsomes and ^{14}C-CCl_4 covalent binding to microsomal lipids. In another experiment clausenamide inhibited ferrous-cysteine induced lipid peroxidation (malondialdehyde formation) of microsomes from the rat brain, heart, liver and testes. Electron spin resonance (ESR) indicated that the compound scavenges oxygen radicals produced by human polymorphonuclear leukocytes (PML, previously stimulated with phorbol myristate acetate (PMA). However, no inhibitory effect on oxygen consumption of PMLs during respiratory burst was measured by spin label oximetry. It may be concluded that clausenamide exhibits its antioxidant activity via scavenging oxygen free radicals. In addition, multiple doses of clausenamide were shown to inhibit the liver lipid peroxidation caused by 50% alcohol and to increase the GSH-peroxidase activity significantly in rat liver and brain cytosols.

Furthermore, clausenamide at a concentration of 10^{-5} M inhibited the contraction of basilar artery preparations caused by serotonin, PGF2α and arachidonic acid, indicating that clausenamide can also act as a cerebral protective agent. Several other tests with clausenamide in neurological assays indicated that only (–)-clausenamide was active; (+)-clausenamide was inactive. The effect of (–)-clausenamine as a new cognition enhancer, on memory deficit and on regional acetylcholine (ACh) levels and anisodine-induced ACh decrease were examined in mice. The protective action of the compound against anisodine-induced amnesia was shown to be due to its ability to reverse ACh decrease. Furthermore, the neurotrophic effects of on rat frontal cortex neurons in culture was also studied.

(–)-Clausenamine increased choline acetyltransferase activity and protein content, stimulated proliferation of neuronal cells, and supported survival and neurite outgrowth of neurons. The neurotrophic action was similar to that of nerve growth factor. In addition, the effects of (–)-clausenamine on synaptic transmission of the hippocampal dentate gyrus in freely-moving rats was studied using an extracellular recording technique. The results obtained suggest that orally-administered clausenamide can enter the brain tissue to affect synaptic transmission.

The root bark of *C. harmandiana* yields the alkaloids heptaphylline, 7-methoxyheptaphylline and 2-hydroxy-3-formyl-7-methoxycarbazole. The latter constituents showed a slight activity against certain carcinoma and leukaemia cell lines in bioassays. Furthermore, the coumarins clausarin, dentatin, osthol, xanthoxyletin, nordentatin and clausine K were isolated. These compounds, except for clausine K, exhibited activity against *Plasmodium falciparum* in vitro.

The essential oil from the leaves of possibly *C. heptaphylla* from Thailand contains (E)-anethole (97%), anisaldehyde (1.5%), estragole (0.6%), anisyl ketone (0.4%) and α-elemene (0.1%) as the main components. Samples collected from other regions (e.g. eastern India) showed that methyl chavicol was the main oil component (57.5–75.6%), followed by anethole (21.7–40.3%). This species probably also shows the existence of chemovariants. Similar results were obtained for the fruits.

Furthermore, in addition to coumarins such as clausmarin A, the carbazole alkaloids clausenapin, clausenal (from the leaves) and clausenalene (from the stem bark) were isolated. Clausenal was found to be active against *Escherichia coli*, *Staphylococcus aureus*, *Bacillus subtilis*, *Salmonella typhi*, and *Pseudomonas aeruginosa*, and the fungi *Candida albicans* and *Trychophyton rubrum* in vitro. The minimum inhibitory concentrations of clausenalene against *Bacillus subtilis*, *Proteus vulgaris*, *Escherichia coli* and *Staphylococcus aureus* were 15, 20, 25 and 33 μg/ml, respectively.

Description Trees or erect shrubs, unarmed, usually evergreen, young branches patently short-hairy. Leaves spirally arranged, at the apex of branches often densely crowded, imparipinnate, surface pellucid punctate, strong smelling when crushed; petiolate; stipules absent; leaflets alternate to subopposite, ovate-oblong to ovate, base often oblique; petiolules short. Inflorescence a terminal, or sometimes axillary, panicle, hairy. Flowers bisexual, 4–5-merous, globose in bud, fragrant, pedicellate; calyx 4–5-dentate, lobed or more deeply incised, persistent; petals 4–5, free, ovate-oblong, glandular, imbricate, soon caducous; stamens (7–)8 or 10, free, unequal, in 2 whorls, often yellow or orange, towards the base usually conspicuously broadened, curving outward at anthesis, anthers dorsifixed; gynophore short, ovary entire or faintly lobed, glabrous, pubescent or scaly, cells with 2 superposed ovules, style short, thick, caducous or persistent. Fruit a globose or ellipsoid, glandular berry, 0.8–2 cm in diameter, seeds 1–3, embedded in mucilaginous pulp, usually sweet-tasting, bright coloured. Seed ellipsoid to ovoid, greenish. Seedling with epigeal germination.

Growth and development *Clausena* is usually evergreen, but species with a wide distribution area, subject to seasonality either through temperature or rainfall patterns, do show ecotypes which are deciduous. *C. harmandiana* and *C. excavata* can be found flowering and fruiting throughout the year.

In South-East Asia the fruits of *C. lansium* mature from June to October, in Queensland in November–December. The fruits of *Clausena* are mainly dispersed by birds, but probably also by small mammals.

Other botanical information *Clausena* species often vary in their vegetative characteristics. This is particularly the case with *C. anisata* in Africa, where it has probably been introduced relatively recently. Identification of *Clausena* species is mainly based on floral characters, and in particular the pistil, just before or after anthesis.

An orthographic variant of *Clausena* is *Claucena*. *Clausena* is closely related to *Murraya*, but differs from the latter by its short, thick style, which is less than half the length of the pistil, ovary and gynophore often differentiated, and stamens towards the base conspicuously broadened.

Ecology *Clausena* is generally found in subtropical to tropical climates, and occurs as understorey in primary and secondary forests, also on forest edges or savanna. They are often planted around villages, and prefer richer, well-drained soils, but are found on a wide variety of soils.

Propagation and planting *Clausena* can be propagated by seed, but several species are propagated by cuttings, air layers or grafts. The seeds do not have to pass the digestive tract of animals, and they often germinate readily within a few days, at the base of the tree. They are relatively short-lived, and desiccate or rot quickly when not in favourable conditions.

In China seeds of *C. lansium* were collected at weekly intervals from mid-maturation to the fully ripened stage. As seed development progressed, desiccation tolerance increased. Seeds remain viable for several weeks if stored cool and if not excessively dried.

In vitro propagation has been successfully tried with e.g. *C. excavata*.

Husbandry *C. excavata* is generally used as a rootstock for *C. anisum-olens*. In experiments in Sumatra *C. excavata* has been used as rootstock for *C. anisata*. Pruning of *Clausena* is recommended to avoid overcrowding of the branches.

Diseases and pests Few important diseases and pests on *Clausena* are recorded, although some can occasionally be a nuisance. A new leaf disease, sooty leaf blotch, was found on *C. excavata* in Java, and the causal fungus was described as *Mycovellosiella clausenae*. *Fusarium* sp. causes leaf spot on *C. anisata*. The causal fungus of wampee shoot rot on *C. lansium* is *Gibberella baccata*.

In Malaysia *C. excavata* was found to be an important natural host of the vector *Trioza erytreae* (*Hemiptera*), which causes citrus greening disease.
Furthermore, *C. lansium* is a host for the immature citrus blackfly (*Aleurocanthus woglumi* (*Homoptera*)). In China, one of the major insect pests of *C. lansium* is *Phyllocnistis wampella*.
C. anisata is a host for the nematode *Tylenchulus semipenetrans*.

Harvesting All plant parts of *Clausena* that are used can be harvested when needed, especially of the species that are cultivated near villages.

Handling after harvest The parts of *Clausena* that are harvested are used fresh or dried and sometimes powdered for future use.

Genetic resources and breeding The *Clausena* species treated here have a large area of distribution, either naturally or as a result of cultivation, and do not seem to be at risk of genetic erosion.
Small germplasm collections of *C. anisata*, *C. excavata* and *C. lansium* are present at the Instituto Valenciano de Investigaciones Agrarias in Valencia, Spain and of *C. anisata*, *C. excavata*, *C. harmandiana* and *C. lansium* in USDA-ARS National Germplasm Repository for Citrus & Dates, in Riverside, California, United States. The other germplasm collections are of *C. lansium*, and can be found in Taiwan and Bangkok, Thailand.

Prospects *Clausena* contains a variety of compounds, for instance clausenamine, which exhibits interesting biological activities. This compound, as well as several others, merits further research to fully evaluate their future potential. Furthermore, the anethole-containing essential oils may be of interest as a local substitute for anise oil, or as an industrial starting material in the production of this component. Seen in this light, the potential for cultivation of *Clausena* species in South-East Asian countries may need further investigation.

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Selection of species

Clausena anisata (Willd.) Hook.f. ex Benth.

in W.J. Hook., Niger fl.: 256 (1849).

Synonyms *Amyris anisata* Willd. (1799), *Clausena willdenowii* Wight & Arn. (1834), *Clausena dentata* (Willd.) M. Roem. (1846), *Clausena dunniana* H. Lév. (1912).

Vernacular names Vietnam: h[oof]ng b[if] n[us]i, d[ax] h[oof]ng b[if].

Distribution *C. anisata* occurs from central and southern China, through Indo-China, Thailand to eastern and southern India and Sri Lanka, also in tropical Africa, southern Africa and the Cape Coast, but excluding Namibia. Cultivated in Malaysia and Indonesia.

Uses In Vietnam the leaves and roots are taken for colds, rheumatism, and arthritis. Externally, they are prescribed in sprain, contusion and fractures. In Africa a decoction of the leaves is drunk to cure gastro-intestinal disorders, fever, headache and sinusitis, and as an anthelmintic. The crushed leaves are considered antiseptic and analgesic and applied on wounds, for toothache and other mouth infections, sores and burns. A root decoction is taken to control convulsions in children and as a tonic by pregnant women.
Bundles of the plant are widely used as an insect repellent. The powdered root is known to be lethal to snails. The twigs are widely used for toothbrushes and the stems for walking sticks. The fruits have a sweet taste and are locally eaten.

Observations A shrub, 1–2(–10) m tall; rachis 15–50 cm long, 9–27 leaflets, ovate to ovate-lanceolate, 2–15 cm × 1–6.5 cm, base oblique, apex rounded to acuminate, sometimes emarginate, margin entire or obscurely toothed, glabrous to densely hairy; panicle axillary, lax, 10–35 cm long, hairy; flowers usually 4-merous, pedicel 2–7 mm long, calyx minute, teeth triangular to filiform, petals ovate-elliptical, 3–6 mm long, pale green to yellowish-white, glandular, stamens 8, filaments 1–3 mm long, thickened at base, gynophore saddle-shaped, 0.5–1 mm long, ovary 4-lobed, glabrous to densely hirsute, glands at apex, style 0.8–1.5 mm long; berry ovoid, 8-15 mm long, red or dark violet, usually glabrous, 1–3-seeded. *C. anisata* occurs in savanna, thickets and secondary forest, from sea-level up to 3000 m altitude.

Selected sources 12, 134, 135, 155, 215, 376, 731, 739, 756, 767.

Clausena excavata Burm.f.

Fl. indica: 87, pl. 29, fig. 2 (1768).

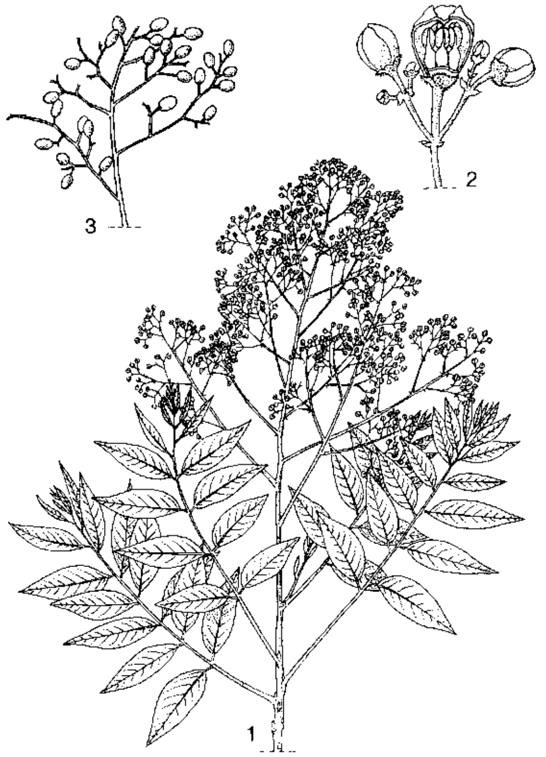
Synonyms *Amyris sumatrana* Roxb. (1832), *Cookia graveolens* Wight & Arn. (1834), *Clausena punctata* (Roxb.) Wight & Arn. ex Steud. (1840).

Vernacular names Indonesia: temung (Aceh), bajetah (Sundanese), tikusan (Javanese). Malaysia: pokok kemantu, cherek hitam, chemama. Philippines: buringit (Tagbanua). Cambodia: cantrouk san hoeut, sanitrok damrey. Laos: tcho kou nhia, khong touang, kok 'sa mat. Thailand: phia faan (northern), khee phueng (eastern), huat mon (central). Vietnam: ch[uf]m h[oo]i, d[aa]m h[oo]i, h[oof]ng b[if] d[aj]i.

Distribution From the Himalayas to southern China, southern Taiwan, throughout Indo-China, Thailand, Malaysia, Indonesia and the Philippines (Mindoro, Culion, Palawan, the Sulu Archipelago).

Uses In China, Indo-China, Thailand, Peninsular Malaysia and Java, the juice from the leaves is taken for intestinal worms or cough, and, sometimes together with *Curcuma longa* L., for fever, malaria or colds. A decoction of the roots, flowers or leaves is taken for bowel complaints, such as colic, dyspepsia and stomach-ache. The pounded root or leaves are used as a poultice on sores, including ulceration of the nose, or sometimes for yaws. Ulcerations of the nose may also be treated by fumigation using burning leaves and bark. The pounded leaves may be applied to the head for headache. A decoction of the leaves is taken after childbirth. In Peninsular Malaysia the plant is also credited with magic virtues. In China, it is considered a bitter, tonic, astringent and emmenagogue. A poultice of the leaves is applied to treat paralysis. In Burma (Myanmar) the leaves are taken for stomach troubles.

In Java the timber is used for handles of axes; it is white and has a fine structure. The leaves are insecticidal.



Clausena excavata Burm.f. – 1, flowering branch; 2, part of inflorescence (one flower with 2 petals removed); 3, part of infructescence.

Observations A hairy, rather strong smelling shrub, 2–4(–15) m tall, stem up to 20 cm in diameter, branching profusely; rachis 15–50 cm long, leaflets 15–31, ovate to ovate-lanceolate, 2–20 cm × 1–7 cm, base very oblique, apex long or short acuminate, margin entire or slightly dentate, when adult glabrescent above, thinly hairy beneath; panicle terminal, 10–45 cm × 3–15 cm, at base with several patent branches, hairy; flowers 4-merous, pedicel 0.5–2 mm long, calyx minute, teeth with broad sinuses, petals ovate, 3.5–5 mm long, pale green to yellowish-white, stamens 8, filaments 1.5–3.5 mm long, base abruptly broadened, gynophore cylindrical, wider at apex, ovary ovoid, hairy, style thick, up to 1.8 mm long, more or less persistent; berry broadly oblong, 1–2 cm long, reddish-pink, glabrous or thinly hairy, usually 1-seeded. *C. excavata* occurs in secondary forest, brushwood and disturbed areas around villages, from sea-level up to 1500 m altitude. Two varieties are distinguished in *C. excavata*: var. ex-

cavata with dense soft hairs on young parts, ovary glabrous or hairy, and var. *villosa* Hook.f. with leaves, branches, inflorescences and ovary covered with hirsute yellow hairs.

Selected sources 74, 135, 407, 623, 646, 949, 1086, 1087, 1088.

Clausena harmandiana (Pierre) Pierre ex Guillaumin

Notul. Syst. (Paris) 1: 219 (1910).

Synonyms *Glycosmis harmandiana* Pierre (1893), *Clausena oliveri* Koord. ex Backer (1911), *Clausena hirta* Ridley (1920).

Vernacular names Malaysia: kasai (Peninsular). Thailand: song faa, long faa dong (north-eastern), men (south-eastern).

Distribution Indo-China, Thailand, Malaysia, Indonesia (eastern Java, Lesser Sunda Islands).

Uses In Thailand a decoction of the roots is taken as an antipyretic, antiflatulent and stomachic, and for food poisoning. It also relieves headache and bronchitis.

Observations An undershrub, 1–5(–8) m tall; rachis 15–55 cm long, leaflets 5–7(–13), largest ones in the upper half, ovate-oblong, 4–8(–25) cm × 2–7(–15) cm, base obtuse to cuneate, apex acute to acuminate, margin entire or crenulate, glabrous or hairy, veins prominent beneath; panicle terminal, conical, compact, little branched in upper part, 3–35 cm × 2–25 cm; flowers usually 5-merous, subsessile, calyx minute, large gland at base of lobes, usually glabrous, petals ovate, 3–4 mm long, pale green to yellowish-white, stamens 10, gland at connective, gynophore short, ovary rounded, glandular, sometimes with a few hairs, style thick, up to 1 mm long, persistent; berry ovoid, up to 1.5 cm long, reddish-purple, glabrous or thinly hairy, 1–3-seeded. *C. harmandiana* occurs in brushwood, from sea-level up to 400 m.

Selected sources 74, 201, 1054, 1109.

Clausena heptaphylla (DC.) Steud.

Nomencl. bot., ed. 2, 1: 377 (1840).

Synonyms *Amyris heptaphylla* Roxb. (1832), *Clausena macrophylla* Hook.f. (1875).

Vernacular names Vietnam: gi[oor]i b[acly l[as].

Distribution From the Himalayas to Thailand and the Philippines.

Uses In the Philippines the essential oil from the leaves is used to flavour alcoholic beverages, in the same way as those of *C. anisum-olens*. The smell is said to have a narcotic action.

Observations A shrub or small tree, 1–4 m tall; rachis 15–40 cm long, leaflets 5–11, ovate to ovate-lanceolate, 4–20 cm × 2–7 cm, base oblique, apex long or short acuminate, margin entire or dentate, veins prominent beneath, glabrous or tomentose; panicle terminal, conical, 15–40 cm long, branches glabrous to tomentose; flowers 4-merous, pedicel 1–2 mm long, calyx small, lobes hardly visible, ciliate, sometimes with gland on back, petals ovate, 3–4 mm long, yellowish-white, stamens 8, gland at connective, gynophore saddle-shaped, up to 0.5 mm long, ovary glabrous, quadrangular, style thin, up to 1 mm long, caducous; berry subconical to ovoid, 1–1.6 cm long, apex truncate, orange-red, finely glandular, 1–2-seeded. *C. heptaphylla* occurs in open forest, from sea-level up to 2500 m altitude.

Selected sources 113.

Clausena lansium (Lour.) Skeels

U.S. Dep. Agr. Bur. Pl. Indust. Bull. 168: 31 (1909).

Synonyms *Quinaria lansium* Lour. (1790), *Clausena wampi* (Blanco) Oliv. (1861), *Clausena punctata* (Sonn.) Rehder & Wilson (1916).

Vernacular names Wampee (En). Vampi (Fr). Malaysia: wampi, wang-pei. Philippines: wampi, huampit (Tagalog). Singapore: wampoi, wang-pei. Cambodia: kantrop. Laos: sômz maf'ai. Thailand: mafai cheen, som mafai (northern). Vietnam: ho[af]ng b[if], gi[oo]i, qu[aas]t h[oof]ng b[if].

Distribution Native to and commonly cultivated in southern China and Vietnam, but has also been extensively planted in South-East Asia (Indonesia, Malaysia, the Philippines, Singapore, Thailand, Cambodia and Laos). It is sometimes grown in India, Sri Lanka, Australia (Queensland), United States (Hawaii and Florida) and in Central America.

Uses In Malaysia and China the leaves are used in traditional medicine to treat coughs, asthma, hepatitis and dermatological diseases. The dried unripe fruits and dried sliced roots are used as a remedy for bronchitis. Ripe fruits are said to have stomachic and cooling effects and to act as a vermifuge. A decoction of the leaves is used to treat dandruff. The leaves, fruits or seeds are widely employed for gastro-intestinal problems, including acute and chronic inflammation and ulcers. In Taiwan the roots are used in traditional medicine to treat bronchitis and malaria.

The ripe fruit is often eaten and has a pleasant flavour. The pulp can be made into pies or jam. Jelly can be made from acid immature fruits. *C. lansium* is sometimes planted as a hedge, or as a lane tree.

Observations A shrub or tree, 3–12 m tall, trunk up to 40 cm in diameter, usually low-branched; rachis 15–40 cm long, leaflets 5–15, ovate-elliptical, up to 14 cm × 7 cm, terminal leaflet largest, lowest pair smallest, glossy dark green, base oblique, apex acuminate to slightly emarginate, margins entire to minutely crenulate, glabrescent to finely pubescent; panicle or raceme (sub)terminal, lax, up to 50 cm long, hairy; flowers 5-merous, subsessile, sweet-scented, sepals tiny, hairy, petals elliptical, 4–5 mm long, whitish to yellowish-green, stamens 10, gynophore short, ovary rounded, glandular and yellowish hairy, style thick, short, caducous; berry subglobose, 1.5–3 cm in diameter, yellowish-orange to red, sparsely puberulent, glandular dotted, 1–3-seeded, pulp watery, semi-translucent, acid to sweet. *C. lansium* occurs in brushwood and open forest, at low and medium altitudes.

Selected sources 215, 268, 269, 614, 624, 627, 630, 739, 1039.

G.H. Schmelzer

Cleome L.

Sp. pl. 2: 671 (1753); Gen. pl. ed. 5: 302 (1754).

Capparaceae

x = 9–12, 15–19; *C. chelidonii*: $2n$ = 20, 34; *C. gynandra*: $2n$ = 34, 36; *C. viscosa*: $2n$ = 20

Major species *Cleome gynandra* L., *C. viscosa* L.

Origin and geographic distribution *Cleome* is a pantropical and subtropical genus with more than 150 species, many of them found in the Americas, and about 65 species in Africa and the Middle East. In Malesia 8 species occur, of which 2 are cultivated, and the others are native or introduced.

Uses In South-East Asia and West Africa, the leaves and seeds of *C. gynandra* and *C. viscosa* are used as a rubefacient and vesicant, and also to treat infections, fever, rheumatism or headache. If the leaves are left too long in contact with the skin, blisters are produced. In Indonesia and Thailand, the bruised leaves are considered counter-irritant when applied externally to treat herpes infections. Internally, they are used as expectorant and digestive stimulant. An infusion is given to women in labour. In the Philippines, the whole plant is used in certain bilious disorders. In Indo-China, the crushed leaves are rubbed on the lower back to calm lumbago. In the Philippines, Thailand, China and India, the seeds are considered carminative. However, if taken in excess, the result is flatulence and oppression of the stomach. A decoction of the seeds is used as a wash to treat piles and rheumatism, and also administered to treat gonorrhoea and dysentery. In Indo-China, the roots are used as a stimulant and anti-scorbutic.

In Malesia, the juice of the leaves of *C. viscosa* mixed with butter is used in the treatment of inflammations of the middle ear. They are also used externally for wounds and ulcers. The seeds have anthelminthic properties, although they are ineffective in treating roundworm infections. In Peninsular Malaysia, a decoction of the whole plant is used for colic and dysentery. In Indo-China, Malaysia and the Philippines, an infusion is applied to skin diseases, and the roots are a remedy for scurvy and rheumatism. The vapour from a steaming decoction of the whole plant is inhaled to treat headache. In Papua New Guinea, it is widely believed that a woman can increase her fertility by chewing the leaves with betel nut (*Areca catechu* L.) for a week. In Thailand, the flowers are considered antiseptic.

In China, *C. chelidonii* is used in the same way as *C. viscosa*: an infusion of the whole plant is used for skin complaints. The Madurese drop warm juice from the leaves into the ear against ear infections. The roots are considered vermifuge.

In Java and Thailand, the bitter leaves of *C. gynandra* are boiled and eaten as a vegetable, or salted and used as a pickle. In Africa, the bitter leaves are very popular and eaten fresh, dried or cooked. In India, *C. viscosa* leaves are eaten as a vegetable by poor people, while the seeds are used as a substitute for mustard seed, as a condiment in curries. In temperate climates, *C. gynandra* is grown as a summer ornamental. The seeds are sold as bird-food in Java.

C. speciosa Raf. and *C. spinosa* Jacq. are cultivated in the tropics, including South-East Asia, as ornamentals. *C. spinosa* has stomachic and antivulnerary properties, and the leaves are used as a poultice against headache. *C. viscosa* is not grazed by cattle.

Production and international trade *C. gynandra* is a common market vegetable in Malaysia and Thailand, where it is sold fresh or in brine.

Properties *C. gynandra* seeds contain the glucosinolates cleomin and glucocapparin (= methyl glucosinolate), and an acrid volatile oil, comparable with mustard oil. This essential oil is also present in the leaves and aerial parts, and is responsible for the odour and flavour of the plant. Its major constituents are: cleogynol, a dammarane triterpenoid, carvacrol (29.2%), a phenolic, trans-phytol (24%), linalool (13.3%), trans-2-methylcyclopentanol (7.2%) and β-caryophyllene (4.4%).

The presence of isothiocyanate derivatives (or glucosinolates), which have irritant properties when in contact with the skin, justify the use of *C. gynandra* as an antirheumatic and counter-irritant in traditional medicine.

Furthermore, the alcoholic extract of the whole plant was found to show anticancer activity against cultured human epidermal carcinoma of the nasopharynx cells in vitro, and against transplanted hepatoma 129 in a mouse model.

The aerial parts of *C. gynandra* show a strong repellent and acaricidal activity to larvae, nymphs and adults of the ticks *Amblyomma variegatum* and *Rhipicephalus appendiculatus*. Field investigations indicated that ticks were not found up to 2–5 m from the plants in areas where it was predominant. Of the essential oil components further investigated, carvacrol, as well as the minor components m-cymenene, nonanal, 1-α-terpineol, β-cyclocitral, nerol, trans-geraniol, β-ionone, trans-geranylacetone and nerolidol were found to be most repellent against *Rhipicephalus appendiculatus*. In addition, the acetone extract of aerial parts showed growth inhibitory and juvenile hormone mimicking activity to larvae of the mosquito *Culex quinquefasciatus*, and deformed flight muscles, small egg rafts, affected biting behaviour and loss of fecundity in adults. There was also a report on anti-HIV activity of the plant.

The seed oil of *C. viscosa* contains up to 70% linoleic acid as well as some volatile components e.g. α-pinene (11%) and δ-cadinene (12%). Rats fed on *C. viscosa* oil did not show any abnormal growth or reproductive performance or altered liver lipid levels, and it is therefore suggested that it might be used safely by humans. A series of coumarino-lignans, the cleomiscosins, have been isolated from the seeds. These exhibited anti-hepatotoxic properties in tests with rats. An aqueous extract of seeds was found to be non-toxic when given orally and intraperitoneally to rats and mice. The extract also displayed significant analgesic activity in mice and local anaesthetic activity in guinea-pigs.

Antibacterial activity was tested from the aerial parts of *C. gynandra* and *C. viscosa* using the filter paper disk diffusion method, and was found to inhibit significantly the growth of *Alkalignes viscolactis*, *Bacillus cereus*, *Klebsiella acrogenas* and *Streptococcus pyogenes*, while *C. viscosa* totally inhibited the growth of *Acromonas hydrophylla* and *B. cereus*. *C. viscosa* seed and shoot extracts have an allelopathic effect on seed germination, leaf sheath elongation and root growth of pearl millet (*Pennisetum glaucum* (L.) R.Br.).

Adulterations and substitutes Mustard seeds are used as a substitute for those of *C. viscosa* or *C. gynandra* as a condiment, and also for medicinal purposes.

Description Annual or perennial herbs, often hairy. Leaves spirally arranged, palmately 3–7-foliolate, central leaflet largest in the Malesian species; petiole present; stipules normally absent. Inflorescence a leafy terminal corymbose raceme or panicle, leaves apically gradually reduced. Flowers pedicelled; sepals 4, free; petals 4, free, (slightly) zygomorphic in their position, the base often clawed; stamens 6 to numerous, sometimes at the base connate to the gynophore or androgynophore; ovary 1-celled; stigma knob-shaped or flattish, subsessile. Fruit a linear, terete capsule, 2-valved, beaked, dehiscing from the base or the apex. Seeds numerous, orbicular to horseshoe-shaped, sometimes with a funiculum, the dorsal side sculptured to scaly.

Growth and development Most Malesian *Cleome* species flower and fruit throughout the year. The seeds are dispersed by water and animals that eat the plants. *C. viscosa* starts flowering 3–4 weeks after germination, and the life cycle is about 3 months. The flowers are ephemeral, they open in the morning and close in the afternoon. The flowers of *C. gynandra* are nocturnal. *C. gynandra* has a C4-cycle photosynthetic pathway, which means a high rate of photosynthesis at high temperature and radiation.

C. chelidonii is found to have 3 flower types in India, which differ in the length of the gynoecium. Those with a short gynoecium do not set fruit and act merely as pollen donors. The other 2 types are bisexual and produce fruit by allogamy and autogamy.

Other botanical information The *Cleome* species in Malesia all have simple and multicellular, densely set hairs, which are often glandular. The genus *Gynandropsis* has been merged with *Cleome*, as the connation of the staminal base with the gynophore to form an androgynophore is merely a quantitative character, not a qualitative one. For the genus *Polanisia*, the original concept is being followed, species having 6 stamens with a large adaxial gland, thus excluding the Old World *Cleome*. *Cleome* is sometimes classified into a separate family, the *Cleomaceae*.

Ecology In Malesia, most *Cleome* species are ruderal weeds along roadsides and in fields, at low altitudes.

Propagation and planting *Cleome* is propagated by seed. *C. viscosa* seeds have no dormancy and germinate readily after shedding.

Husbandry Seeds of *C. gynandra* can be sown by broadcasting on a nursery bed followed by transplanting, or can be direct-seeded in rows followed by thinning. In India, in vitro propagation for mass propagation for medicinal purposes was successfully done on Murashige and Skoog's medium containing 3% sucrose, 0.8% agar and supplemented with auxin, cytokinin and coconut water. *C. viscosa* leaf segments were successfully cultured in a similar way.

Diseases and pests *C. viscosa* is a host for the papaya ringspot potyvirus, which also attacks melons. *Cleome* is a host for the nematodes *Meloidogyne incognita* and *M. javanica*, but no other serious pests are known.

Harvesting Leaves of *C. gynandra* can be harvested for culinary and medicinal purposes from the second month after sowing onwards.

Handling after harvest The leaves of *C. gynandra* can be preserved by drying.

Genetic resources and breeding A germplasm collection of *C. gynandra* exists in Kenya, whereas another small germplasm collection is kept in Griffin (United States). As many *Cleome* species are widespread as weeds, there is no serious risk of genetic erosion. *C. gynandra* is being bred in Kenya, in order to improve its quality and quantity as a vegetable.

Prospects Several compounds of *Cleome* display interesting properties, e.g. the glucosinolates as a counter irritant in the treatment of rheumatism, or the volatile oil in the control of ticks. This might be of interest for rural communities, and therefore merits further research.

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Selection of species

Cleome chelidonii L.f.

Suppl. pl.: 300 (1781).

Synonyms *Polanisia chelidonii* (L.f.) DC. (1824).

Vernacular names Indonesia: bobowan, mamam (Javanese). Thailand: phak saan, phak sian paa (central). Vietnam: m[af]n m[af]n t[is]m, m[aaf]n ri t[is]a.

Distribution *C. chelidonii* occurs in India, Burma (Myanmar), Thailand, and Central and East Java.

Uses In Indonesia, the heated sap from the leaves is dropped into the ear to cure infections, and an infusion of the whole plant is used for skin complaints. In Vietnam, the root is used as an anthelmintic.

Observations An annual, erect, branched herb, 15–80 cm tall, stems angular, with sparse, appressed, pale, stiff hairs with a bulbous base; leaflets 6–7 below to 1–3 apically, obovate, densely appressed-hairy, central leaflet up to 4(–6) cm × 1.2(–1.8) cm, base cuneate, apex rounded to acute, firmly herbaceous, petiole 8–10 cm in lower leaves, almost absent in higher ones; raceme elongated, pedicel 1.5–3 cm long, flowers actinomorphic, sepals elliptical, 2–4 mm long, petals 4(–8), mostly obovate, 7–14 cm long, base narrowed, apex rounded, glabrous, light red-purple, stamens 30–40(–55), anthers 1 mm long, yellow; capsule linear, parallel-veined, 6–8 cm long, glabrous, beak 1–3 mm long; seeds 2 mm in diameter, cleft open, warty with scattered scales, dull blackish. *C. chelidonii* occurs in fallow rice fields, sugar cane fields on heavy clay, and freshwater swamps, in Java below 100 m altitude, and is sometimes so abundant that the field is coloured reddish-purple by the flowers.

Selected sources 135, 407, 557, 830.

Cleome gynandra L.

Sp. pl. 2: 671 (1753).

Synonyms *Cleome pentaphylla* L. (1763), *Gynandropsis pentaphylla* (L.) DC. (1824), *Gynandropsis gynandra* (L.) Briq. (1914).

Vernacular names Bastard mustard, cat's whiskers, wild spider flower (En). Indonesia: bobowan, enceng-enceng (Javanese), bhubhuwan (Madurese). Malaysia: maman(g). Philippines: apoy-apoyan (Tagalog), halaya (Panay Bisaya), tantandok (Iloko). Cambodia: momiënh. Laos: siènz. Thailand: phak sian khaao (central), phak som sian (northern). Vietnam: m[af]n m[af]n tr[aws]ng, m[aaf]n ri tr[aws]ng.

Distribution *C. gynandra* is considered native to Asia, but is widely distributed in the Old World tropics, and has been introduced into the New World. It is cultivated in Asia and Africa.

Uses Both leaves and seeds are used as a rubefacient and vesicant, internally and externally. In Vietnam, a decoction of the roots is taken as a febrifuge, and in Thailand against tuberculosis. In Papua New Guinea, the Goilala women believe that chewing the leaves, together with betel (*Piper betle* L.) for a week will increase their fertility. In Java and Thailand, the bitter leaves are boiled, to rid them of their bitterness, and are eaten as a vegetable, or salted and used as a pickle.

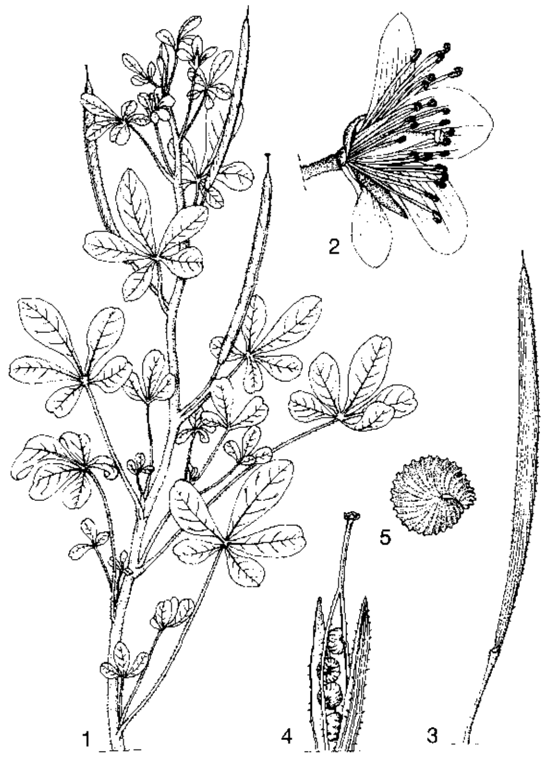
Observations An annual, erect, branched herb, 15–80 cm tall, stem glandular-pubescent to glabrous; leaflets (3–)5, obovate, 2–7.5 cm × 1–4.5 cm, base narrowly cuneate, apex rounded to short-acuminate, thinly herbaceous, petiole 2–10 cm long; raceme elongated, pedicel 1.5–2.5 cm long, sepals acute, 2.5–5 mm long, petals all pointed upwards towards the adaxial side, elliptical, 7–15 mm long, base narrowed, apex rounded, white or tinged purple, androgynophore 9–16 mm long, in fruit 13–20 mm long, stamens 6, anthers 2–3 mm long, purple; capsule cylindrical, 2–11 cm long, tapering to both ends, longitudinal-veined, beak 1–4 mm long; seeds depressed-globular, about 1 mm in diameter, with a shallow and narrow cleft, with many superficial concentric ribs, black-brown. *C. gynandra* is a ruderal and a weed in dry rice fields, along roadsides, near houses, from sea-level up to 500 m altitude.

Selected sources 74, 134, 135, 407, 557, 644, 739, 786, 788, 914, 948, 1069.

Cleome viscosa L.

Sp. pl. 2: 672 (1753).

Synonyms *Cleome icosandra* L. (1753), *Polanisia viscosa* (L.) DC. (1824).



Cleome viscosa L. – 1, flowering and fruiting stem; 2, flower, side view; 3, fruit; 4, detail of dehiscing fruit; 5, seed.

Vernacular names Tickweed (En). Indonesia: ancang ancang (Javanese), bhubhuwan (Madurese), susawi utan (Moluccas). Malaysia: mamang kebo, mamang laki, mamang utan. Philippines: apoi-apoian, silisian (Tagalog), hulaya (Panay Bisaya). Thailand: phak som sian phee (northern), phak sian phee (central, peninsular). Laos: sa phac son tien. Vietnam: m[af]n m[af]n v[af]ng, s[ow]n ti[eef]n.

Distribution Throughout the tropics of the Old World and Australia, and commonly introduced in the New World.

Uses The sap of the leaves mixed with water or milk is applied to the eyes in Java. The whole herb is rubbed on the body against rheumatism. In Sumatra, the dried and powdered leaves and seeds are added to tobacco to enhance its narcotic properties. In Australia, the aerial parts are used for respiratory tract infections and infected wounds. In the USA it is a noxious weed.

Observations An annual, erect, branched herb, up to 1 m tall, with yellowish, glandular hairs, viscid and stinking; leaflets 3–5, central leaflet

1–3(–5.5) cm × (0.3–)0.5–1.5 cm, base cuneate, apex acute to obtuse, thinly herbaceous, petiole 0.5–6 cm long; raceme short to elongated, flowers largely actinomorphic, sepals oblong, (2.5–)6–7 mm long, petals oblong, (4–)7–12 mm long, thin, glabrous, yellow, stamens (8–)10–20(–30), gradually increasing towards the abaxial side, anthers 1.5–2 mm long, bluish; capsule linear, erect, centripetal-veined, (1.5–)6–8(–10) cm long, beak 2.5–4(–7) mm long; seeds 1.2 mm in diameter, cleft narrow, with strong cross-ribs and faint concentric ribs, red-brown. *C. viscosa* is a weed, very tolerant and ruderal, and occurs on fallow land and fields, along roadsides, on rubbish heaps, often on sandy, but sometimes on calcareous soils, both under seasonal dry and ever-wet conditions, from sea-level up to 500 m altitude.

Selected sources 74, 134, 135, 201, 215, 407, 418, 557, 739, 786, 787, 788.

F.I. Windadri

Clerodendrum L.

Sp. pl. 2: 637 (1753); Gen. pl. ed. 5: 285 (1754).
VERBENACEAE

$x = 12, 23$; *C. indicum*: $2n = 40, 48, 52$, *C. inerme*: $2n = 46, 48$, *C. philippinum*: $2n = 46, 52$, *C. phlomidis*: $2n = 48, 52$, *C. serratum* $2n = 48$

Major species *Clerodendrum inerme* (L.) Gaertner, *C. serratum* (L.) Moon, *C. viscosum* Vent.

Origin and geographic distribution *Clerodendrum* (excluding *Kalaharia* and *Rotheca*) comprises some 400 species and is most abundant in tropical and subtropical Asia and Africa, poorly represented in the Americas except where cultivated and naturalized. A few species extend into temperate zones.

Uses A wide range of *Clerodendrum* species is used throughout South-East Asia. The use of individual species is often very restricted as a result of their often very local distribution or because species may well be mutually exchangeable for a given use. Despite their medicinal use several species are much more connected with magic than medicine. A considerable number of species are considered to be febrifuge. Some have both internal and external uses, others only external, such as washes and poultices for sores, boils and skin diseases; they have perhaps depurative, resolvent, and vulnerary properties, or are used as an anodyne to relieve rheumatism or pain. Many of the uses for Indonesia date back to Rhumphius. Great confusion often exists about the actual identity of a given plant and the taxonomical status of that species. In Indonesia, the roots and wood of *C. phyllomega* Steudel (synonym *C. macrophyllum* Blume) are reputed to be highly poisonous. In Malaysia, a decoction of the roots of *C. umbratile* King & Gamble is used for fever in children. Boiled and dried the roots are used to make a powder for rubbing on the face in fever. An extract of the roots of *C. deflexum* Wallich is used for fever and stomach complaints. The leaves of *C. disparifolium* Blume are used to relieve constipation. The roots, pounded and rubbed on the body or the paste placed in a hollow tooth are considered anodyne. In the Philippines, an infusion of the leaves of *C. bethuneanum* Lowe is used as a tonic during pregnancy. The leaves of *C. cumingianum* Schauer are used for stomach-ache. A decoction of the leaves of *C. brachyanthum* Schauer is given as a tonic for stomach problems, and in large doses is considered abortive. The leaves of *C. macrostegium* Schauer in decoction or as a poultice are applied externally to carbuncles. The leaves of *C. navesianum* Vidal (synonym *C. quadriloculare* (Blanco) Merr.) are externally applied for healing wounds and ulcers. They are also used in tonic baths. In India, *C. phlomidis* L.f. (synonym *C. phlomoides* auct.) is used for post-natal complaints in women, and also for dyspepsia, stomach-ache, colic and dysentery. The juice of the leaves and a tonic from the roots are used as an alterative. Externally the leaves are rubbed over the body in cases of oedema and used in poultice on swellings and ulcers. Various parts of *C. infortunatum* L. are used both internally and/or externally in traditional Indian medicine to treat coughs, skin diseases and tumours, and as a vermifuge and expectorant.

Many *Clerodendrum* are widely cultivated as ornamentals. Some of these have medicinal uses, but their ornamental value far outweighs their medicinal importance. *C. minahassae* Teysm & Binnend. is used in the Philippines as an external remedy for chest and stomach pains. Furthermore, the boiled leaves are used as a poultice for carbuncles. The leaves of *C. intermedium* Cham. are used in the Philippines as a cataplasm to relieve the pains following childbirth, and for rheumatism and neuralgia. They are also used as a plaster to relieve colic in children. Furthermore the roots are considered purgative. In the Moluccas the roots of *C. rumphianum* de Vriese & Teysm. (synonym *C. squamatum* Vahl var. *rumphianum* (de Vriese & Teysm.) Bakh.) are used to treat dysentery, and a cold infusion of the leaves in vinegar is considered a remedy for gonorrhoea. The leaves enter in prescriptions for afflictions as diverse as oedema, haematuria and rheumatism. Furthermore, leaves are an ingredient of a herbal bath for newborns. In Malaysia, an infusion of *C. paniculatum* L. is drunk as a purgative, and externally a poultice is applied on a distended stomach. In Indonesia, the leaves are used as a poultice for burns, wounds and ulcers. The roots enter in prescriptions for afflictions as diverse as pulmonary problems, oedema, haematuria and rheumatism. In Thailand, various parts are used for their anti-inflammatory properties. The root is used as an antimalarial, carminative and against tuberculosis, and the leaves are used for chest pain in general. In Indo-China, a decoction of the roots of *C. japonicum* (Thunb.) Sweet (synonyms *Clerodendrum squamatum* auct. non Vahl, *Volkameria japonica* Thunb., *Clerodendrum coccineum* Lam) is prescribed in chest complaints. In China, floral bracts are chewed for haematuria and applied as a poultice to painful joints. The very similar *C. kaempferi* (Jacq.) Siebold ex Steudel (synonym *C. squamatum* Vahl, *Volkameria kaempferi* Jacq.) is also used in folk medicine in Vietnam and Indonesia.

Magical properties ascribed to *Clerodendrum* in particular refer to *C. deflexum*, *C. disparifolium*, *C. serratum*, *C. umbratile* and *C. villosum* Blume in Malaysia and *C. viscosum* and *C. rumphianum* in Indonesia.

Production and international trade *Clerodendrum* is only used on a local scale.

Properties Phytochemical investigations of *Clerodendrum* in general revealed the presence of iridoids (or their glycosides), steroids and flavonoids as important groups of components. For example, of a total of 12 *Clerodendrum* spp. examined, 8 species contained iridoids. They contained iridoid glycosides such as melittoside, aucubin, 8-O-acetylharpagide, harpagide, ajugoside, 8-O-acetylmioporoside, reptoside, euphroside and plantarenaloside. Leaves of *C. inerme* contained melittoside at 0.1%. Leaves of *C. tomentosum* (Vent.) R.Br. and *C. indicum* contained harpagide at 0.01% and 0.02%, repectively. No iridoid glycosides were found in the leaves of *C. buchananii* (Roxb.) Walp., *C. bungei* Steudel or *C. paniculatum*. The leaves of *C. serratum*, which belongs to the section *Cyclonema*, contain iridoid glycosides with a C-4 formyl group, plantarenaloside at 0.05% and euphroside at 0.03%. Such compounds are unique in *Verbenaceae*. Further information is available for *C. inerme*. The presence of a series of iridoid biglycosides is reported: inerminosides A, A1, B, C and D, of which most of them are derivatives of mussaenosidic acid.

Samples from the aerial parts of *C. fragrans*, *C. inerme*, *C. infortunatum* (including seeds) and *C. indicum*, and the seeds of *C. infortunatum* contained 24β-ethylsterols possessing a 25δ-bond, clerosterol and 22-dehydroclerosterol as the dominant components. The other 24-ethylsterols lacking a 25δ-bond, 24-ethyl-22-dehydrocholestanol, 24-ethylcholesterol and 24-ethyl-22-dehydrocholesterol, which were present as minor components, were shown to be mixtures of the 24α- and 24β-epimers, with the 24α-epimers predominanting in all cases. Four minor 24-methylsterols, 24-methylcholestanol, 24-methylcholesterol, 24-methyl-22-dehydrocholesterol, and 24-methyllathosterol, were also shown to be C-24 epimeric mixtures, whereas two others, 24-methyl-22,25-bisdehydrocholesterol and 24-methyl-22-dehydrolathosterol, were found to be present only as the 24β-epimers.

Most flavonoids reported for *Clerodendrum* are commonly found in higher plants (apigenin, luteolin, nepetin). However, some *Clerodendrum* flavonoids are unique. Examples of these include nepetin-7-O-β-D-glucuronide from *C. serratum*, and the methyl ester of acacetin-7-O-glucuronide from *C. infortunatum*.

Extracts and isolated compounds from selected *Clerodendrum* species showed antimicrobial activity in several test systems. For instance, the antimicrobial activity of petroleum ether- and fractionated methanol extracts of the leaves of *C. phlomidis* was evaluated in vitro. At 0.1%, the ethyl acetate fraction of a methanol extract produced maximal growth inhibition of *Penicillium italicum* followed by the hexane fraction of the methanol extract against *Trichoderma* sp. Subsequent column chromatography of both the fractions resulted in the isolation of 5,7-dihydroxy-6,4′-dimethoxyflavone and pectolinarigenin. From the ethyl acetate fraction furthermore 2 glycosides were isolated, 5,7-dihydroxy-6,4′-dimethoxyflavone-7-0-β-D-glucuronic acid methyl ester and 5,7-dihydroxy-6,4′-dimethoxyflavone-7-0-β-D-glucoside. The antifungal activity of the fractions mentioned is thought to be attributable in part to the presence of the flavones, either in their aglycone form or in glycosidic combinations. None of the crude extracts and the pure compounds tested produced any significant inhibition of *Xanthomonas campestris*, *Pseudomonas aeruginosa* or *Al-*

ternaria sp. In addition, cabruvin and quercetin, flavonoids isolated from roots of *C. infortunatum*, showed antifungal activity. Cabruvin at 200, 500 and 1000 mg/ml exhibited good inhibition of spore germination of *Alternaria carthami* and *Helminthosporium oryzae* (*Cochliobolus miyabeanus*). Quercetin at the same concentrations exhibited good inhibition of spore germination of *A. alternata* and *Fusarium lini*. The essential oil of *C. inerme* exhibited antifungal activity against several fungi e.g. *Aspergillus*, *Cladosporum* and *Cunninghamella*.

Antiviral activity is reported for both human and plant viruses. An extract of *C. inerme* significantly inhibited the secretion of HbsAg (hepatitis B surface antigen) into the culture medium at non-cytotoxic concentrations by using a hepatitis B expressing hepato-blastoma cell line. However, it had no effect on intracellular extrachromosomal hepatitis B virus DNA levels. Furthermore, in the field of phytopathology, leaf extracts of *C. inerme* sprayed on tobacco early in the season at a dilution of 1:1000 gave good protection against tobacco mosaic virus (TMV). Subsequent partial purification of the antiviral substance indicated that the active principle is a macromolecule (glycoprotein) containing 74% protein and 26% carbohydrate. Its activity was stable for up to 30 days, and it can withstand a temperature of 90°C at a dilution of 1:500. In addition, infection of tobacco plants by (cowpea) chlorotic mottle bromovirus under greenhouse conditions was inhibited (100%) when aqueous leaf extracts of *C. inerme* were mixed with the virus inoculum. Infection of *Vigna radiata* (L.) Wilczek and *V. mungo* (L.) Hepper by mung bean yellow mosaic virus under natural conditions was suppressed by aqueous partially clarified leaf extracts of *C. fragrans*. Administered as a foliar spray at 4%, every 3–4 days from the seedling stage, the extract reduced infection by about 60%. Flowering and consequent fruiting was advanced by the treatment which also increased nodulation. The yield in plants treated with *C. fragrans* extract was considerably enhanced.

Other pharmacological activities of *Clerodendrum* extracts include a general screening on a range of central nervous system related enzyme- and receptor systems in vitro, in which *C. mandarinorum* Diels and *C. bungei* root bark hydroethanolic extracts displayed affinity for α1-, α2-adrenoceptors, 5HT-1, 5HT-1A, 5HT-2, opiate, adenosine-1, dopamine-1, $GABA_A$ and $GABA_B$ receptors via radioligand studies. A methanolic extract of the leaves of *C. phlomidis* was also tested for its antidiarrhoeal potential against several experimental models of diarrhoea in Wistar albino rats. It showed significant inhibitory activity against castor oil-induced diarrhoea and PGE2-induced enteropooling in rats. The extract also showed a significant reduction in gastro-intestinal motility in charcoal meal test in rats. The results obtained establish at least in part the efficacy of the extract as an anti-diarrhoeal agent thus substantiating the folklore claim. In addition, a methanolic extract from the bark of *C. indicum* was found to be a potent inhibitor of lipid peroxidation with an IC_{50} value of 0.93 μg/ml using bovine brain phospholipid liposomes as model membranes.

Saponins isolated from *C. serratum* showed spermicidal activity in human semen in both the Spot and IPPF (International Planned Parenthood Federation) tests. Spermicidal activity was associated with the β-amyrin C-28 carboxylic acid type of sapogenins linked to a particular sequence of sugar moieties. The aqueous extract of *C. serratum* root bark showed antihistaminic activity when tested on rat ileum and trachea.

Furthermore, the petroleum ether extract of *C. inerme* leaves afforded a compound that matched the clerodane compound (–)-3-epicaryoptin in physical and spectral characteristics. The test compound inhibited the development of larvae of the fly *Musca domestica* and the mosquito *Culex quinquefasciatus*. First- and third-instar fly larvae reared on 3-epicaryoptin-treated diet pupariated later and earlier than their respective controls and adult emergence from puparia was inhibited. Apart from larval mortality, exposure of fourth-instar mosquito larvae to 3-epicaryoptin resulted in death at larval-pupal moult and pupal-adult eclosion, indicating inhibition of the moulting process. An equivalent petroleum ether extract of *C. inerme* leaves at 0.5% also gave 93% seed protection against the pulse beetle *Callosobrunchus chinensis*, with few toxic effects. In addition, a methanol extract of *C. inerme* showed 90% activity against the brown planthopper (*Nilaparvata lugens*) at a dose of 0.5 μg/female, using a topical application method, and a crude leaf extract containing 2.5% *C. infortunatum* completely inhibited adult emergence, whilst a 3% extract produced 100% mortality in fourth-instar *Anopheles subpictus* larvae under laboratory conditions.

Description Vines, shrubs or small trees, usually unarmed, glabrous or pubescent. Leaves opposite or whorled, simple, sometimes lobed, entire or dentate; petiolate or not; stipules absent. Inflorescence a terminal or axillary cyme, sometimes arranged in panicles or corymbs. Flowers zygomorphic, bisexual, usually large, showy, mostly white, blue, violet or red; calyx campanulate or tubular, truncate or 5-dentate to 5-partite, often accrescent; corolla salverform, tube cylindrical, straight or curved, limb 5-lobed, spreading or reflexed, stamens 4, long-exserted, didynamous, inserted in corolla tube; ovary imperfectly 4-locular, style exserted. Fruit a drupe, obovoid or globose, 4-lobed or 4-sulcate, usually separating in 4 pyrenes. Seed exalbuminous. Seedling with epigeal germination; cotyledons emergent, green, fleshy, hypocotyl elongated (*C. inerme*); or with hypogeal germination; cotyledons not emergent, hypocotyl not elongated (*C. serratum*, *C. villosum*).

Growth and development *Clerodendrum* can be found flowering and fruiting throughout the year. Pollination is mostly by butterflies, moths and bees. The fruits are eaten by birds, which disperse the seeds. In many species the calyx provides a contrasting colour. The pseudo-aril present in some species is actually a placental part of the pericarp that acts as an attractant to birds in the fruit dispersal process.

Other botanical information Cladistic analysis of molecular data from both chloroplast and nuclear genomes of *Clerodendrum* s.l. has demonstrated that the classification systems devised in the past do not adequately reflect the natural grouping within the genus. A thorough revision of *Clerodendum* is necessary and the same applies to *Rotheca*. Although some new combinations in *Rotheca* apply to medicinally used *Combretum* in South-East Asia, the *Clerodendrum* name is maintained as such here. All African and Asian species, except for coastal species, form genetically isolated groups. Four species common in cultivation are often confused: *C. intermedium*, *C. japonicum*, *C. paniculatum* and *C. speciosissimum* Van Geert ex Morren. *C. japonicum* has leaves similar to *C. intermedium* but the flowers are twice as big. *C. intermedium* is also similar to *C. paniculatum* L., but the latter has bigger inflorescences and lobulate leaves. The glabrate leaves of *C. intermedium* may be distinguished from the pubescent leaves of *C. speciosissimum*.

Ecology *Clerodendrum* can be found in many habitats ranging from mangrove, salt marshes and beach forest through grassland thickets up to cloud forest, on soils ranging from saline soils with up to 6.4% salinity, sand dunes to limestone formations. It can be grown in full sun or shade in any well-drained, friable soil. However, *Clerodendrum* is most abundant at lower elevations.

Propagation and planting *Clerodendrum* is propagated by seed, softwood and semi-ripe cuttings, root cuttings or simply by rooted suckers.

Husbandry The climbing species of *Clerodendrum* do better when planted in a bed of soil rather than in pots or tubs. They should be trained along pillars and rafters to show off their full beauty. An annual top dressing of fresh compost is advisable. Pruning in general consists of removing the dead twigs on old bushes.

Diseases and pests Leaves of *C. indicum* are often attacked by the fungus *Cercoseptoria clerodendri*.

Harvesting The various parts of *Clerodendrum* are in general simply collected whenever the need arises.

Handling after harvest Roots of *Clerodendrum* are washed and dried either whole or cut in thin slices for future use. Likewise leaves can be dried for future use.

Genetic resources and breeding All *Clerodendrum* species treated here have a large area of distribution, either naturally or as a result of cultivation, and do not seem to be at risk of genetic erosion. There are no known breeding programmes of *Clerodendrum* for medicinal purposes.

Prospects Quite substantial information on biological activities of *Clerodendrum* is available, especially in the field of antimicrobial, antiviral and insecticidal activities. Little information is found in the literature, however, on the plant constituents which might be involved in these actions. Therefore, research is needed to fill the gap in this respect. Only then will a full evaluation be possible of the future potential of the *Clerodendrum* species involved.

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Selection of species

Clerodendrum indicum (L.) Kuntze

Rev. Gen. Pl. 2: 506 (1891).

Synonyms *Clerodendrum siphonanthus* R.Br. (1812), *Clerodendrum fortunatum* Blume ex Hassk. (1844).

Vernacular names Indonesia: genje (Sundanese), sekar petak (Javanese), ringgo dipo (Palembang). Malaysia: ganja ganja, penatoh. Thailand: thao yaai mom (central), phayaa raak dieo (peninsular), leng chon tai (northern). Vietnam: ng[oj]c n[uwx] [aas]n d[ooj].

Distribution Native to India and Nepal, eastward to Burma (Myanmar), southern China, Indo-China, Thailand and Peninsular Malaysia; naturalized in Indonesia, Madagascar, southern USA, West Indies and northern South America.

Uses In Java, the dried leaves are smoked like cigarettes to relieve asthma. In India, the juice of the tender parts of the plant is used as an external application for skin complaints. The pounded root mixed with ginger are considered useful in asthma, coughs and other pulmonary complaints as well as scrofulous affections. In Burma (Myanmar), resin from the plant is employed for syphilitic rheumatism. In New Caledonia the leaves are used as a bitter tonic and vermifuge. Mention is made of the leaves being employed as a substitute for opium.

Observations A shrub or treelet up to 3 m tall, sometimes suffrutescent or even herbaceous, stoloniferous, stems usually very straight or arching, mostly unbranched, hollow, nodes annulate (except the younger ones); leaves linear-lanceolate to oblanceolate, 7.5–23 cm × 0.7–5.5 cm, base attenuate to acute, apex acute or acuminate, mostly entire, glabrous on both surfaces, sessile or petiole 0.3–0.8 cm long; axillary cymes solitary or whorled, 4–6 cm long, 3–7-flowered, terminal panicle up to 45 cm × 25 cm, composed of 3–12 whorls of cymes; calyx very broadly campanulate, tube 5–7 mm long, deeply 5-lobed, lobes 6–10 mm long, green or red, corolla hypocrateriform, tube long and slender, 7.5–14 cm long, lobes 0.8–1.5 cm long, white to yellow, showy, not fragrant, stamens long exserted, purple, fruiting calyx accrescent to 3 cm in diameter, red to purple; drupe 1–1.3 cm in diameter, bright green turning blue-black or reddish-black. *C. indicum* easily escapes cultivation through its stolons. In Java cultivated from sea-level up to 1200 m altitude; naturalized in grassy, sunny or slightly shaded localities near human settlements from sea-level up to 500 m altitude.

Selected sources 74, 135, 215, 375, 407, 459, 571, 688.

Clerodendrum inerme (L.) Gaertner

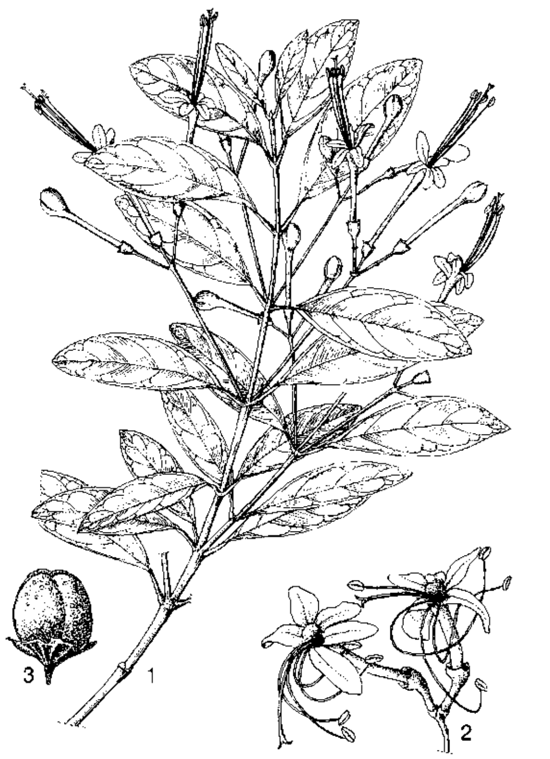
Fruct. sem. pl. 1: 271(1788).

Vernacular names Seaside clerodendron, garden quinine (En). Indonesia: kembang bugang (Sundanese), wiri salo (Buginese), gambir laut (Moluccas). Malaysia: bunga pawang, langa langa, terong gambul. Philippines: mangongot (Tagalog), baliseng (Bisaya), samin anga (Sulu). Thailand: sammangaa (central, eastern), som neraa, sak khree yaan (peninsular). Vietnam: ch[uf]m g[oj]ng.

Distribution From the coast of subtropical and tropical India to Australia, almost throughout the Pacific, and northward to southern China. Introduced in other parts of the tropics to control beach erosion and as an ornamental.

Uses In the Philippines, a decoction of the root is administered as a febrifuge and general alterative. The leaves are used in poultices as a resolvent. In Indonesia, the seeds are reportedly used as a remedy for an upset stomach, especially if caused by poisonous seafood. The finely ground roots are used for the same purpose. This treatment is often combined with a decoction of the leaves, simultaneously employed as a bath but also as a drink. In Thailand, a decoction of the leaves or a poultice of ground leaves is used in the treatment of skin diseases and itches. The roots are used as an alterative and febrifuge. In Vietnam, a decoction of roasted leaves is considered a remedy for beriberi. In India, fresh and dry leaves are credited with alterative and febrifugal properties. The root boiled in oil is used as a liniment useful in rheumatism. The leaves are applied in poulticing.

Observations An evergreen erect bush, often scrambling or scandent up to 3 m tall, sometimes a liana up to 13 m long, branches and branchlets slender, nodes not annulate; leaves elliptical or narrowly lanceolate, 2.3–10 cm × 0.8–4.5 cm, base acute, apex obtuse or shortly acuminate, entire,



Clerodendrum inerme (L.) Gaertner – 1, flowering branch; 2, detail of flower; 3, fruit with persistent calyx.

glabrate above, almost glabrate beneath, aromatic, petiole 0.5–1 cm long; cymes axillary or supra-axillary, solitary, opposite, 4.5–9.5 cm long, 3–7-flowered; calyx campanulate, tube about 4 mm long, 5-toothed, green, corolla hypocrateriform, tube slender, (1.5–)2–3.5(–4) cm long, lobes 0.4–0.8(–1.1) cm long, white or tinged purple, fragrant, stamens long exserted, reddish to purple, fruiting calyx accrescent to 1.5 cm in diameter; drupe 0.8(–1.9) cm in diameter, bright green turning black or brown, splitting into 4 pyrenes. *C. inerme* is a polymorphic species of seashores, saline marshes and swamps, muddy tidal river banks, and the edges of mangrove forest.

Selected sources 74, 135, 140, 141, 278, 407, 411, 459, 688, 706, 730, 739, 777, 782, 786, 810, 867.

Clerodendrum philippinum Schauer

in A.DC., Prodr. 11: 667 (1847).

Synonyms *Volkmannia japonica* Vent. (1798), *Clerodendrum chinense* (Osbeck) Mabb. (1989), *Clerodendrum fragrans* auct., *Volkameria fragrans* auct.

Vernacular names Glory bower (En). Philippines: pelegrina (Bikol, Tagalog), higantong (Bisaya), sabuka (Igorot). Thailand: naang yaem (peninsular, central), ping son (northern), suan yai (eastern). Vietnam: v[aaj]y tr[aws]ng, m[of] tr[aws]ng, b[aas]n tr[aws]ng.

Distribution Possibly originating from China and/or southern Asia. At present widespread throughout the tropics; as a widely cultivated ornamental it tends to escape easily, becoming a weed in suitable climates.

Uses *C. philippinum* is used in Peninsular Malaysia in a fomentation for rheumatism and ague, or as an ingredient of a mixture for skin problems. In Thailand, the root is considered diuretic. It is used in the treatment of abdominal pain and intestinal diseases and kidney dysfunctions. Uses and vernacular names in Vietnam for this species vary according to the various authors. A decoction of the leaves is used for blenorrhoea. Juice from the leaves is an ingredient of a herbal bath for children with furuncles. The roots are credited with antibacterial and antiphlogistic properties. They are used for a wide range of women's disorders, skin afflictions, lumbago, hypertension and jaundice. A decoction is externally applied as an antiseptic. The leaves are used in folk medicine as a diuretic and antiblenorrhagic. A decoction of the root is employed as a remedy for jaundice.

Observations A shrub up to 2 m tall, branches stout, finely pubescent, leaf scars large and prominent; leaves broadly ovate, 6–29 cm × 5–28 cm, base cordate to subtruncate, apex sharply acute or acuminate, margin usually coarsely and irregularly dentate, sometimes 1–3-lobed, lightly strigillose-pubescent on both surfaces, petiole 2–24 cm long; corymb terminal, 3–6 cm × 3.5–9 cm, densely many-flowered; calyx campanulate, 1–1.5 cm long, deeply 5(–8)-lobed, lobes 4–10 mm long, purple or red, sometimes with white blotches, corolla hypocrateriform, tube 2–3 cm long with lobes 0.8–1.5 cm long, white to pink, fragrant, stamens long exserted, or modified petaloid. In cultivation the double flowered and sterile form f. *multiplex* (Sweet) Moldenke is most commonly encountered. Plants with a few single flowers scattered among many double ones are designated as f. *subfertile* Moldenke. Plants with only single flowers represent f. *philippinum*. *C. philippinum* is often confused with the distinct but very closely related *C. bungei* Steudel. *C. philippinum* suckers profusely and is found in pastures, roadsides, river banks, thickets and secondary forest from sea-level up to 1200(–2000) m altitude.

Selected sources 74, 135, 201, 264, 459, 640, 688, 739, 786, 848, 1042, 1130.

Clerodendrum serratum (L.) Moon

Cat. pl. Ceylon: 46 (1824).

Synonyms *Volkameria serrata* L. (1767), *Cyclonema serratum* (L.) Hassk. (1848).

Vernacular names Indonesia: singgugu (Sundanese), sagunggu (Javanese), kertase (Madurese). Malaysia: tinjal tasek, lampin budak, mata kesang. Laos: sa heng. Thailand: akkhee thawaan (northern, central), khwaeng khaa (northern). Vietnam: ng[oj]c n[uwx] r[aw]ng.

Distribution From Pakistan and India eastward to central and southern China, Indo-China, Thailand, Malaysia and Indonesia. Also in Mauritius, Madagascar and South Africa, possibly introduced.

Uses In Indonesia, the leaves are consumed during labour. Pounded leaves are externally applied in various prescriptions for rheumatism and painful joints. Ripe and unripe fruits are chewed with the leaves of *Piper bettle* L. for coughs. They are mentioned as a remedy for cattle with stomach problems. In Malaysia, a decoction is given to relieve colic, and the flowers are consumed during labour. The plant is more commonly used for poulticing skin diseases, yaws, headache, leprosy and persistent fever, and is an ingredient of an embrocation for stiff joints. In Thailand, the dried leaves, roots or stems enter in various prescriptions for haemorrhoids. A decoction of leaves and/or stem is used as an antiflatulent, and to relieve chronic headache. Externally a poultice is applied to skin infections, leprosy and painful joints. A decoction of the stem is used as an antimalarial and to relieve abdominal pain. The wood is considered diuretic, and the root enters in a prescription as an anti-emetic, whereas the fruits are considered a cough remedy. In India, the root is used in medicine for fevers, rheumatism and dyspepsia. The leaves are used in fevers and externally applied in cephalalgia and ophthalmia; the seeds are used to some extent for oedema. In Indonesia, the shoots, raw or toasted, are consumed as a bitter seasoning.

Observations A shrub or treelet up to 4 m tall, or rarely seemingly herbaceous, stems relatively stout, mostly unbranched, nodes not annulate; leaves elliptical to obovate, 7–22 cm × 3–8 cm, base acute to subcuneate, apex acute or short acuminate, margin serrate, glabrous on both surfaces, petiole 0.3–1.2 cm long; axillary cymes 3–5 cm long, terminal racemose panicle slender, 6–45 cm long; calyx campanulate, tube 4–7 mm long, deeply dentate to truncate, bluish turning green, corolla zygomorhic, tube swollen, 5–9 mm long, posterior lobes 0.9 cm long, usually dark blue, lateral lobes usually pale blue, lower (interior) lobe deflexed, 1.5 cm long, dark purple or dark violet, showy, not fragrant, stamens long exserted, blue, fruiting calyx somewhat accrescent; drupe subglobose or broadly obovoid, 6–9 mm long, glossy emerald green turning dark purple or black, not splitting. *C. serratum* is found in grasslands, thickets and secondary forest from sea-level up to 1700 m altitude. Pending a full revision of *Rotheca*, the new combination *Rotheca serrata* (L.) Steane & Mabberley has already been published.

Selected sources 74, 184, 201, 215, 407, 688, 730, 786, 788, 852, 897, 963.

Clerodendrum viscosum Vent.

Jard. Malmaison 1: 25 (1803).

Synonyms *Clerodendrum infortunatum* auct. non L., *Clerodendrum buchananii* auct.

Vernacular names Indonesia: kembang bugang (Sundanese), tintinga (Balinese), marurang (Ambonese). Thailand: naang yaem paa, ping hep (northern), khee khom (peninsular). Vietnam: b[aj]ch d[ooj]ng nam, ng[oj]c n[uwx] v[of]m.

Distribution Native from Pakistan and Nepal through northern India, Burma (Myanmar) and Thailand, to southern China and Indo-China, Malaysia, Indonesia and the Philippines; widely cultivated throughout South-East Asia and naturalized in Brazil.

Uses In the Moluccas, the root is used as an antidote for *Antiaris* poisoning and dysentery. Heated leaves are applied as a poultice on a swollen stomach. Pounded, they are applied to burns, ulcers and boils. Furthermore, leaves are an ingredient of a herbal bath for newborns. In Thailand, the root is considered diuretic and used in the treatment of intestinal infections and kidney dysfunction. A decoction of the ground root is taken as a galactagogue. In Vietnam, leaf sap is used as an antiseptic skin wash. Leaves and roots in decoction are used against leucorrhoea, menstrual disorders and jaundice. An infusion or poultice of the leaves is applied for angina. In India, various parts of the plant are used in local medicine as a remedy for skin diseases.

Observations A shrub or treelet up to 3 m tall, nodes not annulate; leaves elliptical to ovate, 6–25 cm × 3.5–20 cm, base cordate to acute, apex acute or short-acuminate, margin denticulate or serrate, rarely entire, sparingly to densely pubescent on both surfaces, petiole 2–19 cm long; cymes combined in a terminal panicle, 10–25 cm × 10–25 cm; calyx tube 9–16 mm long, deeply 5-lobed, lobes up to 10 mm long, bright green or the lobes red, corolla cylindrical, tube 2 cm long, lobes 0.6–1.5 cm long, white often tinged pink at the mouth of the tube, showy, not fragrant, stamens long exserted, white to purplish, fruiting calyx accrescent to 2 cm long, red to purple; drupe about 1 cm in diameter, bright green turning blue-black or black. This is the plant described by Rumphius as *Petasites agrestis*. *C. viscosum* is often considered a synonym of *C. infortunatum* L. and also closely related to *C. villosum* Blume. In *C. infortunatum* the corolla tube is 3–4 times as long as the calyx tube, the calyx lobes have a prominent midrib and the leaves are entire. In *C. viscosum* the corolla tube is about twice as long as the calyx tube, at most slightly glandular, the calyx lobes without prominent midrib, and the leaves are distinctly dentate. In *C. villosum* the corolla tube is about as long as the calyx and is densely glandular, and the leaves are entire. *C. viscosum* is found in thickets and village groves from sea-level up to 500 m altitude.

Selected sources 74, 169, 201, 263, 407, 459, 688, 739, 786, 788.

J.L.C.H. van Valkenburg & N. Bunyapraphatsara

Combretum Loefl.

Iter Hispan. App.: 308 (1758).

COMBRETACEAE

$x = 13$; *C. erythrophyllum*, *C. micranthum*: $2n = 26$; polyploidy is observed in several species.

Major species *Combretum quadrangulare* Kurz.

Origin and geographic distribution *Combretum* comprises about 250 species, throughout the tropics, and is most abundant in Africa; about 13(–17) species are present in South-East Asia.

Uses In South-East Asia *Combretum* is best known as a vermifuge and for poulticing. Seeds or sometimes other parts of *C. quadrangulare* and *C. trifoliatum* are widely used as a vermifuge or for other intestinal disorders. The leaves or roots of *C. quadrangulare* and *C. sundaicum* are employed for poulticing wounds and boils. The fruits of *C. tetralophum* C.B. Clarke are applied as a substitute for *C. trifoliatum*. Both species are called 'sonsong harus' in Malay. This also applies to *C. acuminatum* Roxb., a third species of which the leaves are employed as a vermifuge; either as a decoction for adults, or as an externally applied plaster on the abdomen of children. In Peninsular Malaysia, the leaves of *C. nigrescens* King are used for poulticing wounds. In Indo-China, the astringent fruits of *C. latifolium* Blume are considered a tonic. In West Africa *C. micranthum* G. Don is traditionally used as an antimalarial. It is locally cultivated in Vietnam as a reputed remedy for bilious fever and haematuria. Several non-indigenous *Combretum* species have been introduced for their ornamental value, e.g. *C. constrictum* (Benth.) Rawson, *C. grandiflorum* G. Don, *C. quadrangulare* and *C. roxburghii* Spreng. (synonym *C. decandrum* Roxb.).

Production and international trade *Combretum* is only used at the local level in South-East Asia, and data on trade for medicinal use are lacking.

Properties The vermifugal properties of the ripe fruits of *C. quadrangulare* were evaluated in buffalo calves after a single oral administration. A dosage of 18–54 mg/kg body weight decreased the number of *Neoascaris vitulorum* eggs in faeces to zero in 1–3 weeks. In a further in vivo study on the anthelmintic activity of *C. quadrangulare*, the ethereal and 95% alcohol extracts of dried roots were as active as the seed extract. However, in a clinical experiment for the treatment of threadworm-infested children, negative results were obtained for moderate doses, and at a high dose negative side effects were observed.

Ripe seeds of *C. quadrangulare* produced no acute toxicity in albino rats and mice when administered orally at a single dose of about 0.6 and 2 g/kg respectively. The LD_{50} of a 80% methanol extract, given orally to male and female mice and male and female rats, was reported to be 3.95, 3.9, 4.4 and 3.5 g/kg respectively. In a subchronic toxicity test, female rats, given the extract at 1 g/kg/day for 4 weeks, had significantly less weight gain without any changes in SGOT, SGAT, alkaline-phosphatase, BUN or in serum albumin levels compared to controls.

Extracts of the seeds furthermore showed antibacterial activity against *Staphylococcus aureus* (ATCC 25923), *Bacillus subtilis* (ATCC 6633), *Salmonella typhosa* (Bangkok), *Escherichia coli* (ATCC 25922) and *Pseudomonas aeruginosa* (ATCC 10045) in vitro.

Triterpene glucosides (e.g. quadranosides I, II, V), isolated from the seeds of *C. quadrangulare*, showed significant hepatoprotective effects against D-galactosamine/tumour necrosis factor-α(TNF-α)-induced cell death in primary cultured mouse hepatocytes. Cycloartane-type triterpenes and flavonoids from the methanolic leaf extract showed significant hepatoprotective effects on D-galactosamine/lipopolysaccharide-induced experimental liver injury in mice in vivo, together with in vitro activity in the previously mentioned assay. A potent inhibition was found to TNF-α-induced cell death for the triterpenes quadrangularol B (IC_{50} 34.3 μM), methyl quadrangularates A, I, N (IC_{50} 45.7, 33.7, 89.3 μM, respectively), norquadrangularic acid B (IC_{50} 67.6 μM), and the flavonoids vitexin (IC_{50} 40.1 μM), kamatakenin (IC_{50} 13.3 μM), 5,7,4'-trihydroxy-3,3'-dimethoxyflavone (IC_{50} 22.4 μM), 5,4'-dihydroxy-3,7,3'-trimethoxyflavone (IC_{50} 13.4 μM) and isokaempferide (IC_{50} 22.8 μM), when compared to silibin (IC_{50} 39.6 μM) as a clinically-used reference.

Methyl quadrangularate B and D also exhibit strong cytotoxicity against murine colon 26-L5 carcinoma cells, having ED_{50} values of 9.54 and 5.42 μM, respectively; all flavonoids showed ED_{50} values equal to or less than 6 μM.

Reported constituents for the roots include sterols and triterpenes, e.g. combretol, daucosterol, 3,6-diketo-olean-12-en-28-oic acid, olean-12-en-28-oic acid, β-sitosterol and 3β,6β,18β-trihydro-urs-12-en-30-oic acid. The 95% alcohol extracts of dried roots showed in vitro antimicrobial activity against several bacteria.

An infusion or decoction of *C. micranthum* shows in vitro antimalarial activity against strains of *Plasmodium falciparum* sensitive to chloroquine (F32-Tanzania) and resistant to chloroquine (FcB1-Colombia)at IC_{50} values lower than that of *Azadirachta indica* A.H.L. Juss.

The methanol extract of *C. micranthum* showed potent acaricidal activity against the two-spotted spider mite (*Tetranychus urticae*) using the leaf dipping method.

A methanolic extract of the leaves of *C. micranthum*, left standing for 7 days, shows in vitro antiviral activity against herpes simplex virus 1 and 2 (HSV-1,HSV-2). EC_{50}s of catechinic acid auto-oxidation products against HSV-1 and HSV-2 replication were 2 μg/ml and 4 μg/ml, respectively, when cell cultures were treated with the compound during virus infection. Several compounds including flavonoids (e.g. myricetin glycosides, vitexin), alkaloids (e.g. stachydrine, 4-hydroxystachydrine) have been isolated from *C. micranthum*)

Description Small trees, scandent shrubs or large woody climbers up to 30 m tall. Leaves opposite, verticillate or rarely alternate, simple, entire, glabrous or hairy, often scaly and often with domatia; usually petiolate; stipules absent. Inflorescence an elongated or subcapitate, axillary or extra-axillary spike or raceme, or a terminal and/or axillary, often leafy, panicle. Flowers usually bisexual, actinomorphic, 4–5-merous; calyx tube (receptacle) glabrous or hairy, usually divided into a lower part adnate to the ovary and an upper part terminating in 4–5 calyx lobes; petals small or showy, white, yellow, orange, red or purple; stamens usually twice as many as petals, usually exserted; intrastaminal disk present; ovary inferior, unilocular. Fruit a pseudocarp, 4–5-winged, ridged or angled, usually indehiscent, 1-seeded, sessile or stipitate.

Growth and development In Java, *C. sundaicum* flowers from January-February, and *C. trifoliatum* from May–November. Dry, indehiscent winged fruits may indicate dispersal by wind. Seed dispersal of narrow-winged or angled fruits of riverine species may be by water.

Other botanical information *Quisqualis* is closely related to *Combretum* and the most recent view is that both genera should be united. The name *Combretum* has priority over *Quisqualis*. However, for the Malesian species so far only *Quisqualis indica* L. has been recombined in *Combretum indica* (L.) Jongkind.

Ecology South-East Asian *Combretum* are found in habitats ranging from riverine and swampy, flood-plains (*C. acuminatum*, *C. tetralophum*, *C. trifoliatum*) to savanna woodlands and monsoon forest (*C. trifoliatum*) and evergreen forest (*C. nigrescens*), quite often in forest borders and secondary forest.

Propagation and planting *Combretum* is propagated by seed or semi-ripe cuttings kept under mist spray or in a closed case to prevent excessive evaporation.

Harvesting Fruits of *C. quadrangulare* are collected when mature; bark or leaves are collected whenever the need arises.

Genetic resources and breeding The *Combretum* species of medicinal importance are relatively widespread in South-East Asia and are also found in disturbed habitats, and therefore certainly not endangered. There are no known breeding programmes of South-East Asian *Combretum*.

Prospects The flavonoids and triterpenes from *Combretum* show interesting in vitro/in vivo effects, e.g. in the field of hepato-protection. Further experimental data will, however, be necessary for their total evaluation. The vermifugal effects which are well-known from traditional medicine were also found in cattle, and further research is therefore merited to fully investigate the possibilities.

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Selection of species

Combretum quadrangulare Kurz

Journ. As. Soc. Beng. 43,2: 188 (1874).

Synonyms *Combretum attenuatum* Wallich (1831).

Vernacular names Cambodia: song ke, sang ke. Thailand: sakae (central), kae (north-eastern), chong khae (northern). Vietnam: ch[uw]n b[aaf]u, ch[aa]n b[aaf]u, tr[aa]m b[aaf]u.

Distribution Burma (Myanmar), Thailand and Indo-China; cultivated in Malesian gardens as an ornamental.

Uses In Thai traditional medicine, the roots are employed in the treatment of abscesses, gonorrhoea, as an alterative and anthelmintic. The leaves are used in the treatment of wounds, as an antipyretic, and against dysentery. The sapwood is used in the treatment of threadworm. The seeds or the whole plant are used in the treatment of roundworm, and gastro-intestinal ailments associated with intestinal parasitism in children. The whole plant is further employed against abscesses in paediatrics, and against stomach-ache. In Indo-China, the roasted seeds, bark or the leaves are used as an anthelmintic against *Ascaris*. It was formerly planted for raising a scale insect *Laccifer lacca* to produce lac, a raw material for the production of shellac.

Observations A shrub or tree up to 12 m tall, branches quadrangular; leaves usually opposite, obovate, 5–13 cm × 3–7 cm, base acute, apex obtuse or rounded, densely scaly, soon glabrescent, petiole 5–10 mm long, ridged and flattened; inflorescence an axillary and terminal spike, 2.5–7.5 cm long, flowers mostly 4-merous, densely scaly, subsessile, 5–6 mm long, receptacle stipitate above ovary, abruptly dilated into the cup-shaped calyx-limb, petals broadly ovate, easily shed, yellowish; pseudocarp thinly 4-winged, about 2 cm × 2 cm; seed fusiform, 4 mm wide. *C. quadrangulare* is found in lowland forest and can tolerate saline conditions.

Selected sources 74, 85, 86, 263, 337, 589, 739, 788, 867.

Combretum sundaicum Miq.

Fl. Ind. Bat. Suppl.: 327 (1860).

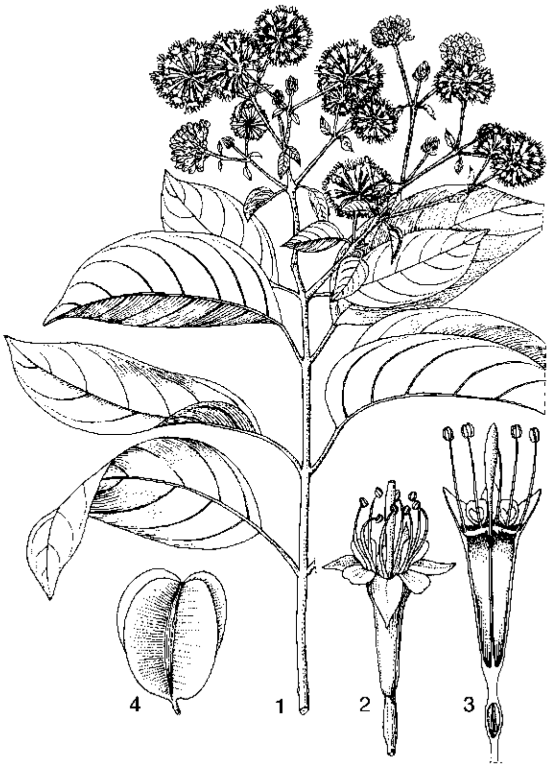
Vernacular names Indonesia: akar gambir-gambir (Malay), sungsung ayer (West Kalimantan), bayit jaha (Lampung, Sumatra). Vietnam: ch[uw]n b[aaf] sun da, tr[aa]m b[aaf]u sun da.

Distribution From Indo-China, (peninsular) Thailand and Peninsular Malaysia to Sumatra and Borneo.

Uses In Peninsular Malaysia, the leaves and roots are used for poulticing boils, and the leaves are applied to sooth a headache. The leaves used to be promoted as a cure for opium-craving.

Observations A scandent shrub or liana up to 30 m, young branches densely ferruginous-scaly, glabrescent; leaves opposite, broadly elliptical, 6–12(–15) cm × 3–7(–10) cm, base rounded or cuneate, apex mostly acuminate, initially densely scaly, petiole up to 2 cm long, rather slender; inflorescence a terminal panicle of head-like spikes or racemes, flowers 4-merous, subsessile, receptacle sparsely pubescent, lower receptacle 3 mm long, densely scaly, upper receptacle narrowly tubular, 5 mm long, somewhat expanding at the apex, petals obovate to suborbicular, greenish white; pseudocarp suborbicular, 2.5–3 cm × 2–2.5 cm, with 4 thin flexible wings up to 1.5 cm broad. *C. sundaicum* is found in open bush vegetation and forest margins from sea-level up to 250 m altitude.

Selected sources 74, 589.



Combretum sundaicum Miq. – 1, flowering twig; 2, flower; 3, longitudinal section of flower; 4, fruit.

Combretum trifoliatum Vent.

Choix pl.: t. 58 (1808).

Synonyms *Combretum lucidum* Blume (1825).

Vernacular names Malaysia: sonsong harus. Cambodia: trâhs, tro, tras. Laos: ben nam. Thailand: chut, yaan tut (peninsular), puei (north-eastern). Vietnam: tr[aa]m b[aaf]u ba l[as].

Distribution From Burma (Myanmar), Indo-China, Thailand to Malaysia, Indonesia (except the Moluccas, Lombok, Sumbawa, Sumba, Flores, Timor), Papua New Guinea and Australia (Queensland).

Uses In Peninsular Malaysia, the seeds are traded as a vermifuge against *Ascaris*. In Cambodia, the roasted seeds mixed with maize, ground and made into pills are chewed as a tonic for the gums and a remedy for angina. The juice is used for dysentery.

Observations A climbing or scrambling shrub up to 5 m tall, young branches fulvous-pubescent, glabrescent; leaves usually 3–4(–5)-verticellate, elliptical to lanceolate, 8–16 cm × 3–5.5 cm, base slightly rounded, apex acute and mucronulate, shiny above with brown hairy domatia below, petiole 4–7 mm long, glabrescent, nigrescent; inflorescence an axillary or terminal panicle, 8–20 cm long, consisting of 2–5 cm long spikes, flowers in whorls of 3, 5-merous, protogynous, sweet-scented, lower receptacle densely pubescent, upper receptacle shallow-cupuliform, petals narrowly elliptical, densely pubescent, white or yellowish-white; pseudocarp sessile, ellipsoid, glabrous, shiny black-brown, 3–3.5 cm × 1–1.2 cm, with (4–)5(–6) rigid wings, 3–4 mm broad. *C. trifoliatum* is found in frequently flooded areas at low elevations, along banks of watercourses, in bush or forest, borders of teak forest, on limestone or alluvial clay, in everwet and seasonal climates, locally common.

Selected sources 74, 91, 135, 223, 589, 786, 788.

Noorma Wati Haron

Commelina L.

Sp. pl. 1: 40 (1753); Gen. pl. ed. 5: 25 (1754).

COMMELINACEAE

x = (8, 9), 11, 14, 15, (21–28), (31–34); *C. benghalensis*: $2n$ = 22, (28, 30, 44, 48, 56, 66, 68), *C. communis*: $2n$ = (16), 22, (28, 32), 36 (40, 44, 46, 48, 50, 52, 84, 88), 90, *C. diffusa*: $2n$ = (18), 20, 28, 30,(42, 45, 56, 58), 60, (72), 90

Major species *Commelina benghalensis* L., *C. communis* L.

Vernacular names Spiderwort, dayflower, widow's tears (En). Indonesia, Malaysia: gewor, tali (also used for other *Commelinaceae*). Thailand: phak plaap. Vietnam: th[af]i l[af]i.

Origin and geographic distribution *Commelina* consists of about (50–)100–150 species from the tropical and warm regions of the world.

Uses The aerial parts of *Commelina* are very mucilaginous, and are therefore generally used for poulticing wounds and skin infections such as boils and ulcers, and also as a maturative. Internally, the fresh juice from the plants is taken for diarrhoea. In Peninsular Malaysia, the Philippines and India, *C. benghalensis* is considered refrigerant and astringent, and is used for strangury. In China, Indo-China and Taiwan, *C. communis* is more commonly used for these purposes. In Vietnam, *C. communis* is applied externally for arthritis. In Indo-China, the sap of the crushed plant is also put on inflamed eyes, while in Africa the sap of *C. benghalensis* or *C. diffusa* is used for this purpose. In India and China, *C. communis* is also used to combat vertigo, fever and bilious disorders, and in Vietnam, India and China as an antidote for snake poisons. In Korea and China, *C. communis* is considered to have hypoglycaemic effects and is therefore applied in diabetes. In East Africa, the sap of *C. benghalensis* is applied for sore throat and burns, and also for thrush in children.

In Indonesia, the crushed leaves and stems of *C. diffusa* are taken in decoction for irregular menstruation, for abortion and to help expel the placenta after birth. In Thailand, *C. benghalensis* and *C. diffusa* are applied for abscesses and fever. In Vietnam, the plant is used for colds, a sore throat and nosebleed. In Nigeria and the West Indies, the leaves are taken as an aperient and a decoction is used in fever or for severe menstruation. In Jamaica, they are also taken in decoction to relieve urinary burning and leucorrhoea.

In Papua New Guinea, a cold water infusion of the crushed leaves of *C. paleata* Hassk. is taken for malaria and fevers.

In Indonesia and Indo-China, the young tops of *C. benghalensis* and *C. diffusa* are steamed and eaten as a vegetable, while in China and India, mainly *C. communis* is eaten. The leaves and starchy roots of *C. benghalensis* are considered a famine food in India and Africa. A blue dye is obtained from the sap of the flowers of *C. benghalensis* in China and India. In Japan, the blue dye from the flowers of *C. communis* var. *hortensis* Makino is used to produce blue 'Awobana' paper. *Commelina* is considered a good fodder for cattle and poultry in Africa and India, also because it provides an important part of the daily water requirements. In humid climates, the fodder quality is thought to be rather poor.

Production and international trade *C. benghalensis*, and sometimes *C. diffusa*, is widely sold in Chinese herbalist shops in South-East Asia.

Properties The flowers of many *Commelina* contain blue coloured anthocyanins, such as delphinidin-3-p-cumaroylglucosido-5-glucoside, stabilized by copigments, such as commelinin. The latter compound, which is also an anthocyanin, found for instance in *C. communis*, yields delphinin (= delphinidin-3,5-diglucoside), glucose and p-hydroxycinnamic acid upon hydrolysis. From the methanolic extract of *C. communis*, the pyrrolidine alkaloid 2,5-dihydroxymethyl-3,4-dihydroxypyrrolidine, and 4 piperidine alkaloids, i.e. 1-deoxymannojirimycin, 1-deoxynojirimycin, α-homonojirimycin and 7-O-β-D-glucopyranosyl-α-homonojirimycin were isolated. As a whole, the methanolic extract showed a potent inhibitory activity on the enzyme α-glucosidase. In a general phytochemical screen, the compounds n-triacontanol, p-hydroxycinnamic acid, daucosteril and D-mannitol were isolated from the aerial parts of *C. communis*. Pharmacological evaluation subsequently revealed p-hydroxycinnamic acid to have some antibacterial activity, and D-mannitol showed an antitussive effect. The hypoglycaemic effects of *C. communis* from Korea were tested in male Sprague-Dawley streptozotocin-induced diabetic rats, by feeding them a diet containing 10% of the aerial parts. Plasma cholesterol and blood sugar were estimated and urinary glucose monitored, and showed a decrease in blood sugar, while urinary glucose was negative in the 4th week, and plasma cholesterol did not change. In another test, benzene extracts of entire plants exhibited cytotoxic activity against Leuk HL 60 and Leuk L 1210.

The whole plant of *C. benghalensis*, including the flowers, yields hydrocyanic acid. The plant is known to cause contact allergy in dogs. An aqueous extract of the aerial parts of *C. benghalensis* showed allelopathic effects by reducing seedling vigour of soya beans and maize.

Description Annual or perennial, procumbent and ascending herbs, stems fleshy, up to 1.5 m long, mat-forming, rooting at the nodes. Leaves spirally arranged, simple, veins parallel; petiole short; basal sheath closed. Inflorescence axillary or terminal, composed of a scorpioid cyme with 2 racemes (cincinni), upper raceme with male or sterile flowers, lower raceme bisexual, cincinni more or less enclosed by a funnel-shaped, folded, keeled bract (spathe), green. Flowers ephemerous, zygomorphic; sepals 3, free, unequal, the lower one hooded; petals 3, free, the upper 2 clawed, the lower reduced, white, yellow, pink, lilac or blue; fertile stamens 3, anterior, often dimorphic, anthers hastate, staminodes 2–3, posterior, anthers X-shaped, all filaments glabrous; ovary superior, 3-loculed, ovules 1–2 per locule. Fruit normally a dry, dehiscent capsule, with few seeds. Seed with mealy endosperm, hilum linear. Seedling with epigeal germination; hypocotyl absent; cotyledon 1, sheath-like, glabrous, transparent; first leaf with closed sheath, parallel-veined, apex rounded.

Growth and development *Commelina* is fast growing and starts flowering and fruiting early in the season. Many *Commelina* species are self-incompatible, but *C. benghalensis* is preferably autogamous.

Other botanical information The large variation in chromosome numbers found in several *Commelina* species suggests that they are in the process of differentiation. Polyploids and aneuploids are often found in cultivation, e.g. *C. communis* f. *albiflora* has $2n = 48$ ($4x + 4$) or 88 ($8x$), var. *hortensis* has $2n = 46$ ($4x + 2$) and f. *caeruleopurpurascens* has $2n = 44$ ($4x$). There has been considerable confusion in older literature about the name *C. nudiflora* L. (synonym *Aneilema nudiflorum* (L.) Sweet) which is now a synonym of *Murdannia nudiflora* (L.) Brenan. It is a perennial herb, with long, linear leaves, and flowers in a long raceme without spathe. *C. nudiflora* in South-East Asian literature is often a wrongly applied name for *C. diffusa* Burm.f., a perennial herb with ovate-lanceolate leaves, and flowers in 2 short racemes in a spathe.

Ecology *Commelina* occurs under moist, swampy and even waterlogged conditions, along irrigation ditches or roadsides, in gardens, in sunny or lightly shaded areas, and also as a weed in arable land. It is often perennial when the dry period is not too long, but becomes annual after an extended dry season.

Propagation and planting *Commelina* is propagated by seed and stolons. The seeds are hydrochorous. One well-developed plant of *C. benghalensis* is able to produce up to 1600 seeds, but normally fewer are produced. Seeds were found to germinate readily between 25–30°C, but not at 10°C. Light did not influence germination, and flowering occurs regardless of photoperiod.

Diseases and pests *Commelina* is a common host for several agriculturally important plant viruses, e.g. cucumber mosaic cucumovirus, U2-tobacco mosaic virus, and groundnut rosette virus, but also for specific viruses attacking *Commelina*, such as Commelina yellow mottle badnavirus and Commelina diffusa virus, both from *C. diffusa*. *Commelina* is also a host for the fungi *Alternaria alternata* and *Pseudomonas solanacearum*, which cause leaf spot diseases on important crops. *C. benghalensis* is furthermore a host for the taro planthopper (*Tarophagus proserpina*) and for the caterpillar of the moth *Diacrisia obliqua*. In China, *C. communis* is attacked by the monophagous insect *Lema scutellaris*, which could offer some perspective for biological control. *Commelina* is also a host for nematodes.

Several *Commelina* are troublesome weeds of annual and perennial crops as they resist desiccation, and are thus difficult to eradicate. *C. benghalensis* is a weed of 25 crops in about 30 countries, while *C. diffusa* has been recorded as a weed of 17 crops in about 25 countries. Many herbicides have been tried for the eradication of *Commelina*, and are best applied as pre- or early post-emergence herbicides. Photosynthesis-inhibiting herbicides are not effective. At later growth stages, removal by hand is often the only effective method of control.

Harvesting *Commelina* is harvested from the wild, whenever needed.

Handling after harvest *Commelina* is normally used fresh.

Genetic resources and breeding The *Commelina* species treated here are widespread and common throughout South-East Asia, and therefore not endangered. There are no known breeding programmes of *Commelina* for medicinal purposes. Several *Commelina* are cultivated for ornamental purposes. Of *C. benghalensis* the cultivar 'Variegata' has variegated creamy white leaves, and of *C. communis* the cultivar 'Aureostriata' has striped creamy white leaves. In Japan, var. *hortensis* Makino 'Awobana' is cultivated as an ornamental and for the production of a blue dye.

Prospects The recorded anti-diabetic activities of some *Commelina* seem to justify more research, especially in the field of safe application. The plants might also be of interest as a local source of blue dye, which could have some application as colourants in foods.

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Selection of species

Commelina benghalensis L.

Sp. pl. 1: 41 (1753).

Vernacular names Wandering jew (En). Indonesia: petungan, kekupu (Javanese), tali korang (Sundanese). Malaysia: rumput mayiam. Philippines: bias-bias (Tagalog), kabilau (Bisaya), kulkul-lasi (Iloko). Burma (Myanmar): myet-cho. Laos: kaab pii. Vietnam: d[aaf]u ri[eef]u, th[af]i l[af]i l[oo]ng.

Distribution Widely dispersed in the Old World tropics and the Pacific Islands, and naturalized in South America and Florida.

Uses In the Philippines and India, the whole plant is considered demulcent, laxative and astringent, and applied for strangury. In Taiwan the aerial parts are used as a maturative poultice. The fresh plants are for sale in Chinese herbalist shops in Malaysia.

Young tops taste slightly bitter and are steamed as a vegetable in Indonesia and Indo-China.

Observations An annual to perennial, creeping or ascending herb, usually pubescent, rhizomatous; leaves ovate to elliptical, 4–7 cm × 2–4 cm, apex obtuse to acuminate, sheath rusty ciliate; normally 1 spathe per axil, boat-shaped, about 1.5 cm long, margins partly connate, upper raceme in spathe with 1–3 sterile flowers, lower raceme with 1–5 bisexual flowers, peduncle short, 0.5–1 cm long; flower 1.5 cm in diameter, petals 3–4 mm long, blue or violet, rarely white, fertile stamens 3, staminodes 3, 1 often without anther, cleistogamous flowers sometimes under ground on rhizomes; capsule elongate-globular, 4–6 mm long, 3-celled, 5-seeded, 1 seed larger than the others; seed 1.5–3.5 mm long, strongly ribbed-wrinkled, greyish-brown. *C. benghalensis* is growing in less humid conditions than *C. diffusa*, on sunny or lightly shaded localities, grass land, waste places and compost heaps, along roadsides, around villages, on rich, often heavy soils, from sea-level up to 1000 m altitude.

Selected sources 22, 134, 135, 215, 352, 459, 605, 747, 914.

Commelina benghalensis L. – 1, flowering stem; 2, inflorescence; 3, opened spathe with fruits; 4, seed.

Commelina communis L.

Sp. pl. 1: 40 (1753).

Synonyms *Commelina polygama* Roth (1790).

Vernacular names Asiatic dayflower, common dayflower (En). Vietnam: rau trai ([aw]n), th[af]i l[af]i tr[aws]ng, c[or] l[af]i tr[aws]ng.

Distribution Native to China, nowadays distributed in India, Indo-China, China, Japan, Malaysia and the Philippines, naturalized in southern Europe, parts of Russia and eastern North America.

Uses The aerial parts are widely used in China, Indo-China, India and Taiwan as a diuretic, a refrigerant and against diarrhoea and diabetes, and externally for boils and abscesses. In Indo-China, the juice of the crushed plant is put on inflamed eyes. In Peninsular Malaysia *C. communis* is sometimes used as a substitute for *C. benghalensis*.

Observations An annual herb, 25–70 cm long, often glabrescent, roots fibrous; leaves oblong-lanceolate, 2–10 cm × 1–3 cm, apex acute to acuminate; spathes 1–3 together, semi-ovate, 2–3 cm long, base cordate, apex abruptly acute, glabrous or pubescent, striate, upper raceme in spathe with 1–2 male flowers, lower raceme with 1–3 bisexual flowers, peduncle 1.5–2.5 cm long; flower 2 cm in diameter, petals blue or pale blue, fertile stamens 3, staminodes 3; capsule subglobose to oblong, 5–6 mm × 4–5 mm, 2-celled, 4-seeded; seed semi-elliptical, dark brown. *C. communis* occurs in many different habitats, often in humid localities, along ditches and roadsides and has a preference for temperate climatic conditions.

Selected sources 215, 459, 536, 605, 952, 1124.

Commelina diffusa Burm.f.

Fl. indica: 18, t. 7, f. 2 (1768).

Synonyms *Commelina nudiflora* auct. non L.

Vernacular names Spreading dayflower, creeping dayflower (En). Indonesia: brambangan (Javanese), gewor lalakina (Sundanese), awarang (Makassar). Malaysia: rumput aur, rumput kupu-kupu. Philippines: alikbangon (Tagalog), gatilang (Bontok), kulkul-lasi (Iloko). Vietnam: th[af]i l[af]i tr[aws]ng.

Distribution Widespread in the tropics and subtropics; in the United States occurring up to New Jersey.

Uses In Peninsular Malaysia, the leaves are widely used for poulticing sores. In Indonesia, the crushed leaves and stems are used for irregular menstruation. Dirty wounds are poulticed with the mucilage from the stems. The leaves are edible and may be used as a vegetable.

Observations A normally perennial, prostrate to ascending, much branched herb, variably hairy; leaves oblong to lanceolate, 3–7 cm × 1–2 cm, apex obtuse to acuminate, often nearly glabrous; spathe normally solitary, semi-ovate, 0.8–2 cm long, apex acute or acuminate, glabrescent, margins free, upper raceme with 1–3 male flowers, lower raceme with 1–5 bisexual flowers, peduncle 0.5–5 cm long; flower 1.5 cm in diameter, petals 6–7 mm long, blue, fertile stamens 3, staminodes 2–3; capsule ovoid, 6–7 mm long, 3-celled, usually 5-seeded, 1 seed larger; seed 2–3 mm long, black, reticulate, ridged on one side. *C. diffusa* is commonly found in moist fields, along ditches, on waste land and under bamboo, on soils rich in clay or humus, from sea-level up to 2000 m altitude. *C. diffusa* var. *gigas* (Small) Faden is hexaploid.

Selected sources 134, 135, 215, 407, 418, 459, 605, 696, 747.

Isa Ipor

Cordia dichotoma J.G. Forster

Fl. ins. austr.: 18 (1786).

BORAGINACEAE

$2n = 48$, (50)

Synonyms *Cordia obliqua* auct. non Willd., *Cordia myxa* auct. non L., *Cordia griffithii* C.B. Clarke (1885).

Vernacular names Sebestan plum, soap berry (En). Capestan (Fr). Indonesia: kendal (Javanese, Balinese), nunang (south-western Sumatra, Malay), toteolo (Halmahera). Malaysia: sekendal, sekendai, petekat (Peninsular). Papua New Guinea: cordia (general). Philippines: anonang (general), guma (Sulu), sinaligan (Iloko). Burma (Myanmar): thanat. Laos: 'man. Thailand: phak mong, man muu (northern), man dong (eastern). Vietnam: l[as] b[aj]c, l[as] tr[aws]ng, ti[ee]n d[aaf]u th[oos]ng.

Origin and geografic distribution *C. dichotoma* occurs from northern India to southern China, southward throughout South-East Asia to Australia and New Caledonia.

Uses In Indonesia, the Philippines, Thailand and Indo-China almost all plant parts of *C. dichotoma* are used for medicinal purposes. A decoction of the stem bark is taken for dyspepsia, diarrhoea, dysentery fever, headache, stomach-ache, and as a tonic. It is also beneficial after parturition. Externally, the moistened bark is maturative when applied to boils, swellings and tumours. It is applied to ulcers in the mouth in the form of a gargle or as a powder. The teeth are rubbed with the bark to strengthen them. In Burma (Myanmar), the bark is used to treat catarrh and the fruit is cooling. The juice of the leaves is also considered cooling, and is applied as a poultice to treat migraine, inflammation and swellings. The powdered seeds or the fresh fruits are applied to skin eruptions and gonorrhoea. The fruit is very mucilaginous and highly esteemed for coughs and diseases of the chest, the uterus and the urethra. In larger quantities it is given in bilious affections as a laxative. In India, the fruit is considered demulcent and the bark mildly astringent and tonic. The seeds are considered a good remedy for ringworm; they are powdered, mixed with oil and applied topically.

The timber of *C. dichotoma* is tough, fairly strong and seasons well, but insects soon attack it. In Indonesia, the leaves are used to wrap fish before cooking, and in Burma (Myanmar) they are used as plates and cigar wrappers. In India, the sweet, translucent pulp of the fruit is considered edible; the fruit can also be pickled. In China though, the fruits are used to stupefy fish. The very mucilaginous pulp yields a short-term glue, similar to that of other species, e.g. *C. cochinchinensis* Gagnep., from Indo-China and Peninsular Malaysia. *C. dichotoma* also provides high-quality fodder which is available throughout most of the year.

Other *Cordia* species, often important for their use as a timber, are medicinally used as well. In India, the mucilaginous fruits of *C. myxa* L. are used for cough and chest complaints on account of their demulcent properties. The entire plant is used for snakebite, and a decoction of the fresh bark is used for fever and dyspepsia. In Indo-China and Africa, the fruits are eaten, and are also used as an emollient and tonic. The bark is a tonic and the powdered seeds are applied as a paste on skin problems. In Vietnam, the ripe seeds of *C. bantamensis* Blume are used as an anthelmintic to treat taenia and ascarids. In Indonesia (Ternate), the young leaves of the timber tree *C. subcordata* Lamk, crushed or rubbed on the hands impart an odour which protects them from the stings of poison fish; if stung, the leaves are rubbed on the wounds to subdue pain. In New Guinea, a decoction of the leaves is used to bathe limbs of people with muscular or rheumatic pain. Fresh leaves are used externally in East New Britain for tropical ulcers and knee wounds.

A decoction of the leaves of *C. alliodora* (Ruiz & Pavon) Oken, from Central and northern South America, but introduced into Sabah as a plantation tree, is taken in Mexico as a stimulating tonic, especially in cases of catarrh and pulmonary ailments. In El Salvador and the West Indies, a decoction of the leaves is applied to bruises, swellings and skin diseases. A decoction of fresh or dried leaves of *C. curassavica* (Jacq.) Roem. & Schult, a shrub from Central America and northern South America, but introduced into West Malaysia, Singapore and Borneo at the end of the 19th Century, where it has become a troublesome weed, is taken in Trinidad to relieve colds, influenza, fever, pneumonia, coughs and insomnia. The pressed juice of the leaves is given to cure malaria.

Production and international trade *C. dichotoma* is only used on a local scale for medicinal purposes.

Properties The stem bark of *C. dichotoma* contains 2% tannic acid, the leaves contain flavonol glycosides and phenolics, the seed contains 46% fat (rich in unsaturated fatty acids), and 31% protein (containing several essential amino acids). A neutral polysaccharide was isolated from the fruits and separated into 2 fractions. The major fraction contained D-glucose and L-arabinose in the molar ratio of 21:4. Analysis suggested it to be an arabinoglucan, and the backbone of the polysaccharide to be composed of (1 -> 6)-linked D-glucopyranosyl and (1 -> 2)-linked L-arabinofuranosyl residues. From the seeds, 11 compounds were isolated and two of these, α-amyrin and 5-dirhamnoside, showed 71 and 68% anti-inflammatory activity, respectively, in tests with rats when applied as an oral dose of 1 g/kg.

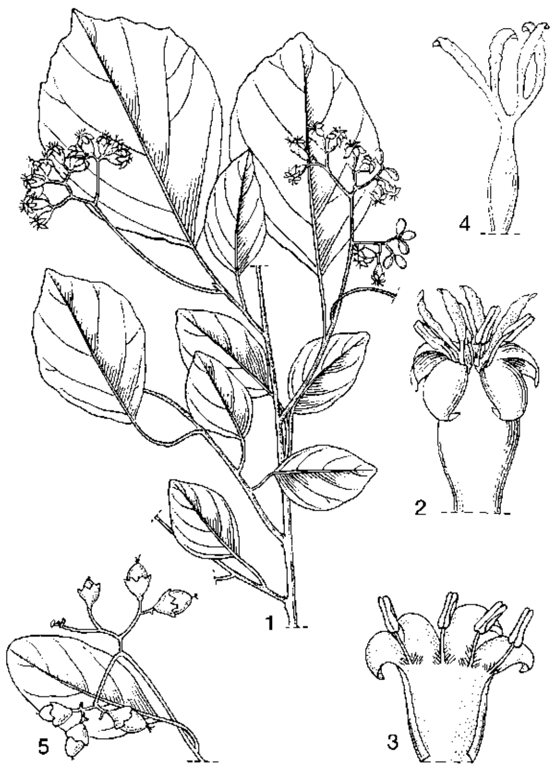
The ethanolic leaf extract was investigated for antifertility effects on male rats in oral doses of 100 mg/kg daily for 21 days. Though none of these extracts interfered with spermatogenesis, anti-implantational and abortifacient effects were observed in females mated by the males fed with the leaf extracts.

Finally, an extract of fruits showed a strong reduction in hatching of nematode eggs of *Meloidogyne incognita* treated with a range of concentrations, but the leaves were ineffective.

From the root bark of *C. alliodora* a phenylpropanoid derivative, 1-(3'-methoxypropanoyl)-2,4,5-trimethoxybenzene, and a prenylated hydroquinone have been isolated. Both compounds exhibited antifungal properties against the phytopathogenic mould *Cladosporium cucumerinum*. The phenylpropanoid derivative, whose structure is closely related to β-asarone, also demonstrated a marked activity against larvae of *Aedes aegypti*.

From the roots of *C. curassavica*, the meroterpenoid naphthoquinones cordiaquinones A and B, J and K have been isolated. The four naphthoquinones demonstrated antifungal activities against *Cladosporium cucumerinum*, *Candida albicans* and toxic properties against larvae of the yellow fever-transmitting mosquito *Aedes aegypti*.

Description A shrub or small tree, 5–10(–25) m tall, bole up to 60(–100) cm in diameter, bark surface smooth, becoming fissured with age. Leaves alternate, variable, ovate to oblong-ovate, 6–15 cm × 5–8 cm, base acute, rounded or cordate, apex acuminate to rounded, margins entire or somewhat undulate, membranaceous to coriaceous, glabrous to sparsely hairy; petiole 1.5–4.5 cm long; stipules absent. Inflorescence terminal or on slender lateral branches with 2–4 leaves, subcorymbose to subthyrsoid, lax, with pseudo-dichotomous branching, 5–11 cm long, with 10–many flowers. Flowers male or bisexual, the two types on different trees, sessile; calyx cup-shaped, 3–5 mm × 3–4 mm, opening irregularly at the apex, hairy, accrescent to 6–10 mm long, glabrescent; corolla cylindrical-campanulate, 6–8(–10) mm long, white, yellowish-white or green, tube 3 mm long, lobes 4–6, oblong, spreading and reflexed; stamens as many as corolla lobes, inserted at corolla, long exserted; ovary superior, 4-locular, 1 ovule per locule, style twice forked. Fruit drupaceous, ovoid, 10–13(–25) mm long, yellowish-white, orange or pinkish when ripe, 1(–3)-seeded, outer mesocarp pulpy and sticky, mucilaginous. Seed ovoid, flattened, up to 6 mm long, endosperm absent. Seedling with epigeal germination; hypocotyl elongated; cotyledons leafy; first leaves alternate.



Cordia dichotoma J.G. Forster – 1, flowering branch; 2, corolla with stamens and style; 3, opened corolla with stamens; 4, pistil; 5, fruiting branch.

Growth and development In Java, *C. dichotoma* flowers in June, and from November-February. The fruits are often deformed by galls.

Other botanical information *Cordia* is a large pantropical genus of about 250–300 species, in Malesia represented by 6 indigenous species and 3 species introduced from tropical America.
The real *C. myxa* L. is a native of the eastern Mediterranean region, but has long been naturalized in tropical Africa, India, Indo-China and Australia, more rarely so in South America. Whether *C. myxa* and *C. dichotoma* are truly different, is still doubtful.

Ecology *C. dichotoma* occurs in coastal hills, inland fringes of mangroves, also in open forests, thickets and savanna, from sea-level up to 500 m altitude, or planted up to 1500 m altitude, sometimes as a roadside tree. It tolerates a range of soils, but thrives on deep, moist, sandy loams, and does not grow well on dry, shallow, or gravelly soils. It occurs naturally in areas where the annual rainfall ranges from approximately 250–3000 mm; in areas with less than 500 mm rainfall it grows in depressions and alongside streams.

Propagation and planting *C. dichotoma* is propagated by seed, cuttings or by stump plants. Branches root easily, and are often used as garden stakes. The number of seeds per kg ranges from 4200–6700. Natural regeneration can be unreliable, because a high proportion of seeds may be affected by seed borers, and the seedlings are susceptible to grazing. Artificial regeneration by direct sowing is possible, but more reliable results can be achieved with planting stock.

Husbandry *C. dichotoma* is moderately tolerant of shade, although from the pole stage it prefers open conditions. It coppices and pollards well.

Diseases and pests Several fungi attack *C. dichotoma* and *C. alliodora*, including *Phellinus noxius* which causes brown root rot and black bud rot, and *Phyllactinia thirumalachari* which causes powdery mildew on leaves. Insect pests recorded on *C. dichotoma* include the Mango mealy bug, the whitefly *Aleuroclava afriae* and the thrips *Austrothrips cochinchinensis*. Leaf galls of *C. dichotoma* are induced by the mite *Eriophyes cordiae*, those of *C. myxa* are caused by weevils (*Baris cordiae*), mites (*Eriophyes cordiae*) and thrips (*Aneurothrips*), and all 3 gall types can appear on the same leaf. The roots of *C. dichotoma* are attacked by the nematode *Meloidogyne incognita*.
C. curassavica, introduced into the Botanic Gardens of Singapore from tropical America, spread rapidly over Peninsular Malaysia from 1954 onwards and has become a weed pest, especially in large coconut plantations. Since 1977, biological control programmes have been developed to eradicate this weed. The galerucid *Metrogaleruca obscura* (attacking the leaves) and the eurytomid *Eurytoma attiva* (attacking the fruits) have become established, and reduced the population of *C. curassavica* to an acceptable level.

Harvesting The plant parts of *C. dichotoma* used for medicinal purposes are harvested whenever needed or when they are available.

Yield In Indo-China, a mature tree of *C. dichotoma* can produce 20–50 kg of fruit per year.

Handling after harvest Most plant parts of *C. dichotoma* are used fresh, but the seeds and sometimes the stem bark may be dried and powdered before use.

Genetic resources and breeding *C. dichotoma* is widespread and common throughout South-East Asia, and therefore not endangered.

There are no known breeding programmes of *C. dichotoma*.

Prospects Little is known about the phytochemistry and phyto-pharmacology of *C. dichotoma*. In a preliminary screening, interesting activity was found in the field of anti-inflammation. More research is needed to fully evaluate the future possibilities of this plant.

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Other selected sources 8, 93, 135, 407, 469, 470, 647, 696, 727, 739, 786, 788, 1066.

N.O. Aguilar

Crateva L.

Sp. pl. 1: 444 (1753); Gen. pl. ed. 5: 203 (1754).

CAPPARACEAE

$x = 13$; *C. magna*, *C. religiosa*: $2n = 26$

Major species *Crateva magna* (Lour.) DC., *C. religiosa* J.G. Forster.

Vernacular names Malaysia: dala.

Origin and geographic distribution *Crateva* is a small genus of about 6 species with a pantropical distribution, but does not occur in Australia and New Caledonia. The 3 Indo-Malesian species are extending from India and Sri Lanka, and southern China, southern Japan, Taiwan, through South-East Asia to Tahiti.

Uses In India, Thailand and Malesia, the juice from the bitter stem or root bark, or sometimes the leaves, of both *C. magna* and *C. religiosa* is used in decoction to stimulate the appetite or as a digestive, as a laxative against colic and as a febrifuge. In India, the root bark is used to treat urolithiasis, and in Thailand the wood is used for this purpose. The fresh leaves are rubefacient, and are applied as a tonic and skin-irritant against high fever.

In India, woodsmoke of *C. magna* is used to treat ulceration of the nose, and the stem bark is used to heal wounds. In Thailand, the pickled flower is eaten as a digestive. An infusion of the flowers of *C. religiosa* is used for relieving sore throat, the fruits are used as antipyretic and a decoction of the stem bark is used against hiccup, and for the treatment of haemorrhoids. In the Solomon Islands, liquid from the bark macerated with water is used for treating constipation, and heated leaves are applied as a remedy for earache. In India, the flower is considered astringent and cholagogue. The crushed leaves are applied as a paste for swelling of the feet and for a burning sensation in the soles of the feet. The bark and the leaves are pounded and applied as a poultice against rheumatism, also in Indo-China. In Taiwan, a decoction of the leaves and stem is used for dysentery, headache and stomach-ache. In the Philippines, the leaves are said to be useful for treating irregular menstruation.

Crateva is widely cultivated for ornamental purposes and occasionally introduced. The wood of *Crateva* is used to make household utensils. The wood of *C. magna* is used in India for making drums, but also match sticks. The bark is used to wash clothes while the wood-chips are made into a moderately strong and poorly water resistant hardboard. In India and Polynesia, *C. religiosa* is planted around temples for religious purposes. In India and Thailand, the young leaves and flowers of both species are cooked or pickled as a vegetable, and the flowers can also be roasted. Young leaves are fed to sheep and goats. In Thailand and Kalimantan, the fruit is used as fish bait.

Production and international trade *Crateva* is only used locally for medicinal purposes and does not enter the international market.

Properties The alkaloids cadabicine and cadabicine diacetate were isolated from the stem bark of *C. magna*. Other components include several triterpenes, e.g. lupeol, lupeol linoleate, friedelin and betulinic acid, the fatty acid ceryl alcohol and the steroid diosgenin (present in bark collected in March, absent in bark collected in August–September). The fruits of *C. magna* contain the fatty

acids ceryl alcohol and triacontanol, and the isothiocyanate derivative glucocapparin (= methyl glucosinolate). Furthermore, the stem and root bark of *C. religiosa* are also known to contain lupeol.
Lupeol and lupeol linoleate, isolated from *C. magna*, were tested for their anti-inflammatory activity in an adjuvant-induced arthritis model in rats, and exhibited about 40% and 60% reduction in hind paw swelling, respectively. The loss of body weight was reduced and the spleen weight increased.
The oral LD_{50} dose of lupeol in rats is more than 2 g/kg. In another test, hyperoxaluria-induced male Wistar rats, with increased levels of urinary enzymes indicating renal tissue damage, were given 25 mg/kg of lupeol per day. This significantly reduced the renal excretion of oxalate and reduced the extent of renal tubular damage, as a result of a decrease in the urinary enzymes, thus minimizing the deposition of stone-forming constituents in the kidney. It also reduced inflammation and other damage in the bladder and kidneys.

Adulterations and substitutes A mustard plaster is used as a substitute for a poultice of *Crateva* leaves as a rubefacient.

Description Small to medium-sized trees. Leaves spirally arranged, 3-foliolate, petiole long, sometimes at the top bearing gland-like appendages on the upper surface; stipules small, caducous; leaflets subsessile, lateral ones asymmetrical at base, sometimes with more or less distinct pellucid dots. Inflorescence a terminal corymb, either with arrested growth or developing into a leafy twig with lateral flowers. Flowers pedicelled, sustained by bracts, opening early, floral parts not persistent; bracts stipulate; sepals 4, equal, ovate-spathulate, green; petals 4, subequal, unguiculate, ovate to rhomboid, with narrowed base, first white, later cream-coloured, the lower pair tending to take a horizontal position; stamens (8–) 12–30, filaments at the base connate with the long gynophore, filiform, spreading; gynophore as long as the stamens, in fruit gynophore and pedicel woody and often thickened; ovary 1-locular, stigma conspicuous, flat, soon after anthesis obsolete. Fruit a large berry, loculed, with tough, sometimes papillate skin. Seed densely packed, embedded in pulp, horseshoe-shaped, smooth or crested, 1 cotyledon larger, curved around the other.

Growth and development *Crateva* starts flowering after 6 years. *C. religiosa* can be found flowering and fruiting throughout the year, while *C. magna* flowers irregularly.

Other botanical information A frequently occurring orthographic variation of *Crateva* is *Crataeva*. In part of the flowers of *Crateva*, the gynophore is shed shortly before anthesis, leaving a scar. In some species only the apical flowers remain bisexual. Few flowers set fruit. The Indo-Malesian species all show considerable variation in the size of the floral parts, the size and form of the fruit and in the sculpture of the seed.

Ecology *Crateva* occurs mostly in periodically inundated lowland forest near rivers, below 700 m altitude. In dry regions they are shortly deciduous, the flowers then appearing with the flush. The fruits of *Crateva* in the wild are probably dispersed by water.

Propagation and planting *Crateva* is propagated by seed. Shoot apices from 40-year-old *C. magna* trees were cultured on Murashige & Skoog medium supplemented with 3% sucrose, 0.8% agar and various concentrations of growth hormones. Best somatic embryogenesis occurred after 6 weeks in media supplemented with 1–2 mg 2,4-D/l, and retained their capacity for up to 5 months. Reducing the concentration of growth hormone, root differentiation was induced instead.

Diseases and pests No serious diseases and pests are known for *Crateva*.

Handling after harvest The parts of *Crateva* that are harvested are either used fresh, or dried for later use, especially the wood.

Genetic resources and breeding Although *Crateva* species are rather scarce in their natural habitat, they are widely cultivated as ornamentals. The parts used are likely to be harvested from planted trees, and overcollection is therefore not a threat to genetic erosion, although the disappearance of the natural habitats certainly is. No breeding programmes are known to exist for *Crateva*.

Prospects Lupeol and lupeol linoleate in *Crateva* display interesting activities on the inflammatory process in vivo, together with significant effects on renal oxalate excretion and renal tubular damage. Therefore the anti-inflammatory and anti-urolithiatic properties of these compounds merit further research.

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Selection of species

Crateva magna (Lour.) DC.

Prodr. 1: 243 (1824).

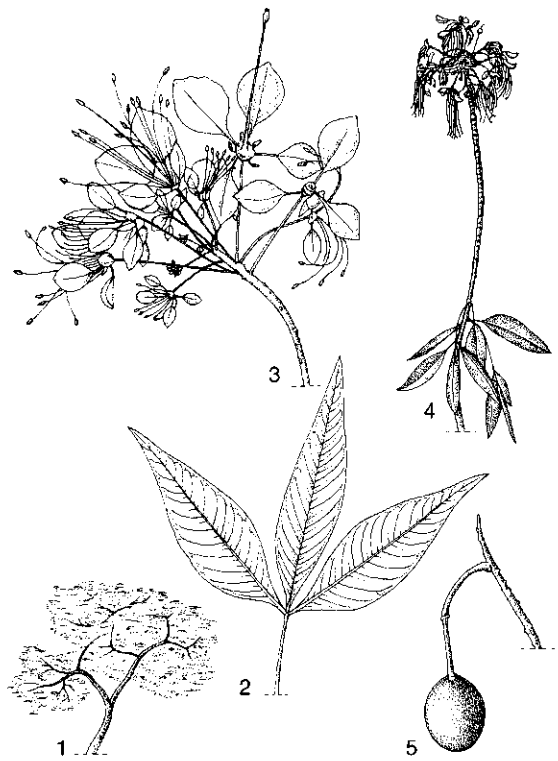
Synonyms *Crateva religiosa* Blume (1825), *Crateva nurvala* Buch.-Ham. (1827).

Vernacular names Indonesia: sibaluak (Sumatra), jaranan (Javanese), pingos (Kalimantan). Malaysia: bulan ayer, dala. Burma (Myanmar): kadat. Thailand: kum nam (general), ro-tha (northern), hoh-thoh (south-western). Vietnam: b[us]n, co c[uj]m.

Distribution India, Burma (Myanmar), southern China, Hainan, Indo-China, Thailand, Peninsular Malaysia, Sumatra, Java and Kalimantan. Cultivated throughout the area, for ornamental or magical purposes.

Uses The juice from the bitter stem or root bark is used in decoction for stimulating the appetite or as a digestive, as a laxative against colic and as a febrifuge in India, Thailand and Malesia. In India, the root bark is used to treat urolithiasis. The fresh leaves are rubefacient, and applied as a tonic and skin irritant against high fever. It is planted as an ornamental, and also used locally for timber.

Observations A tree, 8–15(–20) m tall, branchlets slightly zigzag, yellowish-brown; petiole 4–12 cm long, on top bearing numerous gland-like appendages, up to 1 mm long, pale brown, stipules minute, late caducous, leaflets lanceolate, sometimes oblong, (4.5–)9–15(–28) cm × 2–6.5 cm, central leaflet broadest about or below the middle, lateral ones more or less symmetrical, base acute, apex acuminate, firmly herbaceous, veins 10–22 pairs, petiolule 0–10 mm long; inflorescence 10–16 cm long with 20–100 flowers, bracts early caducous, 5–9 mm long, pedicel 4–7 cm long, sepals ovate, 2–3.5 mm × 1.5 mm, apex acute, petals rhomboid to elliptical, (8–)15–30 mm × (5–)15–22 mm, narrowed base 5–12 mm long, stamens 10–25, 3.5–4.5 cm long, filaments purple, anthers 3 mm long, gynophore 3.5–5.5 cm long; berry ellipsoid, 5–5.5 cm × 4–4.5 cm, yellowish-grey; seed with a crest of sharp, irregular protrusions. *C. magna* is rather rare, and occurs mostly along streams in shady locations, sometimes near the seashore, up to 600 m altitude.



Crateva magna (Lour.) DC. – 1, tree habit; 2, leaf; 3, top of inflorescence; 4, inflorescence (with slightly withered flowers); 5, infructescence.

Selected sources 74, 135, 215, 407, 914.

Crateva religiosa J.G. Forster

Diss. pl. esc.: 45 (1786).

Synonyms *Crateva macrocarpa* Kurz (1874).

Vernacular names Sacred barma (En). Indonesia: jaranan (Javanese), barunday (Sundanese), sibaluak (Sumatra). Malaysia: kepayan, kemantu, dangla. Philippines: salingbobog (Tagalog), balai-lamok (Iloko), banugan (Bisaya). Cambodia: tonliëm. Laos: kumz. Thailand: kum-bok, kum nam. Vietnam: b[us]n thi[ee]u, b[us]n l[owj].

Distribution From India throughout South and

South-East Asia to Micronesia and Polynesia, wild and occasionally cultivated. Frequent in Borneo, New Guinea and the Solomon Islands.

Uses The juice from the bitter stem bark or root is used in decoction as a laxative against colic and as a febrifuge in Malesia and Thailand. In India, the flower is considered astringent and cholagogue. The bark and the leaves are pounded and applied as a poultice against rheumatism. In the Solomon Islands the leaves are heated and applied to treat earache. Leaves are used as a vegetable in Indo-China and India.

Observations A tree, 5–15(–30) m tall, bark grey, wood yellowish-white, turning light-brown when old; petiole (3.5–)6.5–10 cm long, on sterile twigs often much longer, stipules subulate, 0.5–1 mm long, leaflets very variable, asymmetrically oblong to ovate, 8.5–27 cm × 3–10.5 cm, central leaflet oblong to obovate, base narrowly decurrent, apex shortly acuminate, often mucronulate, veins 7–11 pairs, subsessile, thin-herbaceous; flowers 2–14, rachis 3–5(–14) cm long, lower flowers inserted above the axil of normal leaves, the others subtended by an early caducous bract, 10 mm × 1–1.5 mm, pedicel 2–9 cm long, sepals ovate, obtuse to acute, 4–7 mm × 1.5–3 mm, petals broadly ovate to elliptical, 2–4 cm × 1–2.3 cm, narrowed base 5–20 mm long; stamens (10–)13–18(–30), filaments 4.5–11.5 cm long, pink or purple towards the top, anthers 2.5–6 mm long, gynophore 4–7 cm long; berry subglobose to subovoid, 6–15 cm × 5.5–9.5 cm, whitish-grey; seed dorsally keeled, sparsely to densely tuberculate. *C. religiosa* is often found in periodically inundated forest, usually below 100 m altitude, but also occurring up to 700 m altitude.

Selected sources 74, 135, 215, 810, 914.

G.H. Schmelzer

Crescentia L.

Sp. pl. 2: 626 (1753); Gen. pl. ed. 5: 274 (1754).

BIGNONIACEAE

$x = 20$; *C. cujete*: $2n = 40$

Major species *Crescentia alata* Kunth, *C. cujete* L.

Origin and geographic distribution *Crescentia* comprises 6 species ranging from Mexico and the West Indies to Amazonian Brazil; two species have been introduced in South-East Asia.

Uses Originating from Central America and the West Indies, the medicinal uses of *Crescentia* in South-East Asia are rather limited. The medicinal uses pertain to their astringent and diuretic properties, and are similar to the uses in the neotropics. In the West Indies, the fruit pulp of *C. cujete* is used for skin diseases in dogs. The hollowed shell of *C. cujete* fruits is used throughout its distribution area as a household utensil. The smaller fruit of *C. alata* is less often used for rattles, ladles and cups.

Production and international trade *Crescentia* is only used on a local scale.

Properties Phytochemical investigations of the fruits of *C. cujete* afforded 16 iridoids and iridoid glucosides. Eight of them were new, and named crescentins I-V and crescentosides A, B and C. Another 8 compounds were already known, and subsequently identified as ajugol, 6-O-p-hydroxybenzoylajugol, aucubin, 6-O-p-hydroxybenzoyl-6-epiaucubin, agnuside, ningpogenin, 5,7-bisdeoxycyanchoside and a degradation product of glutinoside. Further investigations afforded another 8 compounds: acanthoside D (a lignan), β-D-glucopyranosyl benzoate, (R)-1-O-β- D-glucopyranosyl-1,3-octanediol, β-D-fructofuranosyl 6-O-(p-hydroxybenzoyl)-α-D-glucopyranoside, three glycosides of (2R, 4S)-2,4-pentanediol, two glycosides of (R)-4-hydroxy-2-pentanone, two glycosides of (R)-1,3-octanediol and 6-O-(p-hydroxybenzoyl)-D-glucose.

From the 2-butanone extract of wood chips of *C. cujete* the following compounds were isolated: (2S,3S)-3-hydroxy- 5,6-dimethoxydehydroiso-α-lapachone, (2R)-5,6-dimethoxydehydroiso- α-lapachone, and (2R)-5-methoxydehydroiso-α-lapachone (all naphthoquinones), as well as 2-(1-hydroxyethyl)naphtho(2,3-b)furan-4,9-dione, 5-hydroxy-2-(1-hydroxyethyl)naphtho(2,3-b) furan-4,9-dione, 2-isopropenylnaphtho(2,3-b) furan-4,9-dione, and 5-hydroxydehydroiso-α-lapachone. All compounds exhibited selective activity against DNA-repair-deficient yeast mutants. The first three naphthoquinones exhibited cytotoxic activity against Vero cells, with IC_{50} values of 3.7–4.7 μg/ml.

The methanolic extract of the root bark of *C. cujete* was active against gram positive bacteria but not significantly against gram negative bacteria. Additional fractionation of a chloroform extract led to the isolation of vanillic acid, with minimum inhibitory concentrations (MIC) of 125 and 175 μg/ml against *Staphylococcus aureus* and *Bacillus subtilis*, respectively, and 4-hydroxybenzoic acid with an MIC of 250 μg/ml against both organisms.

Phytochemical and biological studies on *C. alata* are very limited. The methanol extract showed strong antibacterial activity against *Sarcina lutea* and weak activity against *Staphylococcus aureus* and *Proteus vulgaris*. Two flavonoids, chysanthemin and cyanidin-3-O-β-D-rutinosides, were isolated from the flowers of *C. alata*.

Description Small to medium-sized trees, crown open. Leaves simple or 3-foliolate, borne on thick twigs in alternate fascicles; petiolate; stipules absent. Inflorescence consisting of 1–2 flowers, cauliflorous, arising from nodes on the trunk and older branches. Flowers bisexual, whitish; calyx large, usually bilabiately split; corolla tubular to campanulate with a fold midway across the lower side of the throat, behind which is a nectar-storing bulge, lobes deltoid, acuminate; stamens 4, didynamous, slightly exserted, anther cells divergent; ovary superior, ovoid-elliptical, 1-locular, ovules multi-seriate on 4 parietal placentas. Fruit a large berry, more or less spherical, indehiscent with a hard woody shell, pulpy inside. Seed not winged, embedded in the pulp. Seedling with epigeal germination; hypocotyl elongated; cotyledons leafy.

Growth and development *C. cujete* has a relatively short trunk and long spreading branches. The trunk develops as older branches are lost. The long spreading branches become pendulous distantly by their own weight. The renewal shoot arises from the upper surface in the initial curve of the pendulous branch. The part distal to the renewal shoot becomes a branch of the tree, the part proximal to the renewal shoot becomes part of the trunk. Its architecture represents Champagnat's model. The flowers are nocturnal, they expand in the evening and the next morning the corolla falls off, unfaded. They are pollinated by bats attracted by the musky odour. The fleshy fruits are mammal dispersed in their native range. *Crescentia* can be found flowering and fruiting throughout the year.

Other botanical information Species of *Crescentia* are defined entirely by vegetative characters and differences in fruit size. All species are interfertile. Nevertheless species tend to form dense aggregations of homogenous morphotypes where they occur, and taxonomic recognition of different-appearing ecological dominants seems valid.

Ecology The two *Crescentia* species treated here show a preference for relatively open savanna areas, and are common in coastal savannas in Central America and the West Indies. Their natural range and ecological preferences are partly blurred by the long history of cultivation.

Propagation and planting *Crescentia* can easily be propagated by seed or cuttings. In South-East Asia, *Crescentia* is usually propagated by cuttings. In a germination trial in southern Africa seed of *C. cujete* showed a high germination rate within 3 weeks after scarification and boiling-water treatments. High germination may also be achieved without any treatment. Seedlings required about 3 months to achieve the recommended height of 20 cm for field-planting of nursery stock. Plants should be grown in full sun in a moisture-retentive, loam-based soil mix with additional organic matter.

Harvesting Leaves and bark of *Crescentia* are collected whenever the need arises, whereas fruits are collected when mature.

Handling after harvest Leaves of *Crescentia* are used fresh, whereas bark or fruit are used either fresh or dried.

Genetic resources and breeding Both *Crescentia* species treated here have a large area of distribution, either naturally or as a result of cultivation, and do not seem to be at risk of genetic erosion. The genetic basis in South-East Asia may be limited as most plants are propagated by cuttings.

Prospects A vast array of compounds is present in *C. cujete* of which some, i.e. the substituted naphthoquinones, display interesting pharmacological activities in the field of antimutagenesis and cytotoxicity. More research is needed, however, to fully evaluate their potential as possible lead compounds in future medicinal investigations.

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Selection of species

Crescentia alata Kunth

Humb., Bonpl. & Kunth, Nov. gen. sp. 3: 158 (1819).

Synonyms *Crescentia trifolia* Blanco (1837), *Othophora paradoxa* Blume (1847), *Parmentiera alata* (Kunth) Miers (1870).

Vernacular names Philippines: krus-krusan (Tagalog). Thailand: teenpet farang (Bangkok). Vietnam: d[af]o ti[ee]n c[os] c[as]nh.

Distribution *C. alata* originates from Central America and was introduced to the Philippines by the Spaniards; occasionally cultivated throughout South-East Asia.

Uses In the Philippines a decoction of the leaves is employed as an astringent and antihaemorrhagic, and is much used in haemoptysis and dysentery. In Thailand, the leaves are used as astringent, against diarrhoea and dysentery. In Central America, a decoction of the leaves or pulp is prescribed in diarrhoea. The pulp is eaten as a pectoral and for diseases of the kidneys. The grounded fruit pulp is sometimes used as a poultry feed supplement.

Observations A small tree, 5–14 m tall, stem up to 25 cm in diameter, branches crooked, branchlets essentially lacking; leaves simple, oblanceolate, 2–3 cm × 0.5–1 cm, or trifoliolate, leaflets oblanceolate, 1–5 cm × 0.3–1.2 cm, with winged petiole, 2.5–12 cm × 0.3–1.5 cm, all lepidote; flowers solitary or paired, calyx 2-lobed to the base, corolla tube 3–4 cm long, corolla lobes 1–1.5 cm long, 2–2.5 cm wide at mouth of tube, brownish with brown-purple venation; berry more or less spherical, 7–10 cm in diameter. In Central America, *C. alata* is a characteristic element of dry savannas.

Selected sources 74, 810, 864, 883, 1119.

Crescentia cujete L.

Sp. pl. 2: 626 (1753).

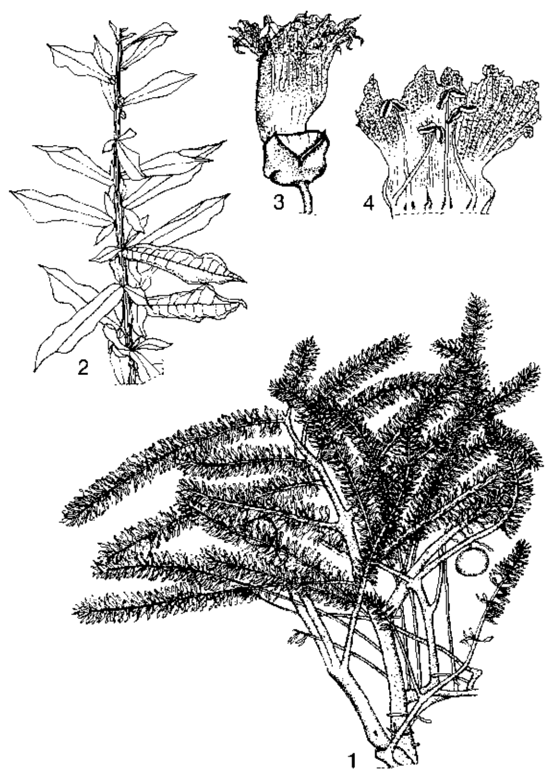
Synonyms *Crescentia ovata* Burm.f. (1768), *Crescentia acuminata* Kunth (1819).

Vernacular names Calabash tree (En). Calebassier (Fr). Indonesia: sikadel (Javanese), bernuk (Sundanese), buah no (Ternate). Malaysia: tabu kayu. Philippines: cujete (Tagalog). Thailand: namtao yeepun, namtao ton (Bangkok). Vietnam: d[af]o ti[ee]n.

Distribution *C. cujete* is extensively cultivated throughout tropical America and its natural range is obscure. It has been introduced throughout the tropics.

Uses In Sumatra, a decoction of the bark is used to clean wounds, and the pounded leaves are applied as a poultice for headache. In West Africa and the Caribbean the fresh fruit pulp is macerated in water and is considered depurative, cooling and a febrifuge, and good for headache and burns. In Vietnamese folk medicine the dried fruit is used as an expectorant, antitussive, laxative and stomachic. In West Africa, the ash of the roasted fruit is considered mildly purgative and diuretic. In Central America, various parts of the fruit are a common ingredient in syrups for cough and colds. In Thailand and Central America, crushed leaves are applied on wounds to stop bleeding and promote healing. A decoction of the leaves or bark is astringent and taken for diarrhoea and dysentery. The shell of the dried fruits is used for a wide range of household utensils of various dimensions.

Observations A small tree, up to 10 m tall, stem up to 30 cm in diameter, branches crooked, branchlets essentially lacking, crown open; leaves simple, of varying size within a fascicle, obovate, (1.5–)4–26 cm ×1–7.5 cm, base attenuate, apex ob-



Crescentia cujete L. – 1, habit; 2, leafy shoot; 3, flower; 4, opened corolla.

tuse to acute, petiole absent; flowers solitary or paired, calyx 2-lobed to the base, corolla tube 3–4.5 cm long, corolla lobes 2.5–3 cm long, 3–4.5 cm wide at mouth of tube, yellowish with purple venation; berry spherical to ovoid-elliptical, (8–) 13–20(–30) cm in diameter and up to 30 cm long. In South-East Asia *C. cujete* is planted in the lowlands, grown in lawns and parks, and used for hedges.

Selected sources 74, 134, 135, 207, 407, 696, 733, 788, 806, 810, 864.

Sri Hayati Widodo

Crinum L.

Sp. pl. 1: 290 (1753); Gen. pl. ed. 5: 141 (1754).

AMARYLLIDACEAE

$x = 11$; *C. asiaticum*: $2n = 22, 33$, *C. latifolium*: $2n = 22$, *C. zeylanicum*: $2n = 22, 33$

Major species *Crinum asiaticum* L.

Vernacular names Cape lily, giant lily (En). Lis de brousse (Fr). Indonesia: bakung. Malaysia: bakong. Vietnam: n[as]ng.

Origin and geographic distribution *Crinum* consists of approximately 100 species and occurs throughout the tropics, often cultivated as ornamentals, and sometimes escaped and naturalized. Two species are indigenous to Malesia, *C. asiaticum* and *C. gracile* E. Mey.

Uses Many *Crinum* species are planted throughout the tropics as ornamentals, but their medicinal uses are also widely known. The bulb and roots of *C. asiaticum* are taken throughout the region as an emetic and diaphoretic, acting without griping or purging effects. They have a strong, unpleasant smell. In New Guinea, juice from the bulb is drunk regularly for about 2 months as an alleged cure for gonorrhoea. In India, the bulb is officially listed in the Pharmacopoeia, and is taken as a bitter tonic, laxative and expectorant. It is used in biliousness, in strangury and in other urinary problems. In Indonesia, the bulbs are used to poultice wounds and as an antidote for poisoned arrows, snakebites and poisonous insects. In the Philippines and Thailand, the bulbs are prepared as an ointment and the leaves as an emollient for external use on inflammations of toes and fingers, or bruises and sprains. The leaves are also widely applied in South-East Asia for rheumatic pains, fever or headache, either oiled and heated to wilt or pounded. The juice of the leaves with a little salt is used for earache. In Vietnam, the fresh juice of the leaves is drunk as a vomitory. In Indonesia, a rub with the pounded leaves is applied to stimulate perspiration, and the oiled, heated leaves are helpful in strangury.

The bulbs of *C. latifolium* and *C. zeylanicum* are extremely acrid and the juice is said to cause inflammation of the skin and the mucous membranes. When roasted, they are used as rubefacient in rheumatism, or crushed on piles and abscesses to cause suppuration. The juice of the leaves is used for earache. In West Africa, the bulbs of *C. zeylanicum* are known to cause diarrhoea that is difficult to control.

The bulbs of the cultivated *C. jagus* (Thomps.) Dandy (synonym *C. giganteum* Andr.) and the aerial parts of *C. kirkii* Baker are used for open sores in tropical Africa. In South-East Asia, they are planted as ornamentals.

The bulb of *C. defixum* Ker Gawl., commonly planted as an ornamental in India, is considered nauseant, emetic, emollient and diaphoretic. In India, the whole plant is used in the treatment of burns, whitlow and carbuncles. In Peninsular Malaysia and Thailand, the crushed leaves are used for poulticing headaches and fevers.

Production and international trade *Crinum* is used medicinally on a local scale only.

Properties The family *Amaryllidaceae* is known to contain isoquinoline alkaloids, biosynthetically derived from the amino acid tyrosin, which are mostly concentrated in their bulbs. For example, the bulb and stem of *C. asiaticum* contain as principal alkaloids: lycorine (or narcissine) and galanthamine, together with haemanthine, 3-acetylhamaine, 6-oxycrinamine, 6-methoxycrinamine, crinidine and (+)-crinamine, (–)-augustine, (–)-buphanisine, and (–)-amabiline. In addition, the bulbs of *C. asiaticum* var. *japonicum* Baker contain the alkaloid N-demethyl-galanthamine, the fruits of *C. asiaticum* contain O-demethylcrinamine, and the bulbs of both *C. asiaticum* and *C. augustum* Roxb. contain the isoquinolines palmilycorine, hippadine and lycoriside.

Several of the alkaloids mentioned display various pharmacological effects. The main isoquinoline, lycorine, has some properties which resemble the indole alkaloid yohimbine, and it is sometimes used in veterinary medicine as an aphrodisiac. In low doses lycorine causes salivation, vomiting, diarrhoea, and at higher doses paralysis and collapse. Furthermore, lycorine shows strong inhibitory effects on tumour cell apoptosis induced by polymorphonuclear leukocyte-derived calprotectin using MM46 mouse mammary carcinoma

cells, and the compound inhibits polio and measles viruses. Lycorine, augustine and crinamine also show general cytotoxic and antimalarial activity, while augustine also shows a high inhibition of tobacco mosaic virus, potato X carlavirus, potato X potexvirus and potato Y potyvirus on tomatoes.
Galanthamine is a potent cholinesterase inhibitor and an analgesic, which is at present under investigation for clinical use (e.g. in treatment of Alzheimer disease). Palmilycorine and lycoriside were also found to inhibit the growth of ascites tumour cells, and hippadine showed significant antifertility effects in a rat testes model.
The petroleum, chloroform and ether extracts of the aerial parts of *C. asiaticum* were tested for their anti-inflammatory effects in mice. The chloroform and ethanol extracts given orally at a dose of 50 mg/kg caused a significant reduction in carrageenan-induced hind paw oedema. The chloroform fraction of the ethanol extract caused dose-dependent reduction in bradykinin-induced contractions of isolated rat uterus and guinea-pig ileum preparations. The MeOH, BuOH and $CHCl_3$ fractions of the leaves were screened for activity in the brine shrimp lethality test. The MeOH extract was most potent, and also exhibited activity against murine P388 D1 cells and the formation of potato disk crown gall tumours. In addition, the sap from the bulbs of *C. asiaticum* at a concentration of 0.1% shows antifeedant and deterrent properties of the locust *Schistocerca gregaria*.
The bulbs of *C. zeylanicum* contain the amines tyramine and zeylamine, and also the alkaloids lycorine, 3-acetyl hamaine, 6-oxycrinamine and 6-methoxycrinamine. Aqueous and ethanolic extracts of *C. zeylanicum* exhibited a high mortality rate against the mollusc intermediate hosts, *Biomphalaria pfeifferi* and *Lymnaea natalensis*, of schistosomiasis and fascioliasis. These extracts, however, also show toxic effects on fish and aquatic insects.
The bulbs of *C. latifolium* and *C. defixum* contain the alkaloids 9-O-demethylhomolycorine and 5-α-hydroxyhomolycorine. The stem fluid of *C. latifolium* also contains 2-epilyocorine and 2-epipancrassidine, and the bulbs pratorimine and pratosine, as well as hippadine, pratorinine, ambelline and lycorine. The sap from the bulbs of *C. defixum* shows antifeedant activity against the larvae of the mustard sawfly (*Athalia proxima*).
Finally, the commonly observed dermatitis, due to the handling of the bulbs of *Crinum*, was found to be induced by the raphides of calcium oxalate found in their tissues.

Adulterations and substitutes Ipecacuanha (*Psychotria ipecacuanha* (Brot.) Stokes (synonym *Cephaelis ipecacuanha* (Brot.) A. Rich.) is used as a substitute for *Crinum* bulbs, as an emetic.

Description Bulbous herbs, usually the top of the bulb developing into a short false stem; bulblets developing from the bulb. Leaves radical, rarely biseriate, linear to lanceolate, margins entire, sometimes undulating; sessile or basally subpetiolate. Inflorescence umbellate, 1–many-flowered; scape (peduncle) lateral, solid, bracts 2, large, papery and reflexed when dry, several smaller ones between the flowers. Flowers actinomorphic or slightly zygomorphic, bisexual, subsessile or pedicelled; tepals in 2 whorls of 3, subequal, united at the base into a long, narrow tube; stamens 6, inserted at the throat, filaments free, anthers medifixed, linear, often curved; ovary inferior, 3-celled, 1–many-ovuled, style filiform, long, stigma entire, small. Fruit a subglobose capsule or a berry, indehiscent or irregularly dehiscent, with a fleshy or membranous wall, few seeded. Seed globose or somewhat flattened, greenish or greyish.

Growth and development *Crinum* grows best in direct sunlight with part-day shade or in bright, filtered light, avoiding full sunlight when the leaves are young. Pollination is done by insects such as bees and bumble-bees.

Other botanical information *Amaryllidaceae* differ from closely related families like *Iridaceae* and *Liliaceae* in having alkaloids. Within *Amaryllidaceae*, 2 large groups are recognized, a more primitive group without corona (e.g. *Amaryllis*, *Crinum* and *Galanthus*) and a more progressive group with corona (e.g. *Hymenocallis*, *Narcissus* and *Pancratium*). *Crinum* is a close-knit genus, and differences between species are quite subtle. The *Hypoxidaceae* are sometimes included in the *Amaryllidaceae* or *Liliaceae*, but is considered a separate family here.

Ecology *Crinum* occurs naturally in savanna at low altitudes, and on sandy localities, including coastal and riverine forests.

Propagation and planting *Crinum* is propagated by fresh seed or bulblets (offsets). The seeds are sown singly in sandy loam with leaf mulch, and are kept rather dry until germination. Somatic embryogenesis was obtained from compact flower bud calli on Murashige and Skoog (MS) medium, and was also possible with bulb scale segments, but at a lower rate. Best results were obtained with shoot tips, on MS medium supplemented with 4 mg/l naphthalene acetic acid and 8 mg/l butyric acid. Adding adenine sulphate at 60 mg/l increased shoot development, and 2 mg/l of indole butyric acid was most effective for rooting. Survival rate of transplanted micropropagated plantlets was more than 95%.

Husbandry The bulbs of *Crinum* are sensitive to transplanting and may take several years to establish and reach their potential stature. Once established however, they reproduce rapidly from offsets, ensuring the overcrowded conditions that stimulate flowering, especially in pots. *Crinum* needs an annual top dressing to promote flowering.

Diseases and pests In India and Vietnam, *C. asiaticum* is attacked by several fungi causing leaf spot, e.g. *Cercospora criniicola*, *Phomopsis crini* and leaf blight, *Helminthosporium* sp.

Harvesting The leaves or bulbs of *Crinum* are harvested mainly from garden plants whenever needed.

Yield In Russia, the highest total alkaloid content (1.6%) in the bulbs of *C. asiaticum* is found at the end of the growing season, after the first frost.

Handling after harvest The leaves and bulbs of *Crinum* are mainly used fresh, but the leaves are sometimes dried before use.

Genetic resources and breeding As most *Crinum* are widely planted as ornamentals, there seems to be no risk of genetic erosion. Breeding is only done for ornamental purposes.

Prospects The alkaloids present in *Crinum* show an interesting array of pharmacological properties. Some of them are well investigated, for example of galanthamine as a cholinesterase inhibitor, but for most of them which showed potential, more research is needed for a full evaluation of their possibilities in future medicine.

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Selection of species

Crinum asiaticum L.

Sp. pl. 1: 292 (1753).

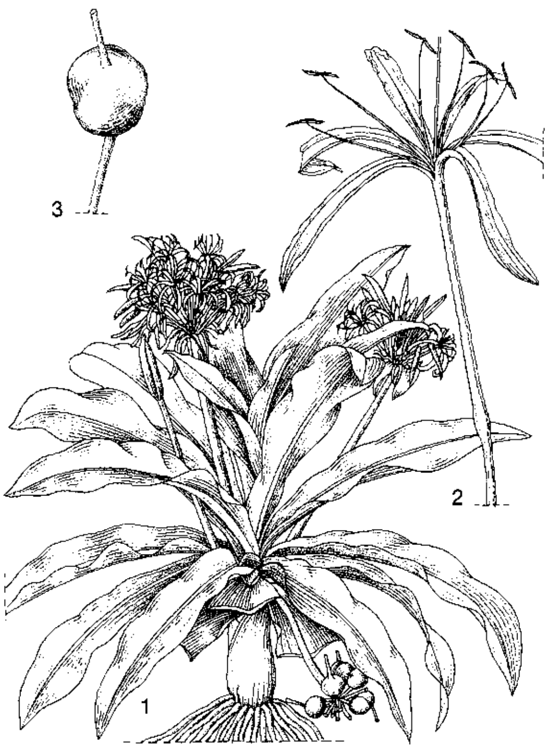
Synonyms *Crinum amabile* Donn. (1811), *Crinum macrantherum* Engl. (1886), *Crinum defixum* auct. non Ker Gawl., *Crinum macrophyllum* Hallier (1913).

Vernacular names Crinum lily, poison bulb (En). Crinole asiatique (Fr). Indonesia: bakung (general), kajang-kajang (Palembang), fete-fete (Ternate). Malaysia: bakong, bawang hutan (general). Papua New Guinea: morabau (Kabulula, Trobriand Islands), didil (Lesu, New Ireland), pokaan (Western Highlands). Philippines: bakong (general), agabahan (Bisaya), biliba (Subanun). Thailand: phlapphueng (central), lilua (northern). Vietnam: n[as]ng hoa tr[aws]ng, t[or]i voi, l[as] n[as]ng.

Distribution From India to South-East Asia, north-western Australia and Polynesia.

Uses In Papua New Guinea, the leaves are applied on swellings and the roots are given to ease childbirth. The hairlike threads from the stem are used to poultice cuts. In Fiji, the plant is used to treat infections of the breast and wounds. In Vietnam, a poultice of the leaves is applied to contusions, sprains and closed fractures, and a poultice of the bulb is used to relieve rheumatism. A decoction of the dried leaves is used as a wash for haemorrhoids. In Thailand, the leaves are used to treat inflammations and the bulbs as a diuretic.

Observations A variable herb, 1–1.8 m tall, bulb about 5–15 cm in diameter, many bulblets present, false stem up to 50 cm long, clothed with old leaf sheaths; leaves 20–30, narrowly to broadly elliptical, 50–150 cm × 3.5–20 cm, lower horizontal, upper semi-erect, margins entire, smooth; umbel 10–50-flowered, scape 50–100 cm long, bracts 9–16 cm × 3–5 cm, pale; flowers fragrant at night, corolla tube straight, 8–13 cm long, 4–5 mm in diameter, lobes lanceolate, 6–12 cm × 0.5–1.2 cm, white, sometimes pink, pedicel 0.5–2.5 cm long,



Crinum asiaticum L. – 1, flowering and fruiting plant; 2, flower; 3, fruit.

filaments of stamens slender, 3.5–7 cm long, anthers straight, 12–25 mm long, yellow, turning purple; capsule subglobose, 2.5 cm in diameter, beaked, pericarp fleshy, yellowish-green, 1–5-seeded; seed ovoid, often angular. *C. asiaticum* is extremely polymorphic, and found along sandy shores and shaded, humid localities at low altitudes. The pink-red flowered form was formerly known under the name *C. amabile*. *C. asiaticum* var. *sinicum* Baker, St. John's lily, has larger flowers than the type form, and var. *declinatum* Baker has deflexed flower buds, and the tips of the perianth lobes are tinged red.

Selected sources 24, 74, 130, 135, 171, 215, 263, 346, 407, 418, 610, 696, 700, 739, 786, 788, 867.

Crinum latifolium L.

Sp. pl. 1: 291 (1753).

Synonyms *Crinum moluccanum* Roxb. (1859).

Vernacular names Philippines: lirio, bakong (Tagalog). Thailand: waan kho daeng (Bangkok), waan raeng khokham (central). Vietnam: n[as]ng l[as] r[ooj]ng, trinh n[uwx] ho[af]ng cung.

Distribution Native to tropical Asia, possibly India, cultivated in Asia as an ornamental, sometimes escaped.

Uses The bulbs are extremely acid. In India, when roasted, they are used as a rubefacient in rheumatism, or crushed on piles and abscesses to cause suppuration. The juice of the leaves is used for earache.

Observations A herb up to 150 m tall, bulb 8–15 cm in diameter; leaves 12–20, oblong-linear, 60–120 cm × 4–7 cm, margins distantly serrated, rough; umbel 10–20-flowered, scape as long as the leaves, green or purplish-green, bracts 5–7 cm long, very broadly ovate, purplish; flowers fragrant, corolla tube 10–13 cm long, curved, green, tinged with purple, lobes oblong-lanceolate, 8–13 cm × 2.5–3.5 cm, white, flushed with pale purple in median part, stamens declinate, filaments 5.5–9 cm long, white, anthers 2.5–3 cm long, yellow, becoming purple-grey, style 17–23 cm long, white; capsule rarely formed, rounded, 4–5 cm in diameter. *C. latifolium* is known from cultivation only.

Selected sources 786, 788.

Crinum zeylanicum (L.) L.

Syst. nat. ed. 13: 236 (1770).

Vernacular names Milk-and-wine lily (En).

Distribution Native to tropical Africa, Sri Lanka and continental Asia; in Java cultivated as an ornamental, and locally naturalized.

Uses The bulb is very acrid, and causes inflammation of the skin and the mucous membranes, and is therefore used in rheumatism. In West Africa, the bulbs are known to cause severe diarrhoea. Externally, the leaves are applied to injuries and ulcers. In Sri Lanka, the bulbs are used as a rubefacient and the leaf juice for relieving earache.

Observations A herb up to 120 cm tall, bulb 6–20 cm in diameter, false stem up to 15 cm long; leaves 9–12, elliptical, 20–70 cm × 2.5–7.5 cm, mostly prostrate, margin long undulate, scabrous; umbel 6–15-flowered, scape 25–60 cm long, bracts 6–9 cm × 2–3 cm, purplish; flowers fragrant, corolla tube 10–14 cm long, more or less pendulous, lobes lanceolate, 8–13 cm × 2.5–3 cm, white with pink bands, stamens declinate, filaments 6–8 cm long, curved suddenly upwards at apex, white, anthers purplish, turning black, style 16–20 cm long; capsule subglobose, 2–5 cm in diameter, beaked, pericarp leathery, purplish, turning yellow. *C. zeylanicum* occurs in slightly moist sites in savanna, and along the sandy sea-coast, in Java up to 1100 m altitude. In Sri Lanka flowering from August to February.

Selected sources 74, 134, 194, 786.

Wardah

Croton L.

Sp. pl. 2: 1004 (1753); Gen. pl. ed. 5: 436(1754).

EUPHORBIACEAE

$x = 9, 10, 14$; *C. aromaticus*, *C. caudatus*, *C. roxburghii*, *C. tiglium*: $2n = 20$

Major species *Croton argyratus* Blume, *C. caudatus* Geiseler, *C. stellatopilosus* Ohba, *C. tiglium* L.

Origin and geographic distribution *Croton* is one of the larger genera in the *Euphorbiaceae*, about 750 species are recognized worldwide in tropical and subtropical regions. The majority of species is found in the Americas and about 75 species in Malesia.

Uses The medicinal uses of *Croton* are very diverse, varying from strongly purgative qualities to providing aromatic tonics. The aromatic species are mainly found in South America: *C. eluteria* (L.) W. Wright, *C. cascarilla* (L.) L. (Cascarilla bark), *C. malambo* Karsten (Malambo bark), *C. pseudo-china* Schlechter (Copalchi bark; by some considered a synonym of *C. niveus* Jacq.). *C. aromaticus* L. from India is also aromatic. Whereas many species are used for their purgative properties, *C. argyratus* and *C. stellatopilosus* are employed to arrest diarrhoea. *C. caudatus* and *C. tiglium* have a reputation for their purgative properties. The seed and seed oil of *C. tiglium* have been widely used as a strong purgative, drastic cathartic and poison throughout South-East Asia. The oil is a strong vesicant but diluted it can be externally applied in liniments as a counterirritant for various skin affections. Caution should be taken with all applications in view of its drastic action. The root has been used as an abortifacient. The wood is said to be diaphoretic when administered in small doses, and purgative and emetic in large doses. An extract of the seed can be used as an insecticide, for field applications as well as in stored cereals and beans. The seed oil of *C. tiglium* may also be used for production of soap or candles. However, for illumination it can only be used for outdoor applications as the smoke is toxic.

The bark and roots of *C. cascarilloides* Raeusch (synonym *C. cummingii* Müll. Arg.), from West Malesia, are used as an antipyretic in Thailand. The bark of *C. roxburghii* N.P. Balakr. (synonym *C. oblongifolius* Roxb.) is externally applied to sprains. A hot decoction of the leaves is used in Indo-China to treat scabies. The seed oil is very similar to that of *C. tiglium*, and seeds are likewise purgative and considered poisonous. The leaves of *C. kongensis* Gagnep. (synonym *C. tonkinensis* Gagnep.) are used in Indo-China for various stomach disorders including ulcers, and a decoction is externally applied for furuncles and impetigo. The roots of *C. crassifolius* Geiseler (synonym *C. tomentosus* (Lour.) Müll. Arg.), another species confined to southern China, Indo-China, Burma (Myanmar) and northern Thailand are used to treat cholera, dysentery and to cure an inflamed and painful throat. The leaves of *C. flavens* L. are a popular ingredient of herbal teas in the Caribbean. Dragon's blood, the red, viscous latex of various South American species e.g. *C. lechleri* Müll. Arg., *C. draconoides* Müll. Arg. and *C. erythrochilus* Müll. Arg., is used for various diseases, in particular for wound healing.

Production and international trade Roots, seeds and seed oil of *C. tiglium* are locally traded within South-East Asia. Trade with western Europe started in the 16th Century and continued to be important until the beginning of the 20th Century. Recent information is, however, lacking.

Properties The seed of *C. tiglium* contains 30–45% of a fixed oil named croton oil. Croton seeds contain the toxic proteins croton globulin and croton albumin, croton resin ('crotonol') responsible for the vesicant and irritant properties; a non-volatile unsaturated fatty acid responsible for the purgative properties; crotin, a phytotoxin and blood coagulant with a delayed poisonous effect; and a glucoside, crotonoside, that has no harmful physiological action. The seeds commonly applied as fish poison, show strong molluscicidal activity as well. Several 12,13-diesters, and 12, 13,20-triesters of the diterpene phorbol have been isolated from croton resin. Phorbol-12-tiglate-13-decanoate showed antileukaemic activity against lymphocytic leukaemia in mice. In general, however, these phorbol esters as found in *C. tiglium* (and many other *Croton* species e.g. *C. roxburghii*) are extremely irritant and also tumour promotors. Their presence in *C. tiglium* and *C. flavens* means their consumption is sometimes held responsible for certain forms of (nasopharyngeal) cancer as they are able to activate e.g. Epstein-Barr viruses.

A considerable number of compounds, diterpenes, diterpene esters, diterpene lactones and furanoid terpenes have been isolated from various parts of *C. stellatopilosus*: furanoditerpene A–B, geranylgeraniol ester A–G, planunol A, plaunotol, plaunol A–E, plaunol monoacetate and plaunolide. Furthermore, stem extracts of this Thai medicinal plant yielded ent-3α-hydroxy-13-epimanool and ent-16β,17-dihydroxykaurene. In earlier studies, 18-hydroxygeranylgeraniol and 5 plaunols were isolated and showed activity against peptic ulcers. The diterpene lactones plaunol A and B also exhibited anti-Shay ulcer activity, as is the case with the acyclic diterpene plaunotol which is used in the clinical treatment of peptic ulcers. The latter compound is marketed under its brand name KelnacFruit® in several countries worldwide. The activity of geranylgeraniol-18-hydroxylase, a novel enzyme catalyzing the C-18 hydroxylation of geranylgeraniol to plaunotol, was demonstrated in a cell-free extract prepared from *C. stellatopilosus* leaves. This enzyme is involved in the final step of the biosynthetic pathway of plaunotol.

Dragon's blood from various South American *Croton* species contains a dihydrobenzofuran lignan (2-(3′,4′-dimethoxyphenyl)- 3-hydroxymethyl-2, 3-dihydro-7-methoxybenzofuran-5-propan-1-ol), inhibiting cell proliferation, which may well explain its application in folk medicine. (–)-Hardwickiic acid in combination with 3,5-secotrachylobanic acid was found in the resin of the root of the South American *C. sonderianus* Müll. Arg. that shows antimicrobial activity. Cyperenoic acid and (–)-hardwickiic acid have been isolated from the roots of *C. aromaticus* and displayed moderate insecticidal activity.

In the stem bark of *C. levatii* Guillaumin, used in Vanuatu as a perfume and aphrodisiac, a diterpenoid levatin has been isolated (ent-15,16-epoxy-18-norcleroda-8(17),13(16)14-triene-19,3:12,12S-diolide).

Adulterations and substitutes The seed oil of other *Euphorbiaceae* such as *Aleurites moluccana* (L.) Willd., *Ricinus communis* L. and *Vernicia* spp., can also be used as a purgative. Their effect is less drastic than that of the oil of *C. tiglium*.

Description Shrubs to small trees, sometimes lianas, usually monoecious; indumentum usually stellate hairs or peltate scales next to simple hairs. Leaves simple, alternate, in some species with rhythmic growth and leaves crowded, margins often wavy or with teeth and glands, at base usually with two abaxial glands, lower surface in some species completely covered by peltate scales or stellate hairs. Inflorescences usually terminal, bisexual thyrses with basally pistillate flowers and apically staminate flowers. Flowers usually clustered on nodes; sepals 5, freeor slightly fused at base, overlapping; petals 5, usually as long as or shorter than sepals, in pistillate flowers sometimes minute or absent; disk of 5 glands or annular in some pistillate flowers; staminate flowers with 5–30 stamens, strongly inflexed in bud, free, filaments hairy or glabrous, receptacle hairy, pistillode absent; pistillate flowers with a usually 3-locular ovary, one ovule per locule, styles long, slender, stigmas usually deeply forked. Fruit a cylindrical capsule, splitting into 3 (bipartite) or 6 parts, smooth or shortly muricate. Seed without arillode, sometimes carunculate. Seedling with epigeal germination; cotyledons emergent, leafy; hypocotyl elongated; all leaves arranged spirally.

Growth and development Most *Croton* species grow fast. *C. tiglium* raised from seed or cuttings will flower within 15 months. Seedlings of *C. stellatopilosus* reach a height of 2–4 m in 3–4 years. In areas without a pronounced dry season *Croton* can be found flowering and fruiting throughout the year. In Prachin Buri, southeastern Thailand, *C. stellatopilosus* flowers and fruits in February–March, shoot formation is most prominent in April–October, and leaves are shed in November–January.

Other botanical information *Croton* is classified in the subfamily *Crotonoideae*, tribe *Crotoneae*. The most recent infrageneric classification identifies 40 sections of which two have been subdivided into subsections. The species are often difficult to identify due to minor differences in characters (e.g. different hair types).

Ecology Most *Croton* species are relatively indifferent to their habitat and they are found on a wide range of soils in disturbed and undisturbed vegetation. Some species are more restricted in their ecological range and confined to tidal zones, mangrove, peat swamp or limestone. In general, *Croton* is found below 1000 m altitude.

Propagation and planting As most material of *Croton* is collected from the wild information is rather scarce. In Vietnam, *C. crassifolius*, *C. kongensis* and *C. tiglium* are planted. In other areas planting efforts appear to be limited to *C. tiglium*, for which small-scale plantings for commercial purposes go back to the beginning of the 20th Century. *C. tiglium* is propagated from stem cuttings and seed. *C. stellatopilosus* can be propagated by shoot tip culture technique for rapid multiplication of superior plant material with higher plaunotol content. *C. argyratus* can be propagated by seed, which shows about 45% germination in 22–73 days. *C. crassifolius* is propagated by root cuttings in northern Vietnam.

Scions from *C. stellatopilosus* can be successfully side-grafted onto rootstocks of *C. roxburghii*, a species not susceptible to root rot under comparable conditions. No root rot was observed in grafted *C. stellatopilosus* during the year after grafting. Grafting promoted the vegetative growth of *C. stellatopilosus* and did not affect the plaunotol content of leaves.

In vitro production of active compounds The production of plaunotol in callus cultures of *C. stellatopilosus* is enhanced by using media containing high concentrations (>0.8%) of gelling agents, especially gellan gum or agarose. The accumulation of plaunotol was observed within 3 weeks after transfer to the medium and was accompanied by increases in chlorophyll content and in the number and size of regions containing tracheids, and by slow growth. Light and high concentrations of gelling agents were required for plaunotol accumulation in the callus.

Husbandry During the resting period *C. stellatopilosus* trees in Thailand should be top-cut at about 2 m above ground; stems with few branches should be thinned and branches with only a few buds cut back. During the growth period only the top part of branches with many leaves should be lightly cut back. Heavy pruning should be avoided to secure an increase in leaf yield and plaunotol content in the leaves of the next harvest. Following this system leaves can be harvested three times a year; at the early stage of vegetative growth late May or late June, a second harvest late July or late August and a third harvest at the late stage of vegetative growth late October or late November. In *C. stellatopilosus* plantations of less than 2 years old, ploughing and the use of *Calopogonium mucunoides* Desv. as cover crop were found to be effective methods of weed control, whereas repeated applications of glyphosate at 1.4 kg/ha followed by hoeing and ploughing were suitable in crops of more than 3 years old. Various control measures have been developed to control root rot in *C. stellatopilosus* plantations. The occurrence of the disease is related to rainfall, frequency of harvesting, ploughing, mulching and soil nutrient status. Control measures include ploughing at the beginning of the dry season in December, sowing a cover crop at the beginning of the rainy season in May followed by mulching 2 months later, supplying sufficient fertilizer together with 60 g dazomet/m^2, and harvesting only once or twice annually.

Diseases and pests Serious diseases or pests have not been reported for the medicinally used *Croton* species. Root rot, caused by e.g. *Fusarium* spp., sometimes causes damage in *C. stellatopilosus* plantations in Thailand. Larvae of *Amyna punctum*, feeding on the leaves, may attack 3-year-old plantations during the rainy season, but carbaryl (1-naphthylmethylcarbamate) is an effective insecticide to control the pest.

Harvesting Since the medicinally used *Croton* species are generally of limited dimensions, the harvesting of fruits, leaves, bark and roots is relatively easy.

Yield By appropriate pruning the dry-weight of 7-year-old *C. stellatopilosus* can be increased from 341 g to 905 g leaves and from 3.3 g to 6.2 g plaunotol, respectively. Plaunotol content is highest in young leaves. The annual production of a 1200 ha plantation in Thailand was estimated at 1700 t dried leaves.

Handling after harvest Fruits, leaves, bark and roots can be dried and stored for future use. The seed oil can be stored only for a limited period of time as a result of oxidation.

Genetic resources and breeding The *Croton* species of medicinal importance are relatively common and widely distributed. The risk of genetic erosion appears rather limited. No germplasm collections of *Croton* is known to exist.

Prospects The Malesian *Croton* species are of limited economic importance. Although croton oil is still officially included in several Pharmacopoeias, its use, as well as that of other plant parts (e.g. seeds), should be limited because of their strong purgative action and the presence of phorbol esters with irritant and tumour-promoting activity. *C. stellatopilosus* seems of interest as a source of plaunotol, a compound used in the treatment of peptic ulcers. However, a patented chemical synthesis is also available for plaunotol.

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Selection of species

Croton argyratus Blume

Bijdr. fl. Ned. Ind.: 602 (1825).

Vernacular names Silver croton (En). Brunei: kemarik. Indonesia: parengpeng (Sundanese), tapen kebo (Javanese), leprak (Madurese). Malaysia: cheret budak, chenderai, semengkeh (Peninsular). Philippines: tubang puti (Pilipino).

Distribution India (Andaman Islands), peninsular Thailand and throughout Malesia (except for New Guinea).

Uses A decoction of the leaves is a medicine for diarrhoea, ulcers and fever, and is also given after childbirth, and used for medicinal baths. A herbal tea is sometimes made from an infusion of the leaves. The roots can also be applied against ulcers; an infusion of the roots is used for thrush. The wood is heavy and hard, seasons well and is suitable in house construction. In the Andamans the wood is a valuable firewood. The seeds yield an oil used in lamps.

Observations A tree up to 20(–27) m tall; leaves ovate, 8–26 cm × 6–11 cm, base subcordate with 2 small, auricled lobes, apex acuminate, margin entire, lower surface densely covered with bronze scale-like hairs, petiole 2.5–18 cm long; inflorescence densely scaly; calyx outside densely scaly; staminate flowers: petals obovate, 2.5–3 mm long, pilose, stamens 11, filaments with long hairs or glabrous; pistillate flowers: apetalous, disk with stellate hairs, ovary densely scaly; fruit globose, 1.5—-2 cm in diameter, 6-grooved. *C. argyratus* is found in a variety of vegetation types and soils in subhumid climates, up to 1000(–1500) m altitude. It flowers throughout the year, and the limits of the species are still not fully understood.

Selected sources 35, 36, 74, 128, 135, 358, 407, 814, 860, 954, 1059, 1066.

Croton caudatus Geiseler

Croton. Monogr.: 73 (1807).

Vernacular names Malaysia: gurah periat, tukul takal, mendarong akar (Peninsular). Philippines: alimpai (Tagalog). Thailand: krado hot bai khon (south-eastern). Vietnam: ba d[aaj]u leo, c[uf] d[ef]n du[oo]i.

Distribution From the Eastern Himalayas to Sri Lanka, to South-East Asia and throughout West Malesia to the Philippines and Sulawesi.

Uses A decoction of the roots alleviates constipation, fever, and colds. In Indonesia, dried bark is used to relieve stomach disorders. In India, the leaves are applied as a poultice to sprains. Twigs may be used for basketry.

Observations A woody climber up to 27 m tall; leaves ovate, 5–18 cm × 2.5–11 cm, base cordate, with two stalked glands, with 5 palmate nerves, apex acuminate, margin shallowly serrate with glands in teeth, lower surface with scattered stellate hairs, stipules caducous, (0.2–)1–1.5 cm long; inflorescence with stellate hairs; staminate flowers with obovate petals, stamens 18–32, disk glands hairy; pistillate flowers with oblong petals, small, pilose, ovary with long stellate hairs; fruit subglobose, 12–18 mm in diameter, finely 6-grooved, warty, stellate hairy; seed with scattered stellate hairs. *C. caudatus* is found in primary and secondary forest and brushwood, up to 1000 m altitude. It flowers throughout the year.

Selected sources 32, 34, 35, 36, 74, 135, 215, 358, 788, 810, 814, 860, 1066.

Croton griffithii Hook.f.

Fl. Brit. India 5: 392 (1887).

Vernacular names Indonesia: tumpung (Malay). Malaysia: tapin batu, melokan ayer, kemesak (Peninsular).

Distribution Lower Thailand, Peninsular Malaysia and Borneo.

Uses A decoction of the leaves is used in Malaysia as a post-partum bath for three days after childbirth. The finely scraped root is sprinkled on ulcers. The wood is probably suitable for house construction.

Observations A small tree up to 12 m tall; leaves elliptical to obovate, 10–27 cm × 5–12 cm, drying clear orange-brown, dark brown or grey-brown, base obtuse to attenuate, apex obtuse to mucronate, margin entire to obscurely serrate, lower surface subglabrous or weakly hairy near midrib; inflorescence glabrous to sparsely lepidote; flowers solitary, sepals apically bearded; staminate flowers, stamens 8–15; pistillate flowers with 5 large disk glands, ovary depressed 3-lobed, stellately tomentose and white with scales; fruit a depressed 3-lobed capsule, about 1 cm in diameter, sparsely lepidote, smooth. *C. griffithii* is found in primary submontane forest on brown sandy soil, limestone or heavy loam over limestone, up to 1050 m altitude.

Selected sources 32, 135, 358, 786, 814, 1066.

Croton stellatopilosus Ohba

Journ. Jap. Bot. 55: 97 (1980).

Synonyms *Croton sublyratus* auct. non Kurz.

Vernacular names Thailand: plau noi.

Distribution South-east Thailand; also cultivated in other parts of Thailand.

Uses The stem bark and leaves are used in Thailand as an antidiarrhoeal and to normalize menstruation. The bark is also used for the treatment of indigestion. The flowers are applied as an anthelmintic.

Observations A shrub or small tree up to 5 m tall, branching verticillate; leaves apically crowded, obovate, 6–18 cm × 3–7 cm, base bluntly attenuate with glandular sessile disk close to and on the petiole, apex acute to short-acuminate, margin serrate, glabrous above, with scattered but distinct stellate hairs below; inflorescence densely set with stellate hairs, flowers solitary; staminate flowers with petals more distinctly ciliate than sepals, stamens 10; pistillate flowers 3-lobed, densely stellate-tomentose; fruit a sulcate capsule about 5 mm long, smooth to slightly muriculate. *C. stellatopilosus* is found in rock crevices, in mixed bamboo forest and along roadsides up to 500 m altitude.

Selected sources 31, 289, 358, 543, 544, 658, 659, 660, 692, 814, 868, 1048.

Croton tiglium L.

Sp. pl. 2: 1004 (1753).

Vernacular names Purging croton (En). Indonesia: simalakian (Minangkabau), kemalakian (Sundanese), ceraken (Javanese). Malaysia: changkian, chemengkian, bua patu (Peninsular). Philippines: tuba (most dialects), saligau (Ilokano, Ibanag), tubang-makaisa (Bikol, Tagalog). Cambodia: bat khlok. Laos: mark tot. Thailand: ma khaang (northern), salot (central). Vietnam: ba d[aaj]u, m[aws]c v[as]t, cong kh[oo]i.

Distribution From India and Sri Lanka eastward to China Indo-China, Thailand and throughout Malesia.

Uses The roots and leaves, but especially the seeds and the seed oil have very drastic purgative qualities and have been used as such since ancient times. Croton oil rubbed on the skin acts as a rubefacient and vesicant. The leaves are mentioned as an ingredient of dart poison and as a poultice for snake bites. Pounded seeds are commonly used as a fish poison.

Croton tiglium L. – 1, flowering and fruiting twig; 2, female flower in longitudinal section; 3, male flower in longitudinal section.

Observations A shrub or treelet up to 3 m tall; leaves ovate, 7.5–17 cm × 4–9.5 cm, base broadly rounded to attenuate, with 2 sessile to distinctly stalked glands on the margin, apex obtuse to acute, margin very shallowly serrate, lower surface subglabrous with a few stellate hairs, basally 5-nerved, stipules caducous, subulate, 1.5–3.5 mm long; inflorescence glabrous; staminate flowers: sepals subglabrous, tips bearded, petals narrowly oblong, hairy, stamens 15–20, glabrous, disk glands small; pistillate flowers: sepals villous at base, petals absent, disk obscure, annular, ovary oblong; fruit obtusely trigonous, 2–2.5 cm in diameter, white, scabrid with stellate hairs. *C. tiglium* is found in a wide range of vegetation and soil types, up to 1500 m altitude, planted around villages. It mainly flowers from October to May in Java.

Selected sources 32, 34, 35, 36, 120, 128, 135, 215, 263, 358, 380, 407, 739, 788, 810, 814, 860, 868.

P.C. van Welzen & H.J. Esser

Cullen corylifolium (L.) Medik.

Vorles. Churpfälz. phys.-öcon. Ges. 2: 381 (1787).

LEGUMINOSAE

$2n = 20, 22, 24$

Synonym *Psoralea corylifolia* L. (1753).

Vernacular names Indian bread root (En). Laos: khad. Vietnam: d[aaj]u mi[ee], ph[as] c[oos] ch[ir], b[oor] c[oos]t chi.

Origin and geographic distribution *C. corylifolium* is found from Java northward through Peninsular Malaysia to Indo-China and southern China (Yunnan, Sechuan), westward to India, Sri Lanka to Oman and Somalia.

Uses The seeds of *C. corylifolium* have long been used in Hindu medicine, and are well known in traditional Chinese medicine. In Vietnam, they are considered a tonic to the genital system, and an aphrodisiac and are prescribed in weakness of the spleen and kidneys, pain in the lower back and knees, rheumatism, impotence, polyuris, urinary incontinence in children and threatened abortion; they are also used for the treatment of leprosy. In India, the drug prepared from the seeds is used as stomachic, anthelmintic, diuretic and febrifuge. It is also prescribed in leucoderma, vitiligo, psoriasis and inflammatory diseases of the skin, both for oral administration and local application. The plant is locally used as fodder for cattle.

Production and international trade *C. corylifolium* is not cultivated on a commercial scale; it is locally grown for its seed in some parts of India.

Properties Besides the presence of several flavonoids, chalcones, coumestans, *C. corylifolium* is reported to contain psoralen and isopsoralen.

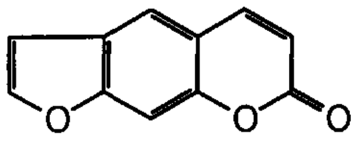
Psoralen belongs to the linear (or 6,7-) furanocoumarins, compounds which are known to have phototoxic activity. The isomeric angular (or 7,8- furanocoumarins e.g. isopsoralen), however, appear to be inactive in this aspect. Dermatosis may arise after plants containing linear furanocoumarins come into direct contact with the skin, if this is immediately followed by exposure to UV-A light, e.g. from the sun. The mechanism of photosensitization by psoralen is based on interference with DNA base pairs. Energy provided by UV-A irradiation leads to the formation of additional products between the furanocoumarin and cytosine and thymine bases. This bridge-building inhibits the replication and transcription of DNA and, consequently, the synthesis of RNA and proteins and the occurrence of cell division. This mechanism makes furanocoumarins such as psoralen, 5- and 8-methoxypsoralen (which are often found all together) suitable for the treatment of psoriasis, a disease characterized by an abnormal production of the outermost layer of the skin.

Isopsoralen administered orally to CD-1 mice daily for 6 days had no effect on liver enzymes like cytochrome P-450. In contrast, orally administered 8-methoxypsoralen induced several hepatic drug-metabolizing enzymes and liver cytochrome P-450.

A fraction from *C. corylifolium* seeds is cytotoxic to murine ascitic tumour cells, transformed human lymphocytes and KB cells in culture. This fraction also significantly increased the lifespan of EAC ascitic tumour-bearing mice. Activity guided fractionation led to the isolation of several active constituents, e.g. the coumestan derivative psoralidin (against SNU-1 and -16 cell lines in vitro) and (+)-bakuchiol (against five kinds of cultured human cancer cell lines, i.e. the A549, SK-OV-3, SK-MEL-2, XF498 and HCT15). Furthermore, an ethanol extract of *C. corylifolium* caused strong inhibition of DNA polymerase in a whole cell bioassay (SV40 bioassay using Simian virus 40) specific for inhibitors of DNA replication enzymes. Bioassay-directed purification of the active compounds led to the isolation of corylifolin, bakuchiol, neobavaisoflavone and daidzein as DNA polymerase inhibitors.

Other pharmacological effects include promotion of bone calcification and an increase in serum inorganic phosphorus, by non-polar fractions of a *C. corylifolium* acetone seed extract in experimental rachitic rats fed with a vitamin D-free, low phosphorus diet.

The methanol extract of the seeds of *C. corylifolium* also inhibited the aggregation of rabbit platelets induced by arachidonic acid, collagen and platelet activating factor (PAF). Bioassay-directed fractionation led to the isolation of 3 flavonoids,



psoralen

i.e. isobavachalcone, neobavaisoflavone and bavachin. Purified isobavachalcone and neobavaisoflavone inhibited platelet aggregation.
An aqueous extract of the seeds inhibits the growth of *Escherichia coli*, *Staphylococcus aureus*, while the alcoholic extract inhibits the growth of *Bacillus subtilis*, *Escherichia coli*, *Pasteurella multicoda*, *Pseudomonas aeruginosa*, *Salmonella pullorum*, *Staphylococcus aureus*, *Streptococcus fecalis* and *Streptococcus pyogenes*. The petroleum extract of the seeds is active against strains of *Staphylococcus aureus*, which are highly resistant to antimicrobials like penicillin, streptomycin, chloramphenicol, erythromycin and tetracycline. Furthermore, the essential oil shows antifungal activity against several species of *Alternaria*, *Aspergillus*, *Cladosporium*, *Cunninghamella*, *Fusarium*, *Helminthosporium*, *Microsporium*, *Mucor*, *Rhizopus*, *Trichophython* and *Trichothecium*.
Petroleum ether extracts of *C. corylifolium* at 0.5% give almost complete protection to black gram (*Vigna mungo* (L.) Hepper) against the bruchid *Callosobruchus chinensis* infestation for up to 135 days. Furanocoumarins (psoralen, isopsoralen) from the roots are possibly responsible for antifeedant activity. Application of *C. corylifolium* extract to mulberry leaves once during the 3rd instar larvae phase of *Bombyx mori* suppresses the incidence of grasserie disease by 60%. This disease is caused by a nuclear polyhedrosis virus and enhances larval and cocoon parameters.

Adulterations and substitutes. Several other *Leguminosae*, *Moraceae*, *Rutaceae* and *Umbelliferae* are known to contain phototoxic furanocoumarins such as psoralen, 5- and 8-methoxypsoralen, e.g. *Ammi* species (*Ammi majus* L.), *Pimpinella* species, *Angelica* species, *Heracleum* species (*Heracleum mantegazzianum* Somm. & Levier), *Fatoua villosa* (Thunb. ex Murray) Nakai and *Citrus bergamia* Risso & Poiteau.

Description An erect annual or short-lived perennial herb up to 1.5 m tall, commonly branched from the base, arising from the crown of a taproot; all parts moderately white-strigose and densely brown-glandular. Leaves alternate, 1-foliolate; petiole 0.5–3.5 cm long, pulvinate; stipules asymmetrically lanceolate-ovate to deltoid, 3.5–7 mm × 2–3 mm, persistent; leaflet narrowly to broadly ovate, 3–11 cm × 2–7.5 cm, base cuneate to cordate, apex acute, margin variably dentate, glabrescent, glandular punctate on both sides; petiolule 2–3 mm long. Inflorescence an axillary, condensed pseudoraceme, consisting of 20–more flowers; bracts lanceolate, 3 mm long, persistent,

Cullen corylifolium (L.) Medik. – 1, flowering and fruiting twig; 2, stipules; 3, base of leaflet; 4, flower; 5, pod.

rachis 1–4 cm long, peduncle 3–7.5 cm long. Flowers papilionaceous, calyx urceloate-campanulate, 5-lobed, 3–4 mm long, lower lobe 5.5 mm long, glandular; corolla 5–6 mm long, standard obovate to broadly elliptical, clawed, wings oblong, clawed, keel petals clawed, white to bluish-purple; stamens diadelphous; ovary 1-ovuled. Fruit a reniform-ellipsoid pod, 5 mm × 3 mm, indehiscent, with persistent calyx and style, densely black-glandular. Seed adhered to the pericarp.

Growth and development Flowering and fruiting of *C. corylifolium* occurs throughout the year following sufficient rain. It is capable of binding atmospheric nitrogen with a cowpea-type *Rhizobium*. However, symbiosis is classified as promiscuous but often ineffective. Roots were found heavily infected with vesicular-arbuscular mycorrhizal endophytes. It absorbs and accumulates nitrogen and potassium most speedily in periods of branching, flowering and fruiting, and phosphate at full flowering and fruiting. Phosphate is accumulated mainly in the seed and potassium in the stem. The nutrient accumulation is positively correlated with that of the dry substances. To produce 100 kg of *C. corylifolium*, an absorption of 10.6 kg of nitrogen, 3.7 kg of phosphate and 10.2 kg of potassium is required. Soaking seed in triacontanol, ammonium molybdate and gibberellin can promote the growth of *C. corylifolium*, reduces premature flower and fruit drop, raises the fruit-bearing rate by 7–17%, and fruit-bearing number by 22–28%, thereby increasing the yield per unit area by 32–35%.

Other botanical information *Cullen* is a member of the tribe *Psoraleae*, all 9 genera of which are characterized by uni-ovulate ovaries, indehiscent fruits, and the presence of furanocoumarins. *Psoralea* sensu Forbes, with about 120 species, has been split into 5 genera. All Asian and Australian species have been reclassified in *Cullen*. *Cullen* consists of 32 species, widely dispersed in the Old World from southern Africa north to Spain, throughout the Mediterranean east to Asia Minor and Asia and south into Australia. In Australia, 26 out of 32 species are found, and 24 of them are endemic. In Malesia a total of 4 species occur, the best-known being *C. corylifolium*. Of the other species *C. stipulaceum* (Decne.) J.W. Grimes extends its range from Australia to Timor, *C. gaudichianum* (Decne.) J.W. Grimes occurs in Timor, Bali, Sumbawa, Flores and Alor. *C. badocanum* (Blanco) Verdcourt is found in the Philippines, Indonesia (Timor), New Guinea and Australia. The roots are traditionally consumed roasted in Australia. The well-known medicinal plant from the Mediterranean and Near-East *Psoralea bituminosa* L., has been renamed *Bituminaria bituminosa* (L.) C.H. Stirton.

Ecology *C. corylifolium* is relatively common in disturbed habitats, such as escarpments roadsides, banks and cropped land, often weedy.

Propagation and planting The most effective way of softening the hard seeds of *C. corylifolium* is by soaking them in concentrated sulphuric acid for 5 minutes, followed by soaking in water for 4 hours and a second dip in sulphuric acid for 20 minutes. This treatment increases germination from 8% to 94%. Mechanical scarification, rubbing between sandpaper for 10 minutes, is also an efficient method, which raises germination from 8% to 79%. Plants can also be propagated by shoot tip and axillary bud culture on Murashige and Skoog medium supplemented with 0.5 mg 6-benzyladenine (BA) and 0.01 mg indole acetic acid (IAA)/litre. Further addition of 0.05 mg giberellic acid (GA3)/litre to this medium improved shoot elongation. Rooting is readily induced in the in vitro-raised shoots by transferring them to MS basal medium supplemented with 2% sucrose. Plantlets can be successfully grown in soil under greenhouse conditions.

Husbandry Seed of *C. corylifolium* is sown in March–April in lines, 30 cm apart, at a rate of 7 kg per ha in India. Flowering starts following rain and seeds mature in November. Under proper management, the crop may continue to grow for 5–7 years.

Diseases and pests *C. corylifolium* may suffer from stem rot caused by *Sclerotinia sclerotiorum*, but this can be effectively controlled by the fungi *Gliocladium virens* and *Trichoderma harzianum*.

Yield Remarkably high concentrations (more than 2 g/kg dry weight) of the anticancer metabolite genistein have been found in the leaves of *C. corylifolium*.

Genetic resources and breeding *C. corylifolium* is very poorly represented in genebanks. However, in view of the large natural distribution, and its preference for disturbed habitats, it does not seem to be threatened by genetic erosion.

Prospects Furanocoumarins induce skin photosensitization followed by skin hyperpigmentation and specific photolesions to the DNA molecule. These activities have led to increasing demand for furanocoumarins, since they are widely used both in cosmetics (sun-tanning products) and dermatology for photochemotherapy of vitiligo and skin diseases characterized by hyperproliferative conditions, such as psoriasis and mycosis fungides. More research is needed to evaluate the potential of *C. corylifolium* as a local or industrial source of psoralens. Other interesting pharmacological effects include cytotoxic, DNA polymerase inhibiting and bone calcification promotive activities.

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Other selected sources 74, 215, 739, 786, 850, 942, 1013, 1038.

L.J.G. van der Maesen

Cyathula prostrata (L.) Blume

Bijdr. fl. Ned. Ind. 11: 549 (1826).

AMARANTHACEAE

$2n = 48$

Synonyms *Achyranthes prostrata* L. (1762), *Pupalia prostrata* Mart. (1825).

Vernacular names Indonesia: rumput jarang-jarang (Malay), ranggitan (Javanese), rai-rai fofoheka (Ternate). Malaysia: nyarang, menjarang, keremak. Papua New Guinea: kinjan (Gaikorovi, Sepik Province). Philippines: dayang, tuhod-manok (Tagalog), bakbaka (Iloko). Cambodia: andot ko. Thailand: yaa phaanngu lek (eastern), yaa phaanghu daeng (central). Vietnam: d[ow]n d[or] g[oj]ng, c[or] x[uw][ows]c, b[oo]ng d[or].

Origin and geographic distribution *C. prostrata* is distributed from Africa to China and Australia, throughout South-East Asia and introduced in Central America.

Uses In Peninsular Malaysia, *C. prostrata* is used internally and externally. The aerial parts in decoction are drunk against cough, and a decoction of the roots is used against dysentery. As a plaster, it is used for caterpillar itch, around the neck for cough and on the belly for intestinal worms or shingles. In Indonesia, the leaves mashed with water are a remedy for cholera, and an infusion of the whole plant is taken for fever and dysentery. In Papua New Guinea, the juice of the stem is used as an abortifacient. In Sierra Leone, the roots are used for this purpose. In the Philippines and Guinea, the ash of the burnt plant mixed with water is rubbed on the body for scabies and other skin ailments. In Thailand, the stem in decoction is taken as a diuretic and to increase menstrual discharge; the leaves are used for irritations of the throat, the flowers as an expectorant and the roots against abnormal and frequent urination. In Vietnam, the roots in decoction are commonly drunk for colds and cough, in Indo-China the same preparation is used for rheumatism and dropsy. In China, the stem and leaves are used as a mild laxative. In Taiwan, a decoction of the leaves is applied to snakebites. Throughout Africa, the plant is used to treat dysentery. In Cameroon, the plant is prescribed for articular rheumatism. In Ivory Coast, the sap of the plant is used as ear drops for otitis and for headache, and the pulped plant is used on sores, burns and fractures, as a haemostatic and cicatrizant. In Gabon and Congo (Brazzaville), the leaves are eaten as a vegetable.

The roots of *C. capitata* DC. are used medicinally in China and Indo-China, to treat rheumatism, backache and paralysis.

Production and international trade Chinese herbalists in Peninsular Malaysia stock *C. prostrata*.

Properties All parts contain the steroid β-ecdysterone and a further undefined saponin.

An ethanol extract of the whole plant at a dose of 0.5 g/kg showed anti-inflammatory activity against carrageenan-induced pedal oedema in rats, and a petroleum extract revealed anti-pyretic activity with yeast-induced pyrexia in rats. In addition, the ethanol extract of the whole dried plant at a dose of 0.5 g/kg showed analgesic activity in the hot plate test and the acetic acid writhing test in mice. The same extracts showed no activity against bacteria, mycoplasma or yeast in culture.

Some compounds from the roots of *C. capitata*, poststerone and sengosterone, showed metamorphosing effects in insects.

Description An annual to perennial herb, 30–50 cm tall, erect or ascending, rooting at the nodes, stem obtusely quadrangular, thickened above the nodes, often tinged with red, covered with patent, fine hairs. Leaves opposite, simple, rhomboid-obovate to rhomboid-oblong, 1.3–15 cm × 0.7–6.5 cm, base contracted or narrowed, rounded, apex triangular, acute to obtuse, entire, ciliate, margin or blade often tinged red; petiole short. Inflorescence an erect, elongated raceme, terminal and in highest leaf-axils, straight or sinuous, 18–33 cm long, rachis densely pubescent; peduncle 1–12 cm long; flowers in small clusters, in the lower part of the raceme distant, in the higher part crowded, pedicel short, erect before anthesis, reflexed in fruiting, bracts ovate, acuminate; lower clusters with 2–3 bisexual flowers and several sterile ones, with up to 20 red, hooked awns, towards the apex fewer sterile flowers, at apex only solitary bisexual flowers, ripe clusters falling off as a whole. Flowers small; tepals 5, free, in bisexual flowers ovate-oblong, 2.5–3 mm long, strongly mucronate, dull pale green, glabrous within, externally clothed with patent long, white hairs,

Cyathula prostrata (L.) Blume – 1, plant habit; 2, flower cluster; 3, stamens; 4, utricle with seed.

tepals of sterile flowers 1.7–2.5 mm long, sessile; stamens 5, filaments connate at base, free parts 1 mm long, anthers 2-celled, pseudo-staminodes rectangular-cuneate, apex truncate; ovary superior, obovoid, 1-celled, funicle short, style filiform, stigma capitellate. Fruit an ellipsoid utricle, 1.5–2 mm long, thin-walled, glabrous, 1-seeded, surrounded by stiff perianth. Seed ovoid or ellipsoidal, 1–1.5 mm long, shiny brown. Seedling with epigeal germination.

Growth and development The flowers of *C. prostrata* are visited by bees for collection of nectar. They are also wind-pollinated. *C. prostrata* is found flowering throughout the year when sufficient water is available.

Other botanical information *Cyathula* consists of about 25 species with a tropical distribution. In the Philippines, a variety of *C. prostrata* with lanceolate to linear-lanceolate leaves occurs.

Ecology *C. prostrata* is weedy and occurs in shaded localities, along roadsides, in teak forests, secondary forests, often gregariously, from sea-level up to 1650 m altitude.

Propagation and planting *C. prostrata* is propagated by seed or by stem cuttings.

Harvesting The plant parts of *C. prostrata* to be used are harvested at the end of the growing season.

Handling after harvest In Vietnam, the leaves, stems and roots of *C. prostrata* are dried in the sun or over a fire.

Genetic resources and breeding As *C. prostrata* is commonly found as a weedy herb throughout the tropics of the Old World, genetic erosion does not seem a problem.

Prospects In general, limited information is available on the phytochemistry and pharmacology of *C. prostrata*. Extracts, however, do have some activity in general screening experiments, and therefore may merit further research to fully investigate their potential.

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Wongsatit Chuakul, Noppamas Soonthornchareonnon, Orawan Ruangsomboon

Deeringia amaranthoides (Lamk) Merr.

Interpr. Herb. amboin.: 211 (1917).

AMARANTHACEAE

$2n = 18$

Synonyms *Achyranthes amaranthoides* Lamk (1785), *Deeringia celosoides* R.Br. (1810), *Deeringia baccata* (Retz.) Moq. (1849).

Vernacular names Indonesia: bayam besar (Malay), pancaluhur (Sundanese), bayem luur (Balinese). Malaysia: bajam besar, bajam pohon. Philippines: ditiran, sili-silihan (Tagalog), aribugbug (Iloko). Thailand: khruea yaang (north-eastern), phaahom plaa (peninsular). Vietnam: d[eef]n leo.

Origin and geographic distribution *D. amaranthoides* occurs from India to China, throughout Malesia to Australia; there are no records from Borneo or the Moluccas.

Uses In the Philippines, a decoction of the leaves of *D. amaranthoides* is considered a cure for dysentery. In Malaysia, the plant is thought to be poisonous. The powder of the root is inhaled to cause violent sneezing. In Java, it is drawn into the nostrils, together with vinegar and onion juice, to get rid of mucous obstructions and the headache caused by the obstruction. The leaves are applied to sores, and an infusion is given to children for chicken pox. The leaves are also externally applied for stomach-ache. In the Solomon Islands, the sap from the cut plants is used to wash pigs with skin diseases. In the western Himalayas, the leaves are applied to inflammatory tumours. In India, fresh leaves are applied on the forehead for fever and headache.

The young shoots are sometimes eaten as a vegetable, mixed with other vegetables because of their rather unpleasant taste.

Production and international trade *D. amaranthoides* is only traded on a local scale.

Properties Several complex triterpenoid saponins and several triterpene glycosides of olean-12-en-28-oate were isolated from the fruits of *D. amaranthoides*. The leaves probably also contain a considerable amount of alkaloids (without further specification). In older literature, the plant is reported to possess anticancer and spermicidal activity.

Description A perennial, scandent or clambering shrub, often with long, pendulous branches, 2–6(–15) m long; stem in higher part slightly angular, finely appressed pubescent when young, terete and glabrous when old. Leaves alternate, ovate to oblong-sublanceolate, 4–15 cm × 2–8 cm, base acute, obtuse, rounded or subtruncate, often unequal, tapering towards the apex or acuminate, mucro long, often caducous, both surfaces thinly patently pilose, later glabrescent, midrib distinct beneath; petiole 1–6 cm long. Inflorescence an axillary or terminal raceme, very often divaricately branched, 5–28(–35) cm long, highest racemes usually collected in a terminal panicle, 15–75 cm long, rather dense or lax in the lower part, raceme often more than 50-flowered, peduncle absent or up to 8 cm long, appressed pubescent; bracts narrowly triangular, very acute, 1.5 mm long. Flowers small, solitary, sometimes clustered, malodorous, subtended by 2 bracteoles, ovate, acute, 1 mm long; pedicel 0.7–2 mm long; tepals 5, free, oval-oblong, 1.5–2.5 mm long, obtuse or rounded, pale green, margin white, often tinged red in fruit, reflexed; stamens 5, filaments at base united into a cup, free parts 1.5–2.7 mm long, anthers 2-celled; ovary superior, ovoid, funicle short, stigmas 3, greenish-white, 1–1.5 mm long, recurved on the fruit. Fruit a berry, globose-obovoid, 4–7 mm in diameter, indehiscent, bright red, falling out of the persistent perianth when ripe. Seeds (1–)5(–9), circular with emarginate base, 1–1.3 mm in diameter, almost smooth, brownish-black. Seedling with epigeal germination.

Deeringia amaranthoides (Lamk) Merr. – 1, flowering and fruiting branch; 2, part of inflorescence; 3, flower.

Growth and development *D. amaranthoides* in Java flowers from April to November.

Other botanical information *Deeringia* consists of about 7 species, occurring in the tropics of the Old World, from Madagascar to Australia. In Malesia, 4 species occur, only 1 with medicinal use.

Ecology *D. amaranthoides* occurs in teak forest, open mixed forest, secondary forest and their borders, tall brushwood, hedges, mainly in somewhat drier regions, often on calcareous soils, from sea-level up to 1500 m altitude.

Propagation and planting *D. amaranthoides* is propagated by seed.

Husbandry *D. amaranthoides* is sometimes planted in hedges for medicinal use.

Harvesting Young shoots, leaves or fruits of *D. amaranthoides* are harvested from the wild or from planted hedges when needed.

Genetic resources and breeding *D. amaranthoides* is fairly common throughout its area of distribution, and does not seem liable to genetic erosion. No breeding programmes are known to exist.

Prospects Very little is known about the phytochemistry or pharmacology of *D. amaranthoides*. Although saponins in general can display a multitude of pharmacological effects, no information is available on the specific types found in its fruits. Therefore, more research is needed to fully evaluate possible interesting effects.

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N.O. Aguilar

Dendranthema (DC.) Des Moul.

Actes Soc. Linn. Bord. 20: 561 (1860).

COMPOSITAE

$x = 9$; *D. ×grandiflorum*, *D. indicum*: $2n = 18, 36, 42, 45, 52, 54, 60, 70, 72, 90$ (polyploids and aneuploids are of cultivated plants)

Vernacular names (Garden) chrysanthemum, mum (En).

Major species *Dendranthema ×grandiflorum* (Ramat.) Kitam., *D. indicum* (L.) Des Moul.

Origin and geographic distribution About 37 species of *Dendranthema* are recognized, of which 2 occur in Europe and the others in Central and South-East Asia. In South-East Asia, both species present are cultivated for ornamental purposes and have sometimes become naturalized. In India, Vietnam, Taiwan, China and Japan *Dendranthema* is cultivated as a medicinal plant.

Uses Worldwide, *Dendranthema* species are best known as ornamentals. In Indo-China, a decoction of the flower heads of *D. ×grandiflorum* and *D. indicum* is used as a depurative, against fevers, headaches, and eye infections. The Chinese also inhale the powder for treatment of colds and headaches. The use of *Dendranthema* flower heads and leaves in pillows is thought to benefit the blood circulation, and to preserve vitality. The white-flowered form of both species is considered to be especially useful in preventing the hair from falling out or turning grey. The flower heads are also soaked in wine, producing a 'chrysanthemum wine', and used for a great variety of digestive, circulatory, and nervous difficulties. In China and Vietnam, the leaves and flower heads are used to treat hypertension. In the Philippines, the leaves of *D. indicum* are applied against flatulence. In China, an infusion of the flower heads is used similarly. The flower heads are considered by the Hindus to be heating and aperient and useful in affections of the brain and in calculus, as well as an antidote to a mental depression.

Concerning the wild form of *D. ×grandiflorum* in Indonesia, the whole plant is thought to be slightly poisonous. It is employed in decoction in the treatment of retained menses, as a wash for infected sores, and as a fomentation for enlarged glands. The flower heads are used in China against fever and headache, and together with black pepper to cure gonorrhoea.

Dendranthema flower heads are eaten as a vegetable, especially in Japan where they are considered a delicacy. In China and Japan, the flower heads of *D. ×grandiflorum*, especially the yellow ones, are used for local production of insecticides.

Production and international trade *Dendranthema* is cultivated all over the world on a commercial basis as an ornamental. As a medicinal plant it is grown commercially in India, Vietnam, China, Taiwan and Japan. In South-East Asia it is grown in gardens for ornamental and medicinal purposes. No statistics are available on production and trade of *Dendranthema* as a medicinal plant.

Properties *D.* ×*grandiflorum* contains an essential oil, of which the main components are camphor (16–58%), eucalyptol (9–30%), 2,6,6-trimethyl-2,4-cycloheptadien-1-one (18%), borneol (13%) and isoborneol (10%). Further phytochemical investigations revealed the presence of 3 sesquiterpenes (chrysanthediol, chrysanthediacetates B and C) as well as β-dictyopterol in the neutral alcoholic extract of the flower heads. 3,4-Dihydroxyacetophenone and 3,4-dihydroxyphenylacetone were isolated from fresh leaves of 10-week-old cuttings.

The water extract of *D.* ×*grandiflorum* contains the phenolic compound ellagic acid, which was found to be a potent aldose-reductase inhibitor. The enzyme aldose-reductase could be responsible for an increased intracellular accumulation of sorbitol in diabetic animals. Inhibiting this enzyme might prevent diabetic complications, including cataracts, neuropathy, retinopathy and nephropathy. Furthermore, ellagic acid also shows marked antioxidant activity, together with effective hydrogen-donating abilities, indicating that it is an effective radical scavenger.

The water extract of *D.* ×*grandiflorum* flower heads contains the flavonoid acacetin-7-O-β-D-galactopyrasonide and the flavone chrysin, which exhibit anti-HIV activity.

D. ×*grandiflorum* ligulate flowers containing 2-hydroxy-taraxastane-type triterpenes, fardiol and heliantriol C, markedly inhibited 12-O-tetradecanoylphorbol-13-acetate (TPA) induced inflammation, as measured by the ear oedema model in mice. These compounds also significantly inhibited the promoting effect of TPA on skin tumour formation, following topical 7,12-dimethylbenz-[a]-anthracene application in vivo.

Many *Compositae* are known to cause contact dermatitis; a study among market gardeners and florists in Germany often indicated *D. indicum* as the cause. Contact dermatitis caused by *D.* ×*grandiflorum* has been investigated in India. The most common type was hand and face dermatitis, followed by airborne contact dermatitis. All patients demonstrated positive patch tests to ethanol extracts of the flower heads, the leaves, the whole plant or the stems. These contact allergies are attributed to the presence of guaianolide type sesquiterpene lactones, e.g. arteglasin-A and alantolactone.

The leaves and flower heads of *D. indicum* yield an essential oil, called kiku oil (0.2% on dry weight base), its principal components being thujone (20%), camphor (13%), eucalyptol (8%), borneol (7%), α-pinene (5%), sabinene (5%) and camphene (4%). Further compounds include the glucoside chrysanthemin, the sesquiterpene chrysanthetriol, the guianolide tunefulin and the ketodiols chrysetunone and indicumenone from the aerial parts.

Intravenous administration of *D. indicum* extract decreased aortic and renal blood pressure in anaesthetized open-chest dogs, and increased aortic, vertebral and coronary blood flow. The extract produced directly and uniformly coronary and systemic vasodilation with renal vasoconstriction. *D. indicum* extract has a protective effect on myocardial injury of neonatal rat heart cells deprived of oxygen and glucose. Furthermore, a clinical study of *D. indicum* preparations in the treatment of bovine mastitis by intramammary infusion showed that the extract was very effective in relieving inflammatory symptoms, but less effective than penicillin and streptomycin in treating intramammary infection.

D. indicum is an effective growth and development inhibitor of the bug *Dysdercus similis*. In vitro studies of the leaf extract tested for nematicidal activity showed that egg hatching of *Meloidogyne incognita* nematodes was greatly inhibited.

Adulterations and substitutes Essential oils of other *Compositae*, e.g. *Blumea* species, contain similar compounds and might substitute *Dendranthema* extracts.

Description Aromatic perennial herbs, up to 1.5 m tall, sometimes woody at base, erect, often much branched. Leaves alternate, pinnatifid to pinnatilobed; petiolate; stipules absent. Inflorescence consisting of terminal or axillary heads, heads solitary or in lax corymbs, rather large and radiate, very variable in size; receptacle flat, strongly convex; involucre semi-globose, cup-shaped, consisting of 3–many-seriate, imbricate, broadly scarious-margined bracts; marginal flowers ligulate, female, disk flowers tubular, bisexual, 4–5-dentate, flowers mostly yellow (many other colours possible when cultivated); style-arms truncate, with a penicillate top. Fruit a cylindrical to obconical achene, 5–8-ribbed, glabrous, pappus absent or consisting of a membranous rim or short scales. Seedling with epigeal germination.

Growth and development After the first year *Dendranthema* becomes woody at the base, its growth is somewhat stunted and flower heads are smaller; therefore it is grown commercially as an annual. Depending on the cultivar, one to many flower heads per stem are formed.

Other botanical information Despite the obvious horticultural interest for *Dendranthema* cultivars, there are only regional reviews of the naturally occurring species. Autumn-flowering *Dendranthema* are probably a complex hybrid group raised in China from *D. indicum* and *D.* ×*grandiflorum*, and around 5000 cultivars are recognized in the United Kingdom, but many more exist around the world. In China first yellow, then white, then purple cultivars were developed: 500 cultivars existed in 1630. They were introduced into Europe in 1688, but were established in France only in 1789. Cultivars with a single row of ligulate flowers usually produce much pollen, cultivars with only ligulate flowers are normally sterile. Korean chrysanthemums are hybrids between *D.* ×*grandiflorum* and *D. zawadskii* (Herbich) Tzvelev cultivars. In Japan, cultivars which flower in (late) summer are considered inferior in petal taste to those flowering in autumn.

Dendranthema belongs to the tribe *Anthemideae*, and forms together with *Argyranthemum*, *Chrysanthemum*, *Leucanthemum* and *Tanacetum* the *Chrysanthemum* complex. It is possible that *Dendranthema* will be reduced again to a group below the genus level and that its species will resume the *Chrysanthemum* names. Three main classes of compounds of chemosystematic interest are present in the *Anthemideae*: polyacetylenes, flavonoids and sesquiterpene lactones.

Ecology *Dendranthema* cultivars are planted in a wide variety of regions, from sea-level to 1000 m altitude. They prefer sunny, fertile locations with loose, moist soil. The optimum temperature range is from 15°C to 30°C.

Propagation and planting Many *Dendranthema* cultivars do not produce seed and are propagated by cuttings. They are taken from stock plants, old plants which are cut back and form new shoots. The cuttings are planted in fertile, moist soil to promote rooting. Tissue culture and plant regeneration studies from protoplasts have been done with *Dendranthema*, but only for ornamental purposes.

Husbandry In China planting time of *D. indicum* cuttings is from March till June, and harvest is 5 months later. Many pot- or field essays have been performed on cultivars to identify optimum nutrient demand, day length sensitivity, optimum temperature, optimum planting time and chilling tolerance. Short days of 8 hours decrease plant height and increase flower head diameter, whereas long days of 14 hours have the opposite effect. On average, *Dendranthema* species flower after 85 days under 8 hours photoperiod, and after 130 days under 14 hours photoperiod.

Diseases and pests A wide range of diseases and pests are recorded for *Dendranthema* cultivars. Diseases are caused by *Phytophthora* spp., *Sclerotinia nivalis*, *Septoria chrysanthemella*, *Alternaria* spp. and *Fusarium oxysporum* f. *chrysanthemi*. The most common pests are aphids, thrips, nematodes and white fly.

Harvesting Leaves and flower heads of *Dendranthema* are collected from cultivated or wild plants whenever needed.

Genetic resources and breeding In the United States a small germplasm collection of *Dendranthema* species is present. In *Dendranthema* self-incompatibility and cross-fertilization are the rule in diploids, but polyploids show weak self-incompatibility. *D. indicum* and *D.* ×*grandiflorum* have been crossed with other *Dendranthema* species in China to provide cultivars suitable for ground cover. These cultivars have a dwarf or creeping habit, and small flower heads of 4–5 cm in diameter. They are resistant to low temperatures, drought, alkaline or saline soils, semi-shade, and pollution.

Prospects *Dendranthema* species contain a multitude of compounds which display interesting pharmacological activities, e.g. ellagic acid, acacetin-7-O-β-D-galactopyrasonide and taraxastane-type triterpenes. The medicinal value of these compounds should be evaluated by specific research.

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Selection of species

Dendranthema ×grandiflorum (Ramat.) Kitam.

Acta Phytotax. Geobot. 29(6): 165 (1978).

Synonyms *Chrysanthemum morifolium* Ramat. (1792), *C. sinense* Sabine (1823), *Dendranthema morifolium* (Ramat.) Tzvelev (1961).

Vernacular names Chrysanthemum, florist's mum (En). Philippines: rosas de Japon (Tagalog), mansanilla (Iloko). Thailand: dok-khee-kai (northern), benchamaat, benchamaat nuu (central). Vietnam: b[aj]ch c[us]c, c[us]c hoa tr[awr]ng.

Distribution *D. ×grandiflorum* is cultivated in many countries as an ornamental, and 13 cultivar groups are recognized. It is of very ancient cultivation, a native of China and Japan, and can be found in gardens, or naturalized, throughout South-East Asia.

Uses *D. ×grandiflorum* is cultivated in Malesia mainly as an ornamental, but is also used medicinally. It is cultivated as a flower-vegetable in China, Japan and Iraq, and is used in Indo-China to flavour tea and alcohols.

Observations An aromatic biannual or perennial herb, 30–120 cm tall; leaves ovate, pinnatilobed to pinnatifid, very variable in size, base cuneate, often with 1–2 small, widely patent segments, on the lower surface densely white- or grey-appressed-hairy, on the upper surface almost glabrous; heads often in a dense corymb, peduncle hardly thickened at the top, hairy, involucre usually cup-shaped, involucral bracts hairy, often widely patent, 6–9 mm long or longer, heads very variable, 2–20 cm in diameter; corolla of ligulate flower 11–35 mm long, white, yellow, pink, red, violet or brown. *D. ×grandiflorum* is a hybrid of unknown parentage, grown in gardens, and flowering throughout the year. It resembles *D. indicum*, but is usually taller.

Dendranthema ×grandiflorum (Ramat.) Kitam. – 1, flowering stem.

Selected sources 28, 54, 138, 144, 163, 282, 309, 322, 327, 365, 407, 451, 512, 546, 628, 639, 647, 775, 788, 810, 843, 999, 1053, 1101, 1104, 1105.

Dendranthema indicum (L.) Des Moul.

Actes Soc. Linn. Bord. 20: 561 (1860).

Synonyms *Chrysanthemum indicum* L. (1753).

Vernacular names False chamomile, Indian chrysanthemum, winter aster (En). Chrysanthème des Indes (Fr). Indonesia: sruni alas (Javanese). Philippines: mansanilla, dolontas (Tagalog). Thailand: benchamaat suan (central). Vietnam: kim c[us]c, c[us]c hoa v[af]ng.

Distribution *D. indicum* grows wild in Japan and China, Taiwan, Java, and the Philippines. It is cultivated in many countries all over the world as an ornamental. In India, Vietnam, China and Japan it is cultivated as a medicinal, and has become naturalized on a small scale.

Uses In Java, a water extract of the flower heads of the wild type is used on the body against fever, and a decoction is used for soothing ophthalmia. A decoction of the leaves, also of cultivated plants, is drunk as a sudorific. In Japan, the young flower heads, preserved in vinegar, are eaten.

Observations An erect or ascending, perennial, aromatic, pubescent herb, 30–60 cm tall, with stolons and rhizomes; leaves ovate to oblong-ovate in outline, 3–5 cm × 2.5–4 cm, pinnately lobed with 2–3 lobes on each side, abruptly narrowed at the base; heads in a corymbose panicle, peduncle short, involucral bracts oblong or elliptical, equalling the achenes in size, heads 1.5–2.5 cm in diameter; corolla of ligulate flower 11–13 mm long. Several varieties are recognized within *D. indicum*, one of which is *D. indicum* var. *edule* (Kitam.) Kitam., which is cultivated as a vegetable in China. The wild type grows on sunny, fertile and humid locations, up to 1000 m altitude.

Selected sources 28, 54, 138, 144, 150, 166, 272, 309, 322, 365, 395, 512, 513, 514, 609, 620, 625, 628, 681, 775, 810, 843, 856, 882, 899, 953.

G.H. Schmelzer

Dendrobium Sw.

Nov. Act. Regiae Soc. Sci. Upsal., ser. 2(6): 82 (1799).

ORCHIDACEAE

$x = 19$; *D. crumenatum*: $2n = 38$, *D. nobile*: $2n = 38$

Major species *Dendrobium crumenatum* Sw., *D. nobile* Lindl.

Vernacular names Indonesia: anggrek. Vietnam: ho[af]ng th[ar]o.

Origin and geographic distribution *Dendrobium* is a large genus of 900–1400 species, distributed from India, throughout tropical Asia and Japan to Australia, New Zealand and Polynesia. Several species are used medicinally, but most of them are ornamentals.

Uses In Peninsular Malaysia and Java, the heated pseudo-bulbs of the common Asian *D. crumenatum* (and similar species) are used for problems with infected ears, by squeezing the juice into it, while the ear is also poulticed with the crushed stems. A preparation of the leaves and flowers is also taken for cholera. In Peninsular Malaysia, the pounded leaves and fruits are applied on boils and pimples. The plant also enters into magic rituals, and is supposed to be very powerful in affections of the brain and nerves.

In Peninsular Malaysia, the Chinese import preparations of *D. nobile*, which is the most popular medicinally used *Dendrobium* in China. The stems are slightly sweetish and salty, and have a cooling effect. The whole plant is considered tonic, stomachic, sialagogue, and is prescribed in mild fever following illness, thirst from stress, dryness of mouth and throat, flatulence, anorexia, lumbago, impotence and amblyopia. In Vietnam, the plant is also used for tuberculosis. An infusion from the cut stems is applied for fever, excessive perspiration and weakness after illness, and also for sunstroke and thirst. It can be used interchangeably with *D. pulchellum* Roxb. and *D. gratiossisimum* Rchb.f. (synonyms *D. boxallii* Rchb.f. and *D. bullerianum* Batem.) from Indo-China, Thailand and India.

In eastern Malaysia and Indonesia the crushed and heated leaves of *D. purpureum* are used for poulticing infected nails (whitlow), for cooling and maturing. The stem and leaves of *D. planibulbe* Lindl. from Peninsular Malaysia are pounded and poulticed on skin infections in the neck. A decoction of the root of *D. pachyphyllum* (O. Kuntze) Bakh.f. (synonym *D. pumilum* Roxb.) is found from Burma (Myanmar) to Borneo and is used for dropsy. In northern Peninsular Malaysia the pounded leaves of *D. subulatum* Lindley are applied as a poultice on the forehead for headache. In Sabah, an infusion of the leaves of *D. umbellatum* Rchb.f. is taken to cure stomach-ache. In the Central Province of Papua New Guinea, the leaves of an unknown *Dendrobium* are chewed for cough.

The bright polished surface of the stems and pseudo-bulbs of several *Dendrobium* are used in the plaiting industry throughout South-East Asia. *D. crumenatum* and similar species are used in the straw-plaiting industry in the Philippines, where the stems are inserted for making a pattern in straw hats. In eastern Malaysia, *D. faciferum* J.J. Smith is similarly used and in Borneo and Sulawesi, *D. utile* J.J. Smith.

Production and international trade *Dendrobium* is used as a medicinal plant on a local scale only. Most species enter international trade for their ornamental value.

Properties The stems and pseudo-bulbs of *D. nobile* contain the alkaloids dendrobine, 3-hydroxy-2-oxodendrobine, dendroxine, dendramine (= 6-oxydendrobine) and 6-oxydendroxine. Biochemically, all are pseudo-alkaloids: the carbon skeleton of the molecule is derived from a sesquiterpene instead of an amino acid. As a purified compound, dendrobine was found to produce progressive paralysis of the peristaltic movement; it seems to act directly on the muscles, and also causes violent uterine contractions. For white mice, the lethal dose is 20 mg/kg, its action being very rapid, resulting in convulsions and paralysis. The effects of the alkaloids dendrobine and nobiline on the electrical activity, and on amino acid-induced depolarisation of primary afferent terminals, were tested in more detail on the frog isolated spinal cord and were compared with those of picrotoxinin and strychnine. Dendrobine caused a slight hyperpolarisation in both dorsal and ventral roots which was accompanied by the augmentation of the dorsal root potential and the ventral root potential and reflex. The amplitude of the dorsal root reflex however, was reduced significantly. It reversibly blocked the presynaptic inhibition caused by antidromic conditioning stimulation of the ventral root. These effects of dendrobine were qualitatively similar to those of strychnine but were somewhat different from those of picrotoxinin. Nobiline had no significant effect on either the root potentials or the reflexes.

From the n-hexane fraction of a methanol extract of *D. nobile*, the compounds gigantol and moscatilin were isolated. Both compounds showed strong antimutagenic potential under the Ames test (*Salmonella typhimurium* TA100 strain), by using well-known mutagens: furylfuramide and Trp-P-1f or gigantol, Trp-P-1 for moscatilin. In another test, the umu gene expression of the SOS response in *S. typhimurium* TA1535/pSK1002, gigantol displayed strong activity when using furylfuramide, Trp-P-1 and UV-radiation as mutagens. Additionally, moscatilin was also tested for its suppressive activity on these and other common mutagens e.g. 4-nitroquinoline-1-oxide, N-methyl-N'-nitro-N-nitrosoguanidine, benzo-α-pyrene and aflatoxin B(1). With all of the chemicals mentioned, moscatilin showed a dramatic reduction in their mutagenic potential.

Two phenanthrenes were isolated from the aerial parts of *D. nobile*, and were identified as 4,7-dihydroxy-2-methoxy-9,10-dihydrophenanthrene and denbinobin. These two compounds were found to be cytotoxic against A549 (human lung carcinoma), SK-OV-3 (human ovary adenocarcinoma), and HL-60 (human promyelocytic leukemia) cell lines in culture. The first compound also showed antitumour activity (increase of the life span) in mice, intraperitoneally implanted with 1×10^{-6} cells of sarcoma 180.

Finally, several patients with chronic superficial gastritis were perfused in the stomach with 20 g of *D. nobile* to observe the variations in gastric acidity output, serum gastrin- and plasma somatostatin concentrations. The result showed a significant increase in both acidity output and serum gastrin concentrations. However, no significant change occurred in plasma somatostatin concentration.

Adulterations and substitutes Other orchids such as *Ephemerantha lonchophylla* (Hook.f.) P.F. Hunt & Summerh. also yield denbinobin and gigantol.

Description Epiphytic perennial herbs, with or without cane-type pseudo-bulbs, rhizomes present or absent; stems slender, hairy or not, coloured or not, internodes present in all parts or only basally, glabrous and shiny. Leaves 1–many, usually articulate, duplicative, ovate to linear, green or differently coloured. Inflorescence terminal or axillary, racemose or fascicled, with 1–numerous flowers. Flowers zygomorphic, showy or not, 1 sepal free, the lateral 2 joined at the base, usually subequal to petals, petals 3, lip entire or trilobed, joined to column foot at base, sometimes forming a spur or spur-like extension with lateral sepals; column-foot usually short; pollinia 4, in 2 pairs, waxy, sessile, without appendages like caudicles or viscidia, extrafloral nectaries present. Fruit a conical capsule, dehiscing by longitudinal slits, with many seeds; seeds minute.

Growth and development *Dendrobium* grows best under permanent warm temperature conditions, and is usually pollinated by bees or ants. The seeds may be dispersed by wind. *D. crumenatum* can be found flowering throughout the year, but its main flowering period is between November–April in the humid tropics. Gregarious flowering follows 8–10 days after a temperature drop caused by heavy rainfall. The flowers are usually ephemeral.

Other botanical information No general review of *Dendrobium* exists, and the large size of the genus makes it difficult to obtain a good overview. Detailed morphological investigations have shown that the name *D. purpureum* has been applied at various times to six distinct taxa: *D. capituliflorum* Rolfe, *D. catillare* Rchb.f., *D. constrictum* J.J. Smith, *D. kraemeri* Schltr., *D. morrisonii* Schltr. and *D. purpureum*. The name *D. catillare* has itself been misapplied to a species which is described under the new name *D. taveuniense* Dauncey & P.J. Cribb.

Ecology Many *Dendrobium* species occur on trees in primary forest, either lowland, mountain or moss forests, in shady conditions, while other prefer more open lowland forest, with a short dry period. *Dendrobium* is found from sea-level up to 3000 m altitude.

Propagation and planting *Dendrobium* is propagated vegetatively by division, by seed or by tissue culture. In vitro multiple shoot production was achieved using axillary buds that were excised from *D. nobile* and *D. crumenatum* and were cultured in vitro on four media (Vacin & Went, Knudson C, Murashige & Skoog and Morel) supplemented with 3 mg butyric acid (BA) plus 1 mg naphthalene acetic acid (NAA)/l. The Vacin & Went medium produced the largest number of shoots/culture. In the second experiment, buds were cultured on Vacin & Went medium supplemented with BA or kinetin with and without 1 mg NAA/l. The largest number of shoots/culture was obtained with 1 mg NAA/l plus 3–6 mg BA/l.

Husbandry Of the *Dendrobium* species treated here, *D. crumenatum*, *D. nobile* and *D. purpureum* are also cultivated as ornamentals in Europe.

In a test, small plants of *D. nobile* potted in sphagnum moss or hemlock bark received NPK-fertilizer in 10 different combinations for a period of 2 years. Growth and development were positively correlated to N application, but the highest N level had little effect on flowering. P deficiency suppressed growth, decreased the number of flowers and delayed flowering, whereas K did not have any significant effect at all. Plants in sphagnum moss grew more vigorously than in bark, but showed some root disturbance during the second season. Sprouting of basal axillary buds was promoted by low temperature treatment at 10°C for 16 hours and 20°C for 8 hours during a period of 30–50 days. The date of terminal leaf emergence was markedly advanced by high temperature treatment at 25°C for 40 days when the length of the pseudobulbs was about 5 mm. Maximum stem length was observed at 10–15°C in all cultivars.

Diseases and pests Many different viruses (e.g. Dendrobium Mosaic Potyvirus, Cymbidium Mosaic Potexvirus), fungi and bacteria are known to attack *Dendrobium*, while cockroaches, scale insects, caterpillars, red spider mites and slugs can be serious pests, although they rarely eliminate the plants entirely. Young mistletoe (*Loranthus pentandrus* L.) plants were found growing on the stems of *D. crumenatum* in the garden of the Botany Department of the National University of Singapore.

Harvesting In Vietnam, *D. nobile* plants are harvested in the dry season.

Handling after harvest In Vietnam, *D. nobile* is dried in the sun or in a stove, then cut into small pieces, humidified with alcohol and cooked in vapour before use.

Genetic resources and breeding Some *Dendrobium* are widespread and common throughout South-East Asia, either naturally or as a result of cultivation, and do not seem to be at risk of genetic erosion. Some of them though have become extinct from the wild, because of overexploitation. Many *Dendrobium* have been brought into cultivation for ornamental purposes in hothouses in temperate climates, and gardens elsewhere, and a vast array of cultivars and hybrids have been developed. The *Dendrobium* species described here are widespread, and plant parts used for medicinal purposes are thus easily obtained.

Most commercial *Dendrobium* orchids grown in Hawaii are seed-propagated hybrids.

Prospects Several compounds (dendrobine, gigantol, moscatilin) isolated from *D. nobile* display interesting pharmacological activities, which merit further research. Purified compounds such as these might have potential as biochemical tools in modern experimental pharmacological research. No information is available on the composition or pharmacological activities of the other *Dendrobium*, although their local medicinal use is similar to *D. nobile*, and it would certainly be interesting to obtain more information on their compounds and activity.

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Selection of species

Dendrobium crumenatum Sw.

J. Bot. (Schrader) 2(2): 237 (1801).

Synonyms *Dendrobium cumulatum* Kraenzl. (1855), *Dendrobium caninum* (Burm.f.) Merr. (1921).

Vernacular names Pigeon orchid, white dove orchid, pigeon flower (En). Indonesia: anggrak merpati (Javanese). Malaysia: daun sepulah tulang. Thailand: waai tamoi (central, peninsular), buap klaang haao (northern). Vietnam: th[aj]ch h[ooj]c, tuy[ees]t mai.

Distribution From Sri Lanka to the Andaman Islands, Burma (Myanmar), Thailand, Indo-China, southern China, the Philippines, Peninsular Malaysia and Sumatra, Java, Borneo, Ambon and Timor.

Uses In Peninsular Malaysia, the pounded leaves and fruits are applied to boils and pimples, while the juice of the heated pseudo-bulbs is used for problems with infected ears.

Observations A robust, branched herb, stems slender, elongated, 60–90 cm long, glabrous, pseudo-bulbs conical, 8–12 cm × 2 cm; leaves scattered, oblong, 5–8 cm × 1.5–2.5 cm, apex rounded, slightly emarginate; inflorescence 2–many-flowered, flowers white, about 4 cm in diameter, very fragrant, dorsal sepal ovate-lanceolate, 25 mm × 8 mm, lateral sepals slightly wider, acuminate, forming a conical, acute, incurved mentum, petals linear-oblong, about 20 mm × 7 mm, lip pale yellow, 33 mm × 14 mm, slightly trilobed, edge crisped or fimbriate, with 3–5 longitudinal ribs. *D. crumenatum* occurs in humid regions, or regions with a short dry season, in open forest and on wayside trees, sometimes on boulders, locally numerous, from sea-level up to 1000 m altitude.

Selected sources 407, 459, 786, 810, 946.

Dendrobium crumenatum Sw. — 1, plant habit; 2, inflorescence; 3, flower; 4, column.

Dendrobium nobile Lindl.

Gen. sp. orchid. pl.: 79 (1830).

Synonyms *Dendrobium lindleyanum* Griffith (1851).

Vernacular names Thailand: ueang khao kiu (northern). Vietnam: th[aj]ch h[ooj]c, kim thoa th[aj]ch h[ooj]c, ho[af]ng th[ar]o.

Distribution From the Himalayas to China, Indo-China and Thailand; in Malesia cultivated as an ornamental.

Uses *D. nobile* is the most widely used among *Dendrobium*, and is considered tonic, stomachic and sialagogue. It is prescribed in mild fever following illness, thirst from stress, dryness of mouth and throat, flatulence, anorexia, lumbago and impotence.

Observations A branched herb, stems erect, compressed, furrowed when old, 30–60 cm long, including pseudo-bulbs; leaves distichous, linear-oblong, 7–12 cm × 1–3 cm, lasting for 2 years, subsessile; racemes on leaf-bearing or leafless stems, flowers in clusters of 2–4, 6–8 cm in diameter, sepals and petals mauve, pink to red, paling to white at base, sepals lanceolate, up to 35–45 mm × 15 mm, acute, petals ovate, 40–50 mm × 25 mm, margin somewhat undulate, lip elliptical-ovate, 45 mm × 30 mm, hairy, funnel-shaped at base, throat dark violet, surrounded by yellow or white. *D. nobile* occurs naturally in dense, humid forest. Many different cultivars have been developed.

Selected sources 407, 459, 569, 678, 739, 786, 946.

Dendrobium purpureum Roxb.

Fl. ind. (Carey ed.) 3: 484 (1832).

Vernacular names Indonesia: anggrek kesumba (Moluccas).

Distribution Native to northern Sulawesi, the

Moluccas, Kai Islands & Aru Islands; widely cultivated as an ornamental.

Uses In eastern Malaysia and Indonesia the crushed and heated leaves are poulticed on infected nails, for cooling and maturing.

Observations A large herb, stems pendulous, elongate-fusiform, terete, 60–150 cm long; leaves lanceolate, 6–13 cm × 1.5–2.5 cm, apex obtuse, slightly emarginate, keeled beneath; racemes usually from leafless stems, dense, globose or semiglobose, many-flowered, flowers up to 3 cm in diameter, bright to pale purple, rarely white, sepals and petals with an acute, green top, dorsal sepal ovate-oblong, 4.5–7 mm × 2–2.7 mm, thickened at base, lateral ones similar, broader, up to 15 mm long, petals obliquely elliptical lanceolate, 5 mm × 2 mm, margin minutely ciliate, lip somewhat constricted below the middle, sides more or less incurved, 7–10 mm × 2.5–5 mm, fused at base with column-foot. *D. purpureum* occurs naturally in mixed forest, often on ridges, from sea-level up to 900 m altitude.

Selected sources 233, 407, 459, 786.

Diah Sulistiarini

Dendrocnide Miq.

Pl. jungh.: 29 (1851).
URTICACEAE
x = unknown

Major species *Dendrocnide meyeniana* (Walp.) Chew, *D. stimulans* (L.f.) Chew.

Vernacular names Nettle tree (En).

Origin and geographic distribution *Dendrocnide* comprises about 37 species and is found from India, Sri Lanka, China, throughout South-East Asia to Australia and the Pacific islands.

Uses The use of leaves or twigs of various *Dendrocnide* in poulticing as an analgesic can be largely ascribed to the irritating hairs. Sap or a decoction from the bark or other parts are taken for pulmonary and intestinal disorders without particular indication of their effectiveness. Likewise a herbal tea from the leaves is taken in some regions as a remedy to counteract the irritation caused by the hairs. The bark is occasionally used to make ropes. The soft wood is only suitable for firewood.

Production and international trade *Dendrocnide* is only used at a local scale.

Properties An aqueous suspension of the root of *D. stimulans* showed strong inhibitory activity against *Staphylococcus aureus* in vitro. Many *Dendrocnide* species cause irritation or stings of varying intensity and duration following cutaneous contact.

In addition, *Dendrocnide moroides* (Wedd.) Chew from Australia, which is also reputed for its stinging hairs is known to contain moroidin. This bicyclic octapeptide, containing an unusual C-N linkage between tryptophan and histidine, was first isolated from the leaves and stalks of *D. moroides* and subsequently shown to be the principle responsible for the long duration of the stings. Although no further phytochemical or pharmacological information is available for the Malesian species, the presence of compounds such as, or related to moroidin cannot be excluded.

Description Dioecious or monoecious evergreen shrubs or trees up to 15(–35) m tall; stem in general softwooded; normally with irritant hairs. Leaves alternate, simple, coriaceous, crenulate, undulate to smooth; petiolate; stipules intrapetiolar, entirely connate, coriaceous. Inflorescence axillary, racemose or paniculate, bracteate, pedunculate. Flowers free, sessile to pedicellate, pedicel swollen or not, in small fascicles or on flabellate receptacles. Male flowers: tepals 4(–5); stamens 4(–5); pistillode present. Female flowers: flabellately or distichously arranged or in loose fascicles, tepals 4; ovary superior, ovoid, unilocular, stigmas usually ligulate; staminodes absent. Fruit an achene, compressed or ellipsoidal to ovoid, not chartaceous, usually strongly warted.

Growth and development Branching of *Dendrocnide* is sympodial, and much like that of *Terminalia*, with the leaves often forming rosettes at the end of the twigs. Most species flower and fruit with no particular seasonality. Seed of Australian *Dendrocnide* remains viable on the forest floor for about 5 years.

Other botanical information *Dendrocnide* comprises 2 sections: *Sarcopus* with 27 species is found from India and China throughout South-East Asia to Australia and the South Pacific with its major centre in New Guinea, and *Dendrocnide* with 10 species confined to China, some parts of mainland South-East Asia and western Malesia as far as the Moluccas with its major centre in the Philippines. In the absence of voucher specimens, the identity of the plants for which uses are mentioned can sometimes be considered doubtful in view of their indicated natural distribution.

Ecology *Dendrocnide* are essentially lowland primary forest species preferring slightly moist and somewhat shady habitats. Some prefer limestones and their derived soils. Many of the New

Guinea species seem tolerant of secondary forest and abandoned vegetable gardens.

Propagation and planting *Dendrocnide* can easily be propagated from seed. Detached branches of *D. sinuata* that become buried resprout easily.

Harvesting Leaves, bark or roots of *Dendrocnide* are collected from wild plants whenever needed.

Handling after harvest All plant parts of *Dendrocnide* are usually used fresh.

Genetic resources and breeding All *Dendrocnide* species treated here have a large area of distribution, and do not seem to be at risk of genetic erosion.

Prospects Very little information is available about the phytochemistry and pharmacology of *Dendrocnide*. More research will therefore be needed to evaluate its possible potential.

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Selection of species

Dendrocnide amplissima (Blume) Chew

Gard. Bull. Sing. 21: 202 (1965).

Synonyms *Laportea amplissima* (Blume) Miq. (1859).

Vernacular names Indonesia: mesi tapalole, soro bilalago, sosoro boboedo (Moluccas).

Distribution Sulawesi and the Moluccas.

Uses In the Moluccas, sap from the pounded bark is used as a remedy for sprue.

Observations A dioecious tree up to 8 m tall, twigs glabrescent, without irritant hairs; leaves broad elliptical to slightly obovate, (20–)30–35 (–45) cm × (12–)15–20(–25) cm, base cuneate, apex acuminate, margin sinuate, glabrous except for a few short irritant hairs at the lower surface, petiole (4–)6–8(–10) cm long, irritant hairs absent, stipules 4–7 cm long, light pubescent, with few irritant hairs; raceme branched, usually solitary, up to 25 cm × 35 cm, bracteolate, male flowers pedicellate, separated from each other, about 1.3 mm long, glabrous except for a few rather long irritant hairs, filaments slightly reflexed, female flowers subsessile to sessile, distichous on peduncular extremities, glabrous except for a few rather long irritant hairs, tepals 4, stigma brush-like, 0.5 mm long; achene broadly ellipsoid, to 3 mm × 2.5 mm, flat, smooth, perianth persistent, stigma persistent.

Selected sources 74, 407.

Dendrocnide latifolia (Gaud.) Chew

Gard. Bull. Sing. 21: 203 (1965).

Vernacular names Papua New Guinea: katche (Plitty, Manus Province).

Distribution Marianna Islands, New Caledonia, New Hebrides, Loyalty Islands, Solomon Islands, Bougainville Island.

Uses On Manus Island, the leaf is rubbed on body bruises and aches to act as an analgesic. A decoction of the leaves is drunk to relieve a headache. In the Solomon Islands, the boiled leaves are applied to itchy skin.

Observations A dioecious tree, up to 12 m tall, twigs variably pubescent, glabrescent with few irritant hairs; leaves elliptical to ovate, (13–)20–26(–33) cm × 5–15 cm, base cuneate, apex acuminate, margin irregularly sinuate, entirely glabrous, petiole (3–)5–8(–13) cm long, usually densely pubescent, glabrescent, irritant hairs present, stipules 1.5–2 cm long, densely pubescent; raceme branched, solitary, up to 15 cm long, with flowers in loose fascicles, bracteolate, peduncle with unevenly distributed irritant hairs, male flowers sessile to subsessile, about 1.5 mm long, slightly pubescent, filaments reflexed, female flowers shortly pedicellate to subsessile, 2 or 3 in each fascicle, lateral tepals large, stigma ligulate to 2 mm long; achene 2.3 mm × 2 mm, asymmetrically obovoid, flattened, smooth to tuberculate.

Selected sources 439.

Dendrocnide meyeniana (Walp.) Chew

Gard. Bull. Sing. 21: 204 (1965).

Synonyms *Laportea pterostigma* Wedd. (1869), *Laportea meyeniana* (Walp.) Warb. (1904), *Laportea subglabra* Hayata. (1911).

Vernacular names Philippines: lipa, lipang kalabau (Tagalog), apariagua (Bisaya).

Distribution The Philippines and Taiwan.

Uses In the Philippines the plant is reputed for its stinging hairs. An infusion of the roots and leaves is taken as a diuretic in case of urine retention. A topical dressing of the leaves is said to cure carbuncles. In Taiwan pounded roots or leaves are applied to treat scrofula.

Observations A dioecious tree, 5–7 m tall, twigs slighty pubescent with short irritant hairs; leaves oblong-obovate, (12–)20–25(–50) cm × (8–)10–15(–30) cm, base broadly shallowly cordate, apex acuminate, margin broadly undulate, upper surface sparsely covered with short irritant hairs, lower surface pubescent to subglabrous, petiole 5–20 cm long, irritant hairs present, stipules about 1 cm long, appressed pubescent; raceme branched, usually solitary, up to 25 cm long, bracteolate, male flowers sessile, about 1 mm long, densely pubescent or subglabrous, filaments slightly reflexed, female flowers sessile, flabellately arranged, the lateral tepals broad, stigma ligulate to 2 mm long; achene 2 mm × 2 mm, sigmoid to circular, somewhat flat, lightly tuberculate. *D. meyeniana* is found in thickets and secondary forest at low and medium altitudes. Subglabrous plants from Taiwan (Lanyu Island) are sometimes considered a separate species, *Dendrocnide kotoensis* (Hayata ex Yamamoto) Shih & Yang.

Selected sources 128, 455, 810.

Dendrocnide sinuata (Blume) Chew

Gard. Bull. Sing. 21: 206 (1965).

Synonyms *Urtica ardens* Blume (1825), *Laportea sinuata* (Blume) Miq. (1869), *Laportea pustulosa* Ridley (1920).

Vernacular names Indonesia: kemaduh, kemadu kebo (Javanese), kemadhu kodok (Madurese). Malaysia: pelutus. Papua New Guinea: batal (Gunantuna, East New Britain), lapot (New Ireland). Thailand: kalangtang chaang (peninsular). Vietnam: n[af]ng hai, han tr[aws]ng.

Distribution From India, Sri Lanka, throughout mainland South-East Asia to Sumatra, Java, Bali and Christmas Island.

Uses In Java, a decoction of the roots in combination with the leaves of a *Schizostachyum* sp. is drunk as a remedy for swollen limbs. The sap is occasionally used as a hair wash. In East New Britain, the leaves are externally applied against scabies. The plant is claimed to be used as an oral contraceptive in New Ireland.

Observations A monoecious tree up to 10(–26) m tall, twigs with irritant hairs pointing downwards; leaves elliptical, oblong to rhombic, (15–)20–65 cm × 7–35 cm, base cuneate, truncate to cordate, apex acuminate, margin sinuate to dentate, glabrous except for sparse irritant hairs at the lower surface, petiole (3–)6–20(–30) cm long, irritant hairs present, stipules about 2 cm long; raceme branched, unisexual, usually solitary, 5–15 cm (male) or 10–30 cm (female) long, bracteolate, densely covered with long irritant hairs, with loosely fascicled flowers, male flowers pedicellate, 2–3 mm long, slightly pubescent, filaments reflexed, female flowers shortly pedicellate, stigma ligulate, 2–5 mm long; achene 3–5 mm × 2.5–4.5 mm, asymmetrically pyriform, bloated, warty, perianth persistent, pedicel greatly elongated. *D. sinuata* is a weedy species colonizing gaps in the forest, locally frequent along roads and tracks, and is commonly found in relatively dry forest on sandy soils, from sea-level up to 1400 m altitude.

Selected sources 74, 135, 331, 407, 418, 430, 556.

Dendrocnide stimulans (L.f.) Chew

Gard. Bull. Sing. 21: 206 (1965).

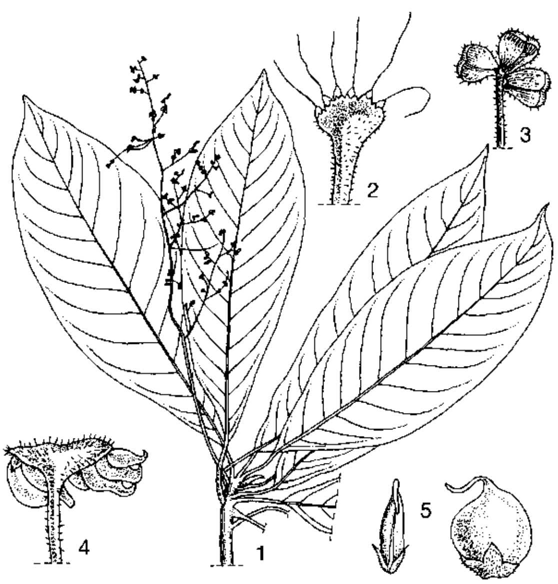
Synonyms *Laportea stimulans* (L.f.) Miq. (1854), *Laportea stenophylla* Quisumb. (1930).

Vernacular names Indonesia: jalatong pulus (Sundanese), kemaduh sapi (Javanese), jelatang kayu (Sumatra). Malaysia: jelatang gajah, jelatang api, daun gatal (Peninsular). Thailand: tamyae chaang (central), saam kaeo (peninsular), haan duea (northern). Vietnam: m[as]n nam, han t[is]m.

Distribution Southern China, Indo-China, Thailand, Peninsular Malaysia, Sumatra, Java, Lesser Sunda Islands, Moluccas, Sulawesi, Borneo, the Philippines, Taiwan.

Uses In Java, the sap is drunk as a bechic. In Sumatra a decoction of leaves and roots is drunk as an anthelmintic in case of a hard swollen stomach, constipation and yellow eyes. The sap is occasionally used as a hair wash. In Peninsular Malaysia, the leaves or roots are commonly used for poulticing.

Observations A dioecious tree up to 7 m tall,



Dendrocnide stimulans (L.f.) Chew – 1, female twig; 2, detail female inflorescence; 3, detail male inflorescence; 4, detail infructescence; 5, fruits.

branches rather widespread, bark light grey, lenticellate, twigs without irritant hairs; leaves elliptical to obovate, (12–)15–30(–40) cm × (4–)6–10 (–14) cm, base cuneate, rounded or emarginate, apex acuminate, margin usually entire, irritant hairs present, petiole (2–)5–10(–15) cm long, irritant hairs present, stipules 0.8–2 cm long, pubescent when young; raceme branched, usually solitary, 10–55 cm long, bracteolate, with 2–10-flowered fascicles, male flowers sessile, 1–2 mm long, slightly pubescent, filaments reflexed, female flowers sessile, slightly sunken in a row of fleshy receptacles, stigma ligulate to 5 mm long; achene asymmetrical, 2–4 mm × 2–4 mm, flattened, smooth to warty, perianth persistent, stigma persistent. *D. stimulans* is found in primary and secondary forest on sandy and loamy soils, from sea-level up to 1200 m altitude.

Selected sources 74, 135, 372, 407, 556.

J.L.C.H. van Valkenburg

Dendrolobium (Wight & Arn.) Benth.

in Miquel, Pl. jungh.: 215 (1852).

LEGUMINOSAE

x = unknown; *D. triangulare*: $2n = 22$

Major species *Dendrolobium triangulare* (Retz.) Schindler, *D. umbellatum* (L.) Benth.

Origin and geographic distribution *Dendrolobium* comprises 18 species. The Indo-Malesian region is a major centre of diversity with 8 species occurring, and 5 species are confined to the Australian region.

Uses In general the uses of *D. triangulare* and *D. umbellatum* are linked to their attributed astringent properties. They are often used in the treatment of dysentery and diarrhoea. In Cambodia, a decoction of the roots of *D. lanceolatum* (Dunn) Schindler from China (Hainan), Thailand and Indo-China, is applied to treat rheumatism. In Thailand, a decoction of the roots is used in the treatment of kidney disorders with mucous, and yellow or red urine. A decoction of the roots of *D. thorelii* (Gagnep.) Schindler, from Thailand and Indo-China, is administered in Thailand to treat leucorrhoea.

Properties Very little phytochemical and pharmacological information on *Dendrolobium* is available. The leaves of *D. triangulare* contain amines, for instance phenylethylamine and tyramine, and alkaloids such as hordenine, as well as general compounds such as tannins and flavonoids.

Hordenine is a phenylethylamine-type alkaloid, which has mild sympathomimetic effects (e.g. increase of blood pressure) similar to ephedrine. Furthermore, leaf extracts of *D. triangulare* displayed antibacterial effects against *Escherichia coli* and *Shigella* spp.

Description Shrubs or small trees up to 7 m tall. Leaves alternate, 3-foliolate or rarely 1-foliolate; petiole pulvinate; stipules present; leaflets variously shaped, lateral leaflets usually smaller than the terminal one, chartaceous to coriaceous, entire or undulate, with 1 stipel at the base of the lateral and 2 at the base of the terminal leaflets. Inflorescence axillary, subumbellate to shortly racemose or sometimes umbellate, densely-flowered, shortly pedunculate; primary bracts convex, scariose, striate, caducous; secondary bracts absent; bracteoles 2 at the base of the calyx. Flowers uniparous, papilionaceous, pedicellate; calyx usually campanulate, deeply 4-lobed; corolla white or pale yellow, standard broadly obovate or nearly orbicular, distinctly clawed, not auriculate; wings narrowly oblong, distinctly clawed, auriculate or not at the base, obtuse or rounded at the apex; keel petals long-clawed, distinctly auriculate or not; androecium monadelphous, stamens 10; ovary superior, sessile, (1–)2–8-ovuled. Pod indehiscent, incurved or straight, 1–8-jointed, usually not reticulate-veined. Seed transversely broadly oblong-ellipsoid to subquadrangular, rim distinctly arillate.

Growth and development In Java, *D. triangulare* and *D. umbellatum* flower and fruit throughout the year. *D. umbellatum* shows nodulating ability.

Other botanical information *Dendrolobium* has formerly been included in *Desmodium*, but it is a distinct natural group that can be distinguished by its axillary subumbellate inflorescences, uniparous flowers, monadelphous androecia, pollen characteristics, conspicuously long styles, thick corky or coriaceous pericarps and conspicuously rim-arillated seeds.

Ecology The wide geographical range of *D. umbellatum*, its occurrence on seashores in combination with the thick-walled pod articles points to dispersal by water.

Propagation and planting In *D. triangulare*, germination at temperatures below 20°C gradually decreases, and ceases altogether with exposure at 50°C. Pretreatment for 4 h at 70°C before transfer to ambient temperatures (24–29°C) gives a germination rate of 70–98%.

Handling after harvest The leaves of *D. triangulare* are used fresh or can be cleaned and dried for storage. Decoctions, extracts or pills from dried extract can be prepared.

Genetic resources and breeding CIAT (Colombia) has a total of 23 accessions of *D. lanceolatum* from China, Thailand and Vietnam, 31 accessions of *D. triangulare* from China, Thailand, Vietnam and Indonesia and 8 accessions of *D. umbellatum* from Vietnam, Indonesia and Papua New Guinea.

Prospects Too little phytochemical and pharmacological information on *Dendrolobium* is available to fully evaluate its potential. More research is therefore needed.

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Selection of species

Dendrolobium triangulare (Retz.) Schindler

Feddes Repert. 20: 279 (1924).

Synonyms *Hedysarum triangulare* Retz. (1783), *Desmodium cephalotes* (Roxb.) Wight & Arn. (1834), *Desmodium triangulare* (Retz.) Merr. s.s. (1942).

Vernacular names Thailand: kraduuk ueng (central), luuk prakham phee (south-eastern), naa nuan, nieo maa (peninsular). Vietnam: ba ch[ex], ni[eex]ng d[uwj]c, d[aaj]u b[aj]c d[aaf]u.

Distribution From tropical Africa, eastward to India, Sri Lanka, Burma (Myanmar), southern China, Taiwan, Indo-China, Thailand, Malaysia and Indonesia (Kalimantan, Sulawesi, Java, Madura, Lesser Sunda Islands, Timor).

Uses In Vietnam, the leaves are used in folk medicine to treat dysentery and diarrhoea. For the treatment of snake bites, the fresh sap of the leaves is drunk, and squeezed leaves applied as a poultice. The roots macerated in alcohol are considered aphrodisiac. In Cambodia, a decoction of roasted leaves is taken to cure coughs. In Laos, the entire plant is used to treat leucorrhoea.

Observations A much branched shrub up to 2 m tall, branches terete, much lenticellate, striate and glabrescent, young parts sharply triangular; leaves 3-foliolate, petiole 1.5–6 cm long, stipules occasionally persistent, leaflets ovate or elliptical, base cuneate and acute or oblong, apex acuminate, entire or slightly undulate, upper surface variably sericeous when young, lower surface sericeous, terminal leaflet 7–15 cm × 3–6 cm, lateral leaflets (2–)6–9(–11) cm × (0.7–)2–4(–5) cm; inflorescence with peduncle less than 1 cm long, 20–30-flowered, primary bracts 2–4 mm × 0.5–1.5 mm; calyx 5–9 mm long, corolla white or yellowish, standard suborbicular or broadly elliptical, wings elliptical, keel petals smaller than the

Dendrolobium triangulare (Retz.) Schindler – 1, flowering twig; 2, flower; 3, detail of infructescences; 4, a selection of pods.

wings, androecium 8–12 mm long, gynoecium 7–15 mm long, ovary densely pubescent; pod sessile, compressed, (1–)3–5(–6)-jointed, swollen on the seeds, variably appressed-sericeous, lower suture more deeply undulate than upper, both sutures variably thickened, articles in outline broadly oblong-elliptical or quadrate, 4 mm × 3–4 mm, not reticulated. *D. triangulare* is found on a wide range of soils from marshy to dry sandy conditions, in forest margins, roadsides, secondary growth, from 50–1500 m altitude.

Selected sources 74, 547, 739, 749.

Dendrolobium umbellatum (L.) Benth.

in Miquel, Pl. jungh.: 216 & 218 (1852).

Synonyms *Hedysarum umbellatum* L. (1753), *Desmodium umbellatum* (L.) DC. (1825).

Vernacular names Indonesia: blanakan (Javanese), kanyere laut (Sundanese), gowou (Ternate). Malaysia: petai laut, petai belalang, dendulang (Peninsular). Papua New Guinea: urara (Barakau, Central Province). Thailand: khamin naang, chamaep, thua rae thale (south-eastern). Vietnam: ba oh[ex] t[as]n, th[os]c l[es]p t[as]n.

Distribution From East Africa, Madagascar, India, Sri Lanka, eastward to Burma (Myanmar), Thailand, Indo-China, China, Taiwan and the Ryukyu Islands, throughout Malesia, northern Australia and further east to the Pacific Islands.

Uses In Papua New Guinea, the crushed leaves and shoots are used to massage an enlarged spleen caused by malaria. A decoction of the leaves is drunk locally as a general tonic. The solution is used to bathe the body to prevent a slight chill developing into a fever. In the Moluccas, the plant is considered astringent and the young leaves are an ingredient of a post-partum medicine used by women after childbirth. In Fiji, the leaves are used to treat scaly skin. In Taiwan, a decoction of the flowers is administered to treat gonorrhoea and irregular menstruation. In India the plant is used as a fodder, particularly favoured by horses. The young leaves are sometimes eaten as a vegetable or for seasoning.

Observations A shrub or small tree up to 3(–6) m tall, branches terete, lenticellate, glabrescent, young parts (4–)6–7-gonous; leaves 3-foliolate, petiole (1–)2–5(–6) cm long, stipules early caducous, leaflets elliptical to broadly ovate, base obtuse to acute, apex obtuse to acute, continuously appressed-sericeous when young, upper surface glabrescent, lower surface remaining covered with appressed fine hairs, terminal leaflet 5–14(–17) cm × (2.5–)3.5–7(–8.5) cm, lateral leaflets 3–11 cm × 1.5–6 cm; axillary inflorescence shortly peduncled or long racemose, 10–20-flowered, primary bracts 2–2.5 mm × 1–1.5 mm, early caducous; calyx 4–5 mm long, corolla white, standard obovate or elliptical, wings narrowly elliptical, keel petals much broader than the wings, androecium 8.5–10 mm long, gynoecium 14–15 mm long, ovary densely appressed-sericeous; pod sessile or slightly stalked, narrowly oblongoid, 3–5(–8)-jointed, rarely 1-seeded by abortion, glabrescent, both sutures not thickened, upper suture slightly undulate, lower suture undulate and constricted between the seeds, articles in outline broadly elliptical-oblong to oblong, (5–)7–8(–10) mm × 3.5–5 mm. *D. umbellatum* is one of the most variable species of the genus, two varieties are distinguished, in Malesia only var. *umbellatum* is found. *D. umbellatum* is found primarily in littoral habitats, but also in monsoon forest edges, river banks, savanna, secondary forest and rocky cliffs up to 180 m altitude.

Selected sources 47, 74, 135, 143, 215, 407, 418, 547, 749, 786, 958, 1038.

N.O. Aguilar

Dianella ensifolia (L.) DC.

in Redouté, Liliac. 1: t. 1 (1802).
PHORMIACEAE
$2n = 16, 32$

Synonyms *Dracaena ensifolia* L. (1767), *Dianella nemorosa* Lamk ex Schiller f. (1787), nom. inval., *Dianella parviflora* Ridley (1915).

Vernacular names Flax lily, umbrella dracaena (En). Brunei: akar yanyang (Sengkurong). Indonesia: jamaka (Sundanese), menuntil (Sumatra), labeh-labeh (Kalimantan). Malaysia: benjuang, sagatit, siak-siak jantan, akar siak (Peninsular). New Guinea: bururl (Mendi), moalengen (Aiome), tanglenu (Wigote). Philippines: ablaas (Bagobo), bariu-bariu (Panay Bisaya), hogangan (Ifugao). Thailand: ka kam laen (eastern), ma phraao paa (northern), lamphan (south-eastern). Vietnam: h[uw][ow]ng, b[af]i, l[uw][owx]i d[oof]ng, r[er] qu[aj]t.

Origin and geographic distribution *D. ensifolia* occurs from tropical Africa through Madagascar, India and Sri Lanka to the Himalayas, tropical Asia, southern China, Taiwan, Japan, Malesia and the Pacific Islands.

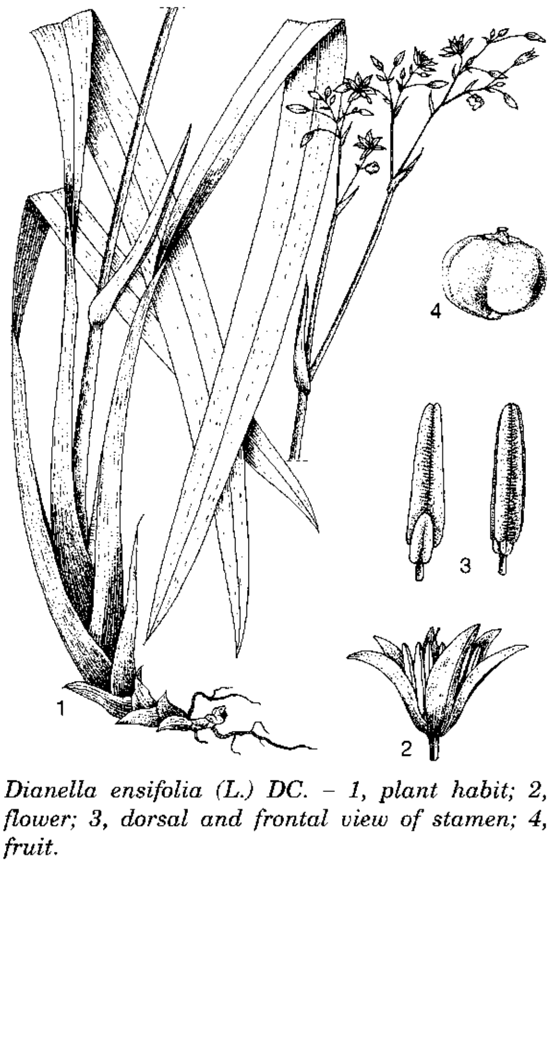
Uses In Peninsular Malaysia and Vietnam, the dried fibrous roots of *D. ensifolia* are chewed as a vermifuge. In Peninsular Malaysia, a decoction is also drunk as a post-partum aid. The taste is sweetish. They are also used in poultices applied to the abdomen as a vermifuge. The ashes of the roots and leaves are applied as an ointment for boils, itch, jaundice, herpes sores and rheumatism. In New Caledonia and Brunei, leaves are applied to wounds. In Thailand, the whole plant is an ingredient in a treatment for chronic infections of the skin. In Laos, an infusion of the stem is recommended to treat fatigue. In China, the herb is considered poisonous, and cattle are said to die from it. As a medicine, it was formerly taken internally for dysentery, dysuria, leucorrhoea and blenorrhoea, but nowadays it is only applied externally in pounded form to scrofulous glands.

In Vietnam, China and Java, the pounded fresh rhizome, mixed with rice, is roasted and used for killing mice and rats. The aromatic rhizomes and roots are ingredients in cosmetics and perfume, and the leaves are boiled for fumigations (incense). *D. ensifolia* is also planted as an ornamental, especially in rockeries.

Production and international trade *D. ensifolia* is used on a local scale only.

Properties At present, little information is available on the phytochemical composition of *D. ensifolia*. The aerial parts contain several benzoids, including 2,4-dihydroxy-6-methoxy-3-methyl acetophenone, 2,4-dihydroxy-1,3,6-trimethyl benzoic acid methyl ester and orselinic acid methyl ester. Besides these benzenoids, 5,7-dihydroxy-2,4,6-trimethyl chromone, 5,7-dihydroxy-2,8-dimethyl chromone isogenitol and musizin have been isolated. Very little is known about other *Dianella* species. However, the seeds of *D. nigra* Colenso, native to New Zealand, can be used to extract enzymes with lipogenase activity. In addition, an extract of the aerial parts of *D. revoluta* R.Br., from Tasmania and New South Wales, showed a strong antiviral activity against polio virus in an in vitro screening assay.

Description A rhizomatous herb, 0.6–1(–2) m tall, stems compressed, rigid, unbranched; rhizomes branching, white, 6–10 mm thick, scales 2–8 cm long, roots fibrous, long, profusely branched, with a particular smell, brown. Leaves rosulate at base, distichous on stem, narrowly elliptical to narrowly lanceolate, 30–60 cm × 2–3 cm, rigid, base keeled, compressed, sheathing, apex



Dianella ensifolia (L.) DC. – 1, plant habit; 2, flower; 3, dorsal and frontal view of stamen; 4, fruit.

acute, margins rough, parallel-veined. Inflorescence a terminal loosely cymose panicle, 30–60 cm long, exceeding the leaves, peduncle 30–75 cm long, ribbed, flexible when young, bracts ovate-lanceolate, 5–10 mm long, base sheathing, bracteoles 2–5 mm long, deltoid. Flowers bisexual, actinomorphic, pedicel 6–12 mm long, jointed just beneath the flower, decurved or not; perianth segments free, in 2 groups of 3, subequal, narrowly ovate, 7–8 mm long, shortly apiculate, pale purplish-blue, sometimes white or yellowish, 5–7-veined, outer segments greenish beneath, spreading at anthesis; stamens 6, filaments 2 mm long, white, dilated at apex into an irregularly lobed structure, 1–2 mm long, bright yellow to orange, topped by the basifixed anther, oblong, 3 mm long, yellowish brown, opening by longitudinal slits; ovary superior, 3-locular, style filiform, 2–4 mm long, stigma minutely papillose. Fruit a fleshy berry, 9–15 mm in diameter, blue-purple and shiny when ripe, 3–4-seeded. Seed ovoid, 5 mm long, shortly beaked, smooth, black, shiny.

Growth and development *D. ensifolia* can be found flowering throughout the year, but more often it flowers for several months only, during the rainy season. The flowers open in the afternoon and are without odour.

Other botanical information The *Phormiaceae*, formerly belonging to *Liliaceae* s.l., comprise 7 genera. *Dianella* consists of 20–25 species from the Old World tropics. *D. ensifolia* is very variable, and different authors have recognized several species, but the large number of intermediates makes this separation impracticable. Most *Dianella* spp. are grown in gardens as ornamentals.

Ecology *D. ensifolia* occurs in a wide range of habitats, from open grassland to primary forest, from sea-level up to 3000 m altitude.

Propagation and planting *D. ensifolia* is propagated by seed or by division. In cooler climates, *Dianella* spp. can be kept during winter in glasshouses, at minimum temperatures of 5–7°C.

Husbandry *D. ensifolia* grows in moderately fertile soils in sun or partial shade.

Diseases and pests In Australia, the fungus *Phyllosticta dianellicola* causes elongate reddish-brown lesions on the leaves of *D. revoluta* and *D. caerulea* Sims. In southern China, the thrips *Danothrips dianellae* causes damage to *D. ensifolia* leaves.

Harvesting The stem and rhizomes of *D. ensifolia* in Vietnam are harvested in June.

Handling after harvest The stem and rhizomes of *D. ensifolia* are washed before drying in the sun.

Genetic resources and breeding *D. ensifolia* is planted widely as an ornamental and does not seem to be threatened by genetic erosion.

Prospects Since hardly any information is available on the phytochemistry and pharmacology of *D. ensifolia* and other *Dianella* species, they need to be analysed further in order to evaluate their possible potential.

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Other selected sources 135, 201, 261, 404, 459, 631, 739, 1047.

Nguyen Nghia Thin & Nguyen Trung Thanh

Dichroa febrifuga Lour.

Fl. cochinch.: 301 (1790).

SAXIFRAGACEAE

$2n$ = unknown

Synonyms *Adamia chinensis* Gardner & Champ. (1849), *Dichroa cyanea* (Wallich) Schltr. (1914), *Dichroa sylvatica* (Reinw. ex Blume) Merr. (1934), *Dichroa versicolor* (Fortune) D.R. Hunt (1981).

Vernacular names Indonesia: gigil (Javanese, Sundanese), tataruman (Sundanese), ramram (Ayawasi, Papua). Cambodia: phuck mon. Thailand: yaai khlang yai (peninsular), hom kham, hom dong (northern). Vietnam: th[uw][owf]ng s[ow]n.

Origin and geographic distribution *D. febrifuga* is found from northern India and the Himalayas to Burma (Myanmar), Thailand, Indo-China and China, southward to mountainous areas of Malaysia, Indonesia, the Philippines and Papua New Guinea.

Uses In Java, the leaves of *D. febrifuga* are finely ground with *Kaempferia galanga* L. rhizomes, red onions, salt and a little water, and applied as a poultice at the beginning of a fever. In Papua, leaves softened over a fire are fed to dogs that refuse to eat. It will cause vomiting, and may dispose of worms. In Vietnam, the roots and especially the leaves have been used for the treatment of malaria in traditional medicine since time immemorial. It is one of the ingredients of a well-known antimalarial formula. An extract of the leaves was successfully used as a substitute for quinine, during World War II.

D. febrifuga has a long-standing reputation in the treatment of malarial fevers in China. The roots and leaves are credited with antipyretic, expectorant, cathartic, emetic and diuretic properties. The wood and bark are also considered medicinal. In humans the fresh sap of the leaves and roots causes vomiting and depresses the circulation of blood. According to traditional medicine, these side effects, especially nausea and vomiting, may be controlled by heating the drug with a little vinegar, and by combination with other drugs as indicated in classic formulas. The dried drug should be steeped in alcohol and subsequently heated to achieve the same effect. The drug is contraindicated in pregnancy and senile debility.

Production and international trade *D. febrifuga* is only used and traded at a local level.

Properties The alkaloids febrifugine (= dichroin A or α-dichroine) and isofebrifugine (= dichroin B or β-dichroine) have been isolated from the leaves and roots of *D. febrifuga*. Tests revealed isofebrifugine, administered intravenously, to be as equally effective as quinine in ducks infected with *Plasmodium lophurae*, whereas febrifugine was 100 times more effective as an antimalarial. In chickens infected with *P. gallinaceum*, febrifugine was 64 times more effective than quinine. Tested against tropozoites of *P. cynomolgi* in monkeys, febrifugine was at least 100 times more effective. The LD_{50} of febrifugine, given orally, in white mice is about 2.5–3.0 mg/kg. It is therefore more toxic than quinine, but the toxic syndromes are different; it has an effect on respiration, urinary incontinence, sweating and a corrosive action on the gastric mucosa.

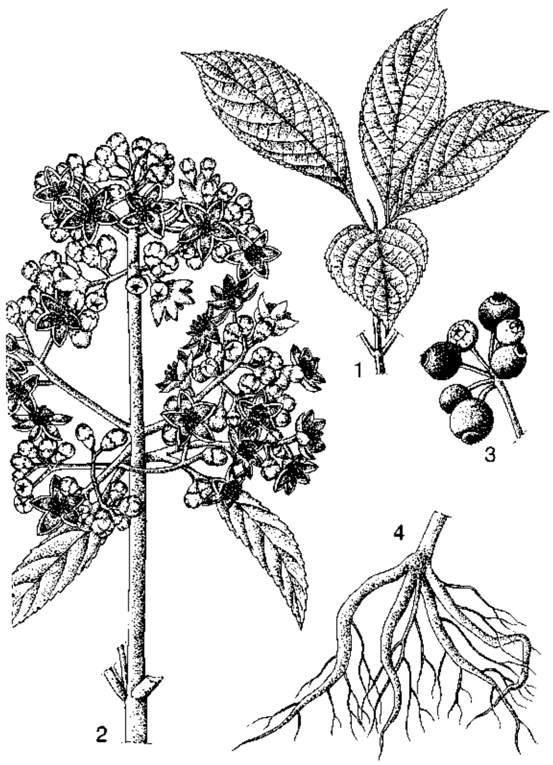
The electrophysiological effects of another alkaloid, changrolin (4- 3′,5′-bis((N-pyrrolidinyl) methyl)-4′-hydroxyanilino-quinazoline), derived from *D. febrifuga* were examined using the whole-cell patch-clamp method on single cells isolated from guinea-pig and rabbit hearts. At a clinically relevant concentration of 50 μmol/l this anti-arrhythmic compound shortened the action potential duration in both guinea-pig and rabbit ventricular cells, and significantly reduced L-type Ca^{2+} current (ICa) values in these cells. Changrolin also inhibited the transient outward current (ITO), but had little effect on fast Na^{+} current (INa). Furthermore, in vivo, changrolin exhibited significant protective and therapeutic effects against experimental arrhythmias induced by aconitine or ouabain. It raised the electrical threshold of ventricular fibrillation. Intravenous injections in dogs and rabbits caused a mild tachycardia followed by bradycardia; a prolongation of P-R interval and a widening of QRS complex in the ECG; a gradual hypotension; a slight weakening of cardiac functions; and only moderate influences on the hearts of dogs and rabbits when the rate of infusion was less than 1 mg/min. Changrolin could be well absorbed by oral administration, although absorption appeared to be more rapid and complete by intramuscular injection.

The effect of the alkaloid halofuginone on collagen α1(I) gene expression and collagen synthesis was evaluated in human skin fibroblasts from patients with chronic graft-versus-host disease (cGvHD) or scleroderma and from a normal individual. Halofuginone caused a dose-dependent inhibition in collagen α1(I) gene expression and collagen synthesis in all cultures tested, the cGvHD fibroblasts being the least sensitive. In normal and scleroderma fibroblasts, concentrations of halofuginone as low as 10^{-10} M and 10^{-9} M were sufficient to cause a significant reduction in collagen α1(I) gene expression and collagen synthesis, respectively. In addition, halofuginone also inhibited the transforming growth factor β-induced collagen synthesis. Three days after halofuginone removal, collagen gene expression returned to control levels. The reduction of collagen mRNA transcript levels by halofuginone appeared to be dependent on new protein synthesis because simultaneous treatment of fibroblasts with protein synthesis inhibitors prevented the suppressive effect of halofuginone on collagen α1(I) mRNA gene expression. The ability of extremely low concentrations of halofuginone to inhibit collagen α1(I) synthesis specifically and transiently at the transcriptional level suggests that this material may be an important tool for studying collagen α1(I) gene regulation and maybe used as a novel and promising antifibrotic therapy.

Extracts of *D. febrifuga* were furthermore shown to inhibit the secretion of nitric oxide and tumour necrosis factor in lipopolysaccharide and/or interferon-γ stimulated mouse peritoneal macrophages, without affecting cell viability. By using a quite similar assay for nitric oxide production, febrifugine was isolated as the main active compound, showing a dose-dependent relationship.

Adulterations and substitutes The alkaloid febrifugine is also present in *Hydrangea* spp. (*Saxifragaceae*).

Description An erect, evergreen shrub, 1–3 m tall, twigs terete, variably pubescent. Leaves opposite, simple, ovate, elliptical to oblong, 7.5–30 cm × 2.5–12.5 cm, base cuneate, apex short- to long-acuminate, margin serrate-dentate, variably pubescent; petiole 1.5–6 cm long; stipules absent. Inflorescence a terminal, erect panicle, 4–15(–20) cm long and up to 25 cm in diameter, many-flowered, axes minutely pubescent. Flowers bisexual, actinomorphic, pedicel 3–8 mm long, calyx tube campanulate, 2–4 mm long, with 5–6 teeth; petals valvate, 5–6(–7), 5–10 mm long, oblong, acute or obtuse, light to dark blue; stamens diplo–(poly-) stemone; ovary semi-inferior, 1-locular, many-ovuled, styles 3–5. Fruit a globose berry, about 5 mm in diameter, with calyx and styles persistent, blue.



Dichroa febrifuga Lour. – 1, leafy shoot; 2, inflorescence; 3, detail of infructescence; 4, roots.

Growth and development *D. febrifuga* can be found flowering and fruiting throughout the year.

Other botanical information Some prefer to retain the family of *Saxifragaceae* s.l. including the tribe *Hydrangeae*, whereas others prefer *Hydrangeaceae* as a separate family. *Dichroa* is part of the tribe *Hydrangeae* or the family *Hydrangeaceae*, respectively. *Dichroa* very much resembles *Hydrangea*. However, the outer flowers of the panicle are not sterile and the fruit is a berry, not a capsule.

Dichroa is a small genus containing about 12 species, ranging from mainland South-East Asia southward to the Pacific islands. However, most species are rather restricted in their distribution. Six species are known from China and Indo-China; 3 are confined to west and north-west New Guinea; 2 are endemic in the Philippines. Only *D. febrifuga* is widely distributed in South-East Asia. In this treatment *D. febrifuga* is considered in the broad sense. A wide range of variation exists in the size of the plants, the shape, texture and dentation of the leaves, and the number of flowers per cluster. Large-flowered plants in cultivation in Hong Kong, were raised to species rank by Hunt. Large-flowered *D. sylvatica* from Java was reduced in synonymy by van Steenis.

Ecology *D. febrifuga* is found in forest undergrowth and forest borders, in montane forest or preferably in moist localities, e.g along rivers and streams at (200–)700–2000 m altitude.

Propagation and planting *D. febrifuga* can be easily propagated by cuttings from young branches.

Harvesting The drug is collected mostly from wild plants of *D. febrifuga*. To harvest the roots 3–4-year-old plants are dug up. Leafy tops are simply plucked.

Yield Root material of *D. febrifuga* from China contained 0.08–0.8% crude alkaloids of which 55% consisted of febrifugine and isofebrifugine at a ratio of 6:1–1:1. The crude alkaloid content of roots from India was 0.05% of which 63% febrifugine and 2% isofebrifugine; the leaves contained 0.01–0.02% total alkaloids of which 50% was febrifugine.

Handling after harvest The roots of *D. febrifuga* are separated from the shoots, washed and dried in the sun, either whole or finely chopped. Leafy tops can be simply dried for future use.

Genetic resources and breeding *D. febrifuga* has a large area of distribution and does not seem to be at risk of genetic erosion. Especially the large flowered plants are locally cultivated. There are no known breeding programmes of *D. febrifuga*.

Prospects Several alkaloids isolated from *D. febrifuga* show interesting pharmacological effects, especially concerning malaria and heart-arrhythmias. More research is needed, however, for example in the field of toxicology, to evaluate the possibilities of these compounds or their semisynthetic derivatives in future medicine.

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Other selected sources 74, 135, 215, 264, 312, 407, 458, 739, 786, 788, 1027, 1079.

J.L.C.H. van Valkenburg

Dichrocephala integrifolia (L.f.) O. Kuntze

Rev. Gen. Pl. 1: 333 (1891).
COMPOSITAE
$2n = 18$

Synonyms *Dichrocephala latifolia* (Lamk) DC. (1833), *Dichrocephala bicolor* (Roth) Schltdl. (1852).

Vernacular names Indonesia: jukut meurit (Sundanese), wedahan, seprah (Javanese). Papua New Guinea: taka (Wapanamanda, Enga), dekemp (Mt. Hagen, western highlands), dakumadan (Duman, Simbu). Cambodia: klét choum thom, kombet choun. Laos: cho ké (Meos, Xiengkhouang). Thailand: phakchee doi (Chiang Mai), saap haeng, haeng khong (Phetchabun). Vietnam: rau chu[oo]i, l[uw][owx]ng s[ows]c l[as] nguy[ee]n.

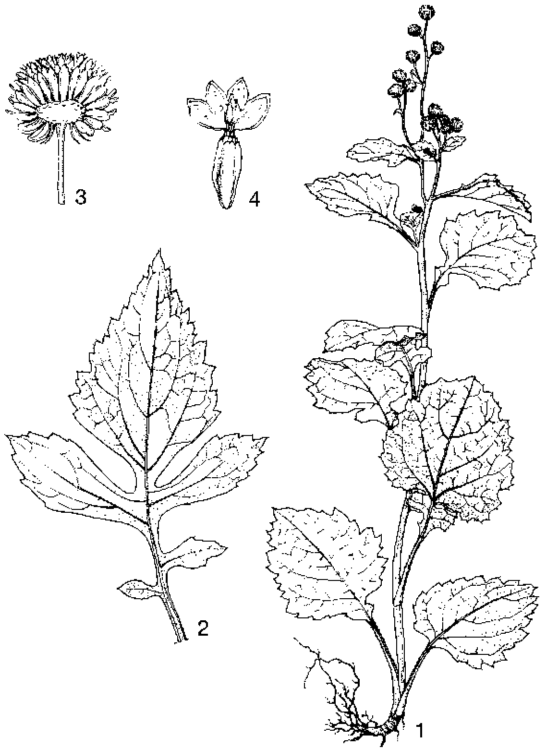
Origin and geographic distribution *D. integrifolia* occurs in tropical and subtropical Africa, India, Indo-China, southern China, Thailand, and throughout Malaysia, Indonesia (Kalimantan excluded) and the Philippines to Australia and the Pacific. It is naturalized in Italy and Turkey.

Uses In Indonesia, decoctions of the flower buds of *D. integrifolia* are used as a sudorific and diuretic. In Papua New Guinea, the crushed leaves are used to treat ulcers and swellings. They are also reported to have antiviral activity. In Cambodia, the young shoots are externally applied as a poultice in treating blennorrhoea, leucorrhoea, and the stings or bites of insects, spiders or scorpions. In Kenya, the plant juice is used against filariasis, whereas in Tanzania and Uganda, the dried and powdered plant is applied to dress old infected wounds.

Production and international trade *D. integrifolia* is used only locally and has no importance in international markets.

Properties The flavonoids kaempferol 3-O-rutinoside and quercetin 3-O-rutinoside (rutin), and 3 isomers of dicaffeoyl quinic acid have been isolated from a methanol extract of *D. integrifolia*. The methanol extract of the entire plant shows weak antibacterial activity.

Description An annual, erect or spreading, puberulent and aromatic herb, 20–60(–100) cm tall, often already branched at the base and rooting at the nodes. Leaves alternate, ovate to lanceolate, 4–8(–13) cm × 2–3(–5) cm, very variable, simple or pinnatifid, terminal lobe large, broadly ovate, and coarsely toothed, lateral lobes 1 or 2 pairs, obovate or oblong, dentate; petiole narrowly winged, 0–6 cm long. Inflorescence a small head, several to-



Dichrocephala integrifolia (L.f.) O. Kuntze – 1, flowering plant; 2, pinnatifid leaf; 3, head in cross-section; 4, disk flower with opened corolla.

gether in a lax axillary or terminal panicle, peduncle up to 2.5 cm long, involucral bracts 2-seriate, lanceolate, 5 mm long, head rounded, 3–5 mm across. Flowers all tubular but different in size, marginal flowers female, numerous, slender, corolla 0.5 mm long, the apex obscurely 5-dentate, greyish-white to purplish, disk flowers bisexual, with short-tubular corolla, 1 mm long, lobes 3–4, greenish to yellowish-white, marginal and disk flowers differently coloured in one head; stamens 4, loosely coherent, forming a tube; ovary inferior with 1–2 awns; style elongated, with a flattened stigma. Fruit a small subcylindrical achene, 1 mm long, 2-ribbed at the edges and smooth. Pappus absent or 1–2 awns persistent. Seedling with epigeal germination; hypocotyl short, cotyledons broadly ovate to broadly elliptical, 2 mm × 2.5 mm, petiolate, base obtuse, apex apiculate, glabrous; epicotyl virtually absent; first leaves alternate, petiolate, (broadly) ovate, base obtuse, margin entire or with a few teeth, apex apiculate, glabrous.

Other botanical information *Dichrocephala* comprises approximately 4–5 species, found in the Old World tropics. It belongs to the large tribe *Astereae*, and is close to *Grangea*, but is distinguished from that genus by the absent pappus, and the elongate stigma, with a flat top.

Ecology *D. integrifolia* is a common weed of fallowed rice fields and moist waste places. It is also found on old clearings, along trails, drainage ditches and roads, especially on clay soils. In Java it occurs sometimes abundantly on humid, mostly hard or stony soils. In Africa it is found in grassland and semi-shaded areas, and in Kenya it is grazed by cattle. *D. integrifolia* grows mainly between 500–3000 m altitude in the tropics. The flowering time is between April and November in regions with a cool and/or dry season, otherwise it flowers throughout the year. The fruit of *D. integrifolia* is hydrochorous.

Diseases and pests *Pseudocercospora dichrocephalae* causes a leaf spot disease in *D. integrifolia* in Taiwan. *D. integrifolia* is also a host plant of the sucking insect *Helopeltis antonii*.

Harvesting The leaves and flower heads of *D. integrifolia* are collected from the wild whenever needed.

Genetic resources and breeding *D. integrifolia* is a widespread weed of minor importance, which does not seem to be at risk of genetic erosion. No germplasm collections or breeding programmes are known to exist.

Prospects *D. integrifolia* contains flavonoids like rutin, which display interesting pharmacological activities. Rutin is known as a 'capillary protectant', the substance is used to treat capillary and venous disorders. Evidence of its value, however, remains somewhat inconclusive.

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Indonesia. Balai Pustaka, Jakarta, Indonesia. pp. 584–585.

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G.H. Schmelzer

Dioscorea L.

Sp. pl. 2: 1032 (1753); Gen. pl. ed. 5: 456 (1754).

DIOSCOREACEAE

$x = 10$ (Old World); *D. deltoidea*: $2n = 20$, 40; *D. japonica*: $2n = 40$, 80; *D. prazeri*, *D. zingiberensis*: $2n = 20$

Major species *Dioscorea deltoidea* Wallich ex Kunth, *D. prazeri* Prain & Burkill, *D. zingiberensis* C.H. Wright.

Vernacular names Yam (En). Igname (Fr). Indonesia: uwi (Javanese), huwi (Sundanese). Malaysia: ubi. Papua New Guinea: yam. Philippines: yam, ubi.

Origin and geographic distribution *Dioscorea* probably originated in the Far East, but spread in early times to the Old and New World, and no overlap occurs now between the species of both worlds. About 600 species are known, 850 according to some authors, distributed through the tropics and warm temperate zones of the world. About 60 species are cultivated or gathered for their edible tubers, and of the 60 *Dioscorea* species occurring in South-East Asia, about 8 have medicinal use or are poisonous.

Uses The rhizomes or tubers of many *Dioscorea* spp. are used in traditional medicine, and some wild species, such as *D. deltoidea*, *D. prazeri*, *D. tokoro* Makino and *D. zingiberensis* from the Old World, and *D. floribunda* M. Martens & Galeotti from Central America and Venezuela, are commercially exploited because they contain diosgenin, which can be used as a precursor in the production of oral contraceptives, sex hormones and corticosteroids. In most of their distribution area, *D. deltoidea*, *D. prazeri* and *D. zingiberensis* have no local medicinal use, but are collected or cultivated for cash income.

In India, the tubers of *D. deltoidea*, *D. prazeri* and *D. tokoro* are used as soap, in particular for washing the hair to kill lice, and also for washing silk and wool. The flesh of the rhizome of *D. prazeri* is very poisonous and thus also used as fish poison. The tuber of *D. zingiberensis* is used by the Chinese as a cooling medicine.

In Indonesia and China, the grated tuber of *D. hispida* Dennst. is applied for beginning leprosy, skin diseases and corns, calluses and whitlow of feet. It is also applied on syphilitic sores, together with the tuber of *Smilax china* L. In Thailand, slices of the tubers of *D. hispida* are also applied topically to relieve abdominal spasms and colic, and to remove pus from wounds. In the Philippines and China, the tuber is used for arthritis and rheumatism, and for cleaning maggot-infested wounds of animals. The tuber is considered very poisonous, and used for stupefying fish or poisoning arrowheads. A piece of tuber the size of an apple is sufficient to kill a man in 6 hours, the first effects being a feeling of discomfort in the throat, which intensifies to a burning sensation, followed by giddiness, the vomiting of blood, a sensation of suffocation, drowsiness and exhaustion.

In Indonesia and Peninsular Malaysia, the white rhizomes of *D. pyrifolia* Kunth and the pink to red rhizomes of *D. laurifolia* Wallich ex Hook.f. are collected and eaten, but also used for poulticing sores, swellings and insect bites. In Indonesia, the stems of *D. pyrifolia* are used for tying purposes. *D. piscatorum* Prain & Burkill from the hills of Peninsular Malaysia, Sumatra and Borneo, has rhizomes with dark red flesh, which are very poisonous and are not eaten by wild pigs or other animals. Man is said to eat them roasted, as heat destroys the poison, but if boiled or inadequately prepared they remain bitter. In Peninsular Malaysia, the rhizomes are used to stupefy fish. In the Philippines, the tuber of *D. filiformis* Blume is eaten with the peel, or a decoction is drunk, to cure malaria.

In Korea, China, Japan and Indo-China, the tuber of *D. japonica* Thunb. is taken as a tonic and used for the treatment of indigestion, intestinal troubles like dysentery and diarrhoea, and night disturbances of the urogenital system. The mucilage from the freshly crushed tuber is applied to treat intestinal pain caused by stoppage or inflammation; the dried tuber is used as an emollient for boils and abscesses.

In Japan, China and Vietnam, the tuber of *D. tokoro* is used as a fish poison, as a mild diuretic in treating arthritis and rheumatism, and as a strong resolvent of blood clots.

Many *Dioscorea* spp. are primarily cultivated for their edible tubers, but some of them have some secondary use as medicinals. Often the tubers or rhizomes contain the poisonous alkaloid dioscorine, and may therefore only be eaten after having been soaked in running water, boiled or baked. The toxic substances from the tubers can cause palpitations, nausea, vomiting, throat irritations,

sweating, blurred vision and unconsciousness.
In China, the tubers of both cultivated and wild *D. bulbifera* L. are considered bitter, cooling, diuretic and antidotal. They are used for boils, swellings, sore throat and snakebite. In the Philippines, the powder obtained from scraping the bulbils is valued for rubbing on abdominal oedema. In Papua (Indonesia), the plant is used to treat diarrhoea. In Indo-China, the tuber of *D. alata* L. is eaten during convalescence from phthisis, kidney and spleen disorders. In Colombia, the leaves are applied as poultices on pimples and tumours, and in baths to relieve various skin irritations and bites from centipedes. The starch from the tuber is applied as a paste to haemorrhoids. In Costa Rica, an infusion of the leaves is drunk as a sudorific, febrifuge and digestive stimulant. The tuber of *D. hispida* is also eaten as a famine food, after boiling properly as careless washing can cause poisoning. *Piper lolot* DC. is believed to be a counter-poison for *D. hispida*.

Production and international trade In Peninsular Malaysia and India, the tubers of *D. japonica* and *D. zingiberensis* are imported from China. In China and India, the tubers of *D. deltoidea*, *D. prazeri* and *D. zingiberensis* are collected or cultivated for the pharmaceutical industry, but statistics are scarce. In China in 1995, about 35 000 t of *D. zingiberensis* tubers were collected for diosgenin extraction.
In Mexico, the export of *Dioscorea* spp. as a source of steroid precursor, was important until a law was introduced allowing only extracts to be exported. The high cost of the fabrication of the extract caused manufacturers to focus on β-sitosterol, the by-product of vitamin E production.

Properties In general, the rhizomes, tubers, or sometimes the seeds or the whole plants of about 50 *Dioscorea* species contain tannins, saponins and alkaloids. However, only about 20 species contain enough diosgenin (at least 2%) to be of economic importance, e.g. *D. deltoidea*, *D. prazeri*, *D. tokoro*, *D. zingiberensis*. *Dioscorea* spp. containing high levels of diosgenin and pennogenin are *D. composita* Hemsl. and *D. floribunda*, both originating from the New World.
The steroidal sapogenins isolated from medicinal *Dioscorea* have an additional ring added to the steroid backbone that makes them particularly similar to human sex hormones. Cortisone and hydrocortisone are two other important hormones that can be synthesized using diosgenin as starting material. They are used for the treatment of severe allergenic reaction, for arthritis and Addison's disease, caused by malfunction of the adrenal glands. In the rhizomes and tubers, diosgenin is present in the form of its glycosides: dioscin, gracillin, or both. Dioscin is composed of 2 molecules of L-rhamnose and 1 molecule of D-glucose while gracillin contains 2 molecules of D-glucose and 1 molecule of L-rhamnose. Diosgenin causes a general paralysis of the central nervous system.
The compound dioscorine is also present in *D. bulbifera* and *D. pentaphylla* L., and to a lesser extent in some races of *D. alata*. It has not been detected in *D. esculenta* (Lour.) Burkill.
The tubers of *D. deltoidea* contain, besides diosgenin, also the steroid glycosides deltoside, oligofurostanosides and deltonine, while the leaves contain deltofolin, an acylated spirostanol saponin.
Treatment of tomato and cucumber plants with furastonol glycosides obtained from cell cultures of *D. deltoidea* decreased their susceptibility to infection by the nematode *Meloidogyne incognita*, while the fecundity of the nematode decreased 5-fold, females were smaller and the sex ratio shifted towards an increase in males.
The tubers of *D. hispida* contain the toxic isochinuclidine alkaloid dioscorine and also dioscoricine. The first compound is bitter and behaves like picrotoxin, producing paralysis of the central nervous system.
The rhizomes of *D. prazeri* also contain prazerol, prazerigenin-D-glycosides, prazerigenin A-3-O-α-L-rhamnopyranosyl-(1->6)-β-D-glucopyranoside and prazerigenin A-3-O-β-D-glucopyranoside. The tubers of *D. japonica* contain allantoin, arginine and choline, and also the glycans dioscoran A–F, which exhibit significant hypoglycaemic activity in normal and hyperglycaemic mice. A methanol extract of the aerial parts, containing (+)-β-eudesmol and paeonol, showed a suppressive, antimutagenic effect on umu gene expression of the SOS response in *Salmonella typhimurium* TA1535/pSK1002 against the mutagen furylfuramide.
The rhizomes, female flowers and seeds of *D. tokoro* also contain other steroid saponins and their genins: dioscin, yononin, tokoronin and kogagenin.

Adulterations and substitutes Fenugreek seed (*Trigonella foenum-graecum* L.) and the related *T. corniculata* (L.) L. contain 0.5–2% diosgenin and small amounts of similar steroids, and could therefore be a useful commercial alternative source of diosgenin. *Derris elliptica* (Wallich) Benth. is a more stable substitute for *Dioscorea* *piscatorum* as a fish poison, and also as a pesticide to kill parasitic worms in rice.

Description Dioecious perennial plants, with rhizomes, or with large and fleshy tuber(s), lignified or renewed annually, varying greatly in number, size and form; roots thick and unbranched or thin, fibrous and branching, sometimes short and spiny; stems climbing and twining, 2–12(–40) m long, tough, often woody at the base and winged with longitudinal ridges. Leaves usually alternate, simple, base cordate, apex acuminate, pointing downwards, palmately veined, or palmately compound with 3–5 lobes or leaflets pinnately veined; petiole with a pulvinus at both sides. Axillary buds often more than one per axil, arranged vertically, with the youngest lowest, sometimes developing into a bulbil. Inflorescence axillary, unisexual, racemose or spike-like. Male flowers usually small, green, opening slightly at anthesis; perianth in 2 whorls of 3 segments; stamens 6, all fertile in South-East Asia. Female flowers usually produced in much smaller numbers; perianth lobes fleshy, opening more widely at anthesis; ovary 3-locular, inferior; stigmas 3. Fruit a 3-locular capsule, 1–3 cm long, 3-winged or strongly angled, dehiscent. Seed flattened, margins partly or completely winged.

Growth and development Pollination of *Dioscorea* is effected by small, night-flying insects. The pollen is glutinous and often sweetly scented.

Other botanical information The taxonomy of *Dioscorea* is confusing, because the group is very closely knit, and a general review is missing. A good review needs to include in order of importance: underground parts, direction of twining, wings, colour and shape of the seeds, position of the capsules, degree of segregation of male and female flowers, and characters such as hairs and glands.

Ecology Most *Dioscorea* are confined to the tropics and do not tolerate frost, although some are montane and are tolerant to low temperatures. In order to produce good tubers, *Dioscorea* spp. need fertile, loamy, and well-drained soils, as they do not tolerate waterlogging.

Propagation and planting Many wild *Dioscorea* reproduce by seed, and also vegetatively by rhizomes or tubers and/or bulbils. The seeds are dispersed by wind. Bulbil dormancy is most pronounced immediately after harvest and declines with time in storage. *D. deltoidea* exhibits no dormancy when planted in evergreen tropical regions, and continues growing and flowering throughout the year. *D. deltoidea* is best propagated vegetatively, through tubers or bulbils, as the plants grow faster and yield more diosgenin.

Stem cuttings of *Dioscorea* do not normally develop adventitious roots, but in some species a mass of tuberous tissue, or small bulbil-like organs, develop in the leaf axils of the cuttings and may be used for propagation. This method is not used in economic production, although it is used for *D. floribunda* grown for diosgenin.

In vitro production of active compounds Tissue cultures of several *Dioscorea* spp., but especially *D. deltoidea*, were tested for their diosgenin content. *D. deltoidea* contained (0.2–)1.6–3.8(–8)% diosgenin in suspension cultures, and (0.3–)1–2.5% in callus cultures, *D. zingiberensis* contained 0.4% diosgenin in callus cultures, *D. composita* contained 0.02–0.06% diosgenin in callus or suspension cultures, and *D. floribunda* contained 0.1–1.3% diosgenin in callus cultures. *D. deltoidea* cells grown in continuous culture, showed a time-dependent concentration of furostanol glycosides, and when the concentration approached a maximum value, cell viability declined rapidly.

Husbandry *Dioscorea* has specific growth requirements in order to ensure the production of a high level of diosgenin in tubers or rhizomes. Waterlogging is harmful and too high soil temperatures are disadvantageous. *D. zingiberensis* accumulates most diosgenin when grown in the (semi-)shade, at a rainfall level of 800–900 mm/year, and a mean annual soil temperature of 15–17°C.

In Pakistan, pieces of the tubers of *D. deltoidea* of 7 cm long and weighing 25–30 g were planted under different growth conditions and time of season, in thin forest and left for 2–10 years. Tuber yield increased up to 6 years after planting, and decreased afterwards. In India, monsoon planting gave more sprouts and a higher yield than autumn planting and the application of N and P fertilizer increased yields. In another experiment, maximum tuber yield was obtained with a low level of nitrogen and high levels of potassium and phosphorus, and no significant difference in percentage of diosgenin yield was obtained. In India, *D. deltoidea* was successfully grown on ridges, with shade provided by *Sesbania aegyptiaca* (Poir.) Pers., in sandy loams.

In India, diosgenin content in the tubers of *D. deltoidea* was found to be positively correlated with leaf width and negatively correlated with petiole length, both under natural conditions of growth and under cultivation.

In India, several field trials were effected at 100, 500, 1000 and 1500 m altitude with 2-year-old plants of *D. prazeri* and *D. composita*. Removal of flowers and fruits resulted in a higher diosgenin content in the tubers as was the case with foliar applications of KNO_3, P, Mg+Mn+B, gibberellic acid or indole acetic acid. Application of a base fertilizer with N and K inhibited diosgenin formation. Altitude did not have any effect on diosgenin content between 100 and 1000 m, but it increased at 1500 m altitude.

Diseases and pests Diosgenin content in tubers of *D. composita*, *D. floribunda* and *D. prazeri*, infected by the tuber rot-causing fungus *Fusarium solani*, increased during the early phase of infection and then decreased with incubation time. Nematodes, like yam nematode (*Scutellonema bradys*), *Meloidogyne* spp. and *Pratylenchus* spp. cause considerable damage in *Dioscorea*. *D. japonica* is attacked by yam mosaic virus.

Harvesting The tubers of wild and cultivated *Dioscorea* are harvested manually at the end of the growing season.

Yield In India, diosgenin content per 100 g of dry tuber or rhizome was 3.1% in *D. composita*, 1–5(–8)% in *D. deltoidea*, 4.7% in *D. floribunda*, 2.6% in *D. mexicana* Scheidw., 2–3% in *D. prazeri*, 6–16% in *D. zingiberensis* and 1% in the rhizome and seeds of *D. tokoro*. Other *Dioscorea* spp. generally have a lower yield. In comparison, *Costus speciosus* Sm. yields about 1.6% diosgenin.

In India, yields of up to 50 g of fresh tubers per *D. deltoidea* plant are obtained in temperate Kashmir, but in tropical Bangalore, improved clones yield 1.25 kg of fresh tubers per plant, containing 5–8% diosgenin on dry weight basis, while 3% is considered a reasonable level for economic processing. In another experiment, fresh tuber weight was 1.8–2.3 kg/plant after 2 years, yielding 4–6% diosgenin. Fresh *D. zingiberensis* tubers yield 3% diosgenin on average in China, the lowest levels being in the south and highest in the north.

Handling after harvest Tubers of *D. japonica* are dried and then sliced in thin pieces before transporting. The optimal time for fermentation of the tubers of *D. deltoidea* is 48 hours as this increases the diosgenin content by about 45%. When storing tubers and bulbils of *D. japonica*, dormancy is prolonged for 500 days at 20°C and by application of gibberellic acid at 100 μM. The extraction procedure for diosgenin normally begins with a mineral acid treatment to hydrolyze the glycosides. After filtering, the insoluble fraction is neutralized, washed and treated with petroleum ether or toluene, which extracts diosgenin.

Genetic resources and breeding Due to heavy collection in their natural habitat in India for the pharmaceutical industries, the natural resources of *D. deltoidea* and *D. prazeri* are being rapidly depleted. Immediate conservation should receive high priority. Plantations of diosgenin-producing *Dioscorea* could prevent this over-collection. Large germplasm collections of edible *Dioscorea* exist in West Africa and Central America. A small collection of *D. japonica* germplasm is kept in Mie-kene (Japan). Breeding programmes of *Dioscorea* spp. for diosgenin production exist in India, China, Japan, Vietnam and Russia.

Prospects Research on different *Dioscorea* spp. to elucidate the composition of tubers and bulbils for their diosgenin and sapogenin content is needed. Although many diosgenin-producing species do not grow naturally in the Malesian region, they could well be cultivated there as a cash crop.

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Selection of species

Dioscorea deltoidea Wallich ex Kunth

Enum. pl. 5: 340 (1850).

Synonyms *Dioscorea nepalensis* Sweet (1830).

Vernacular names Vietnam: c[ur] c[of]i.

Distribution From Pakistan, the Himalaya region, northern Vietnam to central China; cultivated in Vietnam and Russia.

Uses In most of its distribution area, *D. deltoidea* has no local medicinal use, but is sold for cash income. The tuber is used for soap in India, in particular for washing the hair to kill lice.

Observations A long twining vine, stem almost glabrous, slightly angular, bulbils present, tuber large, horizontal, almost superficial, branched, flesh white, soft; leaves alternate, 6–8 cm × 5–6 cm, often narrower in the middle, lobes standing out, apex acuminate, glabrous above, long, stiff hairs underneath, petiole long; spikes pendulous; capsule reflexed, 20 cm × 14 mm, wings larger at apex than at base. In India, *D. deltoidea* grows in forest areas at 1400–3000 m altitude. It grows at a higher altitude than *D. prazeri*, has shorter leaf blades and longer petioles, and requires less rainfall.

Selected sources 116, 130, 257, 267, 311, 328, 407, 457, 504, 525, 739, 788, 806, 927.

Dioscorea japonica Thunb.

Nova Acta Soc. Sci. upsal. 4: 39 (1783).

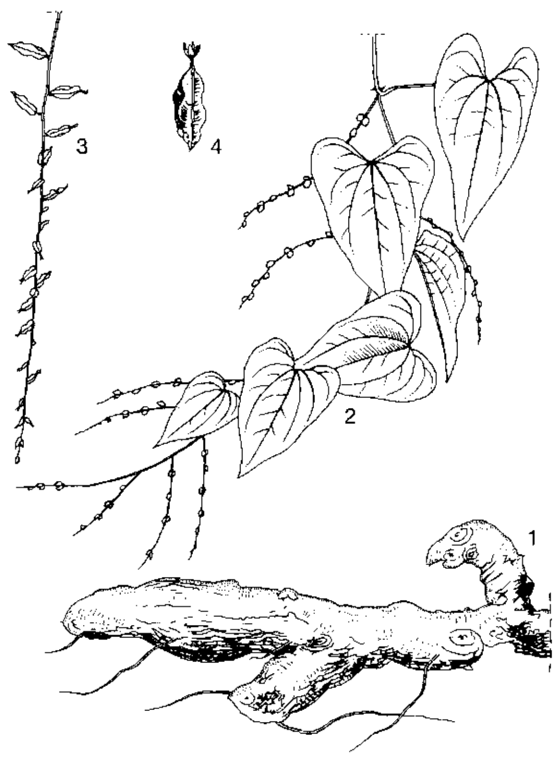
Vernacular names Japanese yam (En). Igname du Japon (Fr). Vietnam: t[uwf] nh[aaj]t l[ar]n.

Distribution From China, Japan, Korea, to Taiwan, Vietnam and Thailand; cultivated in Japan, China and Uzbekistan.

Uses In Korea, China, Japan and Indo-China, the juice of the tuber is used to treat indigestion, intestinal troubles including dysentery and diarrhoea, and night disturbances of the urogenital system as well as spermatorrhoea. The mucilage from the freshly crushed tuber is applied to treat intestinal pain caused by stoppage or inflammation. The tuber is eaten in China and Japan.

Observations A twining vine with slender stems, loosely branched, bulbils present, tuber cylindrical, large, fleshy; leaves opposite, rarely alternate, triangular or ovate-triangular, 5–10 cm × 2–5 cm, apex acuminate, glabrous, 5–9-veined, petiole 2–3 cm long; spike with crowded flowers, male spikes 3–5 together, erect, peduncle short, rudimentary pistil present, female spikes solitary, pendulous, staminodes present; capsule broadly ovoid, 1.4–2 cm long, 1.5 cm in diameter. *D. japonica* occurs in hilly bushland and along streams, and flowers in August in Japan.

Selected sources 135, 311, 605, 679, 750, 753.



Dioscorea zingiberensis C.H. Wright – 1, tuber; 2, flowering stem; 3, infructescence; 4, fruit.

Dioscorea prazeri Prain & Burkill

Journ. As. Soc. Beng., Suppl. 2: 73 (1904).

Synonyms *Dioscorea deltoidea* Wallich var. *sikkimensis* Prain (1936).

Vernacular names Thailand: man khao, man mia (south-western).

Distribution From the eastern Himalayas of India, through Nepal, Bhutan, north Bangladesh, Burma (Myanmar), Thailand and further to the northern edge of Peninsular Malaysia; cultivated in India.

Uses The rhizome of *D. prazeri* is used for soap in India, in particular for washing the hair to kill lice. The flesh of the rhizome is very poisonous and also used for stupefying fish.

Observations A twining vine, up to 4 m long, stem smooth, ridges very indistinct, bulbils rare, rhizome short, stout, branching, grey-brown to nearly black, flesh white; leaves alternate, 12(–20) cm long and broad, base deeply cordate, 7–11-veined, both surfaces shining, petiole half as long as the blade; staminate branches 1–3 together, cymes 1–3 mm apart, bracts broadly ovate and abruptly long-acuminate, narrow wings descending from the bracts, female branches solitary, up to 30 cm long, pendulous, about 20-flowered; capsules 10–15 mm long, satiny chestnut brown, with broadly semi-cordate or sub-rhomboidal wings, uneven; seeds ovate-oblong, reddish at maturity, wing pale. *D. prazeri* grows in temperate regions, ascending the mountains of the Himalaya up to 1600 m altitude.

Selected sources 168, 311, 722, 806, 869.

Dioscorea zingiberensis C.H. Wright

Journ. Linn. Soc., Bot. 36 (250): 93–94 (1903).

Vernacular names Vietnam: c[ur] m[af]i g[uwf]ng, t[uwf] g[uwf]ng.

Distribution China and Vietnam.

Uses The Chinese use the tuber as a cooling medicine.

Observations A twining vine, stem rigid, glabrous, tuber large, cylindrical, branched, roots with spiny appearance; leaves alternate, ovate-lanceolate, 5–8 cm × 4–5 cm, primary veins 7, petiole 3–8 cm long, short triangular spines at base; spikes elongated, pendulous, male spikes branched, female spikes simple; capsule about 1.5 cm long, wings irregularly lobed. *D. zingiberensis* occurs along banks of larger rivers in open forest, at 900–1000 m altitude.

Selected sources 311, 328.

R.C.K. Chung

Dodonaea viscosa Jacq.

Enum. syst. pl.: 19 (1760).

SAPINDACEAE

$2n = 28, 30, (32)$

Synonyms *Dodonaea burmanniana* DC. (1822), *Dodonaea repanda* Schumach. & Thonn. (1827), *Dodonaea candolleana* Blume (1847).

Vernacular names Hop bush (En). Indonesia: cantigi (Sundanese), kayu mesen (Javanese), sikil (Malay). Malaysia: kayu berteh, serengan laut, gelam paya. Papua New Guinea: lokai (Wapenamanda, Enga Province), kelne (Minj, Western Highlands Province), ioia (Erave, Southern Highlands Province). Philippines: kalapinai, tabau (Tagalog), tubu-tubu (Cebu Bisaya). Thailand: chumhet le (peninsular), mai pek. Vietnam: ch[af]nh r[af]ng, r[uf] r[if].

Origin and geographic distribution *D. viscosa* has a pantropical distribution and is found throughout South-East Asia.

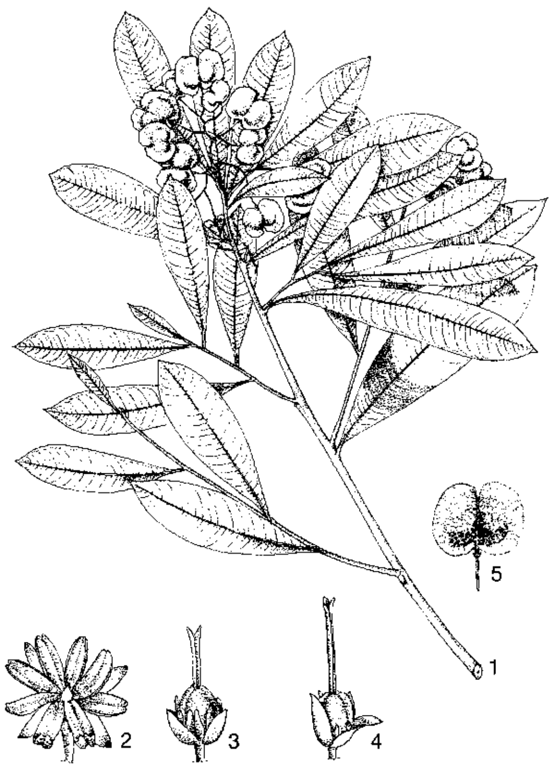
Uses In various parts of the world, decoctions of the leaves, fruits, bark or wood of *D. viscosa* are employed as a febrifuge. Externally the fresh, dried or powdered leaves are applied as a poultice, apparently for their astringent properties, to treat wounds, swellings, burns and to ripen boils, sores and ulcers. Likewise, decoctions of bark and leaves are included in herbal baths for their astringent properties. In a broad sense preparations are employed largely as analgesic, anti-inflammatory, spasmolytic, antiviral and hypotensive agents. Various gastro-intestinal disorders, skin conditions and healing of wounds are managed with these preparations. In Indonesia, wood powder is taken with water as a remedy for flatulence. In the Philippines, a decoction of the bark is used as an astringent in humid eczema and for simple ulcers. Throughout South America a decoction of the leaves is applied in hot compresses on abscesses and boils. In Papua New Guinea a decoction of the leaves or bark is drunk to treat diarrhoea or dysentery. The juice from heated leaves is rubbed on nipples of breastfeeding women as a galactagogue. In Fiji, the plant is used as a remedy for constipation and to treat sore eyes. A decoction of fresh leaves is taken by pregnant women to overcome difficulties in parturition. In Australia, the plant is used in traditional Aboriginal medicine. As an analgesic, the leaves are chewed without swallowing to alleviate toothache. The chewed leaves are poulticed on wounds caused by venomous stingfish or stingray. A cooled infusion is sponged on the body as a febrifuge. Branches with green leaves are put on a fire to produce smoke. A baby is held in the smoke for a short time to promote good health. In Mexico, the bitter leaf decoction is taken to relieve fever, colic, gout and rheumatism, and as a treatment for venereal diseases. In dry frost-free regions in Australia and the United States, the plants are frequently used in amenity and roadside plantings. They withstand drought, salt, wind and pollution. In arid zones the species is used as a windbreak or hedging plant, responding well to light clipping. It is also used to bind sandy soils and reclaim marshland. The wood is very hard, heavy and durable and is sought after as a utility timber. However, the usually small dimensions more or less restrict its use to firewood. It also makes an excellent charcoal.

Production and international trade The medicinal use of *D. viscosa* is of local importance only.

Properties Several parts of *D. viscosa*, e.g. the fruits, seeds and stems contain a mixture of saponins, which in the case of the seeds is sometimes called dodonin. The seeds also yield the

saponins dodonosides A and B which have R_1-barringenol as the aglycone. The saponin mixture in general exhibits anti-exudative, phagocytosis-enhancing and molluscicidal activity.
The plant also contains diterpenoid acids based on the ent-labdane and ent-clerodane skeleton. Hautriwaic acid (containing the ent-clerodane bicyclic skeleton) is the primary example.
In addition, a group of shikimate-derived secondary metabolites were isolated from *D. viscosa*, which includes compounds such as the coumarin fraxetin, the lignocoumarins cleomiscosin A and B and a vast array of flavones (from the seeds, bark, leaves and flowers) of which a significant number contain methoxyl groups at C-3 and C-6.
Aqueous and alcoholic extracts were found to exhibit cardiac depressant and coronary-constricting properties and spasmolytic activity on smooth muscle and intestine preparations in vitro. The alcoholic extract has sedative action on the virgin guinea-pig uterus and a hypotensive effect, unaffected by atropine. Both extracts possess slight anthelmintic activity, and the alcoholic extract exhibits antibacterial properties.
The aqueous and ethanolic extracts obtained from the leaves showed hypotensive properties. In the Langendorff isolated rabbit heart, administration of the alcoholic extract (0.1 ml of a 2 g/ml solution) or the aqueous extract (0.3 ml of a 2 g/ml solution) showed temporary reduction of the contractile force of the heart. Coronary perfusion rate was reduced by 41% on injection of 0.05 ml of the ethanolic extract (2 g/ml) and by 43% with 0.3 ml of the aqueous extract (2 g/ml). In the isolated frog heart, the inhibitory activity was not affected by pretreatment with atropine. Injection of 0.2 ml of a 2 g/ml solution of the ethanolic extract in the femoral vein of cats induced a slight drop in blood pressure; the aqueous extract had no effect. Both extracts (0.2 ml and 0.5 ml of a 2 g/ml solution, respectively) caused a marked relaxation of rat- and rabbit duodenum preparations and of the guinea-pig ileum in vitro. Furthermore, the ethanolic extract counteracted the spasmogenic effects induced by barium chloride, acetylcholine and histamine.
In addition, the effect of a chloroform-methanol extract from the aerial parts was studied on the isolated rat and guinea-pig ileum. The extract was found to inhibit the spontaneous contraction of the intestinal smooth muscle in a concentration-dependent manner in the $1–10^4$ μg/ml range. The activity was associated mainly with four metabolites which were subsequently isolated and identified by bioassay-directed fractionations: sakuranetin and 6-hydroxykaempferyl-3,7-dimethylether (2 flavones) and hautrivaic acid and ent-15,16-epoxy-9-α-H-λ-13(16)14-diene-3-β,8-α-diol (2 diterpenes). All compounds elicited a concentration-dependent inhibition of the spontaneous and electrically-induced contractions of guinea-pig ileum. Sakuranetin and the ent-labdane inhibited the ileum contractions evoked by acetylcholine, histamine, and barium chloride. In addition, both substances were capable of relaxing contractions of the rat uterus in vitro, induced by Ca^{2+} in K^+-depolarizing solutions. These results suggest that sakuranetin and ent-15,16-epoxy-9-α-H-λ-13(16) 14-diene-3-β,8-α-diol produce an interference with the calcium metabolism in smooth muscle cells. The spasmolytic activity provides at least in part a pharmacological basis for the traditional use of the plant as an antispasmodic agent.
The isolated coumarin fraxetin has attracted some attention as an anti-oxidant. When administered to mice (25 mg/kg, 30 days), an increase in the activity of liver glutathione reductase and a decrease in the GSSG/GSH ratio were observed. Furthermore, fraxetin displayed analgesic properties in the acetic acid-induced writhing test in mice.
The crude methanol extract exhibits significant activity against the yeast *Candida albicans* and the bacteria *Bacillus subtilis*, *Escherichia coli*, *Pseudomonas aeruginosa* and *Staphylococcus aureus* at concentrations of 20 mg/ml. The essential oil extracted from the leaves and seeds furthermore exhibits inhibitory activity against the yeast *Saccharomyces cerevisiae* and the bacteria *Bordetella bronchiseptica* and *Staphylococcus aureus*.
An ethanolic extract of the leaves showed antibacterial activity against *Bacillus* spp., *Corynebacterium diphtheriae*, *Escherichia coli*, *Micrococcus* spp., *Salmonella* spp. and *Sarcina lutea*.
Using the wheat rootlet growth inhibition assay, *D. viscosa* showed a concentration-related growth inhibition of wheat rootlets. In addition, various extracts of *D. viscosa* show insecticidal activity against the cotton leafworm *Spodoptera littoralis*; the hexane extract being most effective.

Description A dioecious or polygamodioecious, spreading, dense or erect, multi-stemmed shrub to single-stemmed small tree, 1.5–5(–8) m tall trunk with a diameter up to 20 cm; branches spreading or erect. Leaves alternate, simple, elliptical to obovate, 5–15 cm × 2.5–4 cm, thin, base decurrent into petiole, apex rounded, entire, smooth, veins 4-8 mm apart, ending free; stipules absent. Inflores-



Dodonaea viscosa Jacq. – 1, fruiting twig; 2, male flower; 3, bisexual flower; 4, female flower; 5, fruit.

cence an axillary or terminal panicle, 3–3.5 cm long, laxly and widely branched, with 12–15 flowers. Flowers male, female or hermaphrodite, occurring single per specimen or usually in various mixtures; sepals (3–)4, about 2.7 mm × 1.5–1.8 mm, scar under fruit strongly lobed; petals absent; stamens 5–7, scars distinct in fruit; ovary 2(–3)-locular, style present, stigma slightly lobed. Fruit a reniform-cordate, inflated, winged, septifragal capsule, 8–12 mm × 11–16 mm, thin, yellowish to light brown, very sparsely glandular, smooth, glabrous. Seed subglobular, about 2.5 mm in diameter, attached to swollen placenta, smooth, black. Seedling with epigeal germination; hypocotyl 8–16 mm long; cotyledons lanceolate, acute, glabrous; epicotyl 0.5–1.5 mm long; first 3–4 leaves alternate, simple, sessile.

Growth and development *D. viscosa* is a species with 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 under arid conditions. *D. viscosa* flowers and fruits throughout the year. Pollination is probably by wind in the absence of any factual observations, although a considerable amount of pollen has been found in honey and pollen load samples of the bee *Apis florea* in India. Likewise, dispersal of the broad-winged fruits is enhanced by wind; floating on the water is another option.

Other botanical information *Dodonaea* comprises about 65 species, mainly restricted to Australia, 3 species occur in Malesia. *D. angustifolia* L.f., another species with a worldwide distribution, is often confused with or considered to be a synonym of *D. viscosa* or recognized at subspecies level only. *D. angustifolia* is an inland species, usually dioecious with annular, non-lobed sepal scars beneath the fruit, and usually a (partly) 3-locular ovary. *D. viscosa* is a coastal species and has a distinctly lobed sepal scar and usually 2-locular ovaries. Traditional uses recorded for inland locations may well refer to *D. angustifolia*, in particular those mentioned for highland areas in New Guinea. Based primarily on leaf shape, several subspecies have been recognised in *D. viscosa* including the above mentioned subsp. *angustifolia* (L.f.) J.G. West.

Ecology *D. viscosa* is found in coastal vegetation on or behind sandy beaches or on limestone rock. It can be present in the *Barringtonia* formation and *Casuarina* forest but also in savanna and in coconut plantations, from sea-level up to 90 m altitude. *D. angustifolia* is found at (0–)1200–3600 m altitude, and seems to be adapted to a drier and cooler climate than *D. viscosa*.

Propagation and planting An impermeable seed coat is part of the germination delay system for *D. viscosa*, and impermeability is overcome at different rates within a seed cohort. Burial of the seeds enhances breaking of seed dormancy. Acid-scarified seed stored in paper bags and closed glass bottles at room temperatures retains good viability for 11 months. Propagation by stem-cuttings 20–25 cm long, 0.7–1 cm in diameter, with at least 2–3 nodes, collected from 1–2-year old shoots under artificial mist conditions is also successful. Rooting success can be enhanced by application of indole butyric acid up to 2000 ppm. Plants can be grown in light, well-drained soils in full sun. Plantations of *D. viscosa* can be established by direct sowing or by using seedlings. Direct sowing is done by using 3 seeds per planting hole, which are covered by soil. When the seedlings reach a height of 10 cm, they are thinned to one. The second method involves sowing in seedbeds, and seedlings are transplanted to polythene bags when 5 cm tall. Seedlings are planted out when they have reached 13 cm height. Plants over 60 cm height do not transplant well.

Husbandry For ornamental purposes shrubs of *D. viscosa* should be pruned to improve foliage appearance and to ensure a balanced shape; cutting back into the old wood usually results in collapse.

Diseases and pests A yellowing disease in *D. viscosa* is recorded for Hawaii, caused by an unidentified plant-pathogenic phytoplasma; it causes yellowing and dwarfing of the leaves and a proliferation of fine branches into a witches' broom; in the final stages the plant becomes defoliated and dies. A leaf blight disease caused by *Alternaria tenuissima* and a leaf spot disease caused by *Corynespora cassiicola* are mentioned for India. In New Zealand, *D. viscosa* may suffer from powdery mildew caused by *Sawadaia bicornis* and a leaf spot disease caused by *Pseudocercospora dodonaeae*. In South Australia leaves and branches are damaged by a gall midge (*Asphodylia dodonaeae*). *D. viscosa* is a host of the root-knot nematode *Meloidogyne incognita*. The larvae of *Achnaea janata*, a serious pest of *Ricinus communis* L. and *Citrus* and other fruits in India, also cause damage in *D. viscosa*.

Harvesting Fruits, leaves, bark or wood of *D. viscosa* are collected whenever the need arises.

Genetic resources and breeding *D. viscosa* is widespread and common throughout South-East Asia, and therefore not endangered. There are no known concerted breeding programmes of *D. viscosa*. It is represented in some seedbank collections, and selections for ornamental purposes, e.g. 'Purpurea' and 'Saratoga', are sometimes marketed.

Prospects There is some significant circumstantial evidence for the pharmacological basis of the traditional medicinal uses of *D. viscosa*. It seems likely that a number of compounds (e.g. fraxetin, sakuranetin, ent-15,16-epoxy-9-α-H-labda-13(16)14-diene-3-β,8-α-diol) may provide interesting leads for pharmacological evaluation and therefore merit further reseach.
In addition, the potential for cultivation as a shrub fuelwood on saline and alkaline soils also deserves further attention.

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Other selected sources 3, 123, 136, 353, 418, 459, 461, 526, 696, 810, 842, 847, 881, 1061.

P.C. van Welzen

Eclipta prostrata (L.) L.

Mant. Pl. 2: 286 (1771).
COMPOSITAE
$2n = 22$

Synonyms *Eclipta alba* (L.) Hassk. (1848).

Vernacular names False daisy, ink plant (En). Herbe à l'encre (Fr). Indonesia: orang-aring (Javanese), urang-aring (Sundanese), daun sipat (Moluccas). Malaysia: biu, keremak jantan, nigus. Papua New Guinea: whiteheads (Pidgin). Philippines: higis-manok (Tagalog), karim-buaya (Ilokano), pia (Ifugao). Laos: hoomz kèèwx. Thailand: kameng (central), yaa sap, hom kieo (northern). Vietnam: c[or] m[uwj]c, c[or] mh[oj] n[oof]i, h[aj]n ni[ee]n th[ar]o.

Origin and geographic distribution. *E. prostrata* occurs worldwide in the tropics and subtropics.

Uses *E. prostrata* is widely used in traditional medicine against a number of complaints. The aerial parts are generally known for their antibiotic and haemostatic properties and are prescribed for haematuria, nose and wound bleeding and ulcers. The crushed leaves are used against all kinds of skin diseases, especially eczema, but also for mycosis of fingers and feet, and even leprosy, herpes, elephantiasis, haemorrhoids and ringworm. The fresh juice of the plant is applied against scorpion stings and snakebites. The leaves or flower heads are boiled and rubbed on the gums to ease toothache, or used internally for colic, constipation but also against diarrhoea. The root is

used in hepatic disorders. In the Philippines, India and Ivory Coast a decoction of the leaves is applied to treat jaundice, while in Indo-China and Brazil the plant is also used against bronchitis and asthma.
In northern Vietnam, stonemasons rub the plant on their hands to stop irritation caused by chalk. The fresh juice of the plant drunk with water is used against tuberculosis. The taste of *E. prostrata* is sourish, sweet and cooling and the dried leaves, mixed with coconut oil, are used as a tonic. The roots are also known for their purgative and emetic properties, and in Malaysia a decoction of the roots, mixed with cumin, is given to women after childbirth.
In Africa the roots or leaves are used internally for liver and spleen complaints, and for oedema, while in India the juice of the root is applied for conjunctivitis.
The juice from the pounded plant turns black on exposure to air. In Africa, India, Thailand, Indonesia, Malaysia and Indo-China the juice from the fresh or boiled leaves is used for dyeing hair black and encouraging its growth. The sap is used in tattooing; when applied to wounds, it blackens scar-tissue, so that when the wounds are healed the scar is bluish-black.
In Indonesia and Africa the leaves are cooked as a vegetable, and in some parts of India the leaves are used in chutneys.
In Senegal sheep are reported to graze on *E. prostrata*, while in Kenya it is eaten readily by all cattle.

Production and international trade In Indonesia, between 1984 and 1990, an estimated 80–120 kg of dried leaves of *E. prostrata* were traded annually for herbal medicine, both locally and for export.

Properties *E. prostrata* contains the coumarin-lactone wedelolactone. Other important constituents include the steroidal alkaloids verazine, eclipalbine and ecliptine, the triterpenoid glucosides ecliptasaponin and ecliptasaponin D, the oleanane triterpene glycosides (echinocystic acid glycosides) eclalbasaponins I–VI, and the taraxastane triterpene glycosides eclalbasaponins VII–X. Also nicotine (0.08%), oleanolic acid, daucosterol, stigmaterol-3-O-glucoside, sitosterol, diosgenin, tigogenin, lanosterol and a number of minerals were isolated from dried *E. prostrata* plants.
Among the purified isolated compounds of *E. prostrata*, wedelolactone has been found to be a potent and selective 5-lipoxygenase-inhibitor through an oxygen radical scavenger mechanism with an IC_{50} of 2.5 μM. The steroidal alkaloids all showed weak cytotoxicity against the M-109 cell lines, and in addition, verazine and eclipalbine showed DNA-damaging effects in yeast strains.
The hepatoprotective effects of an extract of *E. prostrata* were studied against CCl_4- or acetaminophen-induced liver damage in mice and against β-D-galactosamine-induced liver damage in rats. The extract significantly inhibited the acute elevation of serum transaminases induced by CCl_4 and β-D-galactosamine, but had no effect in the acetaminophen model. In another test wedelolactone and desmethylwedelolactone had a significant antihepatotoxic activity employing CCl_4-, β-D-galactosamine-, and phalloidin-induced cytotoxicity in rat hepatocyte cultures. They also showed a significant stimulant effect on liver cell regeneration.
The antimyotoxic and antihaemorrhagic effects of *E. prostrata* extract, and three of its constituents (wedelolactone, stigmaterol and sitosterol) were investigated in vitro and in vivo. In the models, the myotoxicity of crotalid venoms (*Bothrops jararaca*, *Bothrops jararacussu* and *Lachesis muta*), purified myotoxins (bothropstoxin, bothropasin and crotoxin) and polylysine were quantified in vitro by the release rate of creatine kinase from mouse or rat extensor digitorum muscles, and in vivo by the plasma creatine kinase activity in mice. *E. prostrata* extract and wedelolactone showed marked antimyotoxic and antihaemorrhagic effects against the crotalid venoms used, which are responsible for most cases of snake poisoning in Brazil. These effects are interpreted as consequences of antiproteolytic and antiphospholipase A2 activities of the constituents.
A decoction of the dried leaves decreased the prothrombin time, it had an anticoumarin activity comparable with vitamin K, and increased the tone of the uterus. In Vietnam, successful results in treating uterine bleeding in pregnant and non-pregnant women have been obtained.
Further biological effects include: antisecretory activity against *Escherichia coli*, heat-labile and heat-stable enterotoxin-induced secretory responses in rabbit and guinea-pig ileal loop models (extracts of aerial parts), inactivation of hepatitis B surface antigens (hBsAg) in vitro (crude extracts) and induction of mouse skin erythema (extracts of leaves, roots or flower heads).
The leaf extract of *E. prostrata* shows a marked inhibition of fungal mycelial growth of 8-day-old petri dish colonies of *Microsporum gypseum*, *Trichophyton simii*, *Malbranchea gypsea* or *Chryso-*

sporium tropicum. Also, the seeds of *E. prostrata* in cattle dung show antibacterial activity against *Bacillus subtilis*, *Escherichia coli*, *Pseudomonas cichorii* and *Salmonella typhimurium*. The alcoholic extract of the whole plant shows antiviral activity against Ranikhet disease virus.

The plant contains α-terthienyl, a sulphur-containing thiophene derivate, which is active against the nematodes *Pratylenchus penetrans*, *Meloidogyne incognita*, *Hopolaimus indicus*, *Tylenchus filiformis*, *Helicotylenchus indicus* and *Tylenchorhynchus brassicae*. It also shows high insecticidal activity against the rice brown plant hopper (*Nilaparvata lugens*). Finally, *E. prostrata* extract shows molluscicidal activity at 100 ppm against adult snails and egg masses of *Biomphalaria glabrata*.

Adulterations and substitutes *Wedelia biflora* (L.) DC. leaves or *Taraxacum* roots are an excellent substitute for roots of *E. prostrata* in hepatic disorders.

Description A straggling annual or rather short-lived perennial herb, (10–)50(–80) cm tall; stem cylindrical, erect or prostrate, rooting at the lower nodes, reddish, with taproot. Leaves opposite, simple, oblong-lanceolate, 2–7 cm × 1–2 cm, base attenuate, apex pointed, margins entire or slightly toothed, villous; (sub)sessile; stipules absent. Inflorescence an axillary or terminal head, solitary or up to 3 together; peduncle 1–6 cm long, with long, appressed white hairs, involucral bracts 5–6, 2-seriate, oblong, 5–6 mm long, pointed, villous at the back, green, heads ovoid, 5 mm in diameter. Ligulate flowers female, numerous, 2-seriate, up to 3 mm long, apex entire or 2-lobed, white; tubular flowers bisexual, numerous, 4-lobed at the apex, white; anthers 5, obtuse, without appendage at the apex, sagittate at the base; style branches linear, short. Fruit an oblong achene, triangular or compressed with 1 central rib on each side, 3 mm × 1.5 mm, truncate at the tip, black; pappus absent, or with 2 weak scales and a few short hairs. Seedling with epigeal germination, hypocotyl up to 8.5 mm long, reddish-green, cotyledons ovate, up to 4.5 mm long, base tapering, apex rounded, epicotyl short, densely hairy, first leaves opposite, ovate, margin shallowly toothed, hairy.

Eclipta prostrata (L.) L. – 1, plant habit; 2, ligulate flower; 3, tubular flower; 4, achene.

Growth and development *E. prostrata* is fast growing and early flowering, and may produce more than 17 000 achenes per plant. Plants grown at low temperatures with short day length are shorter and produce many branches, thick leaves and more achenes. Low light intensity increases plant height and leaf size, but decreases specific leaf weight. It is a quantitative short-day plant.

Branching starts from the second week, and is usually finished around the 10th week. Flowering starts from the 5th week, and from the 7th week mature achenes can be found. After the 10th week, achene formation declines.

Other botanical information *Eclipta* is a small genus of 3–4 species. Much confusion exists whether the correct name for this taxon is *E. alba* or *E. prostrata*, as Linnaeus published both names as *Verbesina* at the same time in 1753. Later, he published *E. erecta* (1771), an illegitimate name, because *V. alba* was cited in synonymy, and also *E. prostrata*, based on *V. prostrata*. Hasskarl (1848) united these taxa, and used *E. alba* (L.) Hassk. as the correct name. Roxburg (1832) however, in his Flora Indica, adopted the name *E. prostrata* (L.) L., and this name is therefore treated as having priority over *E. alba* (L.) Hassk.

Ecology *E. prostrata* is an anthropogenic species, occurring frequently around houses, open spaces in villages, and disturbed soil. It is a very common weed of rice and sugar cane fields and coconut plantations, and is also found in humid locations along water courses and roadsides, from lowland up to 2000 m altitude. In Sri Lanka, *E. prostrata* flowers from November to July, in the Philippines all year round. Where rainfall is more than 1200 mm annually, it tends to become perennial. *E. prostrata* is a polymorphous and troublesome weed in many crops, most difficult in lowland areas with high rainfall. Early control is necessary, and herbicide combinations appear to be more reliable than a single herbicide.

Propagation and planting *E. prostrata* propagates through achenes, which are dispersed by water and animals. There is no seed dormancy, so germination can occur throughout the year when moisture is available. When stored at ambient temperatures, the germination rate decreases after about 5 months. In full light, achenes germinate over a range of 10–35°C, but they do not germinate in the dark. Germination is significantly improved by alternating temperatures of 20°C and 35°C. The achenes have a high pH tolerance.

In vitro production of active compounds Micropropagation of *E. prostrata* from nodal segment explants was established in a culture of Murashige and Skoog (MS) medium supplemented with 4.4 μM benzyladenine. The maximum number of shoots was obtained after 60 days of culture. Wedelolactone was present in shoots cultured in media containing cytokinins, but not in those cultured in basal medium. Callus tissue of *E. prostrata* grown in an MS culture with D-glucose, shows a considerable increase in ascorbic acid content and growth rate.

Husbandry *E. prostrata* is cultivated for biomass and wedelolactone production. Biomass production is not affected by soil pH, but lower pH causes lower concentrations of wedelolactone in the roots.

Diseases and pests *E. prostrata* is a host for *Macrophomina seolina*, powdery mildew in Egypt, and for the mung bean yellow mosaic virus in India. Moreover, it is also a host for the nematodes *Meloidogyne incognita*, *M. javanica*, rice root nematode (*Hirschmanniella oryzae*) and also *Trichodorus mirzai*. Other surveys indicate that *E. prostrata* is resistant to *Meloidogyne* spp., and numerous tests indicate that *E. prostrata* has strong nematicidal properties against a wide variety of nematodes. The eel-worm (*Heterodera radicola*) in particular, is attracted by *E. prostrata*. It would therefore be possible to use *E. prostrata* to attract and remove this pest from fields with sensitive crops.

E. prostrata is a host for the insects *Amsacta moorei*, and girdle beetle (*Oberea brevis*). In field studies conducted in the Philippines, the tephritids *Rhabdochaeta asteria* and *Spathulina acroleuca* were observed infesting *E. prostrata*, and could therefore be potential biological control agents for this weedy species.

Harvesting In Indo-China, the aerial parts of *E. prostrata* plants are gathered throughout the year at the end of flowering. In Indonesia, picking of the leaves starts 5–8 weeks after planting, at the beginning of flowering.

Yield The yield of wedelolactone in vegetative tissues of field-grown *E. prostrata* plants in Italy is approximately twice that of the roots. Yield of demethylwedelolactone is greater in the roots than in vegetative tissue.

Handling after harvest In China whole plants of *E. prostrata* are dried and stored for later use.

Genetic resources and breeding In Brazil and the United Kingdom, small germplasm collections of *E. prostrata* exist, and in Indonesia some in vivo collections are present in botanical and medicinal plant gardens. *E. prostrata* is a pantropical weed, and is not at risk of genetic erosion. No breeding programmes are known to exist.

Prospects The 5-lipoxygenase inhibition, hepatoprotective, antimyotoxic and antihaemorrhagic effects of *E. prostrata* extracts, and of its constituents (e.g. wedelolactone), merit further research. Especially the latter two effects might also be of local interest in the treatment of snake bites. In Indonesia, *E. prostrata* is also a potential plant for the shampoo and the vegetable industry.

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Syamsul Hidayat & S.F.A.J. Horsten

Elaeocarpus L.

Sp. pl. 1: 515 (1753); Gen. pl. ed. 5: 230 (1754).

ELAEOCARPACEAE

x = unknown; $2n$ = unknown

Major species *Elaeocarpus angustifolius* Blume, *E. floribundus* Blume, *E. grandiflorus* J.E. Smith.

Vernacular names Oil-fruit (En). Brunei: sengkurat, suragam. Indonesia: mendang. Malaysia: sengkurat, mendong. Philippines: kalomala. Burma (Myanmar): thitpwe. Thailand: ma mun. Vietnam: c[oo]m.

Origin and geographic distribution *Elaeocarpus* comprises some 300 species occurring from Madagascar and Mauritius to Sri Lanka, India, Indo-China, China, Japan, Thailand, throughout the Malesian region, east to Hawaii and Polynesia (as far as Rarotonga), south to Australia and New Zealand. Malesia harbours the majority of species (some 250); Papua New Guinea alone has about 70 species, Borneo at least 50 and Peninsular Malaysia about 30.

Uses In Indonesia and Malaysia, bark and leaves of *E. floribundus* and *E. grandiflorus* are used in poulticing and an extract is drunk as a general tonic. In Peninsular Malaysia, the leaves of a species resembling *E. macrocerus* (Turcz.) Merr. are used to poultice insect bites. As the leaves of *E. obtusus* Blume resemble those of *Symplocos odoratissima* (Blume) Choisy ex Zoll., they are used in Java as a substitute for the latter species as 'obat seriawan' to treat thrush. In Peninsular Malaysia the pulped leaves of *E. mastersii* King are applied to treat headache, and those of *E. stipularis* Blume to poultice sores. Juice from the leaves of *E. petiolatus* (Jack) Wallich is drunk and used as an application for sunstroke; a preparation from the roots may be administered to treat fever. In Sumatra, an infusion of bark scrapings of *E. mastersii* is drunk for fever, and crushed young leaves are applied to the forehead as a headache treatment. In the Southern Highlands province, Papua New Guinea, the chewed bark of *E. buderi* Coode is used as a poison antidote. *E. angustifolius* fruits are used in the traditional Indian Ayurveda system of medicine for mental diseases, epilepsy, asthma, hypertension, arthritis and liver diseases. The wood of *Elaeocarpus* is used for light interior construction and plywood. It is suitable for the manufacture of particle board, fibreboard and paper pulp. *E. angustifolius* has been used for reforestation in Java whereas *E. grandiflorus* is planted as an ornamental.

Production and international trade The medicinal use of *Elaeocarpus* is of limited local importance and no trade statistics are available.

Properties Pharmacological investigations with the water soluble portion of a 90% ethanol extract of the fruits of *E. angustifolius* showed the presence of a prominent central nervous system (CNS) depressant effect, characterized by typical behavioural actions, potentiating of hexobarbitone hypnosis and morphine analgesia, anticonvulsant and anti-amphetamine effects. The extract also showed cardiostimulant, depressor, smooth muscle relaxant and hydrocholeretic activities, part of these being mediated through β-adrenoreceptor stimulation and part through a direct musculotropic effect. Experiments were carried out in mice, rats, rabbits, guinea-pigs, frogs and dogs. The pharmacological profile of activity of the extract substantiates its traditional use in the treatment of mental diseases, epilepsy, hypertension, asthma and liver diseases.

Sequential petroleum ether, benzene, chloroform, acetone and ethanol extracts (50–200 or 200 mg/kg intra peritoneal, or 200 mg/kg per oral) of dried *E. angustifolius* fruits, pretreatment time 30–45 min, showed significant anti-inflammatory action against both acute and sub-acute models, analgesic, barbiturate-hypnosis potentiating and anti-ulcerogenic activities in rats. All the extracts, except petroleum ether and ethanol decreased swim stress immobility in mice indicating some degree of antidepressant activity. All the extracts protected guinea-pigs against bronchospasms induced by histamine and acetylcholine aerosols. Chemically, the extracts showed the presence of glycosides, steroids, alkaloids and flavonoids.

The effect of *E. angustifolius* fruits on autocoid release has been studied in the rat mesenteric mast cell in vitro. The petroleum ether, benzene, chloroform, acetone and ethanol extracts were found to have mast-cell stabilizing activity, substantiating the efficacy of *E. angustifolius* against bronchial asthma.

Antibacterial activity of petroleum ether, benzene, chloroform, acetone and ethanol extracts of dried *E. angustifolius* fruit was furthermore investigated against 28 gram-positive and gram-negative bacteria using disk diffusion- and plate dilution methods. The acetone fraction showed marked antimicrobial activity against 10 organisms. The benzene extract was active against *Morganella morganii* and *Salmonella typhimurium*, and the ethanol extract against *Plesiomonas shigelloides*, *Shigella flexneri* and *Shigella sonnei*.

In a double blind placebo controlled study, the effect of crude powder of *E. angustifolius* on essential hypertension was evaluated in human patients, with mild to moderate hypertension. There was a significant fall in systolic, diastolic and mean blood pressure in the patients treated with 8 g/day of crude powder of *E. angustifolius*, whereas doses of 2 and 4 g/day failed to result in a significant decrease in blood pressure.

A widespread species such as *E. angustifolius* shows variation in the composition of its alkaloids; in Indian material the content of aromatic alkaloids such as (+/–)-elaeocarpine and (+/–)-isoelaeocarpine is considerably higher than in material from New Guinea (where dienone alkaloids are predominant).

Some *Elaeocarpus* species from New Guinea, initially tested for alkaloids, have been included in general screening assays and pharmacological testing. *Elaeocarpus* species are known to produce numerous indolizidine alkaloids, ranging from simpler elaeokanine C in *E. kaniensis* Schltr. to more complex ones such as (–)-isoelaeocarpiline in *E. angustifolius* and the aromatic bases (+/–)-elaeocarpine which predominate in *E. polydactylus* Schltr. Elaeocarpidine is a major component of *E. densiflorus* R. Knuth.

E. angustifolius leaves (1.3 kg) produced a mixture of 10 alkaloids totalling 5.8 g: (+)elaeocarpiline, (–)-isoelaeocarpiline, 5 other isomers of (+)elaeocarpiline, elaeocarpidine (+/–)-elaeocarpine, (+/–)-isoelaeocarpine. Under pharmacological testing 1000 mg/kg (orally) of the mixture had no effect in mice, 2000 mg/kg was toxic. In the cat 35 mg/kg given intraperitoneally caused emesis, slight ataxia and marked disorientation. It caused transient hypotension and respiratory arrest at low doses of 1–2.5 mg/kg (intravenous). It also had an analgesic effect, which may be related to respiratory depression. The mixture did not test positive for diuretic, anticonvulsant or hypoglycaemic activity.

Furthermore, 1.55 kg of *E. polydactylus* leaves produced a mixture of alkaloids totalling 10.6 g:(+/–)-elaeocarpine, (+/–)-isoelaeocarpine, (+/–)-isoelaeocarpicine, some elaeocarpidine and isomers of 4-acetyl-5-methylcyclohex-3-enol. In mice an oral dose of the mixture at 1000 mg/kg and 2000 mg/kg produced low posture, dyspnea, hypothermia, convulsions and death. In the anaesthetized cat, the mixture caused hypotension at 5 mg/kg and cardiac arrest at higher doses. It also enhanced the response to adrenaline and 1,1-dimethyl-4-phenylpiperazinium iodide (DMPP). In rats elaeocarpine and its isomer produced 50% analgesia at 50 mg/kg and tetrabazine antagonism at 300 mg/kg.

E. densiflorus leaves (1.2 kg) produced a mixture of alkaloids totalling 4.0 g; elaeocarpidine being the major alkaloid. In mice, an oral dose of 500 mg/kg produced low posture, slightly decreased activity, dyspnea, analgesia and hypothermia, at 100 mg/kg no effects were observed. At 30 mg/kg it produced depression, low posture, tremors, somnolence and bradypnea. In rats, elaeocarpidine at a dose of 50 mg/kg produced weak analgesia. Elaeocarpidine at 200 μg/ml is active against gram-positive bacteria, *Bacillus subtilis*, *Mycobacterium smegmatis*, *Sarcina lutea* and *Streptococcus pyogenes*, and the fungi *Aspergillus niger*, *Blastomyces dermatidis*, *Cryptococcus neoformans*, *Fusarium oxysporum* var. *lycopersici*, *Penicillium citrinum* var. *leiter* and *Trichophyton mentagrophytes*.

Additionally, 2.2 kg of *E. dolichostylus* Schltr. leaves produced a mixture of 3 alkaloids totalling 5.9 g: (+)-elaeocarpiline, (–)-isoelaeocarpiline and elaeocarpidine. In mice an oral dose of 1000 mg/kg produced marked central nervous system (CNS) depression and mydriasis, at 2000 mg/kg it produced marked depression, tremors, convulsions and death. In the cat 35 mg/kg given intraperitionally caused emesis, rapid respiration, rage and fine head tremors. In the anaesthetized cat, the mixture caused irregular blood pressure, mydriasis, reversal of bilateral carotid occlusion (BCO) and peripheral vagal stimulation (PVS). This indicates ganglionic blockage or atropine-like or α_1-agonistic cardiovascular activities. The mixture appears to lower the threshold to MES seizures and has weak diuretic action. Finally, in a quest for antitumour compounds the cucurbitacin derivatives hexanorcucurbitacin F, cucurbitacin F and 23,24-dihydrocucurbitacin F were isolated in *E. dolichostylus* from New Guinea. Only cucurbitacin F showed cytotoxic activity.

Alkaloids produced in *E. altisectus* Schltr. are sim-

ilar to those in *E. angustifolius* and *E. dolichostylus*; 1.7 kg of leaves produced 12.9 g of alkaloids. In mice the alkaloid mixture caused bradypnea at an oral dose of 500 mg/kg, at 1000 mg/kg it caused dyspnea and at higher doses it caused tonic convulsions and death. However, the mixture did not produce any cardiovascular, analgesic or anti-inflammatory activity at 100 mg/kg.
Aqueous extracts of leaves and stems of *E. mastersii* from Sumatra (Indonesia) showed strong antimicrobial activity against gram-positive (*Staphylococcus aureus*) and gram-negative (*Escherichia coli*) bacteria.

Description Shrubs or small to fairly large, or occasionally large trees up to 40(–50) m tall; bole straight, cylindrical, columnar or poorly shaped, branchless for up to 18 m, up to 80(–160) cm in diameter, sometimes with steep buttresses up to 3(–5) m high, rarely with stilt roots; bark surface smooth to cracked or rugose or fissured, sometimes lenticellate, brown or grey, inner bark fibrous to granular, brown or yellowish-brown to reddish-brown or pink; crown often symmetrical. Leaves arranged spirally or alternate, simple, dentate or crenate or occasionally entire; petiole often kneed at apex; with or without stipules. Inflorescence an axillary raceme. Flowers bisexual, 4–5-merous, pendulous; sepals valvate; petals only slightly longer than the sepals, white, cream or greenish, generally toothed and/or fringed at apex; disk lobed, glabrous or hairy; stamens 10–many, inserted between disk and ovary or rarely on the disk, anthers with transverse apical slits; ovary superior, 2–7-locular with 2–12 ovules in each cell, style simple. Fruit an often bluish, purplish or brownish-green drupe; stone hard, with 1–7 seeds. Seedling with epigeal germination; cotyledons emergent, leafy; hypocotyl elongated; first two leaves opposite or alternate, subsequent ones alternate.

Growth and development *E. angustifolius* has been planted in trials in Java where the mean annual increment of 10.5-year-old trees planted at about 60 m altitude was 1.1–1.3 m in height and 1.9–2.1 cm in diameter. When planted at about 650 m altitude the mean annual increment of isolated trees was 2.5 m in height and 4.7 cm in diameter. In the Solomon Islands the annual increment of *E. angustifolius* in gaps in natural forest is 0.4 m in height and in plantations 2.9 m in height and 3.9 cm in diameter. Trees often show Terminalia-like branching. Growth form is according to Aubréville's architectural tree model, characterized by a monopodial trunk with rhythmic growth and spiral or decussate phyllotaxis bearing tiers of branches with similar phyllotaxis and indefinite growth of branches. Young leaves are red, pink or purple; old leaves wither red or occasionally yellow. Trees are generally evergreen, but some, e.g. *E. angustifolius*, are briefly deciduous. They flower at regular intervals, often after a dry period, sometimes 2–3 times a year. In Peninsular Malaysia flowering often takes place in March–May and August–October. In West Java, *E. angustifolius* carries fruits more or less throughout the year, but in Sulawesi only in October–November. Detailed flowering studies on *E. floribundus* in India revealed that flowers open at midday and anther dehiscence is completed in 6–8 hours. Development of the fruits shows distinct phases. From 30–60 days after anthesis, fruits grow fast and develop into the 'marble-stage'; development from day 60–120 is rather slow; from day 120 onwards growth of the fruit and swelling is fast, and maturity is reached 180 days after anthesis. Birds, bats, rodents and pigs eat the fruits and thus disperse the seeds.

Other botanical information Probably because of ongoing speciation processes and hybridization, some species groups are regarded as 'complexes' within which it is hard to recognize individual species. The genus *Acronodia* has been incorporated into *Elaeocarpus*. *Elaeocarpus* is occasionally regarded as a member of the tribe *Elaeocarpeae* within the family *Tiliaceae*.

Ecology *Elaeocarpus* may be encountered in primary but more often in secondary rain forest at low to medium altitudes, but sometimes as high as 3500 m and, in Papua New Guinea, can be locally common in montane forest in association with *Nothofagus*. It may occur gregariously and is found in a wide range of habitats including coastal forest, freshwater swamp forest, kerangas and on ultrabasic soils.

Propagation and planting *Elaeocarpus* can be propagated from seeds (which do not tolerate desiccation); the seeds are well enclosed by the hard dry stone. *E. angustifolius* has about 510 dry stones/kg and these should be sown in the shade. The stones of *E. floribundus* have about 15% germination in 4–8 months, and those of *E. stipularis* about 15% in 2.5–4.5 months. Sown fruits of *E. petiolatus* show about 50% germination in 2.5–4 months. It has been recommended that the stones be opened and the seeds sown. *Elaeocarpus* is not resistant to fire.

Husbandry There are techniques for partially ring-barking flowering branches of *E. angusti-*

folius which results in smaller fruits and stones. These stones were highly sought after for trade, e.g. for the production of traditional Hindu bead chains, mainly in India and Peninsular Malaysia.

Handling after harvest In general, leaves and bark of *Elaeocarpus* are used fresh. Mature fruits of *E. angustifolius* are collected in vats. After fermentation for 2 days the fruit pulp can be easily removed mechanically, and the stones are cleaned by washing, followed by drying.

Genetic resources and breeding Most of the *Elaeocarpus* species are endemic and hence have a fair risk of genetic erosion. However, medicinally important species treated here have a large area of distribution, either naturally or as a result of cultivation, and do not seem to be at risk of genetic erosion. There are no known breeding programmes of *Elaeocarpus*.

Prospects Extract and alkaloids from *Elaeocarpus* species exhibit a range of interesting pharmacological effects, which merit further research. For instance, the full toxicological profile has to be firmly established before their possibilities for future medicine can be evaluated comprehensively.

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Selection of species

Elaeocarpus angustifolius Blume

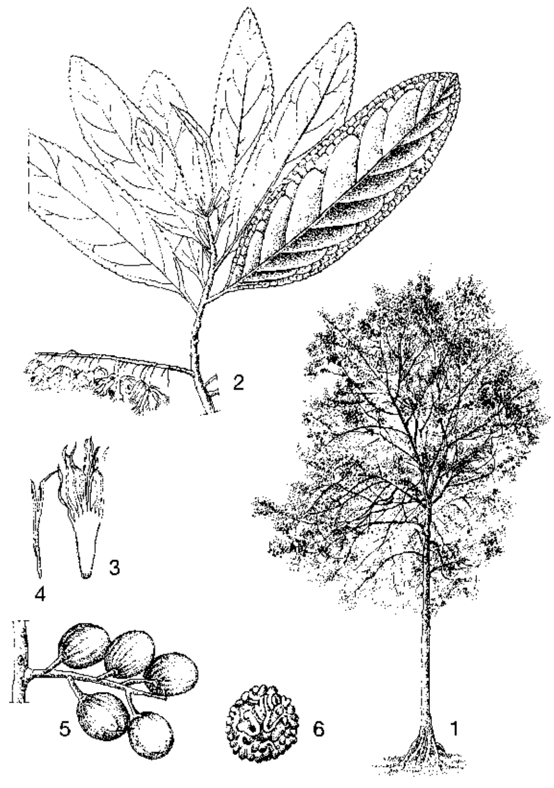
Bijdr. fl. Ned. Ind. 3: 120 (1825).

Synonyms *Elaeocarpus ganitrus* Roxb.(1832), *Elaeocarpus sphaericus* (Gaertner) K. Schum. (1890), *Elaeocarpus novoguineensis* Warb. (1905).

Vernacular names Bead tree, genitri, Indian oil-fruit (En). Indonesia: jenitri, genitri (Java), ganitri (Bali). Malaysia: changkan, geniteri, rijaksa (Peninsular). Papua New Guinea: qozari (Bolinbaneng, Morobe Province) Thailand: mamun dong (north-eastern), mun dong, mun khom (northern). Vietnam: c[oo]m l[as] h[ej]p.

Distribution From India and Nepal through Indo-China to Malesia, Australia and eastward to Fiji; sometimes cultivated.

Uses In Papua New Guinea leaf sap is used to cure stomach-ache or pain in the chest and shoulders. In the Philippines, there is one record of the bark being applied to treat an enlarged spleen. The stones have been a locally important trade



Elaeocarpus angustifolius Blume – 1, tree habit; 2, flowering twig; 3, petal; 4, anther; 5, infructescence; 6, stone.

commodity, in particular when the size was manipulated to obtain small beads called 'rudraksha'. At present they are still important for the production of traditional Hindu bead chains.

Observations A large tree up to 40 m tall, usually with thin buttresses extending up to 6 m from the base, crown often partly deciduous; leaves alternate or grouped at the end of pubescent twigs, elliptical to obovate, 12–17 cm × 4–6 cm, base tapering, apex acute, margin finely serrulate, petiole 5–15(–20) mm long, stipules early caducous; raceme borne on the twigs behind the leaves, spreading, 6–9 cm long, 12–26-flowered, pedicel 9–15 mm long; sepals 8–11 mm × 1–2 mm, pale green or tinged red, petals oblong-obovate, 12–15 mm × 3–4 mm, divided at the tip into 4–5 lobes, the lobes subdivided into 3–7 narrow tapering divisions, 15–25 in total, yellowish or greenish white, stamens about 35, filaments 1–2 mm long, anthers 4–6 mm long, ovary hairy, 5(–7)-celled, usually 4 ovules per cell; drupe globose, (12–)20 mm × 30 mm, bright blue or purplish, stone hard and dense, surface rugose to sculptured, (1–)2–5(–7)-seeded. *E. angustifolius* is commonly encountered in secondary forest, persisting in mature regrowth, from sea-level up to 1400 m altitude.

Selected sources 74, 135, 158, 204, 407, 932, 971, 1066.

Elaeocarpus floribundus Blume

Bijdr. fl. Ned. Ind. 3: 120 (1825).

Synonyms *Elaeocarpus tahanensis* M.R. Henderson (1930).

Vernacular names Rugged oil-fruit (En). Indonesia: hahauwan (Sundanese), kemesu (Javanese). Malaysia: medang biawak, medang teja, medang telur (Peninsular). Philippines: malangau (Manobo). Laos: ma moun, moun. Thailand: muat doi (northern), man som (north-eastern), kalon (central). Vietnam: c[oo]m tr[aa]u.

Distribution From India and Burma (Myanmar) to Indo-China, Thailand, Peninsular Malaysia, Java, Borneo and the Philippines (Palawan).

Uses An infusion of the bark and leaves is used in Sumatra as a mouthwash for inflamed gums. In Malaysia, the bark and leaves are used in a poultice for ulcers and an extract is drunk as a tonic.

Observations An evergreen tree up to 30 m tall; leaves often crowded at apices of pubescent, glabrescent twigs, oblong, elliptical to obovate, (3–)8–17(–22) cm × (2–)3–7(–9) cm, base cuneate, apex acuminate, margin serrate, petiole 2–4 cm long, stipules early caducous; raceme below the leaves, 7–14(–20) cm long, many-flowered, pedicel 4–8 mm long; sepals lanceolate or narrowly triangular, 4 mm × 2 mm, petals obovate-oblong, 5 mm × 2 mm, gradually dilated from a broad base, with a more or less abruptly widened apical portion, white, stamens 30–40, filaments about 0.5 mm long, anthers 1–2 mm long, ovary shortly hairy, 3-celled, usually 2 ovules per cell; drupe ellipsoid, 3–3.5 cm × 1.5–2 cm, often with yellow dots, stone almost smooth, slightly grooved. *E. floribundus* is more frequent in lowland rain forest but also frequent in lower montane forest, found from sea-level up to 1500 m altitude.

Selected sources 74, 207, 311, 407, 1066.

Elaeocarpus grandiflorus J.E. Smith

Rees, Cycl. XII: no. 5 (1809).

Synonyms *Elaeocarpus lanceolatus* Blume (1825).

Vernacular names Indonesia: anyang-anyang (Javanese, Sundanese), ki ambit (Sundanese), maitan (Javanese). Malaysia: ando, andor (Kedah, Peninsular). Philippines: mala (Tagalog). Burma (Myanmar): ye-saga. Thailand: khrai yoi (northern), mun nam (north-eastern), phi nai (peninsular). Vietnam: c[oo]m hoa l[ows]n, c[oo]m n[uw] l[ows]c.

Distribution From Burma (Myanmar) and Indo-China to Thailand, Peninsular Malaysia, Sumatra, Java, Bali, Borneo and the Philippines.

Uses In East Java, the crushed bark is used for poulticing persistent ulcers. In West Java, the bark is an ingredient of a traditional drug for women's diseases. In Central Java, a decoction of the leaves is drunk as a general tonic and used for bilious afflictions. The leaves are an ingredient of a traditional drug against syphilis. The seeds are a common ingredient in many traditional 'jamus'. They are credited with mild diuretic properties and as such are included in prescriptions to relieve bladder stones and painful urination in general.

Observations An evergreen tree, up to 25 m tall; leaves lanceolate, crowded at apices of glabrous twigs, 4.5–20 cm × 1.2–5 cm, base decurrent, apex obtuse to slightly acuminate, petiole 0.2–4 cm long; raceme in between the leaves, pendulous, 2–10 cm long, lax, 4–6-flowered, pedicel 2.5 cm long; sepals lanceolate, 1.2–2.5 cm × 0.2 cm long, bright red, petals obovate, 2–2.5 cm × 1 cm, pure white, stamens 25–60, filaments 2–4 mm long, anthers 2.5–6 mm long, with a 2.5–4 mm long awn, ovary densely pubescent, 2-celled; drupe ellipsoid, 2.5–4 cm × 1.5–2 cm, acuminate, pale green, stone covered with recurved, long, slender spines. *E. grandiflorus* is found in evergreen forest, along streams on riverbanks, at 50–800 m altitude. Widely planted as an ornamental (in Java up to 1000 m altitude).

Selected sources 74, 135, 311, 372, 373, 407, 810, 1066.

S. Aggarwal

Entada Adanson

Fam. pl. 2: 318 (1763).

LEGUMINOSAE

$x = 14$; *E. phaseoloides*: $2n = 28$

Major species *Entada rheedii* Spreng., *E. phaseoloides* (L.) Merr.

Origin and geographic distribution *Entada* has a pantropical distribution and comprises about 30 species; species diversity is highest in Africa. In Malesia, 5 species are indigenous and an additional 2 species are confined to Indo-China.

Uses *Entada* is one of the chief sources of traditional hair wash throughout South-East Asia. Contact with the eyes should be avoided as it is rather painful and irritating. The juice of the bark proper may cause conjunctivitis. However, its cleansing properties mean that it is applied as a remedial wash for pityriasis, wounds and itch. In Fiji, likewise, chewed or pounded leaves are externally applied as a remedy for filariasis or elephantiasis. In the Philippines, both stem pieces and seeds of *E. rheedii* and *E. phaseoloides* are used as a fish poison. The macerated seeds are used for poulticing abdominal complaints such as colic in children. In India, a paste of pounded *E. rheedii* seeds is externally applied to relieve inflammatory glandular swellings in the armpits, pains in the loins and joints, and swollen hands and feet. The seed kernels, in small doses, are taken in various ways and mixtures for abdominal complaints, apparently for their emetic and purging properties. In Peninsular Malaysia little distinction is made between *E. spiralis* Ridley and *E. rheedii*, although the pods and leaflets are very different. In the Philippines, the stems of *E. parvifolia* Merr. are also occasionally used as a substitute for soap. Young leaves of *Entada* are eaten, raw or cooked. The seed kernels can be consumed after careful preparation to get rid of the toxic principles. The long vine is sometimes harvested to obtain drinking water, the bark fibres are used as rope and raw material for basketry.

Properties The medicinal use of *Entada* is largely due to the presence of saponins in the bark, wood and seeds. The seeds of *E. phaseoloides* contain 2 sulphur-containing amides, entadamide A and entadamide B. Furthermore, entadamide C has been isolated from the leaves of *E. phaseoloides* together with entadamide A. Its stereostructure has been established as (R)-(+)-trans-N-(2-hydroxyethyl)-3-methylsulphinylpropenamide, thus being the sulphoxide form of entadamide A. Both entadamide A and B inhibit 5-lipoxygenase activity of RBL-1 cells at 10^{-4} g/ml in vitro. Trans-N-(2-hydroxyethyl)-3-methylthiopropenamide has been isolated and patented as an anti-asthma medicine.

Other components isolated from *E. phaseoloides* displaying pharmacological activity include 2-hydroxy-5-butoxyphenylacetic acid and 2,5-dihydroxyphenylacetic acid methyl ester, which are cytotoxic to P-388 cells in vitro, and a crystalline saponin (empirical formulae $C_{45}H_{82}O_{27}$), which shows significant activity against Walker 256 carcinosarcoma in rats.

Bioassay-guided fractionation of a dichloromethane extract of *E. abyssinica* Steud. ex A. Rich. root bark, a plant used by traditional healers in Uganda for the treatment of sleeping sickness, led to the isolation of a diastereoisomer of the clerodane type diterpene kolavenol. It showed a trypanocidal activity with an IC_{50} value of 2.5 μg/ml against *Trypanosoma brucei rhodesiense*, the causative agent of the acute form of human African trypanosomiasis.

E. phaseoloides extracts possess strong molluscicidal activity, but are also toxic to fish, thereby limiting their potential for controlling transmission of fascioliasis. Water extracts of *E. phaseoloides* bark cause 100% mortality at 200 ppm after 24 hours in *Pomacea* snails, an activity similar to berries of *Phytolacca dodecandra* L'Hér. Analytical work also indicated that the active fraction contained at least 2 kinds of saponins. However, molluscicidal activity against *Oncomelania quadrasi*, the snail intermediate host of *Schistosoma japonicum*, was not realistic under field conditions as 40 g/m^2 would be needed for a satisfactory result.

E. phaseoloides seeds were found to be highly toxic in a series of feeding trials with rats. Since they had low levels of essentially non-toxic lectins it was suggested that the toxicity was due to other antinutritional factors.

Description Lianas or scandent shrubs (in Asia), unarmed, up to 150 m long. Leaves alternate, bipinnate, the terminal pinnae transformed into tendrils; petiole and rachis without extrafloral nectaries; stipules not spinescent, inconspicuous; leaflets opposite; inflorescence a pedunculate, axillary or supra-axillary spike or spiciform raceme; flowers 5-merous, uniform, male or bisexual; calyx connate, valvate; petals free or shortly united at base, valvate; stamens 10, free, anthers with a caducous gland at the top of the connective. Fruit a pod, often large (up to 1 m or more), chartaceous or mostly woody, straight, curved or spirally twisted, at maturity falling apart in one-seeded segments, the exocarp separating from the endocarp, the sutures remaining as an empty frame. Seed globular, flattened or irregularly compressed, with a hard testa without areole, wingless, aril absent, endosperm absent. Seedling with large cotyledons and curved radicle.

Growth and development Trunks of *E. rheedii* and *E. phaseoloides* are twisted close to the ground, and the trunk base of the latter may reach a girth of 3 m. A growth of 9 m in 4 months has been recorded for *E. spiralis* in Peninsular Malaysia.

Other botanical information Confusion surrounding species identity is considerable: in the botanical literature as well as in other disciplines the names *E. scandens* and *E. phaseoloides* have often been misapplied.

Ecology *Entada* species, except *E. parvifolia* which is common in thickets, are frequently found in riverine vegetation, the segments of the pods being dispersed by water. *E. phaseoloides* and *E. rheedii* are dispersed by sea-currents and are found in habitats at the limits of tidal influence.

Propagation and planting Natural germination of the hard *Entada* seeds may take a year or more. Seed treatment by removal of the hilum, including a portion of the testa, and germination in a wet jute sack, results in radicle emergence and seeds ready for potting within 15 days. Seedlings can be planted out in the field after 1 month. *E. rheedii* can be readily grown from cuttings.

Harvesting The bark of *Entada* is cut from the lower part of the trunk, pods can be pulled down, or may simply be collected from the ground. Vines may be cut after 3 years, suckers will develop from the base.

Handling after harvest When harvested for its application as a traditional hair wash, the stem is cut into short pieces, beaten, dried in the sun, and stored, ready to macerate as needed.

Genetic resources and breeding Apart from occasional planting in botanical gardens, no material is present in genebanks or germplasm collections. In view of the wide geographical distribution of the medicinally important *Entada* species, the risk of genetic erosion appears rather limited.

Prospects Saponins, diterpenes and entadamines from *Entada* species possess interesting properties as molluscicidal, trypanocidal, anti-asthma and anti-inflammatory compounds respectively. Research is needed to evaluate their future potential.

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Selection of species

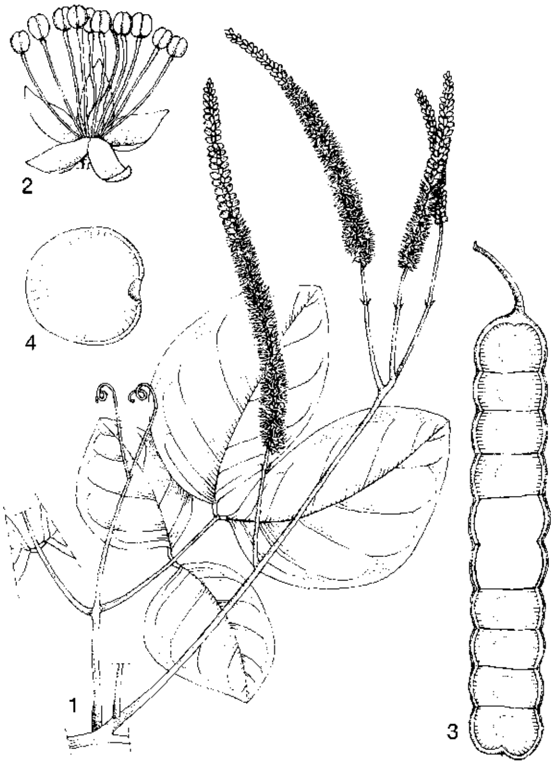
Entada phaseoloides (L.) Merr.

Philipp. Journ. Sci., Bot. 9: 86 (1914).

Synonyms *Entada scandens* (L.) Benth. (1842) p.p., *Entada rumphii* Scheff. (1872), *Entada tonkinensis* Gagnep. (1911).

Vernacular names Philippines: gogo (Tagalog, Bikol). Vietnam: d[aa]y b[af]m b[af]m, d[aaj]u d[ej]t.

Distribution From the Pacific through tropical Australia westward to northern Vietnam and southern China; in Malesia recorded for the Philippines, Borneo, Sumatra, Java, Sulawesi, the Less-



Entada phaseoiloides (L.) Merr. – 1, flowering twig; 2, flower; 3, pod; 4, seed.

er Sunda Islands, the Moluccas and New Guinea.

Uses In Fiji, the juice of the stem is drunk to relieve rheumatic joint and muscle pains, and for respiratory ailments. A decoction of the stem is also drunk for the treatment of hernia, fish poisoning and gonorrhoea. The juice of the roots is given for ulcers, abdominal muscle spasms and headaches. In areas where *E. rheedii* and *E. phaseoloides* occur sympatrically, they are most likely used indiscriminately.

Observations A large woody climber, often with flattened and spiral stem; rachis 2 cm long, pinnae 1–2 pairs, 6.5–9 cm long, 1–2(–3) pairs of leaflets per pinna, leaflets elliptical to obovate-elliptical, unequal-sided, 4.5–10 cm × 1.8–6.3 cm, base asymmetrical or somewhat emarginate; inflorescence an axillary spike, 13–30 cm long, flowers sessile or subsessile, male or bisexual, minute, calyx green, broadly cup-shaped, petals green with a reddish base; pod straight to slightly curved, up to 100(–200) cm × 7–15 cm, exocarp woody, endocarp parchment-like; seed suborbicular, flattened, 4–6 cm × 3.3–5 cm, 1 cm thick, brown. *E. phaseoloides* is found in a wide variety of habitats, ranging from freshwater swamp and inland from the mangrove up to montane forest, up to 900(–1700) m altitude.

Selected sources 17, 143, 360, 463, 739, 786, 788, 810, 1038, 1106.

Entada rheedii Spreng.

Syst. veg. 2: 325 (1825).

Synonyms *Entada pursaetha* DC. (1825). In the literature *E. rheedii* is often wrongly identified as *Entada scandens* auct. non Benth., *Entada phaseoloides* auct. non (L.) Merr. (1923).

Vernacular names Elephant climber, matchbox bean (En). Liane à boeuf (Fr). Indonesia: bendo (Javanese), cariu (Sundanese), bambalu (Bugis). Malaysia: akar beluru, akar kapang. Philippines: gogo (Tagalog, Bikol). Cambodia: var ang koung. Laos: m'ba. Thailand: ma ba (general), saba mon (central), kham ton (northern). Vietnam: d[aa]y ch[af]m, b[af]m b[af]m man.

Distribution From Africa, eastward to tropical Asia, Australia and a small part of the Pacific; in Malesia recorded for the Philippines (Luzon, Mindanao) and Peninsular Malaysia eastward to Borneo, Java, Sulawesi, the Lesser Sunda Islands, the Moluccas and New Guinea.

Uses The bark containing saponins is used as a hair wash and soap substitute, as a medicine against pains, itch and perhaps fever. Seeds also contain saponins and are applied similarly and as a poultice to cure colic in children. The smooth shining seeds are used for games and to polish various artifacts by rubbing.

Observations A large woody climber, up to 120 m long; rachis (4.5–)6–8(–10.5) cm long, pinnae 2 pairs, 5–15 cm long, 3–4(–5) pairs of leaflets per pinna, leaflets obovate to elliptical-lanceolate, unequal-sided, (1.4–)2.3–7 cm × (1–)1.3–3.5 cm, base rounded to broadly cuneate, somewhat asymmetrical; inflorescence an axillary spike, 12–25 cm long, flowers sessile or subsessile, male or bisexual, minute, calyx green, broadly cup-shaped, petals white; pod straight to slightly curved, up to 200 cm × 7–15 cm, exocarp and endocarp woody; seed subcircular, flat, 3.5–4 cm in diameter, 1 cm thick, brown. *E. rheedii* is found in primary and secondary forest, especially along rivers, inland from the mangrove and in beach forest, up to 400(–900) m altitude.

Selected sources 135, 215, 407, 786, 788, 810, 1038.

L.J.G. van der Maesen

Eriosema chinense J.R.T. Vogel

in F.J.F. Meijer, Observ. bot. in Nov. Act. Acad. Nat. Cur. 19, suppl. 1: 31 (1843).

LEGUMINOSAE

$2n = 22$

Synonyms *Dolichos biflorus* auct. non L.

Vernacular names Indonesia: katil. Philippines: katil, okun (Igorot), kitkitil (Bontok). Cambodia: té:l, té:l tuëng'. Laos: kh'o:nz ko:ng. Thailand: man chaang, man thong (peninsular), haeo praduu (central), khon klong (southeastern). Vietnam: mao t[uwr] trung qu[oos]c.

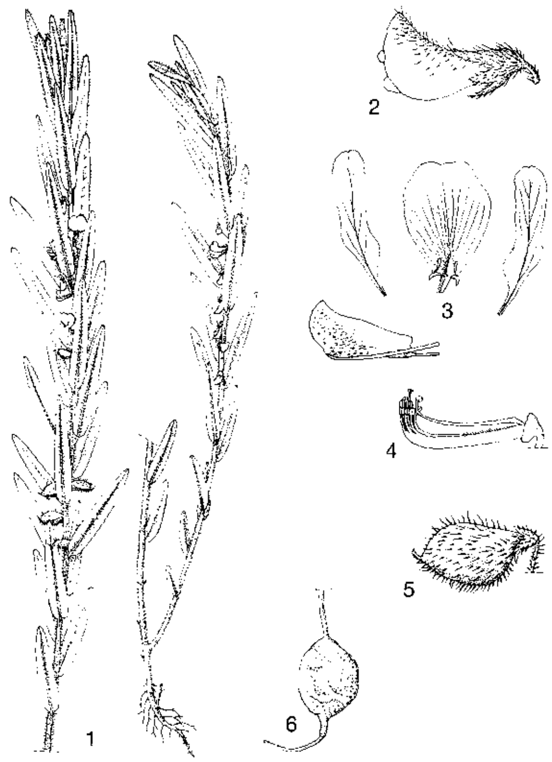
Origin and geographic distribution *E. chinense* is found from India eastward to Burma (Myanmar), China, Taiwan, Indo-China, and Thailand, southward through Malesia, to northern Australia. In Malesia, it is found in the Philippines, Peninsular Malaysia, Java and New Guinea.

Uses In India, the seeds of *E. chinense* are used for their astringent, diuretic and tonic properties. A decoction of the seeds, with grounded pepper added, is used for scrofula and diarrhoea. A decoction of the seeds is given to women to promote discharge of the afterbirth, and to treat leucorrhoea and menstrual derangements. The seed powder is externally applied to check cold sweats.

The small tubers are traditionally eaten in various parts of Asia and Australia, either fresh, cooked or roasted; they contain 30% starch on dry weight basis.

Properties Phytochemical analysis of the roots of *E. himalaicum* Ohashi revealed the presence of chromones, flavones and isoflavones. Several of these compounds showed antifungal activity against *Cladosporium cucumerinum* and *Candida albicans*. Furthermore, a chromone derivative, compound B (structure not further elucidated) is reported to inhibit angiotensin-converting enzyme in vitro at an IC_{50} of 195 μM. Possibly these compounds may be found in *E. chinense* as well.

Description An annual or perennial, erect herb, 12–50(–90) cm tall, not or sparingly branched, tubers cylindrical, up to 3 cm × 5 cm. Leaves alternate, 1-foliolate; stipules linear, 4–5(–10) mm long, persistent; leaflet oblong to linear, 1–8 cm × 0.3–2 cm, base rounded, apex acute or acuminate, with long hairs on margin and midrib, sparsely hairy above, densely pubescent below; petiolule 1–3(–10) mm long. Inflorescence an axillary pseudoraceme, 6–15 mm long, 1–3-flowered. Flowers papilionaceous, about 7 mm long; calyx campanulate, 5-lobed, hairy, tube 2 mm long, lobes narrow-triangular, 2–3 mm long; corolla pale bright yellow, some-



Eriosema chinense J.R.T. Vogel – 1, habit; 2, flower; 3, details of corolla; 4, staminal column with pistil; 5, pod; 6, tuber.

times tinged purple, standard auriculate, wings oblong, longer than the keel-petals; stamens 10, diadelphous, 1 free; ovary 2-ovulate. Fruit a cylindrical pod, 10–12 mm × 5–8 mm, 1–2-seeded, brown to black, covered with long brown to grey hairs, dehiscent. Seed reniform, 2–4 mm long, minutely pitted, arillate all along the width.

Growth and development In Java, *E. chinense* flowers from December–March.

Other botanical information *Eriosema* is a large genus of some 130 species, with just one or two species in Asia and Australia. Apart from *E. chinense* a second, quite similar species, *E. himalaicum* Ohashi (synonym: *E. tuberosum* (Buch.-Ham. ex G. Don) Wang & Tang non A. Richter) has been distinguished. In fact all higher-altitude Indian accessions from the Himalayas (most > 1500 m) have been classified as *E. himalaicum*, *E. chinense* being the species in Bihar, Madhya Pradesh and Orissa. The distinction would be a fusiform tuber, thinly pubescent leaflets below, and short broad calyx teeth in *E. chinense* as opposed to a globose tuber, more densely pubescent leaflets below, and longer narrower calyx teeth in *E. himalaicum*. In general, Australian and Papuan specimens of *E. chinense* have many more linear leaflets than the Indian and Chinese ones. The fresh tuber or the cortex of *E. himalaicum*, dried and powdered mixed with water, is used to treat dysentery. In traditional Chinese medicine the plant is used to treat diarrhoea, orchitis and hydrophobia, and as a detoxifying agent. Several African *Eriosema* species are used as fish poison.

Ecology *E. chinense* is found in habitats ranging from coniferous and open broadleaf forest, savanna, grassland and roadsides on sandy soils up to 1500(–2000) m altitude.

Propagation and planting Seeds of *E. chinense* are the likely vehicles of propagation, tubers in rest would probably serve that purpose too.

Harvesting In general plants of *E. chinense* are simply uprooted to collect the tubers.

Genetic resources and breeding In view of its widespread distribution and presence in disturbed habitats, *E. chinense* is not likely to be threatened by genetic erosion.

Prospects Very little is known about the phytochemistry and pharmacology of *Eriosema* species. The activities in the fields of anti-fungal activity and angiotensin-converting enzyme inhibition are interesting. The compounds involved may have potential to serve as new leads.

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Other selected sources 47, 74, 307, 1038.

L.J.G. van der Maesen

Erythrina L.

Sp. pl. 2: 706 (1753); Gen. pl. ed. 5: 316 (1754).
LEGUMINOSAE
$x = 7$; *E. fusca*, *E. subumbrans*: $2n = 42$; *E. variegata*: $2n = 42, 44$

Major species *Erythrina fusca* Lour., *E. subumbrans* (Hassk.) Merr., *E. variegata* L.

Vernacular names Coral tree (En). Arbre au corail (Fr). Indonesia: dadap (general). Malaysia: dedap (general), dadap (Sabah), derdap (Peninsular). Philippines: dap-dap (Pilipino). Burma (Myanmar): kathit. Thailand: thong lang. Vietnam: v[oo]ng.

Origin and geographic distribution *Erythrina* comprises about 110 species distributed pantropically. Tropical America is richest in species (about 70), followed by Africa (32), whereas Asia has 18 species. Some 6 to 8 species occur naturally in Malesia, but many more are planted as ornamentals.

Uses the leaves and bark of various *Erythrina* species are commonly applied for poulticing. The boiled bark is applied for poulticing the forehead of an elephant if it is swollen, after heavy pushing. *Erythrina insularis* F.M. Bailey 'radap'(synonym *Erythrina merrilliana* Krukoff)is reportedly used in the highlands of Papua as a contraceptive. Their conspicuous red flowers make many *Erythrina* species popular as ornamentals, and they are commonly planted in gardens and parks. They are also widely planted as shade trees, e.g. in cocoa, coffee and tea plantations, and as living stakes to support black pepper (*Piper nigrum* L.), betel (*Piper betle* L.), yams (*Dioscorea* spp.) and vanilla (*Vanilla planifolia* H.C. Andrews). They are additionally used as green manure because they can fix atmospheric nitrogen in symbiosis with rhizobia. The more prickly forms are often planted as live fences. The lightweight wood is of local importance only. The leaves of some species (e.g. *E. fusca* and *E. variegata*) are eaten as a vegetable, and also used as fodder. The shiny red seeds are often used to decorate clubs or are made into necklaces, rosaries and good-luck charms. In Thailand, the flowers of *E. variegata* have been used to dye clothes red.

Properties Many *Erythrina* species contain in all parts series of related isoquinoline alkaloids, biosynthetically derived from phenylalanine, called erythrina-alkaloids. For instance, erysotrine, erythraline, erysodine, erysovine and erysopine were isolated from *E. fusca*. The seeds of *E. subumbrans* contain erysoline, erysopine and erythratine, together with hypaphorine, a tryptophan derived alkaloid. The seeds of *E. variegata* contain erysodine, erysopine and hypaphorine, and the leaves and bark erythrinine. Hydrocyanic acid has been found in the leaves, stems, roots, and fruits of *E. variegata*, and their seeds are known to contain considerable amounts of the amino acid histidine, as is the case with those of *E. fusca*.

Erythrina-alkaloids are known to show curare-like effects, together with a sedative-, hypotensive- and central nervous system (CNS) depressive action. The isolated alkaloidal fraction of *E. variegata* produces curare-like effects in frogs and rabbits, both in vivo and in vitro. Isolated total alkaloids from the stem bark have a relaxant action on smooth muscles in guinea-pigs (ileum) and rats (uterus), which is not antagonized by adrenergic blocking agents. This fraction also exhibits CNS-depressant action against pentylenetetrazol and electroshock-induced convulsions in rats. A 40% aqueous extract of the seeds of *E. fusca* at a dose of 16, 23, 32 g/kg body weight showed a sedative effect in male rats, and orally administered alcohol and chloroform extracts of the seeds of *E. fusca* diminished motor activity and curiosity of mice and rats at a dose of 18.6 g/kg and 13.3 g/kg, respectively. Acute toxicity was investigated in male mice, using the ethanol extract of the seeds of *E. fusca*; the LD_{50} was determined to be 277 mg/kg body weight for subcutaneous administration. The crude extract of the root or the total alkaloidal fraction of *E. variegata* also showed antibacterial activity against *Bacillus aureus*, *Bacillus pumilus*, *Escherichia coli*, *Klebsiella pneumoniae*, *Mycobacterium smegmatis* and *Staphylococcus aureus*.

Several lectins with proteinase inhibiting properties have been isolated from the seeds of *E. variegata*, e.g. the chymotrypsin inhibitor ECI (Erythrina chymotripsin inhibitor), the trypsin inhibitors ETIa and ETIb (Erythrina trypsin inhibitor) and the galactose-specific binding isolectins ELVI, ELVII and ELVIII. ETIa is unique in its ability to inhibit tissue-type plasminogen activator, while ETIb does not possess this characteristic. However, both ETIa and b prolonged the activated partial thromboplastin and prothrombin times, but EBI and ECI did not. Using the soluble MTT tetrazolium/formazan assay, the cytotoxicity of *E. variegata* proteinase inhibitors in some tumour hematopoietic stem cell lines was also investigated. Among the proteinase inhibitors, EBI, which belongs to the Bowman-Birk family of inhibitors, was cytotoxic in relatively differentiated cells such as Molt4 and Jurkat lines, derived from acute T lymphoblastic leukemia (T-ALL) cells specifically. ETIa and ECI, which are classified as Kunitz family inhibitors, were not cytotoxic. It was suggested that the differences in the cytotoxicity might be due to the molecular size of the inhibitors. The succinylation of lysine residue of EBI led to about 50% loss of the trypsin inhibitory activity compared with the authentic EBI. When Molt4 cells were incubated with this derivative, no significant cytotoxicity was observed. This suggests that the proteinase inhibitory activity might be involved in the cytotoxicity in human tumour cell lines.

The edible portion of the leaves of *E. fusca* contains per 100 g dry matter: 20–22 g crude protein; in vitro digestibility ranges from 30–55%. The mineral content of the leaves per 100 g dry matter is: N 3.2 g, P 0.15 g, K 1.0 g, Ca 1.3 g, Mg 0.5 g. Loppings of *E. subumbrans* contain per 100 g dry matter: N 1.5–3 g, P 0.2–0.35 g, K 1–2 g. Leaves of *E. variegata* contain per 100 g dry matter 1.5 g N, 1.5 g K, and 0.15 g P. Leaves and seeds have narcotic properties.

Description Mostly deciduous shrubs or small to medium-sized trees, occasionally small subshrubs or perennial herbs; bole and branches often armed with conical spines, occasionally with buttresses. Leaves arranged spirally, 3-foliolate; stipules persistent or caducous; leaflets entire, lateral ones often asymmetrical; stipels usually fleshy and glandular. Flowers solitary, paired or fascicled in an axillary or terminal, racemose, inverted inflorescence, bisexual, often scarlet or red; calyx tubular-campanulate, bilabiate or spathe-like with a slit down to the base on the lower side, 5-lobed, sometimes inconspicuously so; corolla papilionaceous, often showy, keel and wings usually much smaller than standard; stamens 10, upper one free or partly connate with the staminal tube; ovary superior, stipitate, many-ovuled, style incurved. Fruit a pod, often constricted between the seeds, usually dehiscent, 1–14-seeded. Seed ovoid or ellipsoid, often red or orange, some with a black spot, also brown or black; cotyledons fleshy, endosperm absent. Seedling with epigeal or semi-hypogeal germination; cotyledons emergent or not emergent, fleshy; hypocotyl elongated; first 2 leaves opposite and simple, subsequent ones alternate and 3-foliolate.

Growth and development Most *Erythrina* species are deciduous during or after the dry season, and flower when leafless. The pendulous flowers are scentless, strong and elastic, so constructed that cross-pollination is universal, and are typically pollinated by birds, particularly by passerines such as *Chloropsis* species and crows. They visit the flowers in the morning collecting the copious nectar. The seeds of *E. fusca* and *E. variegata* float and are distributed by sea currents.

Other botanical information *Erythrina* belongs to the tribe *Phaseoleae*, subtribe *Erythrininae*, characterized by the very unequal petals and the conspicuous androecium and gynoecium. *Mucuna* is a lianescent representative of this subtribe.

Ecology Most *Erythrina* species occur in monsoonal climates and on sandy soils. *E. fusca* prefers wet locations such as freshwater swamps, stream banks and badly drained soils, up to 2000 m altitude; it may develop into almost pure stands. *E. subumbrans* occurs in open places or in secondary forest, often near streams, up to 1500 m altitude. *E. variegata* is adapted to coastal forest, but it is frequently cultivated inland, up to 1200 m altitude.
Most *Erythrina* species are ecologically separated, even when occurring in the same geographical region. Hybrids, however, occur frequently in cultivation, as there appear to be no barriers to interspecific crosses.

Propagation and planting *Erythrina* can be propagated by seed and by large stem cuttings. There are about 1450–5000 seeds of *E. fusca* per kg and the germination rate is 80–95%. Seed of *E. variegata* can germinate within 2 weeks after sowing, but sometimes it germinates poorly with only 30% result over a period of 11 months. Generally, large cuttings about 2–3 m long and 5–10 cm in diameter are used, which sprout easily within 2–4 weeks. They establish easily, as the leafy twigs are out of reach of livestock. Cuttings of *E. subumbrans* up to 25 cm in diameter sprout readily.

Diseases and pests At the end of the 19th Century *E. subumbrans* was severely attacked by a still unknown root disease in Java, which locally destroyed all trees. Around 1930 it was infested by a *Fusarium* disease in Java and South Sumatra. In Sumatra stakes of *E. fusca* in pepper plantations are frequently attacked by a stem borer (*Bactocera* sp.) and by a ring borer (family *Lecanidae*). Leaf-eating caterpillars commonly found on *Erythrina* belong to the genera *Agathodes*, *Hypolimnas*, *Parasa*, *Phalera* and *Striglina*; they seldom cause severe damage. Top-boring caterpillars of the genus *Terastia* may cause serious damage in *Erythrina*.

Genetic resources and breeding *E. fusca*, *E. subumbrans* and *E. variegata* have large areas of distribution and are planted widely; they are not liable to genetic erosion. Germplasm collections of *Erythrina* species including *E. fusca* and *E. variegata* are maintained in Hawaii and Costa Rica. There is a selection and breeding programme of *E. fusca* at CATIE (Costa Rica), whose aim is to improve its shade tree characteristics.

Prospects *Erythrina* species contain several compounds which display interesting pharmacological activities. Both the erythrina-alkaloids with curare-like effects, and especially the lectins with proteinase inhibiting- and cytotoxic activities may be of interest as tools in fundamental research and development of future medicines.

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Selection of species

Erythrina fusca Lour.

Fl. Cochinch.: 427 (1790).

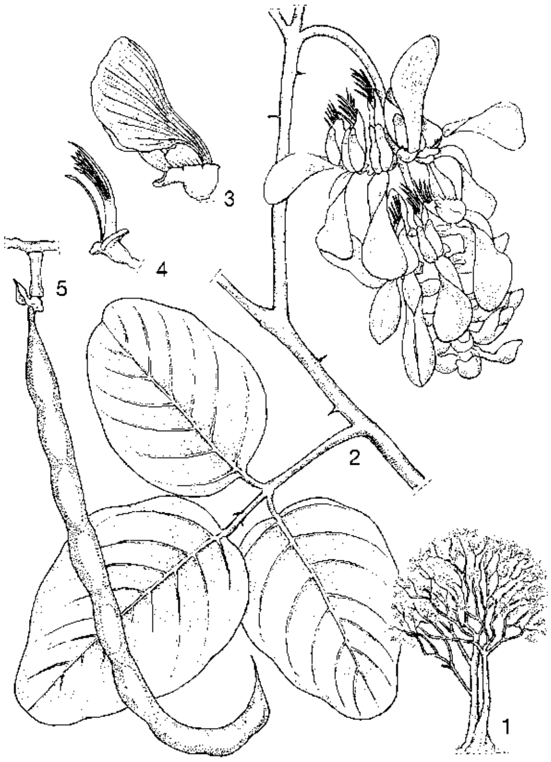
Synonyms *Erythrina glauca* Willd. (1801), *Erythrina ovalifolia* Roxb. (1832), *Erythrina atrosanguinea* Ridley (1911).

Vernacular names Purple coral-tree, coral bean, swamp immortelle (En). Bucayo (Am). Bois immortelle, immortelle blanc (Fr). Indonesia: cangkring (Javanese, Sundanese), rase, kane (southern Sulawesi). Malaysia: dedap, dadap. Papua New Guinea: maor (Lamekot), vatamida (Ugana). Philippines: anii (Tagalog), korung-korung (Bisaya). Cambodia: roluŏhs phâ-'aông. Laos: th'o:ng hla:ng. Thailand: thonglang nam, thonglong (central). Vietnam: v[oo]ng d[oof]ng, v[oo]ng gai.

Distribution *E. fusca* is the most widespread species in the genus occurring wild in both the Old and New World tropics. In Asia and Oceania it occurs along coasts and rivers from India to the Philippines, New Guinea and Polynesia; in Africa it occurs in Madagascar, the Mascarene Islands, the Comoro Islands and Pemba Island, but not in continental Africa. Furthermore in Central and South America in the West Indies, throughout the Amazon basin, and along the coast of Brazil, Colombia, up to Honduras and Guatemala; planted throughout the humid tropics.

Uses In Indonesia the scraped inner bark is used for poulticing fresh wounds, and bark or root decoctions are applied against beri-beri. The grated wood is used to treat haematuria; the root is used for rheumatism; bark and leaves serve as vermifuge. In Thailand, roots, bark and leaves are used as an antipyretic. In Vietnam, the bark is used to treat toothache. The young leaves are eaten as a vegetable in Java and Bali, as are the flowers in Guatemala. In Central America, the leaves are a source of animal fodder.

Observations A medium to large, spreading tree, 10–15(–26) m tall, crown rounded, trunk short, spiny, much branched, sometimes with buttresses up to 2 m; petiole up to 25 cm long, stipules orbicular, rachis up to 5 cm long, leaflets ovate to elliptical, 2.5–20 cm × 1.5–15 cm, rounded or subacute at both ends, subcoriaceous, glabrous to velvety hairy, petiolule up to 1.5 cm long, stipels orbicular; inflorescence racemose, terminal, appearing when leaves are present, peduncle up to 13 cm long; flowers in fascicles scattered along the rachis, covered with deciduous, ferruginous hairs, pale brick-red or salmon (rarely white), pedicel up to 2 cm long, calyx asymmetrical, broadly campanulate, about 1.5 cm long, lacerate or subentire but with a 0.5–1.5 mm long spur on the keel side, pubescent; standard rounded-rhombic, 4–7 cm × 3.5–6 cm, orange or scarlet, claw 9 mm long, keel slightly longer than the wings, both about half the length of the standard, stamens 4–6 cm long, subdiadelphous, 1 free, 9 united in lower half into staminal tube; fruit a woody, linear, compressed pod, 14–33 cm × 1.5–2 cm, on a stout stalk 1.5 cm long, slightly constricted between the 3–15 seeds, velvety ferruginously hairy when young, later glabrescent, dehiscent; seed oblong-ellipsoid, 12–18 mm × 5–8 mm, dark brown or black.



Erythrina fusca Lour. – 1, habit; 2, flowering branch; 3, flower; 4, flower (petals removed); 5, pod.

Selected sources 74, 135, 273, 407, 786, 1038.

Erythrina subumbrans (Hassk.) Merr.

Philipp. Journ. Sci., Bot. 5: 113 (1910).

Synonyms *Erythrina lithosperma* Miq. (1855), *Hypaphorus subumbrans* Hassk. (1858), *Erythrina hypaphorus* Boerl. (1899).

Vernacular names December tree (En). Indonesia: dadap duri (general), dadap rangrang (Sundanese), dadap ri (Javanese) (armed forms); dadap minyak (general), dadap lesang (Sundanese), dadap srep (Javanese) (thornless forms). Malaysia: dedap batik, cengkering. Papua New Guinea: dadap. Philippines: dap-dap (Tagalog), rarang (Bikol), anii (Bisaya). Burma (Myanmar): ye-katit. Laos: th'o:ng hla:ng. Thailand: thonglang-pa (northern), thong-lang (central). Vietnam: v[oo]ng h[aj]t d[as].

Distribution *E. subumbrans* occurs naturally from India and Sri Lanka, throughout South-East Asia (except New Guinea) to Fiji and Samoa; planted throughout the tropics.

Uses In Indonesia the bark is pounded and applied as a poultice against fever. A decoction of the bark is drunk to treat spleen afflictions in the Philippines. In Malaysia, the juice of the bark is drunk to relieve cough, and the bark is applied simultaneously as a poultice. An infusion of the bark in vinegar is prescribed for rubbing the body after childbirth, if vomiting occurs. In Indonesia, pounded young leaves are used as a poultice for haemorrhage after giving birth, against menorrhagia and to relieve headache; juice of the leaves is used as an eye-wash and a decoction of the leaves is given for coughs. Very young leaves are steamed and eaten in salads in Java. The leaves are good and palatable fodder, but if eaten by rabbits can cause sterility and death. The wood is utilized in canoe and raft building. In Papua New Guinea, trees are planted near villages for their showy red flowers, while in certain districts (e.g. Morobe) they are used in ritual ceremonies.

Observations A deciduous, medium-sized tree, 5–25 m tall, crown spreading, trunk reaching 60 cm in diameter, armed with stout prickles, under cultivation mostly unarmed; petiole 8–16 cm long, thickened at the base; stipules orbicular, small, rachis 2–5 cm long, leaflets ovate-triangular-rhomboid, terminal one largest and 8–16 cm × 6–14 cm, base rounded or cordate, apex acuminate, glabrous, petiolule up to 7 mm long; stipels stipitate, cup-like, glandular; inflorescence racemose, in the upper leaf axils, 5–23 cm long, brownish-tomentose, peduncle 3–15 cm long; flowers many, arranged in groups of 3, pedicel 2– 3 mm long, in fruit up to 6 mm long, calyx campanulate, 1–1.5 cm long, splitting open up to halfway down, tomentose, yellow-green; standard broadly elliptical, 2.5–4 cm × 2–3 cm, shortly clawed, scarlet, at base inside with numerous white stripes, wings as long as the keel or slightly longer, about 1.5 cm long, pale red with a blackish upper margin; stamens 3–3.5 cm long, monadelphous but vexillary stamen slightly shorter than other ones and only connate for the lower 0.5–1 cm, pinkish red; fruit a flat, curved pod, 10–15 cm long, on a slender stalk 3–4.5 cm long, lower part seedless and 2–2.5 cm wide, upper part thicker, 1–1.5 cm wide and 1–5-seeded, septate between the seeds, dehiscent; seed ellipsoid, 7–18 mm × 5–11 mm, smooth, dull black.

Selected sources 74, 135, 407, 481, 747, 786, 972.

Erythrina variegata L.

Herb. Amb.: 10 (1754); Amoen. acad. 4: 122 (1759).

Synonyms *Erythrina indica* Lamk (1786), *Erythrina orientalis* (L.) Murray (1787), *Erythrina variegata* L. var. *orientalis* (L.) Merr. (1917).

Vernacular names Indian coral tree, variegated coral tree (En). Indian coral bean, tiger's claw (Am). Arbreau corail, arbre immortel (Fr). Indonesia: dadap blendung (Sundanese), dadap ayam, (Javanese), dede bineh (Madurese). Malaysia: dedap, cengkering, radap (Rungus, Sabah). Papua New Guinea: balbal (Ravat, East New Britain Province), bigini (Hulu, Central Province), namatia (Buang, Morobe Province). Philippines: karapdap (Tagalog), andorogat (Bikol), bagbag (Ilokano). Burma (Myanmar): penglay- kathit. Cambodia: roluöhs ba:y. Laos: (do:k) kho, th'o:ng ba:nz. Thailand: thong baan, thong phueak (northern), thong laang laai (central). Vietnam: v[oo]ng nem, h[ar]i d[oof]ng b[if].

Distribution *E. variegata* is a native of the coastal forests from East Africa, the Indian Ocean Islands, from India, throughout South-East Asia, to the Pacific Islands and the Northern Territory and Queensland in Australia; widely cultivated throughout the tropics.

Uses The leaves and bark are widely used medicinally in many South-East Asian countries. The bark is used as an antipyretic in Burma (Myanmar), and in decoction to treat liver problems in China and intermittent fever in Indo-China. A decoction of the bark and leaves is used to treat dysentery in Indonesia; sweetened, it is considered a good expectorant. The leaves, either fresh or as a decoction or extract of dried leaves, are employed as a soporific in Indonesia and Indo-China. The leaves, when eaten, are considered to act as a galactagogue; alternatively the breasts can be bathed with a lotion of the leaves. In Indonesia, the leaves and flowers are used to treat menstrual disorders. Throughout South-East Asia, the bark and leaves have been used in various ways to treat rheumatism and to relieve asthma and coughs. The roots and leaves are often employed to alleviate fever in the Philippines and Papua New Guinea. In the Philippines and Malaysia, the bark is employed as an anodyne to relieve toothache. Crushed seeds are used as a poultice to treat cancer and abscesses in Indo-China, and are boiled in a little water as a remedy for snakebites in Malaysia. The leaves are commonly applied as a poultice on sores. In Sabah, the bark of the trunk is boiled to prepare teas or make a bath for skin diseases and impetigo. In India, the root and bark are called 'paribhadra', a drug used in Ayurvedic medicine. The leaves are used as green manure and to a limited extent as fodder. Cooked leaves are eaten as a pot-herb. The raw seeds are poisonous but may be eaten after boiling or roasting. They are also said to have narcotic properties. The wood is of little use, even as firewood.

Observations A deciduous tree, 3–27 m tall with fluted bole and much branched crown; trunk and branches thick and sappy, armed with large, scattered prickles, flowering branches often leafless; in cultivation often unarmed; petiole 2–28 cm long, stipules lanceolate, 1–1.5 cm long, rachis 10–12 cm long, leaflets ovate to broadly rhomboid, 4–25 cm × 5–30 cm, terminal one largest, base rounded or slightly cordate, apex acuminate, entire or sometimes shallowly lobed, thinly coriaceous, glabrescent, petiolule up to 1.5 cm long, at base with globose glandular stipels; inflorescence an axillary, dense raceme 10–40 cm long, ferruginous tomentose, lateral near the top of branchlets; peduncle 7–25 cm long; pedicel up to 1.5 cm long; flowers in groups of 3 scattered along the rachis; calyx eventually deeply spathaceous, 2–4 cm long, glabrescent, red; standard ovate-elliptical, 5–8 cm × 2.5–3.5 cm, shortly clawed, bright red (occasionally white) without white veins; wings and keel subequal, 1.5–2.5 cm long, red (occasionally white); stamens 5–7 cm long, monadelphous, vexillar stamen basally connate with the tube for 1 cm, red; fruit a sausage-shaped or long cylindrical pod, 10–45 cm × 2–3 cm, 1–13-seeded, slightly constricted between the seeds, glabrescent, distinctly veined and exocarp bursting irregularly, indehiscent; seed ellipsoid to reniform, 6–20 mm × 5–12 mm, smooth, glossy black, purplish or purplish red-brown.

Selected sources 74, 135, 176, 264, 407, 418, 739, 747, 786, 810, 1038.

Undang A. Dasuki

Eucommia ulmoides Oliv.

Hook., Icon. pl. 20: t. 1950 (1891), emend. Hook., Icon. pl. 24: t. 2361 (1895).

EUCOMMIACEAE

$2n = 34$

Vernacular names Hardy rubber tree, gutta-percha tree (En). Vietnam: d[oox] tr[oj]ng.

Origin and geographic distribution *E. ulmoides* is probably not known in a true wild state at present. It originated from southeastern China, where it has long been cultivated as a medicinal, and recently it has also been cultivated for medicinal purposes in Korea, Japan, Taiwan and Vietnam. It is commonly encountered in Chinese pharmacies throughout South-East Asia.

Uses *E. ulmoides* is well known in traditional Chinese medicine, and its recorded use dates back 2000 years. The major pharmacological effects include hypotensive, diuretic, tonic, analgesic and sedative actions. The drug is traded as 'Cortex Eucommiae'. In general it is used in mixtures. The bark is mainly used as a medicinal herb material for tonics and hypotensive drugs, and this use is specified in the Japanese Pharmacopoeia. In China and Vietnam it is prescribed in deficiency of liver and kidney functions, hypertension, lumbago, articular pains and rheumatism. It is further credited with strengthening the musculoskeletal system, and as a panacea during and after pregnancy. The leaves are used as a basis for beverages. The plant yields a gutta-percha, resistant to acids and alkalies. At one stage it was regarded a temperate alternative for tropical *Hevea* rubber. It has been used extensively in electrical insulation and as filling material in dentistry. The timber is used for furniture, construction, farming tools and as firewood.

Production and international trade The market value in Japan of health foods and drugs containing *E. ulmoides* amounted to US$ 1500 million in 1991. In the United States the wholesale price of bark is US$ 20/450 g and 20 teabags (2 ounces/56.7 g) containing the leaf or bark as additive cost US$ 5.

Properties Phytochemical investigations of bark, leaves, flowers and fruits of *E. ulmoides* have revealed the presence of a wide range of iridoids, lignans and related phenylpropane compounds. Several of them, as purified compounds, showed pharmacological activities in laboratory animals using in general screening assays. Examples of these are the furofuran-type lignans pinoresinol-di-O-β-D-glucoside and syringaresinol-di-O-β-D-glucoside, and the iridoid glucosides geniposide, geniposidic acid and aucubin (= aucuboside). The effects observed included hypotensive, psychogenic, hypokinesis preventive and cholagogic activities. Furthermore, eucommiol is a characteristic compound from the leaves of *E. ulmoides*, which is derived from the plant by reduction of C9-iridoids.

In addition, extracts of *E. ulmoides* also display a variety of pharmacological effects. For example, methanolic extracts strongly inhibited the growth of *Clostridium perfringens* in vitro, using a paper disk agar diffusion method under anaerobic conditions. An antifungal protein isolated from the bark inhibited at 0.3 mg/ml the growth of *Trichoderma viride* and some other crop fungal pathogens.

The methanolic extract of the bark exhibited antihyperglycaemic activity via glucose uptake and insulin induction at a dose of 100 mg/kg.

In an exercise load testing experiment with castrated 4-week-old male Wistar rats, *E. ulmoides* extract significantly increased the relative weight of the adrenal gland, enhanced androgen secretion from the reticular layer of the adrenal cortex, and promoted protein anabolic action. In addition, this extract appeared to increase the adaptation ability of the adrenal cortex to the stress caused by exercise.

Furthermore, in a test using spontaneous hypertensive rats, *E. ulmoides* leaf extract suppressed the increase in blood pressure in a dose-dependent manner.

Several experiments focused on the liver/cholesterol metabolism. In an experiment with rats, the leaf extract suppressed significantly the high-fat diet-induced increases in total serum cholesterol, serum triacylglycerol and hepatic triacylglycerol, but not the total hepatic cholesterol. The leaf extract also suppressed the high-fat diet induced increases in very-low density lipoprotein and low density lipoprotein without affecting high density lipoprotein cholesterol. These results suggest that *E. ulmoides* leaf extract may be beneficial for the regulation of hyperlipidemia. In addition, stroke-prone spontaneously hypertensive rats fed on a high-fat and high-cholesterol diet (HFC) were used to induce hypercholesterolaemia. The experimental group was given the HFC-diet containing 5% w/w *E. ulmoides* leaf powder for 2 weeks with free access to the diet and water. It was found that leaf powder prevented the elevation of serum total cholesterol. The hypocholesterolaemic effect was due mainly to a decrease in the content of cholesterol in the VLDL fraction, which was associated with decreases in the levels of apolipoprotein-B and -E. Results suggest a decrease in atherogenic and cholesterol-rich VLDL produced by the HFC diet feeding. In the liver, elevation of cholesterol content was also prevented by administration of the leaf powder, whereas no significant change in the contents of phospholipid and triglyceride was observed. Also, no significant changes were found in the activities of the microsomal enzymes cholesterol-7-α-hydroxylase and cholesterol acyltransferase.

The antimutagenic potential was furthermore investigated in vivo and vitro. The ingestion of *Eucommia* tea may reduce human exposure to dietary mutagens as was shown in an experiment with humans. Additionally, an anticlastogenic effect of the tea was observed in mice using the micronucleus assay. After extraction with boiling water and frozen vacuum drying, *E. ulmoides* leaves were tested in the Ames test in vitro. *E. ulmoides* (+/- S9) was found to significantly induce His^+ revertants in *Salmonella typhimurium* TA98 and/or TA100. The antioxidant effect of extracts from leaves, raw cortex and roasted cortex was evaluated using various lipid peroxidation models. The antioxidant activity of extracts is correlated to their polyphenol content. Extracts of the leaves may therefore be useful in inhibiting membrane lipid peroxidation and preventing free radical-linked disease.

Other experiments with *E. ulmoides* investigated effects on the muscle and skeleton. For example, a diet enriched with *E. ulmoides* leaves results in harder muscles in cultured eel. While most characteristics of the meat remain similar, a considerable increase in muscle protein stroma fraction which mainly consists of collagen is observed. In chickens, dietary suppletion with *E. ulmoides* leaves resulted in improved meat quality due to the quality and quantity of collagen. The administration of geniposidic acid or aucubin as purified compounds was also found to stimulate collagen synthesis in false-aged rats. The reported pharmacological effects of *E. ulmoides* leaves, including healing organs and strengthening bone and muscle, seem to be closely related to collagen metabolism. Moreover, ovariectomized (OVX) or sham-operated 6-week old female rats were given a low-calcium diet (Ca 0.01%, P 0.3%) for 33 days. Subsequently, OVX rats were given a control diet or a diet containing 2% *E. ulmoides* bark extract. The diet for the control group and the sham group was the control diet and contained 0.3% Ca and 0.3% P. Each group was given the experimental diet for 31 days. Bone mineral density (BMD) and the breaking strength of the control group were lower than those of the sham group. However, BMD and bone strength improved in the *E. ulmoides* group and intestinal Ca absorption increased. Moreover, the muscle weight of the latter was higher than that of the control group.

Finally, in the carbon-clearance test in mice, used to evaluate the stimulating effect on the phagocytic activity of granulocytes, eucomman B isolated from a hot water extract, increased the phagocytic index, suggesting that it activated the reticuloendothelial system.

Adulterations and substitutes The iridoid glucoside aucubin (= aucuboside) is also found in e.g. *Aucuba japonica* Thunb., *Verbascum densiflorum* Bertol., and *Plantago lanceolata* L. The closely related compound geniposide is furthermore found in e.g. *Gardenia jasminoides* J. Ellis.

Description A deciduous, dioecious tree up to 20 m tall, with ascending twiggy branches forming a broadly domed crown; branchlets hollow, pith lamellate, with articulate lactifers in phloem and cortex and scattered latex-cells elsewhere. Leaves spirally arranged, simple, narrowly ovate to elliptical, 7–15(–20) cm × 3–7(–9) cm, apex acuminate, margin serrulate; petiolate; stipules absent. Flowers solitary, shortly pedicellate in the axils of bracts racemosely arranged on the proximal section of a distally leafy shoot, sepals and petals lacking; male flowers composed of (5–)6–12 stamens, anthers red-brown; female flowers with a unilocular ovary, stigmas 2, unequal, reflexed. Fruit a samara, compressed ellipsoid to oblong, 3–4 cm long, winged, 1-seeded. Seed with large embryo embedded in copious endosperm.

Eucommia ulmoides Oliv. – 1, fruiting twig.

Growth and development *E. ulmoides* trees may flower before or simultaneously with the emergence of new foliage. Flowers are wind-pollinated.

Other botanical information *E. ulmoides* is the only species of the family *Eucommiaceae*. The family *Eucommiaceae* is variously associated with *Urticales*, *Hamamelidales* (for pollen similarity) or even *Magnoliales*, and is morphologically nearest to the *Urticales*.

Ecology *E. ulmoides* originated from the relative warm and humid part of south-eastern China from 300–1300 m altitude. As a medicinal raw material it has been cultivated in the same region at 500–1100 m altitude. In Vietnam it is cultivated above 1000 m altitude. The plant can tolerate frosts as low as –15°C and is grown as an occasional ornamental in temperate climates.

Propagation and planting *E. ulmoides* is usually propagated by seed. Seed should preferably be collected from 10–20-year-old trees, and sown in spring or autumn. Natural germination is rather poor, 10%, but can be enhanced to 60% by immersing the seeds in water, and up to 80% by peeling off the seed coat. Seedlings are spaced 10 cm apart. In winter or spring 1-year-old seedlings are planted at 2.5–3 m intervals. Information on propagation by softwood cuttings is contradictory. For propagation by tissue culture, the epicotyl of the seed shortly after germination is a suitable starting material, in particular with the addition of 0.1–5 mg/l butyric acid (BA) to a B5 medium. Rooting was recorded at a rate of 60% after immersion in 100 ppm naphthalene acetic acid (NAA). When using 1-month-old seedlings as starting material, the explant is an excised shoot tip, 3–5 mm tall. Murashige and Skoog (MS) basal medium supplemented with 1 mg/l BA is employed to establish primary cultures and subsequently multiply shoots. Shoots are subculturable on the same medium and can be increased at a rate of 7.5 new shoots per 2-shoot sector every 3 weeks. Rooting is achieved in a Gelrite medium with the MS salts reduced to 1/3 strength and the BA replaced by 0.1 mg/l NAA. The method is not directly applicable to mature trees. Applicability will require explants from rejuvenated sources, possibly attainable by the method of repeated grafting of shoot apices onto juvenile rootstocks, repeated subculturing of shoots, or culturing shoot apical meristems.

In vitro production of active compounds In vitro production of iridoids and lignans, in particular the active compounds pinoresinol di-O-β-D-glucoside (PRDG), syringaresinol di-O-glucoside (SRDG), geniposidic acid (GA) and aucubin, is inferior to the concentration present in bark or leaves of *E. ulmoides*.

Husbandry Plantings for the production of bark of *E. ulmoides* are tended for about 15–20 years before actual production starts. Plantings for the production of leaves for beverages are pruned at 40 cm height in order to induce the growth of lateral branches in 2 years; leaves to be used are cropped from the epinasty branches after 3 years.

The application of 2000 ppm 2-diethylaminoethyl-3,4-dichlorophenyl ether (DCPTA) to greenhouse-grown *E. ulmoides* plants resulted in an 18% increase in the gutta content. Leaf area and plant height were also enhanced. Field studies employing 100 ppm of a proprietary regulator, FVCL2, produced a 20% increase in leaf gutta.

Diseases and pests Regeneration of bark in *E. ulmoides* can be seriously affected by fungal rot after harvesting.

Harvesting The bark of *E. ulmoides* is peeled in spring or early summer, from about (10–)15–20-year-old trees, at least 15 cm in diameter. Care should be taken not to girdle the tree; preferably a third should be spared.

Yield The concentration of medicinally important compounds in the leaves of *E. ulmoides* is influenced by production area, harvest time and treatment after harvesting. Leaves and branches are harvested for the production of gutta-percha. 3–4-year-old plantations for gutta-percha production yield 200–250 kg gutta-percha per ha.

Handling after harvest The pieces of bark of *E. ulmoides*, folded with the inner surfaces together, are tied with rice straw and left to sweat for a week. When the inside is brownish-black, the bark is untied, flattened and dried in the sun, and the coarse outer bark is scraped off. The remaining stringy inner bark, revealing silvery and extensible filaments when broken, is chopped into blocks and marketed.

Genetic resources and breeding The high demand for *E. ulmoides* poses threats of genetic erosion locally as a result of over-collecting. Despite its long history of use and cultivation the genetic diversity does not seem to be fully exploited let alone properly guarded. The genetic basis for the recently established plantings outside its natural distribution is unclear.

Prospects The extracts and compounds isolated from *E. ulmoides* display interesting pharmacological activities, especially in the field of hypertension, cholesterol metabolism, muscle pathology and bone-calcium metabolism. All these effects are of great interest for the treatment of major global complaints, such as heartdiseases and osteoporosis. Therefore *E. ulmoides* might be of interest for future developments (for example lead-compounds), and merits further research.

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Nguyen Nghia Thin

Evolvulus alsinoides (L.) L.

Sp. pl. ed. 2: 392 (1762).

CONVOLVULACEAE

$2n = 26$

Synonyms *Convolvulus alsinoides* L. (1753).

Vernacular names Thailand: bai to kaan (north-eastern). Vietnam: b[aas]t giao.

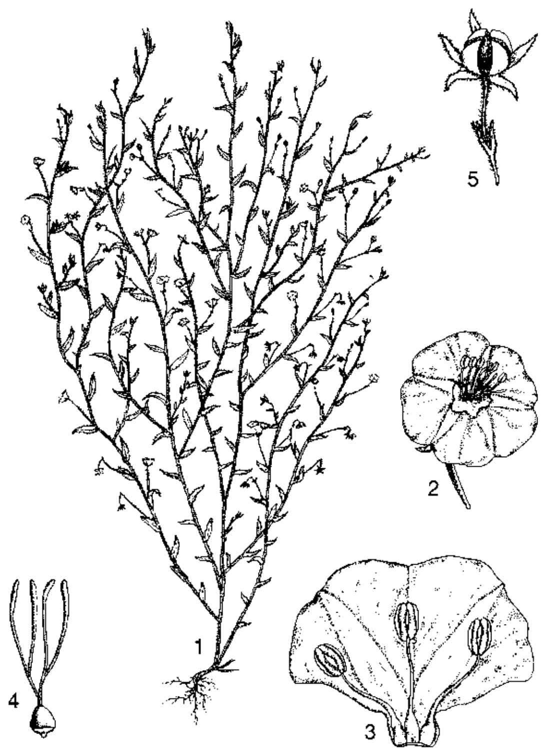
Origin and geographic distribution *E. alsinoides* occurs in most dry tropical and subtropical regions of the world.

Uses In South-East Asia, India and Africa, the whole bitter plant is used extensively as a febrifuge, tonic, alterative, antidiarrhoeal and anthelminthic. In the Philippines, the entire plant is taken in an infusion to cure bowel complaints, and also as a vermifuge and a febrifuge. In India, it is also applied for syphilis, scrofula, snake bites and an infusion prepared with oil is applied to promote hair growth. In Kenya, sores are treated by application of the powdered leaves, and in Tanzania, the pounded leaves are put on enlarged glands in the neck. In India and Nigeria, the leaves are made into cigarettes, which are smoked to relieve bronchitis and asthma, while the fragrant smoke is also used to perfume houses. In northern Ghana the plant is used in love-potions and in religious practices. In Mexico, the bitter plant decoction is taken as a remedy for gonorrhoea.
E. alsinoides is grazed by cattle, although the leaves are bitter.

Properties *E. alsinoides* is reported to contain flavonols and saponins. Cultured tissues of *E. alsinoides* accumulate ergot alkaloids: amides of the indole derivative D-lysergic acid, which is biosynthetically derived from the amino acid tryptophan. Although the best known source of the ergot alkaloids is the sclerotium of the fungus *Claviceps purpurea* or related fungi, several lysergic acid alkaloids have also been isolated from members of the family *Convolvulaceae*.
The ethanol extract of the whole plant shows antiulcer and anticatatonic activity in rats. In vivo, the extract significantly reduced the incidence of ulcers in aspirin-treated rats and reduced the incidence of catatonia in chlorpromazine-treated rats. In mice, the extract showed central nervous system depressant activity with ED_{50} at 450 mg/kg. A water extract of the corolla inhibited spore germination and mycelial growth of the fungi *Alternaria brassicae*, *A. brassicicola* and *Fusarium oxysporum*. Other types of extracts also showed some (weak) antifungal and antibacterial activity.

Adulterations and substitutes Several members of the family *Convolvulaceae* contain lysergic acid alkaloids, e.g. *Ipomoea violaceae* L. and *Rivea corymbosa* (L.) Hallier f.

Description A very variable, perennial herb or subshrub; stems slender, reclining and spreading, or erect, 12–70 cm long, not twining, more or less branched, deep-rooted. Leaves alternate, entire, widely spaced, oblong to elliptical or lanceolate, 1–4 cm × 0.2–1 cm, base cuneate, apex acute or mucronate, densely or sparsely white hairy; petiole absent; stipules absent. Inflorescence an axillary 1–3 flowered cyme, peduncle filiform, 2.5–3.5 cm long, pedicel up to 1 cm long, often 2–4 subulate bracts at the base. Flower 5-merous, actinomorphic, calyx 5-partite, sepals small, 3 mm long, villose, not enlarged in fruit, corolla campanulate to rotate, 4–8(–12) mm wide, pale blue, sometimes white; stamens 5, included or exserted, filaments adnate to the corolla tube; ovary 2-celled, styles 2, each with 2-lobed stigma. **Fruit** a rounded capsule, 3–4 mm long, mostly 4-valved, glabrous, partly enclosed in the calyx. Seeds (1–)4, smooth, black. Seedling with epigeal germination, cotyledons deeply emarginate.



Evolvulus alsinoides (L.) L. – 1, plant habit; 2, flower; 3, part of corolla, cut open; 4, pistil; 5, fruit.

Growth and development *E. alsinoides* germinates at the beginning of the rainy season, and starts flowering after 8 weeks.

Other botanical information About 98 species are described in *Evolvulus*, mainly in the New World, from the South of the United States to Argentina. Two of these are also present in the Old World, of which the polymorphic *E. alsinoides* occurs with about 15 varieties. Six of these are recognized in Malesia, but they tend to intergrade. Some *Evolvulus* species are cultivated for their striking blue flowers.

Ecology *E. alsinoides* is a weed of sandy, open, dry grassland and rock localities, in most of the tropics and subtropics, often on limestone, at low and medium altitudes. It is locally abundant.

Propagation and planting *E. alsinoides* is propagated by seed.

In vitro production of active compounds Ergot alkaloids occur in small amounts in callus tissue cultures of the leaves of *E. alsinoides*. The cultures are established on Murashige and Skoog medium supplemented with 2 mg/l 2,4-D, 0.4 mg/l kinetin and 2% sucrose. The production of these alkaloids can be increased by a factor of 10–40, depending on the treatment, by supplementing known precursors such as L-tryptophan, 5-methyltryptophan and mevalonic acid.

Diseases and pests In India, *E. alsinoides* is attacked by the root fungus *Sclerotium rolfsii*, and gall formation on the aerial parts is caused by *Albugo evolvuli*. It is also an alternative host for the larvae and pupae of the potato cutworm (*Agrotis ypsilon*) in India.

Harvesting Whole plants of *E. alsinoides* are uprooted for use.

Handling after harvest *E. alsinoides* is normally used fresh.

Genetic resources and breeding *E. alsinoides* is a relatively widespread herb, and is not likely to be threatened by genetic erosion. Some cultivation trials for medicinal purposes of the species have been carried out in India.

Prospects Little information is available about the pharmacology and phytochemistry of *E. alsinoides*, therefore it is not yet possible to fully evaluate its potential. Since ergot alkaloids are of interest in medicine (e.g. in the treatment of migraine, and in reducing post-partum haemorrhage) it might have some potential for the local market, depending on the quantity and type of compounds that can be isolated.

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G.H. Schmelzer & N. Bunyapraphatsara

Excoecaria L.

Syst. nat., ed. 10, 2: 1288 (1759).

EUPHORBIACEAE

x = unknown; *E. agallocha*: $2n$ = about 70, 140, 168, *E. cochinchinensis*: $2n = 22$, *E. indica*: $2n = 64$

Major species *Excoecaria agallocha* L., *E. cochinchinensis* Lour.

Origin and geographic distribution *Excoecaria* comprises about 40 species occurring in tropical Africa, Madagascar, and from India and Sri Lanka eastwards to Indo-China, southern China, Taiwan, the Ryukyu Islands, Thailand, throughout the Malesian region, northern Australia and the Pacific Islands. Most species are found in the Asiatic tropics, including 12 in Malesia.

Uses Various parts of most *Excoecaria* species contain highly irritating and poisonous substances, most prominent in the latex. Trees of *E. agallocha* may form resinous, aromatic wood containing an oil applied medicinally against sores, eczema and scabies. Various parts of *E. agallocha*, *E. cochinchinensis* and *E. indica*, most likely substances from the latex, are used as fish poison. The bark of *E. agallocha* is also used as an ingredient for dart poison and as a purgative. In Sarawak the leaves of *E. borneensis* Pax & Hoffm. are heated over a fire and applied as a poultice to relieve rheumatism. Its leaves are poisonous to cattle. *E. bantamensis* Müll. Arg. (synonym *E. macrophylla* J.J. Smith) from Borneo, the Philippines and Java is known for its irritating latex. *E. oppositifolia* Griffith from Burma (Myanmar), Thailand and Indo-China is also known to cause skin irritation. The wood of various *Excoecaria* species has limited applications as a timber, but yields good quality charcoal and can be used as raw material for the production of kraft pulp. Pieces of the resinous, aromatic wood of *E. agallocha* are called 'garu laut' or 'garu mata buta' in Ternate and 'menengan' in Bali. It serves as a substitute for 'gaharu' (incense) from *Aquilaria* spp. However, the low likelihood of its occurrence and the amounts available render it insignificant. The leaves of *E. agallocha* and *E. indica* contain tannin and are used to prepare a dye.

Properties The extremely irritant and caustic latex of *E. agallocha* is known to contain a complex mixture of polyfunctional diterpene esters: C-20 compounds, esterified with aliphatic saturated homologous n-carboxylic acids (even numbered, C22–C30). The mixture can be further divided into 3 groups of compounds, which are also known as cryptic irritants. Based on their ground skeletons, the largest group (group I) contains analogues of aliphatic, polyunsaturated 9,13,14-ortho-esters of the daphnane-type parent alcohol 5β-hydroxyresiniferonol-6α,7α-epoxide. Group II contains analogue structures of 5β,12β-dihydroxyresiniferonol-6α,7α-epoxide, and group III contains analogues of aliphatic 13-polyunsaturated, 20-saturated diesters of the tigliane-type parent alcohol 12-deoxyphorbol. In general, the 3 groups exhibit practically no irritant activity in the well-known mouse ear irritation test. However, alkaline transesterification of groups I–III releases the corresponding highly irritant multicomponent mixtures of *Excoecaria* factors A (OH-20 deacylated). They comprise a mixture of the well-known *Excoecaria* factors A1/A2/A3 and mixtures of *Excoecaria* factors A4/A5, A6/A7 and A8/A9. The highly irritant mixture A1/A2/A3 was obtained directly (0.2% of the latex) using an alternative, extremely mild separation procedure. These represent the so-called free *Excoecaria* factors, the natural constituents of the latex responsible for its bioactivity.

In contrast to its irritant effects, latex from *E. agallocha* has been successfully applied for wound healing in both humans and animals. Despite the toxic constituents in the leaf, protein extracted from mature leaves can be used for feeding fish.

Several labdane-type diterpenes have been isolated from the wood of *E. agallocha*.

Leaf extracts of *E. agallocha* show significant antiviral activity against tobacco mosaic virus (>70% inhibition), and the phorbol ester 12-deoxyphorbol 13-(3E,5E-decadienoate) isolated from leaves and stems of *E. agallocha* shows anti-HIV activity. The latter compound is also a potent displacer of H^3-phorbol dibutyrate from rat brain membranes. To search for possible antineoplastic agents, 17 diterpenes isolated from the resinous wood of *E. agallocha* (grown in Okinawa, Japan) were screened using an in vitro synergistic assay system. Of these diterpenes, ent-16-hydroxy-3-oxo-13-epimanoyloxide, (13R,14R)-ent-8α,13,14,15-diepoxy-13-epi-labda-3β-ol, ent-3β-hydroxy-15-beyeren-2-one and ent-15-hydroxy-labda-8(17),13E-dien-3-one exhibited significant inhibitory effects on Epstein-Barr virus activation induced by the tumour promoter 12-O-tetradecanoylphorbol-13-acetate (TPA). In a 2-stage in vivo carcinogenesis test on mouse tumours using 7,12-dimethylbenz-α-anthracene as initiator and TPA as promoter, ent-3β-hydroxy-15-beyeren-2-one exhibited remarkable antitumour-promoting activity.

Using juvenile Nile tilapia (*Sarotherodon niloticus*) as test organism, 96 hour bioassays were run from the highest concentration in which no death occurred to the lowest concentrations in which mortality was 100%. LC_{50} values were 0.002–0.003 ppt for *E. agallocha* sap and 0.05 ppt for *E. agallocha* root.

Leaves of *E. oppositifolia* yielded the irritant *Excoecaria* factor O1, an ester of 5β-hydroxyresiniferonol-6α,7α-epoxide. Its structure was shown to be identical with that of a factor obtained by transesterification of the cryptic *Excoecaria* factor group Oz from the latex of the same plant, and with *Excoecaria* factor B4 from *E. cochinchinensis*. Furthermore, the latex of *E. oppositifolia* contained *Excoecaria* factors O2 (an ester of 5β-hydroxyresiniferonol-6α,7α-epoxide) and O3 (an ester of 5β, 12β-dihydroxyresiniferonol-6α,7α-epoxide). *Excoecaria* factor O3 is identical with *Excoecaria* factor A7 from *E. agallocha*, and *Excoecaria* factor B6 from *E. cochinchinensis*. From the non-irritant ethyl acetate fractions of *E. agallocha*, *E. oppositifolia* and *E. cochinchinensis* latices, three thin layer chromatography (TLC)-homogenous non-irritant mixtures, A'z, O'z and B'z, were isolated.

The latex of *E. cochinchinensis* is also very rich in diterpene esters of the same 3 structural groups as found in *E. agallocha* latex. After alkaline trans-esterification, the corresponding highly irritant multicomponent mixtures of *Excoecaria* factors B1–B8 were isolated. From the first group, *Excoecaria* factors B1/B2/B3 are identical with A1/A2/A3 from *E. agallocha*, and B4 is identical to O1 from *E. oppositifolia*. From the second group B5/B6 is identical with A6/A7 from *E. agallocha*, and B6 also with O3 from *E. oppositifolia*. Finally, from the third group, *Excoecaria* factor B7 is identical with A8 from *E. agallocha*. Furthermore, 4 TLC-homogeneous fractions (F1–F4), highly enriched in diterpene esters were obtained from the latex of *E. cochinchinensis*, collected from Thailand. These fractions were analysed by GC-MS, and were found to consist of mixtures of highly unsaturated esters of both daphnane and tigliane type parent alcohols.

E. cochinchinensis is used in traditional medicine for its uterotonic properties. Also, daphnane type esters are currently used routinely in China for fertility regulation. Similarly, daphnane and tigliane type *Excoecaria* factors present in the latex of *E. cochinchinensis* may be responsible for the uterotonic activity of its leaves utilized in Thai herbal medicine.

The screening of pharmacological activities of alcoholic extracts of *E. cochinchinensis* was performed using different test systems. In the hippocratic screening (rat), signs and symptoms such as decrease of motor activity, depression of respiration, loss of screen grip, enophthalmos, blanching of ears and oral mucosa, and hypothermia were observed following the intraperitoneal injection of *E. cochinchinensis*. Effects on the cardiovascular system were hypotension (pentobarbital anaesthetized rat), and the depression of myocardial contractility (isolated atrial strips of guinea-pig and rat). A marked stimulant activity of *E. cochinchinensis* on smooth muscles was observed with the smooth muscle of ileum (guinea-pig and rat) and uterus (rat), but not with that of the trachea (tracheal chain preparation of guinea-pig).

Several diester diterpenes, based upon phorbol, 4-deoxyphorbol, 4α-deoxyphorbol, 4-deoxy-5-hydroxyphorbol and 4,20-dideoxy-5-hydroxyphorbol were isolated from the fruit oil of *E. indica*, e.g. sapatoxin A (12-0-[n-deca-2,4,6-trienoyl]-4-deoxyphorbol-13-acetate), B (12-0-[n-deca-2,4,6-trienoyl]-4-deoxy-5-hydroxyphorbol-13-acetate), C (12-0-[n-deca-2,4,6-trienoyl]-4,20-dideoxy-5-hydroxyphorbol-13-acetate), and sapintoxins B, C and D.

Corresponding tri- and tetra-esters were produced by acetylation and mono-esters by selective hydrolysis. Twenty-six of these diterpenes were tested for production of erythema in vivo, and induction of human and rabbit platelet aggregation in vitro. The flatter shape of the AB-ring-trans compounds is necessary for interaction of phorbolesters with their receptor; the cis analogues were inactive. The tertiary C-4 hydroxy group of phorbol was not necessary for activity, although the 4-deoxy derivatives were less potent than the 4-hydroxy diterpenes. A primary hydroxy group at C-20 was essential for biological activity because the methyl and aldehyde derivatives of this position were inactive. The C-20 acetates were also inactive on platelets, but they did produce erythema, possibly because of the removal of the ester due to lipase activity in the skin. 5-Hydroxy-analogues which had undergone intramolecular hydrogen bonding had greatly reduced activities in both systems. Membrane stabilisers, phospholipase A2 and calmodulin inhibitors were antagonists for phorbol esters in platelet aggregation tests, whilst cyclo-oxygenase inhibitors and free radical scavengers had no inhibitory effects. Consequently, one electron withdrawal and free radical formation seem to play no part in the biological activity of these compounds. Furthermore, sapintoxin D exhibited a weak tumour promoting activity in the Sencar mouse skin assay.

The antihypertensive activity of geraniin and the phenolic glycoside 6-O-galloyl-D-glucose isolated from the leaves of *Triadica sebiferum* (L.) Small (synonyms *Sapium sebiferum* (L.) Roxb., *Excoecaria sebifera* (L.) Müll. Arg.,) has been confirmed in various test systems. Methyl gallate, methyl-3,4,5-trihydroxybenzoate, also isolated from the leaves, showed strong in vitro antiherpetic activity in the plaque reduction assay using herpes simplex virus 2.

Description Evergreen or briefly deciduous, usually dioecious, small to medium-sized trees up to 25(–40) m tall, occasionally shrubs; bole cylindrical, sometimes poorly shaped, up to 60(–100) cm in diameter, without buttresses; bark exuding abundant dirty white to pale yellow latex. Leaves arranged spirally or opposite, simple, entire or crenulate, petiole short, with two glands at the base of the blade; stipules small. Flowers unisexual, small, in an axillary or terminal, unisexual or bisexual raceme or spike; bracts small, biglandular; sepals (2–)3, free or shortly connate; petals absent; disk absent. Male flowers 1–3 together; stamens (2–)3; pistillode absent. Female flowers at the base of the raceme or on separate inflorescences; ovary superior, 3-locular with 1 ovule in each cell, styles simple, connate at base, recurved. Fruit a small, smooth, green to dark brown, dehiscing capsule with 3 bivalved parts. Seed without caruncle. Seedling with epigeal germination; cotyledons emergent; hypocotyl elongated; all leaves arranged spirally, conduplicate.

Growth and development In Bangladesh, the mean annual diameter increment of *E. agallocha* in different plots in mangrove forest ranges from

0.1–0.2 cm. Inflorescences develop on younger shoots, usually from the upper of the axillary bud pair and seemingly independent of the time of shoot extension. They may remain unextended for a long time, but the final extension at anthesis is rapid. Bees are particularly common flower visitors and may be the chief pollinators. They are attracted by the yellow nectar-secreting glands at the margin of the catkin bracts. Old trees of *E. indica* have branches drooping to the ground. The seeds are probably dispersed by water.

Other botanical information The generic boundaries between *Excoecaria* and related genera of the section *Hippomaneae* (e.g. *Sapium*) are not very clear, and various taxonomic publications treat some of the species mentioned here in various other genera. The delimitation followed here represents a conservative view. *Triadica sebiferum* (L.) Small (synonyms *Sapium sebiferum* (L.) Roxb., *Excoecaria sebifera* (L.) Müll. Arg.), cultivated and locally naturalized throughout the tropics, is well known for its fruits yielding tallow and oil. The root bark is used in folk medicine for its diuretic properties and reported successful in the treatment of schistosomiasis. The leaves are traditionally used in Chinese medicine for shingles.

Ecology *E. agallocha* is frequently found in the drier parts of mangrove swamps and along rocky shores, and may occur in pure stands. The other species occur in primary or occasionally secondary evergreen rain forest, up to 800 m altitude. *E. indica* is additionally found in sago swamps, gallery forest and on the inland edge of mangrove swamps.

Propagation and planting *Excoecaria* can be propagated by seed. Sown fruits of *E. indica* show only 5% germination in 318–413 days. In India direct sowing by broadcasting the viable seeds of *E. agallocha* has proven very satisfactory. The species has become more common in Indian mangrove forest because the trees coppice well, can survive repeated felling and are disliked by browsing deer. Rooting of stem cuttings of *E. agallocha* is promoted by application of indole butyric acid (IBA) (2500 ppm) and naphthalene acetic acid (NAA) (500 ppm). Cuttings should preferably be taken from the middle part of the stem. Treatments with 1000 ppm indole acetic acid or indole butyric acid give good growth and rooting. In vitro propagation using nodal segments is also possible. The best axillary sprouting was seen on a medium containing benzyladenine, zeatin and indole butyric acid in concentrations of 13.3, 4.65 and 1.23 μM, respectively. Nodal segments from rooted cuttings and seedlings responded better than those of mature tree explants. Multiple shoot induction was complemented with efficient shoot elongation, and repeated subculture of binodal segments from axillary shoots resulted in 10–12 shoots per explant in 3 months. Rooting was achieved by growing shoots in the medium with 0.23 μM indole butyric acid. Regenerated plants showed 85% survival under ex vitro conditions. *E. cochinchinensis* is commonly propagated by cuttings.

Diseases and pests In North Sumatra and Peninsular Malaysia, localized mass defoliation of *E. agallocha* by caterpillars of the noctuid *Achaea janata* has been observed, but trees survived the attack.

Yield The yield of sapintoxin D, present in unripe fruits of *E. indica* amounts to 5 mg per kg dried fruit.

Genetic resources and breeding Apart from a few individuals in botanical gardens, there are no records of ex situ conservation of *Excoecaria*.

Prospects The presence of substantial quantities of extremely irritant and caustic diterpene derivatives in *Excoecaria* will strongly limit their use as a medicinal plant. Some compounds, however, may serve as models in research.

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Selection of species

Excoecaria agallocha L.

Syst. nat., ed. 10, 2: 1288 (1759) & Sp. pl. ed. 2: 1451 (1763).

Synonyms *Excoecaria camettia* Willd. (1805), *Excoecaria affinis* Endl. (1833), *Stillingia agallocha* (L.) Baillon (1858).

Vernacular names Blind-your-eyes, milky mangrove (En). Indonesia: kayu buta-buta (Indonesian), kayu betah (Javanese), menengan (Madurese, Javanese, Balinese). Malaysia: buta-buta (general), bebuta (Peninsular). Papua New Guinea: sismet (Manus Island), te'eria (Korina, Central Province), su (Madang Province). Philippines: buta-buta (Tagalog, Pilipino), lipata (Bikol, Bisaya, Tagalog). Burma (Myanmar): kayaw taway. Thailand: buu-to (peninsular), tatum thale (central). Vietnam: gi[as], tr[af] m[ur].

Distribution Along the coasts of southern India and Sri Lanka to Burma (Myanmar), Indo-China, China, Taiwan, the Ryukyu Islands, Thailand, throughout the Malesian region, northern Australia and the Pacific.

Uses In the Philippines, the latex is used as a caustic for obstinate ulcers. Oil extracted by distillation of the wood or latex is applied to cutaneous diseases. Chewing a little piece of bark will cause instant vomiting and purging, but is in general considered too drastic a cure for constipation. The roots pounded with ginger may serve as an embrocation to reduce swellings on hands and feet. In Milne Bay, New Guinea, the root is applied as an abortifacient. In the Central Province, very small amounts of the juice are taken orally with coconut juice to treat pneumonia or asthma. It may also be taken as a purgative or vomitory, thereby acting as a poison antidote. A decoction of the leaves is given in epilepsy and externally applied to ulcers. The latex is an adjunct to *Antiaris toxicaria* Lesch. sap in making dart poison. In Thailand, the resin is used as an anthelmintic, for its purgative effect.

Observations A shrub or tree up to 15(–20) m tall; leaves spirally arranged, ovate or elliptical, 3–9 cm × 2–5 cm, apex shortly blunt acuminate, margins crenulate-serrate; inflorescence unisexual, male inflorescence densely spicate, almost catkin-like when young; fruit a capsule, tricoccous, lobed, about 1 cm in diameter, borne in short racemes. Common in mangrove forest, tidal thickets and freshwater swamp forest up to 100(–400) m altitude.

Excoecaria agallocha L. – 1, twig with male inflorescences; 2, fruiting twig; 3, male inflorescence at early anthesis; 4, male flower side view.

Selected sources 31, 32, 33, 34, 36, 74, 82, 90, 128, 135, 215, 286, 351, 407, 418, 431, 450, 505, 509, 554, 555, 654, 666, 769, 786, 788, 828, 915, 1008.

Excoecaria cochinchinensis Lour.

Fl. Cochinch.: 612 (1790).

Synonyms *Excoecaria bicolor* (Hassk.) Zoll. ex Hassk. (1855), Sapium cochinchinense (Lour.) Kuntze (1898), *Excoecaria orientalis* Pax & Hoffm. (1912).

Vernacular names Indonesia: daun remek daging, daun sambang darah (Javanese). Thailand: ka buea (southwestern), kamlang krabue, krabue jed tua (central). Vietnam: d[ow]n t[is]a, d[ow]n l[as] d[or], m[awj]t qu[ir].

Distribution Burma (Myanmar), Thailand, Indo-China, southern China, Peninsular Malaysia, often cultivated as an ornamental, or for medicinal purposes.

Uses In Thailand, the plant is used in traditional medicine for its uterotonic properties. In Indo-China, a decoction of roasted leaves is a traditional remedy for urticaria and herpes zoster. In Java, the leaves with a blood red colour underneath, are externally applied to arrest bleeding. The latex is an irritant and used as a fish poison.

Observations A shrub up to 2 m tall, rarely a tree up to 15 m tall, bark grey, becoming fissured; leaves opposite, oblong-ovate, (4–)10–12 cm × 2–4 cm, acuminate, crenulate-serrulate, broadest above the middle, deep purplish-red (or green) beneath; inflorescence unisexual or bisexual, male inflorescence up to 3 cm long, slender; fruit a trigonal capsule, 1 cm in diameter; seed brownish. Flowering and fruiting occur throughout the year. Two subspecies are distinguished; the leaves of var. *viridis* (Pax & Hoffm.) Merr. are green underneath. In the literature confusion is possible with *Triadica cochinchinensis* Lour., which, however, is a tree up to 25 m tall

Selected sources 31, 74, 135, 215, 288, 407, 739, 786, 788, 868, 1074, 1093.

Excoecaria indica (Willd.) Müll. Arg.

Linnaea 32: 123 (1863).

Synonyms *Sapium indicum* Willd. (1805), *Stillingia indica* (Willd.) Baillon (1858), *Excoecaria diversifolia* (Miq.) Müll. Arg. (1912).

Vernacular names Mock willow (En). Indonesia: ai tui (Ambon), gurah (Kalimantan), tagewa (northern Halmahera). Malaysia: apid-apid, gurah (Sabah), ludai (Peninsular). Thailand: krahut, samo thale (central), ku-ra (peninsular). Vietnam: s[of]i t[is]a.

Distribution From India to Indo-China, Thailand, Sumatra, Borneo, the Lesser Sunda Islands (Sumbawa), the Moluccas, New Guinea and the Solomon Islands.

Uses In Malaysia the leaves are externally applied as a febrifuge, and an infusion is taken as a cure for gonorrhoea. A decoction of the root bark is used as a purgative and emetic. The young fruits, in particular the husks, are used as fish poison. In New Guinea the juice of the fruit is taken as a cure for toothache. The leaves are a traditional source of a greenish-yellow dye, that turns black on boiling. The ripe seeds are edible.

Observations A tree up to 18(–27) m tall, trunk thorny; leaves elliptical or lanceolate, 5–12 cm × 2–4 cm, with 2 small glands at the base, apex tapered, margin crenate or serrate, petiole 0.7–2 cm long; flowers in pseudo-terminal spikes, 5 cm long, male flowers many, female flowers 1–2 at the base of the spike; fruit a globose, woody capsule, about 3 cm in diameter, blackish, borne singly. *E. indica* prefers swampy habitats up to 250 m altitude. It is possible that after stabilization of the nomenclature in the section *Hippomaneae*, the correct name of this taxon will become *Shirakiopsis indica* (Willd.) Esser.

Selected sources 31, 32, 33, 34, 135, 277, 288, 602, 664, 788, 995, 996, 1008.

J.L.C.H. van Valkenburg

Fallopia multiflora (Thunb.) K. Haraldson

Acta Univ. Upsal. serie Symb. Bot. Upsal. 22(2): 77 (1978).

POLYGONACEAE

$2n = 22$, (40, 60)

Synonyms *Polygonum multiflorum* Thunb. (1784).

Vernacular names Fleece flower (En). Laos: manh one ling. Vietnam: h[af] th[ur] [oo], h[af] th[ur] [oo] d[or].

Origin and geographic distribution *Fallopia* consists of about 9 species from the northern temperate region. *F. multiflora* originates from China and is widely cultivated and naturalized in Japan, Taiwan and Vietnam, and to a lesser extent in Laos and Thailand.

Uses The rhizome of *F. multiflora* is the most used part, it is bitter with a sweet aftertaste. It is astringent and warming. The fresh rhizome is widely used in China and Japan as a laxative and antiseptic for boils. A decoction of the rhizome is taken for renal or hepatic insufficiency, anaemia, hyperglycaemia, leucorrhoea, neurasthenia, chronic malaria, tumours, piles, nervous disorders, night sweats from weakness and colds, fatigue, exhaustion, scrofula and impotence. The rhizome is also an excellent tonic for the liver, kidneys and bones. It is used as a medicine to give long life, increase vigour and promote fertility. In Vietnam, the whole plant is widely used, and is especially valued by older people in the treatment of premature grey hair, blurred vision, lassitude of loins and legs and spermatorrhoea. In Indo-China, the rhizome is used as a tonic and a treatment for cholera. In Peninsular Malaysia, a decoction of the rhizomes is given to women after childbirth. If the rhizomes are taken for a long time, the hair and beard turn black.

Production and international trade The rhizomes of *F. multiflora* are traded in China and

Japan, and are found on Chinese markets in Peninsular Malaysia.

Properties The rhizome contains 1.7% of total anthraquinones, e.g. emodin, chrysophanol, rhein, and physcion. These compounds are well-known laxatives: in the colon, they are reduced to their anthrone form which acts directly on the large intestine to stimulate peristaltis. An ethyl acetate extract of the aerial parts yielded a fraction which contains anthraquinones as well. In vitro, this fraction produced a dose-dependent protection against myocardial ischemia-reperfusium injury in isolated rat hearts, associated with an enhancement in myocardial glutathione antioxidant status.

Several stilbenes have been isolated from the rhizomes of *F. multiflora*: rhapontin (4′-methoxy-3,3′5-trihydroxystilbene-3β-D-glucoside) and 2,3,5,4′-tetrahydroxystilbene-2β-D-glucoside. These compounds, together with isolated E-3-butylidene-4,5,6,7-tetrahydro-6,7-dihydroxy-1(3H)-isobenzofuranone showed an inhibitory effect on the enzyme calmodulin-depleted erythrocyte calcium-dependent ATPase in vitro.

The water and ethanol extract of the aerial parts showed a marked antimutagenic action against benzo[a]pyrene and 3,9-dinitrofluoranthene. The tannins and related compounds epigallocatechin, epigallocatechin gallate, and epicatechin gallate, strongly inhibited the mutagenicity of benzoapyrene in *Salmonella typhimurium* TA98 with S9 mix. The extracts were also tested in vivo. F344/DuCrj male rats were given a subcutaneous benzopyrene injection, and were then given a water extract of *F. multiflora* for 50 weeks. At the end of the experiment, the tumour incidence was significantly reduced in favour of the extract. Additionally, a rhizome extract exhibits inhibitory effects on liver enlargement and triglyceride accumulation of mice induced by CCl_4, cortisone acetate and thioacetamide.

Other pharmacological effects of *F. multiflora* rhizomes include inhibition of the growth of *Streptococcus aureus* by an aqueous extract, and a significant protective effect against liver and brain monoamine oxidase in senescence-accelerated mice in vivo by an ethanol extract. The dried aerial parts extract is patented in Japan as a food additive, to improve liver functions.

Description A perennial, dioecious, scandent herb, stems elongate, 1–3(–7) m long, glabrescent; rhizome thick, brown, red inside. Leaves alternate, simple, ovate, 3–6 cm × 2.5–4.5 cm, base cordate, apex acuminate, margins entire; petiole long, ocrea rather short, membranaceous. Inflorescence an axillary or terminal panicle, many-flowered. Flowers actinomorphic, 1.5–2 mm long, perianth segments 5, outer perianth segments becoming winged in fruit, white; pedicel present; male flowers with 8 stamens, base enlarged; female flowers with ovary superior, styles 3, stigmas capitate. Fruit a glossy nutlet covered by the perianth, broadly obovate to suborbicular, 7–8 mm long, 3 prominent wings abruptly decurrent on the pedicel. Nutlet acutely trigonous, 2.5 mm long, dark brown.

Fallopia multiflora (Thunb.) K. Haraldson – 1, flowering stems; 2, female flower; 3, fruit; 4, rhizome.

Growth and development In Japan and Vietnam, *F. multiflora* flowers from August to October, and fruits from November to December.

Other botanical information *Fallopia* is closely related to *Polygonum* and *Persicaria*. The genus *Reynoutria* is now treated as a section of *Fallopia*.

F. japonica (Houtt.) Ronse Decr. (synonym *Polygonum cuspidatum* Siebold & Zucc.) is a close relative of *F. multiflora*. It originates from China and Japan, but has been widely introduced into other temperate regions as an ornamental climber. In Chinese medicine, it is well known as a laxative and an anticancer drug.

Ecology *F. multiflora* prefers sunny habitats with enough moisture, and tolerates shade and drought, but no flooding. It is commonly found in secondary forest or savanna.

Propagation and planting In China and Japan, *F. multiflora* is mainly propagated through stem cuttings and rhizomes. Stem cuttings 30–40 cm long and rhizomes 3–5 cm long are commonly used. The optimum growing temperature is 25–27°C. In Vietnam, the best time for planting *F. multiflora* is March–April, but August–September is possible as well.

Husbandry *F. multiflora* will produce many rhizomes when grown in sandy to light-clay, fertile soils with pH of 6.5–7. During planting time, stable manure or NPK fertilizer is applied.

Harvesting In Vietnam and China, rhizomes of *F. multiflora* are harvested at the beginning or end of the cold season, 2–3(–5) years after planting or from the wild.

Yield In Vietnam, *F. multiflora* produces 1.5–3 t/ha, after 3–5 years.

Handling after harvest Rhizomes of *F. multiflora* can be used fresh or dried. In Vietnam, various methods are used to preserve rhizomes and stems. Rhizomes are cut into small pieces and simply dried in the sun. In a more elaborate method, stems or rhizomes are cut into small pieces and soaked overnight in water with black beans. The next day the pieces are dried in the sun. This is repeated 9 times. This method can be extended, so that after soaking, the pieces and black beans are cooked in water till the water has evaporated. This is also repeated 9 times. In China, rhizomes are dried or treated with wine and black soya bean juice for preservation.

Genetic resources and breeding No germplasm collections of *F. multiflora* are known to exist. It is threatened by overexploitation and conservation measures are urgently needed. Breeding programmes are being developed in China and Japan.

Prospects *F. multiflora* contains anthraquinones which might be of interest, for example in the production of laxatives, or local use. It also shows potential as a liver protecting product, which is patented. *F. multiflora* is a promising crop for South-East Asia, which is not difficult to plant as it is relatively easy to propagate.

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Other selected sources 215, 261, 363, 388, 446, 734, 739, 788, 792, 978, 1097.

Nguyen Nghia Thin

Flemingia Roxb. ex W.T. Aiton

Hort. Kew., ed. 2, 4: 349 (1812).

LEGUMINOSAE

x = 10, 11; *F. grahamiana*, *F. macrophylla*, *F. stricta*: 2*n* = 22

Major species *Flemingia macrophylla* (Willd.) Merr., *F. strobilifera* (L.) Roxb. ex W.T. Aiton.

Origin and geographic distribution *Flemingia* comprises about 40–50 species in the tropical regions of South and South-East Asia and Australia, and two species occur naturally in Africa. *F. macrophylla* and *F. strobilifera* have been introduced in Africa and the Americas as cover, hedge and mulch crop.

Uses In Indonesia, the leaves of *F. lineata* (L.) Roxb. ex W.T. Aiton are used in traditional medicine. The leaves of *F. stricta* Roxb. ex W.T. Aiton, from West Java, Indo-China, Thailand and Burma (Myanmar), are used in Cambodia to treat scabies. A decoction of the tuber *F. vestita* Benth. ex Baker found from India eastward to southern China, is used in India as a vermifuge. In India, *F. grahamiana* Wight & Arn. is used externally for skin diseases and internally as a purgative and specific for colds. *F. grahamiana* and *F. macrophylla* are the principal sources of the resinous powder known as 'waras' or 'warrus'. 'Waras' is a coarse purple or orange-brown powder, consisting of the glandular hairs rubbed from the dry pods, principally used for dyeing silk; the active compound is called flemingin. In Arabia, it is employed as a cosmetic, anthelmintic and a remedy for coughs and chills. *F. macrophylla*, *F. stricta* and *F. strobilifera* are minor hosts of the Indian and Chinese lac insects. *F. macrophylla* is an important hedge plant and forage crop in various parts of the tropics. Various other *Flemingia* species are likewise used as a forage or green manure.

Properties Phytochemical analysis revealed the presence of some general compounds e.g. quercetin, rutin and quercimetrin in the leaves, flowers and stems, and phloridzin (2-phloretin-β-glucoside) and naringin (naringenin-5-rhamnoglucoside) in the leaves of *F. strobilifera*. Four isoflavones (genistein, formononetin, pseudobaptigenin and daidzein) have been isolated from the outer tissues of the tuber of *F. procumbens*. Flavonoids, fleminone and flemiphyllin were isolated from *F. macrophylla*, while flamiflavone, flemistrictin, myricitrin, noringenin, quercetin, genistin were isolated from the leaves and roots of *F. stricta*.

The in vitro activity of tuber peel extract of *F. procumbens* was tested against helminth parasites. Live nematodes (*Ascaris suum*, *A. lumbricoides*, *Ascaridia galli* and *Heterakis gallinarum*), cestodes (*Raillietina echinobothrida*) and trematodes (*Paramphistomum* sp.) were collected in physiological buffered saline (PBS) and maintained at 37 ± 1°C. In vitro treatment of the parasites with the crude plant extract (50 mg/ml) in PBS revealed complete immobilization of the trematodes and cestodes in about 43 and 20 minutes, respectively. However, the cuticle-covered nematodes did not show any changes in physical activity and remained viable even after a long period of exposure to the extract. Exposure of *R. echinobothrida* to genistein (0.5 mg/ml), an active principle isolated from the tuber peel, caused spontaneous loss of movement (paralysis) in 4.5 h, which was slower than the time required for the reference drug praziquantel (0.01 mg/ml). The treated parasites showed structural alterations in their tegumental structure. The results indicate that *F. procumbens* tuber peel extract has anthelmintic properties against cestodes and trematodes.

The 70% ethanol extract of the roots of *F. prostrata* Roxb. (synonym: *F. philippinensis* Merr. & Rolfe), from the Philippines, Taiwan, China and India, showed cytotoxic activity against a P-388 lymphocytic leukaemia cell culture. In addition, two prenylated isoflavones, flemiphilippinins A and B, were isolated from the roots and showed significant cytotoxicity in vitro.

Description Perennial herbs, subshrubs or shrubs, mostly erect. Leaves alternate, 3-foliolate, sometimes 1-foliolate; stipules caducous; leaflets ovate to lanceolate, with vesicular glands below; stipels absent. Inflorescence an axillary or terminal spike, raceme or panicle, sometimes crowded and head-like or few-flowered, bracts large or small, persistent or caducous, bracteoles rarely present. Calyx 5-lobed, glandular; corolla slightly larger than the calyx, standard elliptical or orbicular, short-clawed pink, red or purple, often mixed with green or yellow; androecium diadelphous, adaxial stamen free; ovary subsessile, 2-ovuled. Fruit a pod, oblong, 6–12 mm long, inflated, dehiscent, 2-seeded. Seed globose, brown or black.

Other botanical information The tuber bearing *Flemingia vestita* is often incorrectly considered as synonym of *F. procumbens* Roxb. an essentialy non-tuberous species. A thorough taxonomical revision of the entire genus is due, especially the status of the many synonyms at times given to *F. macrophylla* deserves attention. Several new species have been described in the course of time, even just in the context of local Floras (between 1980 and 1999).

Ecology *F. lineata*, *F. macrophylla* and *F. strobilifera* flower and fruit throughout the year in Indonesia. *F. lineata*, *F. macrophylla*, *F. prostrata* (synonym: *F. philippinensis*) and *F. strobilifera* have nodulating ability and fix atmospheric nitrogen.

Propagation and planting *Flemingia* species are normally propagated by seed. Scarification of the seed is usually required to increase the germination percentage. *F. macrophylla* and *F. strobilifera* can also be propagated by cuttings.

Harvesting Leaves and branches of *Flemingia* are collected whenever the need arises. Whole plants are uprooted to obtain the tubers.

Handling after harvest Leaves and roots of *Flemingia* can be used fresh, or dried for storage and later use.

Genetic resources and breeding Germplasm collections of the important forage crops include *F. macrophylla*. *Flemingia* species do not seem to be particularly threatened or at risk of genetic erosion in view of their preference for disturbed habitats.

Prospects The activity of tuber peel extracts of *F. vestita* on helminth parasites is interesting, and merits further research in order to fully evaluate the potential of compounds such as genistein as lead compounds for development of future anthelmintics.

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Selection of species

Flemingia macrophylla (Willd.) Merr.

Philipp. Journ. Sci., Bot. 5: 130 (1910).

Synonyms *Flemingia congesta* Roxb. ex W.T. Aiton (1812), *Flemingia latifolia* Benth. (1852), *Moghania macrophylla* (Willd.) O. Kuntze (1891).

Vernacular names Indonesia: apa-apa (Javanese), hahapaan (Sundanese, pok kepokan (Madurese). Malaysia: serengan jantan, beringan. Philippines: laclay-guinan (Tagalog), gewawini (Ifugao), malabalatong (Pampanga). Laos: thwàx h'è: h'üad, thwàx h'üad (Vientiane), h'ôm sa:m müang (Xieng Khouang). Thailand: mahae nok (northern), khamin naang (central), khamin phra (southeastern). Vietnam: t[os]p m[owx] l[as]to, d[aaj]u ma.

Distribution *F. macrophylla* originated in and is widely distributed in South-East Asia and in India, Sri Lanka, southern China and Taiwan. It has been introduced and naturalized in Papua New Guinea, northern Australia, East, Central and West Africa and is cultivated in tropical America.

Uses In Peninsular Malaysia, the entire plant is given to relieve stomach-ache. In India, the roots are applied externally to ulcers and swellings. In China, a decoction is used to bathe swellings and sores. In Taiwan, it is used as an antipyretic in post-partum fevers and to treat paralysis and painful joints.

Observations A deep-rooting, tussock-forming shrub, 1–4 m tall, young branches ribbed, triangular in cross section; leaves 3-foliolate, petiole up to 10 cm long, leaflets elliptical-lanceolate, 6–16 cm × 4–7 cm, base rounded, apex rounded to acuminate, veins covered with silky hairs, papery, dark green; inflorescence a dense axillary raceme, subspiciform, sessile, 2.5–10 cm long, silky, bracts ovate, 3–6 mm long; calyx 6–13 mm long, pale green, velutinous; corolla standard elliptical, greenish with distinct parallel red veins, wings narrow and much shorter than the keel, light purple at the apex; pod oblong, 8–15 mm × 5 mm, covered with fine glandular hairs, dark brown, 2-seeded; seed globular, 2–3 mm in diameter, shiny black. The natural habitat of *F. macrophylla* is along watercourses and in brushwood in general under shaded conditions, both on clay and lateritic soils, as well as under drier conditions up to 2000 m altitude.

Selected sources 74, 135, 215, 511, 662, 667, 827.

Flemingia strobilifera (L.) Roxb. ex W.T. Aiton

Hort. Kew., ed. 2, 4: 350 (1812).

Synonyms *Hedysarium strobiliferum* L. (1753), *Moghania strobilifera* (L.) J. St.-Hil. ex O. Kuntze (1891).

Vernacular names Brunei: ringan, ringan, pancar angin (Senkurong). Indonesia: apa-apa kebo, gatak (Javanese), hahapaan (Sundanese). Papua New Guinea: arana (Rabagi, East New Britain Province), rara (Guanantuna, East New Britain Province), aafec (Keregia, Morobe Province). Philippines: payang-payang (Tagalog), piragan (Sulu), gangan (Samar Leyte Bisya). Thailand: khee dang (north-eastern), ngon kai (northern), nhut phra (peninsular). Vietnam: t[os]p m[owx] b[oo]ng to, du[oo]i ch[oof]n.

Distribution *F. strobilifera* is distributed from India, eastward to southern China and throughout South-East Asia; widely grown in the tropics and extensively naturalized in the Pacific.

Uses In Peninsular Malaysia and Vietnam, a decoction or infusion of the leaves is given as a post-partum medicine. In Brunei, Peninsular Malaysia, the Philippines and Papua New Guinea, the plant is also used for bathing after childbirth. It is further used as a lotion to relieve rheumatism. In the Philippines, a decoction or infusion of leaves and flowers is prescribed in tuberculosis. In Java and Papua New Guinea, the leaves are employed both externally and internally as an anthelmintic for children. In East New Britain, one seed a month is chewed by women as a contraceptive. In India and Burma (Myanmar), the root is used to treat epilepsy. In India, the roots are also employed to induce sleep, relieve pain and for epilepsy. In Morobe Province, Papua New Guinea, flowers are credited with magical powers. They are rubbed on the legs of a baby in the belief it will assist it to walk. Likewise the flowers are rubbed on the mouth to assist speech development. In Brunei, twigs are used to beat children' legs to strengthen the joints. Leaves are also used as cattle feed. *F. strobilifera* is occasionally grown as an ornamental.

Flemingia strobilifera (L.) Roxb. ex W.T. Aiton – 1, flowering twig; 2, inflorescense within bract; 3, details of corolla; 4, staminal column with pistil; 5, pod.

Observations An erect shrub up to 3 m tall, branches cylindrical; leaves 1-foliolate, petiole (0.2–)1–2.5 cm long, leaflets ovate-elliptical to lanceolate, (3–)7–13(–20) cm × (1.5–)3–7(–12) cm, base obtuse, apex obtuse to acuminate, pubescent underneath; inflorescence composed of short axillary racemes, hidden by bracts, 10–18 cm long, bracts foliaceous, folded, (1.2–)2(–3.5) cm long, emarginate, bracteoles present or not; calyx pubescent, corolla standard obovate, wings narrow, yellowish-green to white; pod oblong, 7–12 mm × 5–7 mm, velutinous, 2-seeded; seed orbicular, 2(–4) mm in diameter, brown or black. *F. strobilifera* is found in teak forest, scrub, savanna, grasslands, and as a weed in plantations and open dry waste places up to 1300 m altitude. *F. strobilifera* is not uncommonly confused with *Phyllodium pulchellum* (L.) Desv., also used as a post-partum medicine.

Selected sources 74, 135, 215, 418, 511, 662, 667, 786, 810, 1038.

L.J.G. van der Maesen

Gelsemium elegans (Gardner & Champ.) Benth.

Journ. Linn. Soc., Bot. 1: 90 (1857).
LOGANIACEAE
$2n = 16$

Synonyms *Medicia elegans* Gardner & Champ. (1849), *Leptopteris sumatrana* Blume (1850), *Gelsemium sumatranum* (Blume) Boerl. (1899).

Vernacular names Laos: nguoan dok, nguoan han. Thailand: ma khet (northern), kok muan (north-eastern). Vietnam: l[as] ng[os]n, thu[os]c r[us]t ru[ooj]t, do[aj]n tr[uw][owf]ng th[ar]o.

Origin and geographic distribution *G. elegans* is distributed disjunctively from north-eastern India, northern Burma (Myanmar) and Thailand to southern China and Indo-China, Sumatra and northern Borneo.

Uses All parts of *G. elegans*, but especially the leaves and the roots are reputed to be poisonous in China as well as Indo-China. Mention is made of its use in murder and suicide. In Chinese traditional medicine the plant is used as an analgesic, antispasmodic and as a remedy for certain kinds of skin ulcers. Externally fresh plant parts or aqueous extracts are applied to various skin afflictions including eczema, boils, ulcers, ringworm as well as in the treatment of haemorrhoids or neuralgic pains.

Production and international trade *G. elegans* is only used on a local scale.

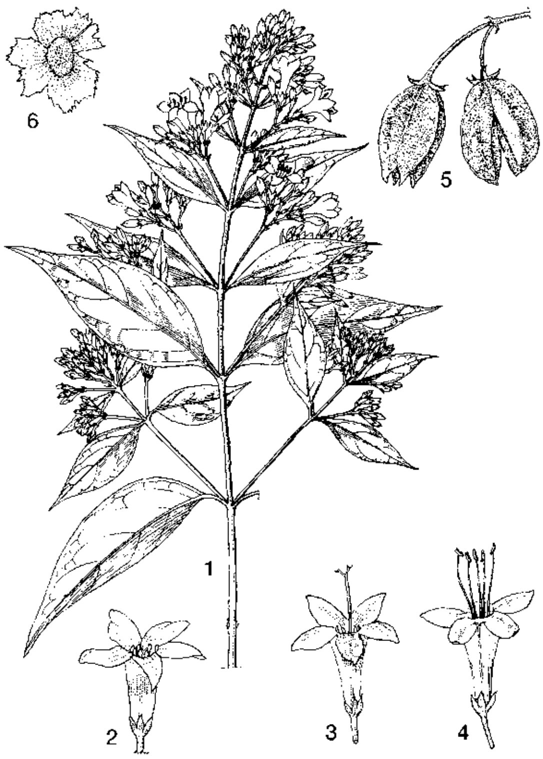
Properties Numerous oxindole and indole-alkaloids have been isolated from *G. elegans* and *G. sempervirens* (L.) J. Saint-Hilaire. These include gelsemine, and additional alkaloids such as hydroxydihydrogelsemine, gelsemicine, gelsenicine, gelsevirine, koumine, koumidine, kumantenidine, kumantenine and sempervirine. Fractional amounts of the alkaloids of *Gelsemium* have a stimulating effect on the central nervous system. The minimum lethal dose of gelsemine in rabbits is 0.1 mg/kg (subcutaneous). Toxic symptoms in humans may vary considerably individually, but in general these will include loss of appetite, stomach upset, internal bleeding, muscle weakness, paralysis of respiration (which will eventually lead to death), heart rate disturbances, hypotensive and and vasodilating effects.

Isolated from a methanolic extract of stems of *G. sempervirens*, the steroids 12β-hydroxy-5α-pregn-16-ene-3,20-dione and 12β-hydroxy-pregna-4,16-diene-3,20-dione were found to be the main cytotoxic constituents in the KB and P-388 cytotoxicity test systems.

Adulterations and substitutes Sterile parts of *G. elegans* are sometimes confused with sterile parts of *Jasminum subtriplinerve* Blume, a non-poisonous species used as a post-partum medicine and for skin problems in Vietnam.

Description A straggling shrub or large woody climber up to 12 m long; twigs glabrous. Leaves opposite, simple, entire, ovate-lanceolate, 5–14 cm × 2–5.5 cm, base rounded to decurrent, apex long acuminate; petiole about 1 cm long; stipular lines only. Inflorescence a compound thyrse, terminal or axillary, together making a pyramidal leafy panicle; bracteolate; pubescent or glabrous. Flower 5-merous, distylous or homostylous; pedicel 0.3–1 cm long; sepals lanceolate, 2–4 mm long, green; corolla tube about 1 cm long, lobes imbricate, blunt to acute, 0.5–1 cm long, bright yellow to orange, throat spotted with red; stamens inserted halfway the tube, 4–8 mm long; ovary superior, oblong to obovoid-lanceolate, 2–2.5 mm long, style 6–12 mm long, stigma 4-fid. Fruit a 2-valved, septate, ellipsoidal capsule, 4–10 mm × 3–4 mm, 20–40-seeded. Seed reniform to ellipsoid, about 3.5 mm long, warty, surrounded by an irregularly dentate wing.

Growth and development In Hong Kong *G. elegans* flowers in November–December, mature fruits are found from March–April.



Gelsemium elegans (Gardner & Champ.) Benth. – 1, habit; 2, short-homostyle flower; 3, long-styled flower; 4, short-styled flower; 5, mature capsules; 6, seed.

Other botanical information In *G. elegans* short-styled homostylous plants as well as short- and long-styled distylous plants are found. North-American *G. sempervirens* is equally poisonous but widely grown as an ornamental for its fragrant yellow flowers.

Ecology *G. elegans* is found in forests and thickets on various soils from 250–2000 m altitude.

Propagation and planting *G. elegans* can be easily propagated by seed or semi-ripe cuttings.

Husbandry In view of its twining habit, *G. elegans* is suitable for training on trellis and pergolas or for growing on steep banks. Severe pruning after flowering is recommended to retaina moderately sized plants.

Harvesting Roots, twigs and leaves of *G. elegans* are collected from wild plants whenever needed.

Handling after harvest In general plant parts of *G. elegans* are used fresh.

Genetic resources and breeding *G. elegans* has a large area of distribution and does not seem to be at risk of genetic erosion.

Prospects In general, the alkaloids of *G. elegans* will be too toxic for application. Since little additional information on the phytochemistry and phyto-pharmacology is available, this merits further research to fully evaluate its future potential.

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Other selected sources 600, 786.

Nguyen Tap & Nguyen Kim Bich

Gleditsia L.

Sp. pl. 2: 1056 (1753); Gen. pl. ed. 5: 476 (1754).

LEGUMINOSAE

x = unknown; *G. sinensis*, *G. triacanthos*: $2n = 28$

Major species *Gleditsia australis* Hemsley ex Forbes & Hemsley, *G. sinensis* Lamk, *G. triacanthos* L.

Vernacular names Honey locust (En).

Origin and geographic distribution *Gleditsia* comprises about 14 species, of which 2–3 are native to eastern North America, 1 species is found in southern South America, and 1 species in Malesia; the majority of species are found in temperate and tropical Asia.

Uses The uses of *G. australis*, *G. japonica* Miq. and *G. sinensis* are very similar. The fruits and seeds of the three species are important as a mucus-loosening and diuretic drug. A decoction of the leaves is used to bathe wounds. The root and bark are ingested as an anthelmintic and an antifebrile. The pods are said to be bechic and depurative, emetic and purgative; they are used to treat flatulence, chronic dysentery, as well as intestinal and urinary obstructions, and prolapse of the rectum. The thorns, dried and powdered are prescribed for swellings, especially on breasts, however, pregnancy is noted as a contra-indication. Likewise or in decoction they are used as a mouthwash for abscesses, or a wash for ulcers and skin diseases in general. The fruit pulp of *G. triacanthos* is used for catarrh of the lung. The pods of *G. officinalis* Hemsley, traded as 'ya-tsao', are used to treat coughs and lung disorders.

Properties Phytochemical investigations of the fruits of *G. sinensis* revealed the presence of a series of oleanane type triterpene saponins, acetylated with one monoterpenic acid (gleditsiosides A–D) or two monoterpenic acids (gleditsiosides E–G).

Several benzenoids were isolated from *G. triacanthos* including turgorine PLMF-4, turgorine PLMF-5, turgorine PLMF-6, 40-(3,6-di-O-sulpho-b-D-glucopyronosyl gallic acid and 40-(6-O-sulpho-b-D-glucopyranosyl gallic acid.

The anti-inflammatory activity of the aqueous extract from dried thorns of *G. sinensis* was investigated utilizing carrageenin-induced oedema, granuloma pouch and adjuvant arthritis in rats. The effects of this agent on vascular permeability and acetic acid-induced writhing in mice were also examined. Its anti-inflammatory activity on carrageenin-induced oedema was observed with oral administration. The aqueous extract from *G. sinensis* thorns, at 400 mg/kg for 7 days, showed significant inhibitory effects on granuloma and exudate formation in rats. In the method of adjuvant arthritis, the aqueous extract at 400 mg/kg, orally administered for 21 days, inhibited the development of hind paw oedema in rats. The aqueous extract also inhibited the increase in vascular permeability and the number of writhings induced by acetic acid in mice. The methanol (80%) extract exhibited tyrosinase inhibition at 100 μg/ml, which may be useful in cosmetics as a whitening agent.

Test results in the 1,1-diphenyl-2-picryl hydrazyl free radical generating system indicate that *G. japonica* may well prove to be a potential source of free radical scavengers. *Gleditsia* saponin C (a triterpene saponin) was isolated from *G. japonica* as an anti-HIV principle. It demonstrated inhibitory effects against HIV replication in H-9 cells with EC_{50} values of 1.1 μM. Evaluation of the

anti-HIV activities of the pro-sapogenins suggested that the unusual monoterpenyl moieties are essential for the anti-HIV activity. Derivatives of echinocystic acid, the aglycone of *Gleditsia* saponin C, were also prepared and evaluated: 3,16-di-O-acetylechinocystic acid was shown to be active at an EC_{50} 2.3 μM.
The juice of *G. triacanthos* pods is reported to possess antibiotic activity. Furthermore, an enzyme inhibitor could be isolated from *G. triacanthos*, which inhibits chymotrypsin (a group of major proteolytic enzymes found in the pancreatic juice), but had no effect on other proteases e.g. trypsin.

Description Trees, with trunk and branches armed with simple or branched thorns. Leaves alternate, pinnate and/or bipinnate; petiole present; stipules minute, caducous; leaflets subopposite or alternate, slightly asymmetrical, often with a crenate margin; petiolule present. Inflorescence axillary, racemose, solitary or fasciculate, rarely paniculate; bracts and bracteoles absent at anthesis; pedicel articulate. Flowers perfect or imperfect, unisexual or bisexual, the plants dioecious or polygamous; hypanthium campanulate, lined with nectariferous tissue; calyx 3–5-lobed, subequal; petals 3–5, subequal, imbricate, not clawed; stamens 5–10, exserted in male and bisexual flowers, filaments free, somewhat unequal; ovary subsessile, rudimentary or absent in male flowers, 2–30-ovuled; style short; stigma terminal, 2-lobed. Fruit an indehiscent or tardily dehiscent pod, oblong or elongate, compressed, variably coriaceous, 1–many-seeded. Seed transverse, broadly ellipsoid to subquadrate, compressed, albuminous.

Growth and development *G. triacanthos* may start bearing fruit from the fourth or fifth year of planting. Pods of *G. triacanthos* are distributed by water and wind.

Other botanical information Linnaeus named the genus *Gleditsia* in honour of J.G. Gleditsch. In later publications the spelling *Gleditschia* is used. However, the original spelling is to be retained. Some controversy exists on the status of some of the South Chinese species of the genus, including *G. australis*, *G. officinalis* and *G. sinensis*. In some Vietnamese literature *G. fera* (Lour.) Merr., *G. rolfei* S. Vidal and *G. sinensis* are considered synonyms of *G. australis*, adding further confusion to uses of the species involved. The status of *G. fera* and *G. rolfei* in particular still causes confusion. *Gleditsia* is in general considered an archaic taxon and therefore placed near *Ceratonia*. Species of *Gleditsia* show an unusually high level of variability in many inflorescence and floral development characters.

Ecology *Gleditsia* is found on damp sandy soils, on rich alluvial soils and on limestone. Most species tolerate atmospheric pollution and a range of soil types and pH.

Propagation and planting The native North-American *G. triacanthos*, naturalized in Australia and various parts of Europe, can easily be propagated by seed, cuttings or suckers and is fairly fast-growing. Plants coppice vigorously when cut. Germination is enhanced by scarification.

Harvesting Fruits of *Gleditsia* are collected when mature. Thorns are harvested throughout the year whenever the need arises.

Handling after harvest The thorns of the various *Gleditsia* species are collected, sliced and dried, for later use. Likewise, fruits can be dried for later use.

Genetic resources and breeding Breeding efforts in *Gleditsia* have concentrated on *G. triacanthos* for ornamental purposes.

Prospects There is little prospect for *Gleditsia* in South-East Asia unless plants that are well-adapted to the tropics, are selected. Some biological effects of extracts are interesting e.g. anti-inflammatory, anti-HIV. Activity guided isolation procedures might yield new leads for drug development.

Literature |**1**| Kim, B.J., Kim, J.H., Kim, H.P. & Heo, M.Y., 1997. Biological screening of 100 plant extracts for cosmetic use (II): Anti-oxidative activity and free radical scavenging activity. International Journal of Cosmetic Science 19(6): 299–307. |**2**| Konoshima, T., Yasuda, I., Kashiwada, Y., Cosentino, L.M. & Lee, K.H., 1995. Anti-AIDS agents, 21. Triterpenoid saponins as anti-HIV principles from fruits of Gleditsia japonica and Gymnocladus chinensis, and a structure-activity correlation. Journal of Natural Products 58(9): 1372–1377. |**3**| Paclt, J., 1982. On the repeatedly confused nomenclature of Chinese species of Gleditsia Caesalpiniaceae. Taxon 31(3): 551–553. |**4**| Park, E.H. & Shin, M.J., 1993. Anti-inflammatory activity of aqueous extract from Gleditsiae Spina. Journal of the Pharmaceutical Society of Korea 37(2): 124–128. (in Korean) |**5**| Schnabel, A. & Wendel, J.F., 1998. Cladistic biogeography of Gleditsia (Leguminosae) based on NDHF and RPL16 chloroplast gene sequences. American Journal of Botany 85(12): 1753–1765. |**6**| Zhang, Z., Koike, K., Jia, Z., Nikaido, T., Guo, D. & Zheng, J., 1999. Triterpenoidal saponins acylated with two monoterpenic acids from Gleditsia sinensis. Chemical and Pharmaceutical Bulletin (Tokyo) 47(3): 388–393.

Selection of species

Gleditsia australis Hemsley ex Forbes & Hemsley

Journ. Linn. Soc. 23: 208, tab. 5 (1887).

Synonyms *Pogocybe entadoides* Pierre (1899).

Vernacular names Févier de Chine (Fr). Vietnam: b[uf] k[ees]t, tao gi[as]c, b[oof] k[ees]p.

Distribution *G. australis* is found in southern China and Vietnam, also often in cultivation.

Uses A decoction of the pods is a popular shampoo in Vietnam, due to its high saponin content; it is considered an antidandruff treatment. The smoke of burned pods is inhaled to loosen mucus, and to get rid of it at the beginning of a cold. The liquid from macerating the pods in alcohol is applied to contusions.

Observations A tree up to 10 m tall, branches armed with branched thorns up to 15 cm long; leaves up to 12 cm long, usually bipinnate with 2–4 pairs of pinnae, leaflets oblong, 2–3.5 cm × 1–2 cm, crenulate; inflorescence a downy raceme or panicle up to 15 cm long, flowers 5 mm in diameter, pedicel short; fruit oblongoid, up to 12 cm × 2 cm, smooth, up to 10-seeded; seed 10 mm × 7 mm, brown. The tree could be grown in Malesia especially at higher elevations.

Selected sources 263, 585, 739, 786.

Gleditsia fera (Lour.) Merr.

Philipp. Journ. Sci., Bot. 13: 141 (1918).

Synonyms *Gleditsia rolfei* S. Vidal (1886), *Gleditsia celebica* Koord. (1898), *Gleditsia formosana* Hayata (1911), *Gleditsia thorelii* Gagnep. (1913).

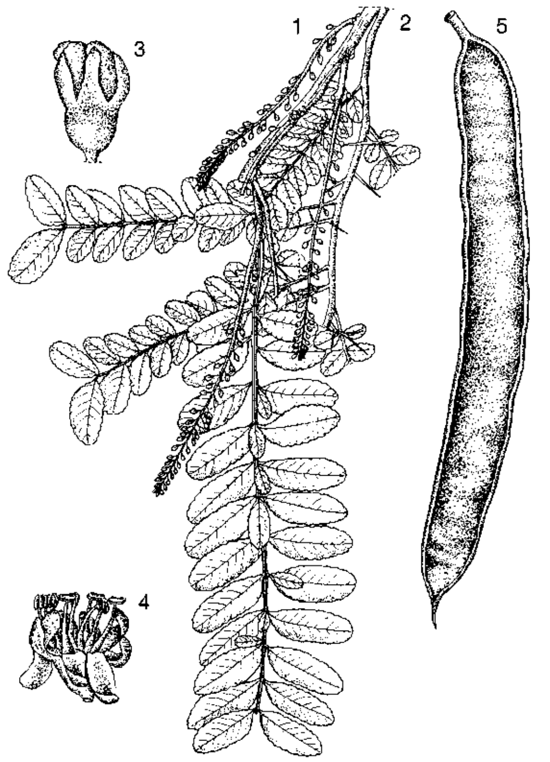
Vernacular names Philippines: tahid-labuyo, tiri (Tagalog). Vietnam: tao gi[as]c, ch[uf]m k[ees]t.

Distribution *G. fera* is found in northern Thailand, Indo-China, southern China, Taiwan, the Philippines and Sulawesi. Occasionally cultivated in China and Vietnam.

Uses A decoction of the leaves is used as a purgative in Indo-China. The pulp of the pods is also applied in local medicine, whereas the pods are locally used as an insecticide. The wood is suitable for indoor construction purposes.

Observations A tree up to 22 m tall, branches armed with thorns up to 8 cm long; leaves 10–24 cm long, bipinnate or pinnate and up to 26-foliolate; leaflets oblong to lanceolate, 2.5–7 cm × 1–2.5 cm, irregularly crenate; inflorescence a downy raceme up to 12 cm long, flowers up to 6 mm in diameter, pedicel short; fruit straight or bent, 15–30 cm × 2–4 cm, up to 20-seeded; seed ellipsoid, 12 mm × 6 mm, yellowish, embedded in pulpy tissue. *G. fera* is found in rain forest up to 250(–900) m altitude, in Thailand at 1400 m.

Selected sources 256, 407, 584, 585.



Gleditsia fera (Lour.) Merr. – 1, flowering twig; 2, leafy branch; 3, flower bud; 4, flower; 5, pod.

Gleditsia sinensis Lamk

Encycl. 2: 465 (1788).

Distribution *G. sinensis* is found in southern China and Vietnam. It is cultivated in India for the pods.

Uses See under genus.

Observations A tree up to 12 m tall, branches armed with branched, terete thorns up to 20 cm long; leaves up to 20 cm long, mostly pinnate and 8–18-foliolate or bipinnate with 2–6 pairs of pinnae; leaflets ovate or ovate-lanceolate, 8 cm × 3 cm, crenulate; inflorescence a pendulous, downy raceme, up to 9 cm long, flowers 6.5 mm in diameter, staminate flowers clustered, bisexual flowers with a pedicel up to 10 mm long; fruit oblongoid, 25 cm × 3 cm, flat but thick, heavily coriaceous to woody, dark purplish brown, many-seeded. The tree could be planted especially in the drier parts, and at higher elevations in the rest of South-East Asia.

Selected sources 135, 215, 459, 647, 786, 910, 1125.

Gleditsia triacanthos L.

Sp. pl. 2: 1056 (1753).

Vernacular names Honey locust (En). Carouge de miel (Fr).

Distribution Originating from the eastern United States, *G. triacanthos* has been widely planted and often naturalized in the Mediterranean region, the Near and Far East, Asia and northern Australia.

Uses Honey locust is a well-known folk remedy among various tribes of Amerindians in North America. Honey locust pods are used for dyspepsia and measles. An infusion of the bark is used for whooping coughs. The bark is furthermore used for blood disorders, coughs, colds, fevers, smallpox and measles. In Argentina, a decoction of dried pods is used to cure diarrhoea. The pods are relished by livestock and constitute an excellent feed.

Observations A tree up to 45 m tall, branches armed with simple or branched, flat thorns; leaves up to 20 cm long, bipinnate with 4–16 pairs of pinnae, or pinnate and 14–32-foliolate, leaflets oblong-lanceolate, 4 cm × 1.5 cm, sparsely crenulate; inflorescence a downy raceme up to 7 cm long, flowers 3 mm diameter, green, staminate flowers preponderant, bisexual flowers with a pedicel up to 8 mm long; fruit flat, falcate, twisted, 45 cm × 4 cm, dark shining brown, many-seeded; seed 9 mm × 5 mm, embedded in pulpy tissue. The tree could be planted especially in drier parts, and at higher elevations in South-East Asia.

Selected sources 215, 273, 303, 459, 647, 697, 880.

H.C. Ong

Glycosmis pentaphylla (Retz.) A.DC.

Prodr. 1: 538 (1824).

RUTACEAE

$2n = 18$

Synonyms *Limonia pentaphylla* Retz. (1788), *Glycosmis arborea* (Roxb.) A.DC. (1824), *Glycosmis cochinchinensis* auct.

Vernacular names Indonesia: gongseng (Sundanese), jerukan, totoan (Javanese). Malaysia: merapi, nerapi, terapi. Philippines: gingging (Tagalog), linauin (Iloko). Cambodia: dom phlang. Laos: som sum, om chune. Vietnam: c[ow]m r[uw][owj]u, b[uw][owr]i bung.

Origin and geographic distribution *G. pentaphylla* is found from India and Sri Lanka eastward to Burma (Myanmar), Thailand, southern China and Indo-China, possibly the Philippines, Peninsular Malaysia, Sumatra and Java and also cultivated elsewhere.

Uses In Java (Indonesia), a decoction of the roots of *G. pentaphylla* is taken to treat bilious attacks. A decoction of roots and leaves is taken for intestinal trouble. In Vietnamese folk medicine the leaves are considered appetitive, stomachic and an infusion of roasted leaves is prescribed for women after delivery as an appetizer. In Peninsular Malaysia, *Glycosmis* (e.g. *G. parviflora* (Sims) Little, *G. puberula* Lindley ex Oliv., *G. pentaphylla*) is an ingredient of various medicinal mixtures. An infusion of leaves and roots is given after childbirth as a protective medicine. In traditional Indian medicine *G. pentaphylla* is used to treat diarrhoea, coughs, rheumatism, anaemia, and jaundice. Juice of the leaves is used in fever, liver complaints and as a vermifuge. A paste of the leaves mixed with ginger is applied for eczema and skin affections. A decoction of the roots is given for facial inflammation. The pale wood is sometimes used for tool handles.

Production and international trade *G. pentaphylla* is only used on a local scale.

Properties Chemical investigations in *Glycosmis* have generally focused on 3 species, i.e. *G. pentaphylla*, *G. parviflora* and *G. mauritiana* (Lamk) Tanaka. The extracts from the leaves, stems, and roots were mainly characterized by different classes of alkaloids. Quinoline-, acridone-, carbazole-, and quinazoline-type were the most widespread structural groups. Recently a naphthaquinone alkaloid has been added to this list. Amides also represent an important and characteristic chemical character of *Glycosmis*. Some of the amides in *Glycosmis* are derived from anthranilic-, isovaleric-, and senecioic-acid. The most characteristic group of amides, however, are the sulphur-containing derivatives of (E)- or (Z)-3-(methylthio)-propenoic acid: about 45 have so far been isolated and identified. They are mainly accumulated in the leaves, and to a lesser extent in stem and root bark.

In general, the majority of *Glycosmis* species contain varying amounts of different sulphur-containing amides, with the exception of *G. penta-*

phylla. However, *G. pentaphylla* is particularly characterized by the accumulation of quinazolines in the leaves.

Biological activity of the sulphur-containing amides was investigated using spore suspensions of the test fungus *Cladosporium herbarum*, as well as germ tube inhibition test using different phytopathologic fungi including *Alternaria*, *Botrytis*, *Fusarium* and *Pyricularia*. The bioassays were also extended to assess toxicity towards insects: the activity of the compounds against the polyphagous pest insect *Spodoptera littoralis* was tested for contact toxicity, growth inhibition, and survival rate against neonate larvae.

Results revealed that all amides derived from methylthio-propenoic acid linked with styryl (phenylethenyl) amine moieties (methylillukumbin A, illukumbin B, methylillukumbin B) showed higher antifungal activity than those linked with phenethyl amine (sinharin, methylsinharin). By contrast, amines without a linkage to an aromatic system (penangin, isopenangin) showed no activity against the tested fungi at all. The same was true for the series of amides derived from methylsulphonyl-propenoic acid, which differ from their related methylthio-propenoic acid derived compounds through a different oxidation state of the sulphur atoms. Furthermore, it is interesting to note that, with respect to insect toxicity, also the styryl or phenethyl amine part was found to be essential.

Also the methylthio-carbonic acid derived amides, which may be regarded as products of chain shortening of methylthio-propenoic acid derived compounds, are highly bioactive. The antifungal activity of dehydroniranin B was comparable to the activity of methylillikumbin A, with an ED_{50} value of 5.5 µg/ml in the germ tube inhibition test towards *C. herbarum*. In all insect toxicity tests the most active compounds were the methylthiocarbonic acid derivatives niranin, dehydroniranin B and ritigalin. As an example the values for niranin were $LC_{50} = 0.03$ µmol/dm^2 in the contact toxicity test, and $EC_{50} = 0.25$ µmol/g for the growth inhibition, and $LC_{50} = 0.81$ µmol/g for the lethality of the larvae in the feeding tests. By contrast, the corresponding methylpropenoic acid amides e.g. methylillikumbin A, only showed moderate activity against *S. littoralis*. In general, from the results available, it became clear that derivatives elongated with prenyl chains or carrying oxidized sulphur (sulphones) have considerably less insect and fungitoxic activities.

Several alkaloids and amides, isolated from *G. pentaphylla*, are reported to have biological activities. For instance glycozolidol, a carbazole alkaloid isolated from the roots of *G. pentaphylla*, is active against some gram-positive and gram-negative bacteria. Furthermore, arborinine, an acridone alkaloid, exhibited significant inhibition of crown gall tumours produced by *Agrobacterium tumefaciens* in a potato disk bioassay.

Additionally, leaf extracts of *G. pentaphylla* exhibited a high degree of nematicidal action against the adults and larvae of the nematode *Radopholus similis*. The leaf extracts inhibit the juvenile hormone III-biosynthesis in vitro of corpora allata from 3-day-old females of the field cricket *Gryllus bimaculatus*. The bio-active compound responsible for this activity was identified as the quinazolone alkaloid arborine. This alkaloid also showed larvicidal activity against the mosquito *Culex quinquefasciatus*.

Roots of *G. pentaphylla* were furthermore shown to inhibit the growth and survival of larvae of the citrus root weevil *Diaprepes abbreviatus*, when incorporated in their diet. This assay was used to guide fractionation of an active acetone extract, which led to the identification of dehydrothalebanin B (an amide) as the active compound.

Biological activities of extracts included effects of leaf- (250, 500 and 750 mg/kg body weight) and stem bark- (100, 200 and 400 mg/kg body weight) extracts of *G. pentaphylla*, which were studied on CCl_4 (1 mg/kg body weight) induced hepatic injury in albino rats. Parameters studied were plasma ALAT, ASAT, ALP, total bilirubin and tissue histopathology. Recovery of hepatic tissue was indicated using the highest dose (750 mg/kg body weight) of the leaf extract. The therapeutic dose range was devoid of toxic effects; toxicity was only observed histopathologically at and above 2.5 g/kg body weight of this extract.

Petroleum ether, chloroform, ethanol and aqueous extracts of root bark of *G. pentaphylla* were evaluated for their effect on experimentally-induced diarrhoea in albino rats. In general, all extracts exhibited significant activity. The ethanol extract, however, was found to be very effective at low dosages (100 and 200 mg/kg). Acute toxicity tests on rats and mice revealed no toxicity at doses up to 5000 mg/kg, except for the petroleum ether extract where symptoms such as CNS excitement followed by depression, and 25% mortality in mice were observed at a dose of 1000 mg/kg.

The petroleum ether extract of the root of *G. pentaphylla* was lethal to the larvae of *Culex quinquefasciatus*, *C. sitiens*, *Aedes aegypti* and *Anopheles* *stephensi* with LC_{90} values of 54.20, 42.66, 57.14 and 43.85 mg/l, respectively. The column chromatographic fraction isolated from the crude extract showed promising biological activity with LC_{90} values of 20.42, 16.98, 21.87 and 19.95 mg/l against *C. quinquefasciatus*, *C. sitiens*, *Aedes aegypti* and *Anopheles stephensi*, respectively.

Finally, a steam distillate of *G. pentaphylla* leaves showed high antifungal activity against *Cladosporium cladosporioides*, but no activity against *Staphylococcus aureus* or *Escherichia coli*. The essential oils from the bark, leaves and seeds of this species were also analysed using high-resolution gas chromatography. Substantial differences in the composition of the oils from the three plant parts were noticed. The bark and leaf oils were rich in aliphatic ketones (about 80% and 47%, respectively) while the seed oil contained a high percentage of aliphatic (26%) and monocyclic (24%) terpene alcohols.

Adulterations and substitutes Amides are also found in *Clausena*, another member of the tribe *Clauseneae*.

Description An evergreen shrub or small tree, 1–5 m tall; branches glabrous, unarmed, young parts finely rusty puberulent. Leaves alternate, imparipinnate with (1–)3–5(–7) leaflets; petiole 2.5–5.5 cm long; stipules absent; leaflets narrowly elliptical or oblong-elliptical, 6–24 cm × 2–7 cm, base acuminate, apex acuminate, margin entire or minutely to distinctly crenulate-serrate, lateral veins 6–12 pairs; petiolules 3–8 mm long. Inflorescence axillary, paniculate, elongated up to 8 cm long, narrow, tri-pinnate, branches short, ascending, axes and bracteoles rusty puberulent. Flowers mostly 5-merous, about 5 mm long, fragrant; sepals broadly ovate to rotund, 1–1.5 mm long, margin ciliolate; petals obovate to elliptical, 5 mm × 2.5 mm, glabrous, white; stamens up to 3.5 mm long; ovary ovoid, up to 2.5 mm long, coarsely pustular-glandular, usually 5-celled, style scarcely distinct. Fruit a berry, subglobose, white to pink or crimson, 10–13.5 mm in diameter, 1(–3)-seeded, edible. Seed round to plano-convex, suboblong, green.

Growth and development The fragrant flowers attract bees that most probably effect pollination. *G. pentaphylla* can be found flowering and fruiting throughout the year.

Other botanical information *Glycosmis* is a difficult and taxonomically confusing genus, that is badly in need of a critical taxonomic and nomenclatural review. However, the genus as such can be easily distinguished from the closely

Glycosmis pentaphylla (Retz.) A.DC. – 1, fruiting branch.

related other members of the subtribe *Clauseninae*: *Clausena* and *Murraya*. *Glycosmis* comprises some 40–50 species and occurs from India and Sri Lanka eastward to southern China and Taiwan, throughout South-East Asia to northern Australia; in Malesia some 25 species occur. The name *G. pentaphylla* has often been incorrectly applied to other species and forms, including *G. parviflora*, further adding to the confusion. The species has often been confused in India and western South-East Asia with another highly variable species: *G. mauritiana* (Lamk) Tanaka. As medicinal uses in South-East Asia almost exclusively refer to *G. pentaphylla*, the information has been grouped under this name here. *G. parviflora* (synonym *G. citrifolia* (Willd.) Lindley), native to southern China and Indo-China, is cultivated as an ornamental and naturalized in various parts of the tropics. In Taiwan, it is used in folk medicine for the treatment of skin itch, scabies, boils and ulcers.

Ecology *G. pentaphylla* prefers relatively dry habitats from sea-level up to 1000 m altitude, and is commonly encountered in secondary thickets.

Propagation and planting *G. pentaphylla* can be propagated by seed or semi-ripe cuttings.

Husbandry *G. pentaphylla* should preferably be grown in a fertile, moisture-retentive, but well-drained medium that is rich in organic matter, with full sun to partial shade.

Harvesting Leaves and roots of *G. pentaphylla* are collected whenever the need arises.

Handling after harvest Roots of *G. pentaphylla* can be chopped in smaller pieces to be dried and stored for future use.

Genetic resources and breeding *G. pentaphylla* has a large area of distribution, either naturally or as a result of cultivation, and does not seem to be at risk of genetic erosion.

Prospects Alkaloids, amides and especially the sulphur-containing amides of *G. pentaphylla* show a range of interesting biological activities, mainly in the field of phytopathology and insect control. They might be of great interest for future development of new crop protection agents, and as such merit further research. As a spin-off of this research, an evaluation should take place to find out if extracts might have potential as a local source of protectants in rural communities.

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L.S.L. Chua & J.L.C.H. van Valkenburg

Gmelina L.

Sp. pl. 2: 626 (1753); Gen pl. ed. 5: 274 (1754).
VERBENACEAE
$x = 19$; *G. arborea*: $2n = 36, 38$, *G. asiatica*: $2n = 38, 40$, *G. philippensis*: $2n = 38$

Major species *Gmelina asiatica* L., *G. elliptica* J.E. Smith, *G. philippensis* Cham.

Vernacular names Malaysia: bulang, bulangan.

Origin and geographic distribution *Gmelina* consists of about 33 species of trees and shrubs and is distributed from Pakistan and India, Sri Lanka and southern China through the Malesian Archipelago towards northern and western Australia, Fiji, New Zealand and New Caledonia. About 12 species occur in Malesia. *G. arborea* Roxb. is the best-known species of the genus. It has frequently been planted as a fast-growing plantation tree in South-East Asia as well as in India, tropical Africa and Brazil.

Uses The uses of the various medicinally important *Gmelina* appear to be mutually exchangeable. Some confusion exists on the specific identity of a particular use in some regions. The uses can be largely described as demulcent, purgative and diuretic, and the plants are also applied in rheumatic affections. Furthermore, it is primarily externally applied as a rubefacient and counterirritant. In the Moluccas, sap of the inner bark of *G. moluccana* (Blume) Backer ex K. Heyne is externally applied to cleanse wounds and ulcers. Roots, leaf sap and flowers of *G. arborea* are used in Indian traditional systems of medicine in the form of a decoction as an anodyne, diuretic, laxative, for loosening phlegm, as an appetite stimulant and a galactagogue, and for the treatment of liver disorders. In Thailand, the roots of *Gmelina* are applied externally on wounds and abscesses. Several species are used as a hedge plant, and the leaves are used as cattle fodder.

Production and international trade *Gmelina* is only used on a local scale.

Properties From the leaves of *G. arborea* several monoacylated, diacylated, and triacylated iridoid glycosides have been isolated. These include 6-O-α-L-rhamnopyranosylcatalpol, 6-O-(3″-O-trans-feruloyl)-α-L-rhamnopyranosylcatalpol, 6-O-(2″-O-acetyl-3″,4″-O-di-trans-cinnamoyl)-α-L-rhamnopyranosylcatalpol, 12 acylated iridoid glycosides named gmelinosides A–L, and the related phenylpropanoid glycosides verbascoside (acteoside) and martynoside. A similar range of rhamnopyranosylcatalpol esters and related compounds is present in the leaves of *G. philippensis*. Furthermore, the leaves of *G. arborea* contain glycosides of the flavonoids luteolin, apigenin and quercetin, and the presence of several lignans (including arboreol, isoarboreol, methyl arboreol, arborone, gmelanone, gummadiol, and 7-oxodihydrogmelinol) in the heartwood is reported in the literature.

In the field of biological activities, an ethanol extract of the stem of *G. arborea* showed antiplasmodial activity against *Plasmodium falciparum* (IC_{50} 36 μg/ml) and a 59–85% inhibition at 50–100 μg/ml.

In addition, hexane- and chloroform-soluble extracts of *G. asiatica* roots exhibited prominent oral antipyretic activity in rabbits receiving subcutaneous yeast injections. Furthermore, carrageenan-induced rat paw oedema (acute inflammation) and cotton pellet granuloma (chronic inflammation) methods have been used to test the anti-inflammatory effect of *G. asiatica* root powder in male albino rats. A reduction was observed in both acute and chronic inflammation. *G. asiatica* also reduced the lipid peroxide content of granuloma exudate and liver, and γ-glutamyl transpeptidase in the granuloma. Serum albumin in granuloma was normalized. *G. asiatica* also normalized the increased levels of serum acid and alkaline phosphatase. Therefore it was concluded that the crude drug may exert anti-inflammatory activity through antiproliferative, anti-oxidative and lysosomal membrane stabilisation.

Adulterations and substitutes The isolation of monoacyl, diacyl, and triacyl derivatives of 6-O-α-L-rhamnopyranosylcatalpol has been reported for several plant families including the *Buddlejaceae*, *Scrophulariaceae*, and *Verbenaceae* (e.g. *Premna*).

Description Shrubs or small to medium-sized trees, up to 30(–40) m tall, with cylindrical bole having a diameter of up to 100(–250) cm, without buttresses but sometimes flanged; bark smooth or scaly, pale brown to grey; twigs glabrous or pubescent, spinous or unarmed. Leaves opposite, simple, entire, toothed or lobed, often strongly varying in shape within the same plant, reticulately veined; petiolate; stipules absent. Inflorescence a terminal or axillary cymose, raceme or panicle. Flowers zygomorphic, bisexual, with small bracts; calyx tubular or somewhat campanulate, with 4–5 teeth or subentire, generally with large glands; corolla with (4–)5 fused petals, tube slender below, ventricose upwards, more or less 2-lipped, hairy outside, yellow to orange or purplish; stamens 4, didynamous, alternate with the corolla-lobes, inserted in the lower part of the corolla-tube, filaments flat, filiform, often sparsely glandular, anthers 2-celled, dorsifixed, elliptical to oblong; ovary 4-locular, with one ovule in each cell, ovule attached to an axile placenta at or above the middle, style filiform, with two unequal stigmatic lobes. Fruit a succulent drupe, with hard and stony endocarp, usually 4-celled. Seed oblong. Seedling with epigeal germination; cotyledons somewhat fleshy.

Growth and development Trees of *G. arborea* are deciduous, shedding their leaves around January–February in all areas where they are planted. Flowering occurs when new leaves have just begun to develop (March–April). Trees 3–4 years old are able to flower and fruit regularly. The fruit matures within 2–3 months. Other *Gmelina* have been found to flower and fruit in almost every month of the year.

G. arborea and *G. asiatica* are self-incompatible and obligately outcrossing. The bilaterally symmetrical flowers with deep-seated nectar are manipulated and pollinated by large-bodied carpenter bees (*Xylocopa*).

Other botanical information The genus *Gmelina* is closely related to the large genus *Vitex*, from which it is distinguished by its large and usually broadly bell-shaped corolla-tubes, and the well-shaped bole. In *Vitex* the corolla-tube is short and cylindrical, and the bole is usually poorly shaped.

Ecology *Gmelina* is frequently found in primary or secondary, more open forests, along streams and on ridges. It usually prefers well-drained, moist soils and occurs from sea-level up to 1200 m altitude. Most species appear to be pioneer species, and may regenerate gregariously.

Propagation and planting *Gmelina* is usually propagated by seed. At present direct sowing is preferred. However, planting of stumps is still widely practised. Vegetative propagation from stem cuttings using various hormone preparations is also successful. Germination of *G. arborea* occurs 7–15 days after sowing and amounts to about 80%. Trials for *G. elliptica* show poor and slow germination. The depth of the root system in *G. arborea* varies. Growth is very rapid during the first 6 years, but decreases sharply from the 7th year onwards. Growth is strongly site-dependent.

Husbandry For ornamental purposes *G. philippensis* is usually severely pruned to maintain a balanced shape.

Diseases and pests *G. asiatica* is often parasitized by *Dendrophtoe falcata* (L.f.) Ettingsh.

(*Loranthaceae*) and suffers seriously from powdery mildew (*Sphaerotheca verbenae*) in India.

Harvesting In general *Gmelina* is harvested whenever the need arises. Leaves, flowers and fruits are in general present throughout the year.

Handling after harvest Plant parts of *Gmelina* are usually used fresh but roots and leaves may well be dried for future use.

Genetic resources and breeding The various species of *Gmelina* are usually widely distributed, and although they are not abundant (except on favourable sites), none of them seems to be threatened with extinction.

Prospects Although *Gmelina* species are known to be rich sources of iridoids, and iridoids as a class of natural compounds are known to display a variety of biological effects (e.g. in the field of anti-inflammation, and on the central nervous system). Not much pharmacological information is available for the specific compounds found in the species treated.

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Selection of species

Gmelina asiatica L.

Sp. pl. 2: 626 (1753).

Synonyms *Gmelina coromandelica* Burm.f. (1768), *Gmelina parvifolia* Roxb. (1798).

Vernacular names Malaysia: bulangan (Peninsular). Cambodia: an chanh. Thailand: khaang maeo (central). Vietnam: tu h|us| gai, tu h[us] bi[eer]n.

Distribution From India and Sri Lanka through Burma (Myanmar) and Thailand eastward to Indo-China and southern China, southward to Malaysia and Indonesia. Widely cultivated in warmer parts of the world; in a few cases naturalized to a limited extent.

Uses In Peninsular Malaysia, it is used locally as a demulcent and alterative. In India, the plant is widely esteemed as a demulcent and alterative. The root is employed as a blood purifier and in the treatment of rheumatism, incontinence, gonorrhoea and syphilis as well as for infections of the bladder and to promote micturition. The macerated leaves are used in urogenital affections. Soaking the leaves in water renders a mucilaginous mixture, which is credited with antibacterial properties. In Cambodia, an infusion of the shoots is used internally, against rheumatism, yaws and nervous diseases. A decoction of the roots is likewise employed externally.

Observations A large, straggling or scrambling deciduous shrub, or a semi-deciduous tree up to 8 m tall, usually spiny, bark yellowish or brownish-white, smooth, twigs puberulous or villose when young; leaves ovate to elliptical or triangular in outline, entire or 3–5-lobed, 1–9.5(–13) cm × 1.5–6 cm, base acute to cuneate or rounded, apex acute or obtuse, glabrous on both surfaces when mature, pale green above, glaucescent and minutely white-glanduliferous below; racemiform panicles axillary or terminal, 2.5–5 cm long, nodding or pendulous, bracts small, caducous; calyx about 4 mm long, very shortly 4-toothed, glandular, corolla bilabiate, yellow, 4–5 cm long, externally finely pubescent, internally glabrous, tube widening into a 4-lobed limb, the lowest largest, fertile stamens 2, staminodes 2; drupe ovoid or pyriform, about 2–3 cm long, 1- or 2-celled and -seeded, yellow when ripe. *G. asiatica* is found in forest edges, thickets, dry forest and secondary vegetation from sea-level up to 500(–1000) m altitude.

Selected sources 74, 135, 207, 464, 688, 788, 836.

Gmelina elliptica J.E. Smith

in Rees, Cycl. 16: no. 2 (1810).

Synonyms *Gmelina villosa* Roxb. (1814), *Gmelina asiatica* L. var. *villosa* (Roxb.) (1921).

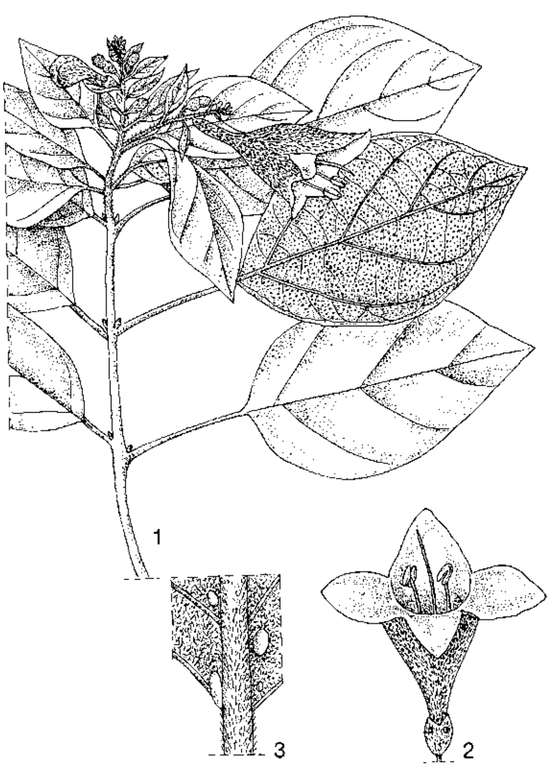
Vernacular names Indonesia: wareng (Javanese, Sundanese), bulangan (Madurese, Malay), pongranga (Buginese). Malaysia: bulangan, belongeh, pukang matahari (Peninsular). Philippines: talungud (Sulu), bohol (Cebu Bisaya), kalungun (Panay Bisaya). Thailand: khaang maeo (central, peninsular), kra bia luenag (eastern), nom maeo (south-western, peninsular). Vietnam: tu n[us] l[as] b[aaf]u d[uj]c.

Distribution Thailand, Indo-China, Malaysia, Indonesia and the Philippines.

Uses In Indonesia, sap from the leaves or fruits is used as ear drops in earache. An infusion of the slightly crushed fruits is applied as an eye lotion. In Peninsular Malaysia, the plant is chiefly used in poultices for headache and swellings. The fruit rubbed with lime and garlic is vigorously applied to the body in cases of dropsy. The leaves or roots may be applied to wounds. The uses probably reflect its activity as a rubefacient.

Observations An evergreen shrub or small tree up to 10 m tall, spiny, bark light grey becoming fissured, twigs glabrous, tomentose when young; leaves ovate or elliptical, entire, sometimes 3-lobed, 3–9 cm × 2–5.5 cm, base cuneate, apex acute, glabrous above, tomentose and glaucous below, with minute green glands at base; raceme terminal, up to 10 cm long, bracts rather large; calyx about 5 mm long, usually 4-lobed, with large glands, corolla yellow, 2–4 cm long, upper lip entire, the middle lobe of the 3-lobed lower lip larger than the other lobes, tomentose; drupe spherical, about 2 cm long, yellow. *G. elliptica* is common in open secondary vegetation especially near the coast, in Java from sea-level up to 500 m altitude.

Selected sources 74, 207, 407, 523, 730, 810.



Gmelina elliptica J.E. Smith – 1, flowering twig; 2, flower; 3, detail of leaf base.

Gmelina philippensis Cham.

Linnaea 7: 109 (1832).

Synonyms *Gmelina asiatica* sensu Blanco (1837), *Gmelina hystrix* Schult. ex Kurz (1871), *Gmelina asiatica* L. var. *philippinensis* (Cham.) Bakh. (1921).

Vernacular names Malaysia: bulangan duri (Peninsular). Philippines: alipung (Tagalog), bosel-bosel (Iloko), tulongan (Pinay Bisaya). Thailand: khaang maeo (central, peninsular), khaao che (general), so maeo (northern). Vietnam: tu h[us] philippin, tu h[us] l[as] b[aws]c t[is]m.

Distribution From India eastward to Burma (Myanmar), Thailand and Indo-China, southward to Malaysia, Indonesia and the Philippines. Widely cultivated as an ornamental throughout the tropics.

Uses In the Philippines, juice of the fruit is applied to eczema of the feet. It is further mentioned as a leech repellent. In Peninsular Malaysia, the fruit pounded with lime is applied as a poultice to the throat as a remedy for coughs. In Indo-China, the juice of the roots is used as a purgative and in treating fatigue. The extract of the roots is used internally as a stimulant, resolvent, and in treating diseases of the joints and nerves. Likewise an extract of the leaves is employed externally.

Observations An evergreen, moderately sized, straggling or scandent shrub or tree up to 7 m tall, usually spiny, bark yellowish, ultimate branches divaricate, drooping or subscandent; leaves mostly anisophyllous, ovate or elliptical to obovate, entire or distantly toothed to slightly few-lobed, 1.5–10 cm × 1.5–6 cm, base cuneate, apex obtuse, subacute or cuneate, glabrous and shiny above, pale and often glaucous below; raceme terminal, 10–20 cm long, bracts large, foliaceous, conspicuous, green, yellow, purple or red; flowers pendulous, calyx with 2–4 glands outside, corolla inflated upwards, 4.5–5.5 cm long, yellow, moderately densely pubescent or glabrous; drupe obovoid, about 1.2 cm long, yellow. *G. philippensis* is found in thickets in secondary forest at low and medium altitudes.

Selected sources 74, 135, 207, 788, 810.

R.C.K. Chung

Goniothalamus Hook.f. & Thomson

Fl. ind. 1: 105 (1855).

ANNONACEAE

x = unknown; *G. macrophyllus*: 2*n* = 16

Major species *Goniothalamus amuyon* (Blanco) Merr., *G. giganteus* Hook.f. & Thomson, *G. macrophyllus* (Blume) Hook.f. & Thomson, *G. tapis* Miq., *G. velutinus* Airy Shaw.

Vernacular names Indonesia: pisang-pisang (used for most *Annonaceae*). Malaysia: mempisang (used for most *Annonaceae*). Vietnam: gi[as]c d[ees].

Origin and geographic distribution *Goniothalamus* is an Old World genus comprising 50–115 species; it is found from India eastward to the Philippines, throughout South-East Asia to New Guinea and Australia (Queensland).

Uses In traditional Malay medicine, *Goniothalamus* is used in connection with childbirth (e.g. *G. macrophyllus*, *G. tapis*, *G. fulvus* Hook.f. & Thoms. and *G. scortechinii* King). Uses vary from an ingredient of an abortifacient in early pregnancy to a post-partum medicine. The leaves of several species have also been recommended as a hot poultice for swellings. Leaves of some fragrant species such as *G. malayanus* Hook.f. & Thomson, *G. macrophyllus* and *G. scortechinii* when burned are effective as mosquito repellent. In Sarawak, a number of closely resembling species known in Malay as lim panas, hujan panas or in Iban as selokai (*G. longistipites* Mat Salleh ined., *G. sinclairianus* Mat Salleh ined., *G. tapisoides* Mat Salleh ined., *G. velutinus*) or selokai ladah (*G. moniliformis* Mat Salleh ined., *G. uvariodes* King) are used more or less indiscriminately. The bark is smoked to scare off bees while collecting honey, but also to scare away evil spirits. The leaf stalks are used as a medicine for stomach-ache. The Kelabit in Sarawak drink a decoction of the roots of *G. tapis* and *G. dolichocarpus* Merr. to ease stomach-ache. The bark of several species is used for rope of varying quality and durability (e.g. *G. punctilatus* Boerl. & Koord., *G. sumatranus* Miq.) The species with a trunk of reasonable size are locally used for timber, e.g. *G. malayanus*.

Production and international trade *Goniothalamus* is only used on a local scale. Wood of *G. velutinus* is traded in local markets in Sabah and Sarawak at US$ 2 a stick. Fragrant flowers of *G. tapis* are on sale in local markets like those of *Cananga odorata* (Lamk) Hook.f. & Thomson.

Properties Phytochemical studies of *Goniothalamus* have led to the isolation and characterization of a large number of styryl lactones and acetogenins, which were found to possess significant cytotoxic activities against several human tumour cell lines.

For instance, a methanolic extract from the stem bark of *G. macranii* Craib, from Thailand and Peninsular Malaysia, revealed strong toxicity in the brine shrimp lethality test with LD_{50} values of 3.1 μg/ml and also showed cytotoxity against the human tumour cell lines A-549 (lung carcinoma), HT-29 (colon adenocarcinoma), MCF7 (breast carcinoma), RPMI (melanoma) and U251 (brain carcinoma) with ED_{50} values of about 1 μg/ml. Activity-directed fractionation resulted in the isolation of the following cytotoxic compounds: marcanine A, B, C, D and dielsiquinone, which are all azo-anthraquinones, together with 5-hydroxy-3-amino-2-aceto-1,4-naphthoquinone. They exhibited cytotoxic activities against the human tumour cell lines A-549, HT-29, MCF7, RPMI and U251 with the ED_{50} values in the range of 0.04–3.03 μg/ml.

Furthermore, activity-guided fractionation using the brine shrimp lethality test also identified 2 bioactive acetogenins in the bark of *G. giganteus*: goniotriocin and a mixture of (2,4-cis and -trans)-xylomaticinones. The two compounds showed significant and selective cytotoxicity towards 6 human solid tumour cell lines in a seven-day MTT test panel. Both compounds exhibited potent and selective cytotoxicities against MCF-7 (breast adenocarcinoma) and HT-29 (colon adenocarcinoma) cell lines with 10–10 000 times the potency of adriamycin as reference. In addition, goniotriocin was quite active in the yellow fever mosquito (*Aedes aegypti*) larvae microtitre assay, with an ED_{50} value of 3.5 μg/ml. Mono-tetrahydrofuran acetogenins such as 4-deoxyannomontacin, a mixture of (2,4-cis and -trans)-annomontacinone isolated from the bark of *G. giganteus* showed selective and potent cytotoxicity to certain human tumour cell lines and furthermore were comparable to the activity of rotenone against yellow fever mosquito larvae. Bis-tetrahydrofuran acetogenins (e.g. 4-deoxygigantecin, a mixture of (2,4-cis and -trans)-gigantecinone) were more potent than rotenone in pesticidal activity, and the compound showed selective and potent cytotoxicity against PC-3 human prostrate adenocarcinoma cell line with an ED_{50} value of $1.08 \cdot 10^{-3}$ μg/ml. The acetogenins pyranicin, pyragonicin and goniotrionin, isolated from the stem bark of *G. giganteus* show an unusual hydroxylated-allylic moiety. In addition to goniotrionin, also pyranicin and pyragonicin are selectively cytotoxic against the pancreatic cell line (PACA-2) in a panel of six human solid tumour cell lines, pyranicin showing 10 times the potency of the adriamycin control. Goniotrionin showed more potent selectivity against the breast cell line (MCF-7).

The styryl lactone goniodiol isolated from the stem bark of *G. giganteus* showed significant and selective toxicity against human lung tumour cells (A-549). Furthermore, 2 other cytotoxic acetogenins were isolated from the ethanol extract of the bark: gigantetronenin and gigantrionenin. They exhibited selective and potent cytotoxicity against A-549, MCF-7 and HT-29 human tumour cell lines, with ED_{50} values of 2.92 10^{-3}–8.06 μg/ml. The styrylpyrone, goniodiol-7-monoacetate, isolated from *G. amuyon*, showed potent cytotoxicities against KB, P-388, RPMI and TE671 tumour cell lines, with ED_{50} values of less than 0.1 μg/ml; it lacked cytotoxicity against A-549 and HCT-8 tumour cell lines when tested at 4.0 μg/ml. Finally, goniodiol-8-monoacetate isolated from the methanol extract of the leaves showed potent cytotoxicities against KB, P-388, A-549, HT-29 and Hl-60 tumour cell lines, with an ED_{50} value of 4.85, 1.68, 4,79, 3,99 and 1.85 μg/ml, respectively.

Extracts of *G. dolichocarpus* and *G. tapis* showed strong antibacterial activity against *Bacillus subtilis*, *Escherichia coli*, *Micrococcus luteus*, *Pseudomonas aeruginosa*, *Staphyllococcus aureus* and *S. faecalis*. Extracts of various parts of *G. grandiflorus* (Warb.) Boerl., from New Guinea, show antibacterial activity against *Escherichia coli* and *Staphyllococcus aureus*.

The styrylpyrone derivative goniothalamin has been isolated from roots, wood, bark and fruits of *G. tapis*, *G. scortechinii*, *G. malayanus*, *G. macrophyllus*, *G. fulvus* Hook.f. & Thomson and *G. andersonii* J. Sinclair. The antifertility effect of goniothalamin, isolated from *G. tapis*, was studied in mice during the early stage of pregnancy. Treatment with goniothalamin, intraperitoneally at the dose of 138.9 mg/kg body weight from day 1 to day 7 of gestation, prevented the normal maintenance of pregnancy. Serum level of progesterone in goniothalamin-treated mice was found to be significantly ($p < 0.01$) lower than the control group while the luteinising hormone levels were significantly ($p < 0.001$) higher on days 5 and 6. The uterus wet weight was also significantly ($p < 0.001$) lower than the control, an indication that the animals were not pregnant. Thus, the failure to maintain pregnancy could be attributed to a direct or indirect effect on the corpus luteum, which may result in the inhibition of the synthesis and/or the secretion of progesterone by the corpus luteum.

Finally, several alkaloids have been isolated from *G. velutinus*, e.g. velutinam I and aristolactam B-II which showed cytotoxicity against HeLa and L-1210 cells in culture. The aporphine alkaloid, oxostaphanine has been isolated from *G. scortechinii* and *G. tapis*.

Description Shrubs or small trees with simple hairs. Leaves alternate, simple, entire; petioles short; stipules absent. Flowers bisexual, usually axillary, solitary or in few-flowered fascicles, often on the trunk. Sepals 3, valvate; petals 6, valvate, coriaceous, in 2 whorls, inner much shorter than outer ones, shortly clawed, cohering above the reproductive organs; stamens numerous, connective with a truncate dilated or conical apex, anther cells frequently transversely septate; carpels numerous; ovules 1–2(–5), basal or lateral; pedicel with several imbricate, distichous bracts at the base. Fruit a monocarp, globose to oblong, stipitate or sessile.

Growth and development Many *Goniothalamus* species flower and fruit throughout the year e.g. *G. macrophyllus*, whereas others have a more strictly defined flowering period, e.g. *G. amuyon* in Taiwan flowers in May, and fruits are mature in October. *G. velutinus* in Borneo flowers and fruits from June–August. *Goniothalamus* has cleistogamous; flowers and seems to be completely autogamous, to date no pollinators have been observed. In Sarawak, however, beetles (*Carpophilus* spp., *Endaenidius* spp and *Endaeus* spp.) were observed feeding on stigmatic secretions.

Other botanical information *Goniothalamus* is badly in need of revision. According to a classification based on both flower and fruit characters of *Annonaceae* from all over the world, *Goniothalamus* is placed in an informal group which also includes the Asian genera *Anomianthus*, *Fissistigma*, *Friesodielsia*, *Melodorum*, *Mitrella*, *Mitrephora*, *Neo-uvaria*, *Oreomitra*, *Papualthia*, *Petalolophus*, *Phaeanthus*, *Popowia*, *Pseuduvaria*, *Pyramidanthe*, *Richella*, *Schefferomitra* and *Trivalvaria*.

Ecology *Goniothalamus* species are usually confined to forests at low elevations, although some montane species exist.

Propagation and planting Some trials with low survival rates have been carried out with wildings transplanted into the open.

Harvesting Sticks about 1–1.5 m long are cut from *G. tapis* treelets and traded in the market.

Genetic resources and breeding *Goniothala-*

mus comprises numerous endemic species and some widespread ones, mostly in the understorey of primary forest, some also are common in secondary vegetation. The narrow endemics from primary forest habitats in particular are potentially threatened by forest degradation.

Prospects The annonaceous acetogenins and styrylpyrones as found in *Goniothalamus* are relatively new classes of promising anticancer and pesticidal natural compounds for which a potent inhibition of ATP production via blocking of the plasma membrane bound NADH oxidase leading to apoptosis (programmed cell death) is at least in part, involved in their mechanism of action. This unique mechanism of action for cancer chemotherapy will certainly merit further research, in order to fully evaluate the potential of the compounds in future medicine.

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Selection of species

Goniothalamus amuyon (Blanco) Merr.

Philipp. Journ. Sci., Bot. 10(4): 264 (1915).

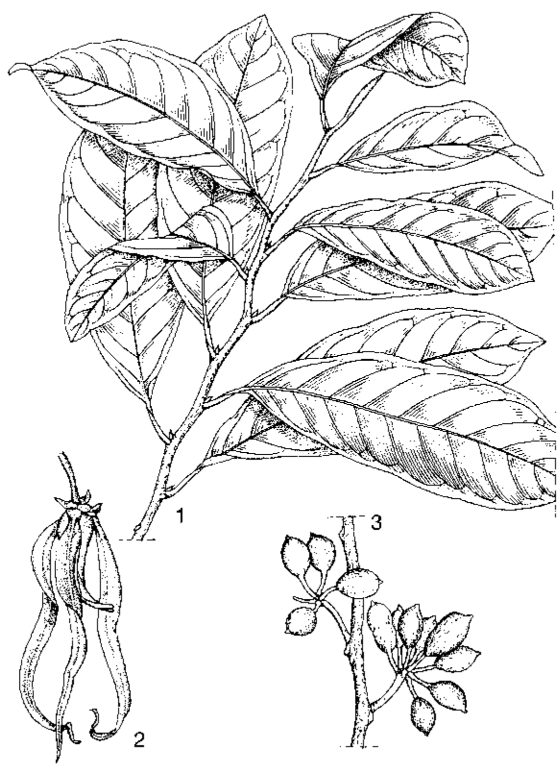
Synonyms *Uvaria amuyon* Blanco (1837), *Unona cauliflora* Blanco (1845), *Polyalthia sasakii* Yamam. (1927).

Vernacular names Philippines: amuyong (Tagalog), amuyon (Cebu Bisaya), sagiat (Iloko).

Distribution Southern Taiwan and the Philippines from Luzon to Mindanao.

Uses In the Philippines, the fruit is used as a stomachic and antidote for poison. The seeds cooked with oil are rubbed on the skin to soothe sores and inflammations, and the preparation also makes an effective liniment for rheumatic complaints. A decoction is used in tympanites. In Taiwan, extracts of the seeds have been used for the treatment of oedema and rheumatism. The bark yields an attractive apricot-buff coloured bast fibre, which is made into rope.

Observations A shrub or small tree 3–10 m tall; leaves oblong, obovate or lanceolate, 15–25 cm × 5–7.5 cm, base cuneate, apex acute or obtuse, coriaceous, petiole 1–1.5 cm long; flowers usually solitary, axillary, pedicel up to 1 cm long, sepals broadly triangular ovate, green, outer petals lanceolate, 3–6 cm × 1 cm, yellow-green, inner petals 3 cm × 1.2 cm, fleshy, stamens about 100, carpels 12–24, only 6–16 reaching maturity, ovules 1–3



Goniothalamus amuyon (Blanco) Merr. – 1, leafy twig; 2, flower; 3, part of leafless twig with infructescences.

(–5); monocarp cylindrical elongated or sausage-like, about 1–3 cm long, smooth, stalk about 1 cm long, 1–3(–5)-seeded, indehiscent. *G. amuyon* is found in forests at low and medium elevations.

Selected sources 380, 605, 786, 810, 1089.

Goniothalamus giganteus Hook.f. & Thomson

Fl. ind. 1: 109 (1855).

Vernacular names Malaysia: penawar hitam, dedanum, galang hutan. Thailand: paanan chaang (peninsular).

Distribution Thailand, Peninsular Malaysia, Sumatra and Borneo.

Uses Its Malay name 'penawar hitam' points to its medicinal uses which are similar to those of *G. macrophyllus*. The bark is used for rough cordage.

Observations A tree 10–23 m tall; leaves oblong, 16–26 cm × 4–6 cm, shortly acuminate, glabrous, petiole 0.7–1.5 cm long; flowers in axils of fallen leaves, pedicel 2.5–4.5 cm long with 2 bracts at base, sepals ovate, acute, 1 cm long, pubescent outside, outer petals broadly ovate to ovate-oblong, 8–15 cm × 4.5–9 cm, accrescent, yellow tinged green, inner petals ovate, acute, 1.5–2 cm long, golden-tomentose outside, stamens numerous, carpels about 20, elongate, 6–7 mm long, rusty tomentose, ovules 2; monocarp oblong, apiculate, tapering into stalk, 3–4.5 cm × 1.5 cm, granular or warted, 1–2-seeded. *G. giganteus* is a common forest species throughout Peninsular Malaysia.

Selected sources 40, 41, 104, 135, 294, 786, 916.

Goniothalamus macrophyllus (Blume) Hook.f. & Thomson

Fl. ind. 1: 109 (1855) in nota.

Synonyms *Unona macrophylla* Blume (1825), *Polyalthia macrophylla* (Blume) Blume (1830), *Goniothalamus macrophyllus* (Blume) Miq. (1858).

Vernacular names Brunei: limpanas putih, linpanas puteh, talipanas puteh (Sengkurong). Malaysia: akar beranak gajah, penawar hitam, lada hutan. Indonesia: ki cantung (Sundanese). Thailand: kaa-yoh braa-noh, king dok dieo, khruu dam (peninsular).

Distribution Thailand, Peninsular Malaysia, Sumatra, Java and Borneo.

Uses In Malaysia, a decoction of the roots is used externally for colds, and likewise a steam bath is used in fevers. Heated leaves may be poulticed on swellings. A decoction is drunk after childbirth. In Java, mountain dwellers use an infusion of the roots to treat typhoid fevers. In Brunei, a patient with fits is subjected to the smoke. The smoke can also be used to repel mosquitos, snakes and other wild animals.

Observations A shrub or tree up to 8 m tall; leaves oblong-lanceolate to oblong-oblanceolate, 22–30(–50) cm × 6–11 cm, base sub-acute to rounded, apex acute, coriaceous, glabrous, petiole 1–3 cm long; flowers solitary, axillary, pedicel 1–1.2 cm long with 2–3 bracts at base, sepals oblong-ovate to oblong-lanceolate, 1.5 cm long, purplish, outer petals oblong-lanceolate, 3.3 cm long, almost glabrous, greenish, inner petals rhomboid, 1.8 cm long, greenish, stamens numerous, carpels 12–18, elongate, 6 mm long, glabrous, ovule 1; monocarp globose to ovoid, slightly apiculate, 1–2 cm × 1 cm, glabrous, sessile, red, 1-seeded. *G. macrophyllus* is found in humid forest from 50–1500 m altitude.

Selected sources 135, 407, 487, 522, 786, 916, 970.

Goniothalamus tapis Miq.

Fl. Ind. Bat., Suppl. 1: 371 (1861).

Vernacular names Malaysia: kenarak, galai (Peninsular), gertimang (Kelabit, Sarawak), tongkat bumi (Limbang, Sarawak). Thailand: chi-nokoh, naara (peninsular), bu ngaa lam chiak (Bangkok).

Distribution Peninsular Malaysia, Sumatra and Borneo.

Uses In Peninsular Malaysia, a decoction of the root in combination with *Plumbago* is swallowed as an abortifacient in the early months of pregnancy. In Sarawak, a decoction of the roots is drunk to treat diarrhoea and stomach-ache. A solution of boiled leaves or roots is used to bathe patients with skin diseases. In Kalimantan, the bark is used as a mosquito repellent. It is locally grown as an ornamental for its fragrant flowers.

Observations A shrub or small tree up to 10 m tall; leaves oblong to elliptical-oblong, 15–27 cm × 6–12 cm, base rounded or slightly cuneate, apex abruptly, shortly and bluntly acuminate, coriaceous, petiole 0.5–0.7 cm long; flowers solitary or paired, axillary, sweet-scented, pedicel about 0.6 cm long, sepals ovate, acute, 0.5–0.6 cm long, pubescent outside, green tinged purple, outer petals ovate-lanceolate, 3–5 cm long, greenish to creamy-white, inner petals ovate, 1–1.7 cm long, stamens numerous, carpels elongate, 3 mm long, tomentose; monocarp ellipsoid, apiculate, 1–1.2 cm long, glabrous, sessile, ripening red, then purple, finally black, 1-seeded. *G. tapis* is a forest species of lower elevations, rather common in Peninsular Malaysia.

Selected sources 135, 207, 298, 522, 699, 786, 916.

Goniothalamus velutinus Airy Shaw

Kew Bull.: 286 (1939).

Vernacular names Brunei: linpanas hitam, talipanas hitam (Sengkurong). Malaysia: kayu tas, limpanas (Malay), selokai (Iban).

Distribution Borneo.

Uses Sticks of this tree have a long reputation for warding off snakes, and are traded as such to Peninsular Malaysia. Sticks are often placed in field borders to ward off bad spirits and dangerous animals. In Brunei, smoke from burning twigs is used in the same way as smoke from *G. macrophyllus*.

Observations A small tree up to 6 m tall, young shoots densely dark-rusty velutinous; leaves oblanceolate, 40–42 cm × 8.5–10 cm, base rotundate, apex acuminate, acumen 1.5–2 cm long, papyraceous, covered with dark-rusty hairs, petiole 1.8 cm long, densely velutinous; cauliflorous, pedicel 0.5–0.9 cm long, with 4 bracts at base, sepals triangular-ovate, about 0.7 cm × 0.4 cm, outer petals ovate-lanceolate, 1.8 cm × 0.8 cm, inner petals ovate, 1.2 cm × 0.6 cm, greenish, stamens more than 100, carpels 12–16. *G. velutinus* is found in mixed dipterocarp forest, common on upper slopes and ridges.

Selected sources 466, 487, 652.

Khozirah Shaari

Guazuma ulmifolia Lamk

Encycl. 3: 52 (1754).

STERCULIACEAE

$2n = 16$

Synonyms *Theobroma guazuma* L. (1753), *Guazuma tomentosa* Kunth (1823).

Vernacular names Bastard cedar, West Indian elm (En). Bois d'orme, orme d'Amérique (Fr). Indonesia: jati belanda (Malay), jati londo (Javanese).

Origin and geographic distribution *G. ulmifolia* is a native of tropical America, but long naturalized in various parts of the Old World tropics.

Uses In Java, at one stage the leaves were a popular herbal tea for losing weight. However, excessive use is injurious to the bowels. The seeds are roasted, pounded and used in decoction as a mild astringent to treat stomach problems. In South America, Central America and the West Indies, various plant parts are used in folk medicine. A decoction of the astringent and mucilaginous bark is a remedy for malaria, diarrhoea and syphilis, and a uterine stimulant. It is applied externally on skin diseases. The inner bark is likewise applied on ulcerous sores. A decoction of the leaves is taken to relieve liver and kidney complaints. A sweetened decoction of the dried and pounded fruits is taken as a cold remedy. A decoction of the root bark is taken to halt dysentery and is given as an enema to relieve haemorrhoids. In Brazil the use is confined to a decoction of the bark that is used indiscriminately for all above mentioned applications and to relieve coughs, bronchitis, asthma and pneumonia. The bark and fruits are also mentioned for losing weight.

The fruit is edible and has an agreeable mucilaginous tissue, but eating too much may cause diarrhoea. The leaves and fruits are used as fodder. The bark is locally used for cordage. Throughout its natural range the wood is used for firewood and charcoal. *G. ulmifolia* is also planted as a wayside tree in Indonesia. The wood is good and sometimes sold under the name of 'bastard cedar'.

Production and international trade The retail price of powdered bark of *G. ulmifolia* was about US$ 55/kg in 2001.

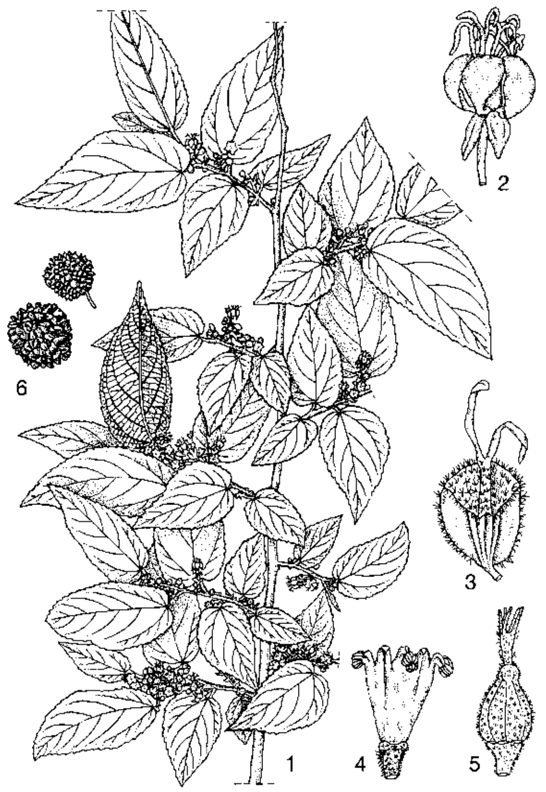
Properties The antisecretory activity of *G. ulmifolia* bark was examined in vitro, using the isolated rabbit distal colon mounted in an Ussing chamber. Chloride secretion was stimulated by cholera toxin and prostaglandin E-2 (PGE-2). An ethanol extract of the bark completely inhibited cholera toxin-induced secretion if the extract was added to the mucosal bath prior to the toxin. Adding the extract after administration of the toxin had no effect on secretion. The extract did not inhibit PGE-2-induced chloride secretion. These results indicate an indirect antisecretory mechanism. SDS-PAGE analysis furthermore showed that the extract specifically interacted with the A subunit of the toxin. Subsequent bioassay-guided fractionations of the bark extract led to the isolation of polymeric proanthocyanidins which inactivated cholera toxin. The average degree of polymerization of the active compounds ranged from 14.4 to 32.0, and the polymers consisted almost exclusively of (−)-epicatechin units.

Furthermore, bark and leaf extracts of *G. ulmifolia* have been incorporated in a variety of general screening assays. These include an antihyperglycaemic test, in which a leaf decoction of *G. ulmifolia* intragastrically administered to temporarily hyperglycaemic rabbits showed a significant decrease of the hyperglycaemic peak and the area under the glucose tolerance curve. Furthermore, an ethanolic leaf extract showed over 90% inhibition in vitro of KB cells.

In addition, extracts have been tested with variable results (often depending on the plant part used) in antimicrobial assays. Examples include a bark extract, which showed good in-vitro activity against 5 enterobacteria pathogenic to humans (*Escherichia coli*, *Salmonella enteritidis*, *S. typhi*, *Shigella dysenteriae* and *S. flexneri*), as opposed to acetone, ethanol and n-hexane extracts of the leaves, which were devoid of activity against a selection of the enteropathogens mentioned (*E. coli*, *Salmonella enteritidis*, *Shigella flexneri*). In a *Neisseria gonorrhoeae* assay, the bark extract of *G. ulmifolia* showed no significant activity.

Finally, the major constituents in the essential oil from leaves collected in Brazil, were precocene I (56.0%), β-caryophyllene (13.7%) and (2Z,6E)-farnesol (6.6%).

Description A tree up to 25 m tall, with a diameter at breast height of 30–60 cm, branches



Guazuma ulmifolia Lamk – 1, flowering twig; 2, flower; 3, petal; 4, staminal column; 5, pistil; 6, fruit.

stellate-tomentose. Leaves alternate, ovate to oblong or lanceolate, 3–21 cm × 2–6 cm, base unequally cordate, apex long-acuminate, margin serrulate, basally 6-veined, scabrous above, tomentose below; petiole 0.5–2 cm long; stipulate. Inflorescence axillary or terminal, thyrsiform cyme, the ultimate elements scorpioid, 2–4 cm long; bracts and bracteoles subulate, caducous; pedicel 3–6 mm long. Flowers bisexual, up to 8 mm across; calyx tube subglobose, lobes 3, subequal, 2–3 mm long; petals 5, obovate, yellow, the lower part up to 4 mm × 2 mm, cucullate, the appendage divided more than halfway, 4–5 mm long; staminal column of 5 fascicles of 3 anthers, opposite the sepals, alternating with 5 triangular staminodes; ovary superior, globose, 5-locular, styles 5, basally connate. Fruit a subglobose woody capsule, 1.5–4 cm × 1.2–2.5 cm, tubercled, indehiscent, many-seeded. Seed 2.5–4 mm × 1.8–2 mm. Seedling with epigeal germination.

Growth and development *G. ulmifolia* can be found flowering and fruiting throughout the year. In Java flowering is from April–December. Apparently some seasonality is essential for flowering, as trees do not flower in Singapore.

Other botanical information *Guazuma* comprises 3 species from the tropics of Central and South America, one (widely) naturalized in the Old World. In South America a further distinction can be made within *G. ulmifolia* between var. *ulmifolia* with the capsule remaining closed at maturity and var. *tomentella* K. Schum. with the capsule incompletely dehiscent by five slits not wide enough to allow the seeds to escape; to a certain extent these differences are correlated with differences in shape of fruit, and outline and indumentum of the leaves.

Ecology In its natural range *G. ulmifolia* grows on soil types varying from fertile to barren limestone although it grows best in rich lowland soils, alluvial and clay soils. It is found in both dry and wet forest and commonly encountered in secondary forest, from sea-level up to 1200 m altitude, in areas with a dry season ranging from 4–7 months and an annual rainfall of 700–1500 mm. It is a pioneer species that grows best in full sunlight, it colonizes recently disturbed areas and is found growing along the banks of streams and in pastures.

Propagation and planting *G. ulmifolia* can be propagated by direct seeding or by planting cuttings, root stumps or bare-root seedlings. Seeds collected from standing trees are dried in the sun, stored at ambient temperatures and are viable for

5 months. Germination can be enhanced by scarification of the seeds or by soaking them in boiling water for 30 seconds. With fresh seed, germination occurs in 7–14 days at rates of 60–80%. The number of seeds per kg ranges from 100 000 to 225 000 and averages 187 500. Seedlings are ready for transplanting when 30–40 cm tall, after about 15 weeks. With root stumps, plants are left in the nursery for 5–8 months or until they reach a stem diameter of 1.5–2.5 cm.

Husbandry *G. ulmifolia* has the ability to fix atmospheric nitrogen, regenerates rapidly and is suitable for coppicing. When it has been planted, regular pruning can increase the fodder yield. When pruned four times per year for fodder, it can produce 10 kg/tree dry matter.

Diseases and pests Pests of *G. ulmifolia* are mainly defoliating insects, such as *Phelypera distigma*, *Arsenura armida* and *Epitragus* species, which can occasionally cause problems.

Harvesting All plant parts of *G. ulmifolia* are collected throughout the year whenever the need arises.

Handling after harvest Plant parts of *G. ulmifolia* are used fresh or simply dried for future use.

Genetic resources and breeding Although widespread and common in its natural range, the genetic basis for *G. ulmifolia* in South-East Asia might be limited. There are no known breeding programmes of *G. ulmifolia*.

Prospects The quite specific antisecretory activity of the proanthocyanidins isolated from *G. ulmifolia* on cholera-toxin is very interesting. Since from time to time, epidemic cholera infections still have a high rate of fatalities, these compounds merit further research to evaluate their possible potential in the development of a future cure for this infective disease.

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Other selected sources 74, 135, 219, 407, 448, 662, 724, 786, 810, 1028.

J.L.C.H. van Valkenburg & S.F.A.J. Horsten

Harrisonia R. Brown ex A.H.L. Juss.

Mém. Mus. Natl. Hist. Nat. Paris 12: 517 (1825).
SIMAROUBACEAE
x = unknown

Major species *Harrisonia perforata* (Blanco) Merr., *H. brownii* A.H.L. Juss.

Origin and geographic distribution *Harrisonia* comprises 3–4 species distributed in the Old World, two of them in Malesia.

Uses In Indonesia, young shoots of *H. perforata* are considered a remedy against diarrhoea. In the Philippines, a decoction of the root bark is recommended in the treatment of diarrhoea and dysentery as well as against cholera. In Indo-China, ashes of the roasted leaves mixed with oil or simply crushed leaves are applied to relieve itch. In Thailand, the dried root is considered antipyretic and anti-inflammatory; it is used in wound healing and in the treatment of diarrhoea. The stems are also employed in the treatment of diarrhoea. In the Central Province, Papua New Guinea, the bitter decoction of the leaves of *H. brownii* is used, with caution, in the treatment of diarrhoea, malaria, coughs and asthma.

Properties Phytochemical investigations of *H. perforata* revealed the presence of seven chromones, perforatins A–G, from the wood. Furthermore, the closely related tetranotriterpenoids (limonoids), perforatinolone and perforatin, were isolated from its leaves. As a result of preliminary chemical analysis using general screening reactions steroids, flavonoids and alkaloids have also been found. However, the actual isolation and identification of an alkaloid has not yet been recorded.

Stem bark extracts of *H. perforata* have a strong antibacterial action against *Shigella shigae*, a weak action against *Vibrio eltor* but are inactive against other *Salmonella*, *Shigella* and *Vibrio* species. A MeOH extract of *H. perforata* showed potent inhibitory activity in the HIV-1 reverse transcriptase model with 68% inhibition at 200 μg/ml.

Two keto-steroids stigmasta-3,5,22-trien-7-one and campesta-3,5-dien-7-one were isolated from the stem bark of the African *Harrisonia abyssinica* Oliv., of which the chloroform extract exhibited a broad antifungal activity. Furthermore, the roots showed antibacterial action against 12 strains of *Helicobacter pylori* with minimum inhibitory concentrations (MIC_{50}) of about 250 μg/ml. Finally, good molluscicidal properties were also found for *H. abyssinica* extracts, and the isolated compound 12-β-acetoxyharrison is an antifeedant against armyworms.

Description Scandent to erect prickly shrubs or small trees up to 12 m tall; branches with thorns. Leaves spirally arranged, imparipinnate, sometimes trifoliolate, petiolate, stipulate; leaflets subentire to lobed, rachis narrowly winged. Inflorescence an axillary or terminal cyme or thyrse. Flowers bisexual, 4–5-merous, pedicellate; calyx small, lobes triangular, about as long as the tube; petals much longer than the sepals, slightly imbricate in bud; stamens twice as many as the petals, attached at the base of the disk, filaments with an adnate 2-lobed or emarginate hairy ligule; ovary, superior, 4–5-celled, 1 ovule per cell, styles 4–5, connate or sometimes free at the very base. Fruit a berry. Seed with a thin testa, endosperm present, cotyledons horseshoe-shaped, radicle pointing upwards.

Other botanical information The inclusion of *Harrisonia* in *Simaroubaceae* as followed here is subject to some controversy. Contrary to other simarouboid genera, it has fused rather than free carpels, stipular thorns and pellucid dots in the leaves (*H. perforata*), and isodiametric secretory cavities in the mesocarp. Molecular and phytochemical evidence points to a close affinity with *Cneorum*. Whereas quassinoids are typical in simarouboids, in *Harrisonia* and *Cneorum* limonoids are present and alkaloids are absent. Limonoids occur in combination with chromones, a very rare combination.

Ecology Both Malesian *Harrisonia* species prefer dry, open localities such as light secondary forest, thickets and forest edges, often on limestone rocks; less common in monsoon forest. They prefer distinctly seasonal conditions from sea-level up to 700(–900) m altitude.

Genetic resources and breeding Their widespread distribution and ability to grow in disturbed and open habitats means that the two Malesian species are unlikely to be in danger of genetic erosion.

Prospects The good molluscicidal properties of the African *H. abyssinica* may be of value in the control of schistosomiasis. This together with the antifungal properties merits further research, also in other *Harrisonia* species.

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Selection of species

Harrisonia brownii A.H.L. Juss.

Mém. Mus. Natl. Hist. Nat. Paris 12: 540, pl. 28, n. 47 (1825).

Vernacular names Indonesia: kaju bilis (Madura), tara kedauk (Sumba), kai tudu (Timor). Philippines: kankasira (Tagbanua), malomanhak (Cebu Bisaya). Papua New Guinea: iburo (Delena, Central Province).

Distribution Disjunct from the Andamans to the drier parts of Malesia (southern Philippines, eastern Sulawesi, East Java, Lesser Sunda islands, southern Moluccas, south-east New Guinea), extending to northern Australia.

Uses In Papua New Guinea, the bitter decoction of the leaves is used in weekly doses to treat malarial fever or asthma.

Observations A sprawling to erect shrub or a tree up to 4 m tall; leaves sometimes in clusters, trifoliolate, petiole 0.5–3 cm, stipules conical 0.5–1.2 mm, leaflets ovate, base attenuate or oblique, apex acuminate, entire or irregularly serrate, terminal leaflet to 8.5 cm long, lateral leaflets to 5 cm long; inflorescence few-flowered up to 5(–7) cm long; flowers 4(–5)-merous, pedicellate, calyx small, petals lanceolate to oblong, 3.5–5 mm × 1.5–2.5 mm, green-white or yellow, stamens 8(–10), anthers 1.5–2 mm long, filaments 2 mm long, at base with a ligule; disk cylindrical, slightly 8–10 lobed; ovary rather deeply lobed, styles 0.5–2.5 mm long; fruit a berry, 4–5 mm × 7–9 mm, exocarp thin fleshy, endocarp hard, each cell with an abaxial suture.

Selected sources 74, 311, 406, 418, 423, 432, 746, 949.

Harrisonia perforata (Blanco) Merr.

Philipp. Journ. Sci., Bot. 7: 236 (1912).

Synonyms *Harrisonia paucijuga* Oliv. (1868), *Harrisonia bennettii* Benn. (1875).

Vernacular names Indonesia: sesepang (Lampung), garut (Sundanese), ri kengkeng (Javanese). Malaysia: kait-kait (Murut, Sabah). Philippines: asimau, mamikil (Tagalog), muntani (Bisaya). Laos: dok kin ta. Thailand: khonthaa (Central), naam chee (Northern). Vietnam: s[aa]n, da da, h[ar]i s[ow]n.

Distribution *H. perforata* is found in the drier parts from Burma (Myanmar) eastward through Thailand to Indo-China and the Philippines, southward to Peninsular Malaysia (Perlis), South Sumatra, Borneo (Sabah), Sulawesi, Java and the Lesser Sunda Islands.

Uses In Indonesia, young shoots are considered a remedy against diarrhoea. In the Philippines, a decoction of the root bark is recommended in the treatment of diarrhoea and dysentery as well as against cholera. In Indo-China, ashes of the roasted leaves mixed with oil or simply crushed leaves are applied to relieve itch. In Thailand, the dried root is considered antipyretic and anti-inflammatory, it is used in wound healing and in the treatment of diarrhoea. The stems are also employed in the treatment of diarrhoea.

Observations A scandent to erect prickly shrub up to 4(–6) m tall, leaves imparipinnate up to 20 cm long, with 1–15 pairs of leaflets; petiole 5–30 mm long; stipulate thorns slightly recurved, accrescent to 7 mm; leaflets rhomboid to ovate-lanceolate, 10–20 mm × 5–15 mm, subentire to lobed, rachis narrowly winged; inflorescence 8–20-flowered, flowers (4–)5-merous, pedicellate, calyx small, lobes triangular, petals lanceolate, 6–9 mm × 2–4 mm, red outside, pale red to white inside, stamens (8–)10, anthers 1.5–4.5 mm long, filaments 7–10 mm long, at base with a ligule which is densely woolly at the margin, disk cup-shaped, ovary slightly lobed, styles 5–8 mm long, pubescent; fruit a berry, 4–9 mm × 11–15 mm, exocarp coriaceous, at least 1 mm thick, endocarp hard, without suture.

Harrisonia perforata (Blanco) Merr. – 1, flowering and fruiting twig; 2, flower.

Selected sources 74, 78, 135, 311, 407, 746, 786, 788, 794, 810, 868, 948, 949, 985.

R. Kiew

Hedychium J. König

Observ. bot. 3: 73 (1783).

ZINGIBERACEAE

$x = 17$; *H. coronarium*: $2n = 34$, 54, *H. spicatum*: $2n = 34$

Major species *Hedychium coronarium* J. König.

Vernacular names Ginger lily (En).

Origin and geographic distribution *Hedychium* comprises 40–50 species and is primarily a Himalayan genus, but occurs also throughout tropical and subtropical Asia to Malaysia, Indonesia and the Pacific Islands. Several species are cultivated throughout the tropics and subtropics as ornamentals, and some of them have become naturalized.

Uses In Peninsular Malaysia, a decoction of the boiled leaves of different *Hedychium* species is eaten for indigestion. The leaves are sometimes eaten with betel nut (*Areca catechu* L.) to ease pain in the abdomen. The rhizome is used in local magic rites. In the Moluccas and the Philippines, a decoction of the basal part of the stem is used as a gargle for tonsilitis, and the juice of the chewed stem is applied to swellings. In Hawaii, the chewed stem is applied to infected nostrils. In Bali, the rhizome is combined with onion (*Allium sativum* L.) and fennel (*Foeniculum vulgare* Miller) in a poultice applied to the abdomen to treat fever. In Indo-China, the rhizome is considered stimulant. Rhizomes macerated in water are used to wash swollen ganglia in cattle, and some of the maceration is given to the animals to eat. In Thailand, the dried rhizome is taken as a general tonic, or more specifically for the kidneys. The rhizome is also ground and made into pills, which are given with honey to weakened patients and for muscular pains. The rhizome oil is applied as an insecticide. In India, the ground rhizome is used as a febrifuge, while in Brazil, a decoction is considered antirheumatic, tonic and excitant. In Brazil, the aromatic flowers are considered diuretic, hypertensive, antidiabetic and antisyphilitic, and are also credited with fungicidal properties.

In China, the rhizome of *H. spicatum* Buch.-Ham. is a remedy for stomach-ache and toothache. It is considered a fragrant stomachic and a spice. In India, the dried rhizome is reputed to be an insect repellent, and is also put between clothes for its sweet fragrance, or mixed with tobacco for smoking. The rhizomes are stomachic, carminative, stimulant and tonic, and are used for dyspepsia in the form of powder or decoction.

Thin slices of dried rhizomes of *H. spicatum* are sold in the markets of India, and used as a fragrance during festivals. In Indonesia, the rhizomes of *H. coronarium* are eaten after roasting in a fire. *H. coronarium* and *H. gardnerianum* Sheppard ex Ker Gawl. are also a source of cellulose for paper manufacture, fibres for textiles, edible starch and can be used for animal feed. In India, the rhizomes of *H. coronarium* are an ingredient of cosmetic powders for promoting hair growth. Fried and mixed with other ingredients, they are used as fish bait. The dried fruit is added to soften meat and pulses during cooking. The leaves are also woven into mats.

Many *Hedychium* species are widely cultivated as ornamentals, for their lush appearance and striking inflorescences, with often very fragrant flowers. Many cultivars and hybrids have been developed, showing variation in plant size, size and colour of the flowers and hardiness.

Production and international trade No statistical data are available on the production of *Hedychium* for medicinal purposes.

Properties The essential oil of the fresh flowers of *H. coronarium* is quite different from that of the leaves and rhizomes, and contains about 300 compounds, of which the most important are linalool, (E)-isoeugenol, indole and methyl benzoate. Minor components include: α-pinene, sabinene, β-pinene, β-myrcene, 1,8-cineole, β-ocimene and α-ocimene. In Japan it was found that the methyl-benzoate level reaches a maximum at night. During the flowering period, linalool and methyl- benzoate decreased by a third, and indole decreased to trace amounts. These changes corresponded to an alteration in floral odour from a fresh, spicy, flowery, green, gardenia-jasmine-like fragrance in summer, to a monotonous odour in the winter-flowering flowers. The rhizome oil of *H. coronarium* from French Polynesia contains β-pinene (25%) and 1,8-cineole (40%) as major constituents, as well as the cytotoxic terpenes coronarin A–F, (E)-λ-8 (17),12-diene-15,16-dial, isocoronarin D, λ-8(17), 11,13-trien-15(16)-olide and 7-β-hydroxycoronarin B. It acts as a carminative, and has a depressant effect on the smooth muscles of excised intestines of the cat. The compounds λ-8(17),12-diene-15, 16-dial and coronarin E were found in several other Malaysian *Zingiberaceae*.

Antimicrobial screening indicated that the essential oil from *H. coronarium* flowers has good activity against yeasts and fungi (plant and animal pathogens), but weak activity against the bacteria tested. In another in vitro test, essential oils of the rhizomes of *H. coronarium* (0.3%) and *H. spicatum* (1.6%) were found to be more effective against the human fungus *Taenia solium* than piperazine phosphate. The essential oils, however, were not as effective as hexylresorcinol against *Bunostomum trigonocephalum* and *Oesophagostomum columbianum*.

The essential oil from *H. coronarium* shoots inhibited mycelial growth of *Aspergillus flavus* at 1000 ppm and was fungitoxic at 3000 ppm.

In addition, extracts of *H. coronarium* are popularly used in Brazil for their supposed diuretic and/or antihypertensive properties. This has been investigated in vivo using normal- and spontaneously hypertensive rat models. Extracts were made of the leaf-sheaths in aqueous ethanol (50:50) at low temperature, after which the alcohol was evaporated. The extract showed antihypertensive and diuretic effects in the models used. Furthermore, seeds of *H. coronarium* show molluscicidal activity against *Lymnaea cubensis* and *L. columella* at 25 ppm. The extracts also showed some insecticidal activity against the rose aphid *Macrosiphum rosae*.

The rhizome of *H. spicatum* smells strongly of camphor, and contains an essential oil (4%) whose main compounds are the ethyl ester of p-methoxy cinnamic acid (68%), ethyl cinnamate, sabinene, 1,8-cineole, and as minor compounds α-pinene, limonene, δ-3-carene, β-phellandrene, β-pinene, p-cymene, β-caryophyllene, β-caryophyllene oxide, linalool and elemol in varying percentages. The essential oil of the rhizome was screened against *Helminthosporium oryzae* and *Fusarium moniliforme*. Besides being fungicidal to the test fungi, the rhizome oil also proved toxic to 11 other plant pathogenic fungi. 1,8-Cineole was isolated and identified as an active constituent. Furthermore, the rhizome oil of *H. spicatum* showed antihistaminic activity in another test assay. In another test, the alcoholic extract of rhizomes exhibited significant anti-inflammatory activity in the carrageenan-induced hind paw oedema model in rats. It also exhibited analgesic properties in the acetic acid-induced writhing model in mice and Randall-Selitto assay in rats. Also, aqueous and ethanolic extracts of *H. spicatum* from China were screened in in vitro and in vivo tests, and showed marked activity.

The essential oil from the rhizomes of Indian *H. gardnerianum* contained pinenes (46%), other monoterpenes and about 30% sesquiterpenes, mainly cadinane derivatives. The molluscicidal action of aqueous agents of *H. gardnerianum* against *Lymnaea truncatula* collected from the Azores was studied. The extracts assayed from 1000 to 30 000 ppm, were found to be active, which might be caused by the presence of monodesmosidic saponins arising only in the water extraction. The efficacy shown by these aqueous extracts could thus lead to savings in *Lymnaea truncatula* control costs in the Azores. In addition, an in vitro bioassay was used to determine the antithrombin activity of dichloromethane- and methanol extracts prepared from *H. gardnerianum* of the Azores, and these were found to have an activity of 78% or higher in the system used.

Description Erect, terrestrial or epiphytic perennial herbs, often with fleshy rhizome; stems leafy. Leaves distichous, penniveined, sheath long clasping; usually sessile; ligule usually prominent. Inflorescence a terminal spike; bracts broad and densely imbricating, concealing the rachis or narrow, enfolding the flowers; 1–6 flowers per bract, each subtended by a tubular bracteole. Flowers bisexual, very fragrant, white, yellow or red; calyx tubular, slender, apex unequally dentate; corolla tube slender, usually much longer than the calyx and bracts, lobes 3, long, narrow, reflexed; labellum (anterior staminode) wider than lateral staminodes, base narrow, usually conspicuously deeply bilobed, lateral staminodes 2, petaloid, as long as corolla, but wider, apex entire, fertile stamen 1, filament usually long and slender, much longer than anther, anther broadly linear, up to 10 mm long, crest absent; ovary superior, 3-locular, placentation axillary, ovules numerous, style slender, stigma pappillate. Fruit a globose to ovoid, 3-valved capsule, several seeds per valve. Seed with aril, deeply divided into narrow lobes.

Growth and development In India, flowering of *H. coronarium* is from September–October, after which the growth declines and the leaves turn yellow. In Java, *H. coronarium* can be found flowering throughout the year.

Other botanical information Cladistic analysis of 29 *Hedychium* spp., and representatives of 16 genera belonging to 4 different related tribes in *Zingiberaceae* strongly supports the monophyly of *Hedychium*, but relationships to other genera are unclear. Within *Hedychium*, four major clades, which are also distinguishable on the basis of number of flowers per bract and distribution, are moderately supported.

Ecology *Hedychium* (except the epiphytic species) often prefers moist or temporarily flooded soils in lowland or mountainous forests or semi-shaded conditions.

Propagation and planting *Hedychium* is mainly propagated by division, but propagation by seed is also possible. In vitro plant regeneration of several *Hedychium* species through rhizome-meristem culture has been successful.

Husbandry *Hedychium* requires fertile, moist soils for an abundant growth. Although *Hedychium* is usually considered frost sensitive, a number of species grown in the temperate zone have survived temperatures as low as −7°C.

Diseases and pests *Hedychium* can be attacked by leaf-spot fungi, but this rarely causes substantial damage. Several *Hedychium* species, including *H. coronarium* in South America and *H. gardnerianum* in Reunion, Hawaii and New Zealand, have invaded the local vegetation, where the different stages of succession become dominated by aggressively expanding populations, and it appears very unlikely that native species will replace invaders as the succession proceeds. The survival of many indigenous plant species probably hinges on the active control of *Hedychium* and other alien species.

A possibility for biological control of *Hedychium* is bacterial wilt caused by the ginger strain of *Ralstonia solanacearum* (synonym *Pseudomonas solanacearum*), which systemically infects the species. The suitability of *R. solanacearum* as a biological control agent in Hawaii was investigated by inoculating seedlings and rooted cuttings of native forest plants, ornamental gingers, and solanaceous species to confirm host specificity. No native forest or solanaceous species developed wilt or other symptoms during the study, but the bacterium caused limited infection with reversible effects near the inoculation site on *H. coronarium*, several other *Zingiberaceae* and also *Musa sapientum* L. All inoculated *H. gardnerianum* plants developed irreversible lethal symptoms. The destructiveness of the ginger strain of *R. solanacearum* to edible ginger has raised questions regarding its use for biological control. However, because locations of *H. gardnerianum* infestations are often remote, the risk of contaminating planted *Zingiberaceae* is unlikely.

Several herbicide treatments were evaluated for their use against *H. coronarium* in South America. The best treatment was picloram + 2,4-D amine sprayed on plants 22 and 60 days after sprouting, resulting in 92% and 99% control, respectively. Hand weeding killed only 36% of the weed but is a cheap form of control.

Harvesting All plant parts of *Hedychium* used, e.g. leaves, flowers or rhizomes, are harvested when needed.

Handling after harvest Most plant parts of *Hedychium* are used fresh.

Genetic resources and breeding Several wild *Hedychium* from the eastern Himalayan region of India are rare or endangered and require in situ or ex situ conservation measures. *H. longicornutum* is not very common in its distribution area, but collection seems limited. *H. coronarium* is widely cultivated as an ornamental and certainly not endangered, although its genetic diversity might be limited as the plants are often propagated vegetatively. No substantial germplasm collections of *H. coronarium* and *H. longicornutum* are known to exist. No breeding programmes are known for medicinally used *Hedychium*.

Prospects In South-East Asia, *H. coronarium* is better known as an ornamental than for its medicinal use. Its antimicrobial effects are interesting though, and merit further research. Cultivation of *H. coronarium* for the perfume industry could be an alternative, as the fragrant flowers yield a pleasant and delicate essence. Although *H. longicornutum* is locally medicinally used, knowledge on its biological activities or chemical constituents is scarce, and more research in these fields is needed.

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Selection of species

Hedychium coronarium J. König

Observ. bot. 3: 73 (1783).

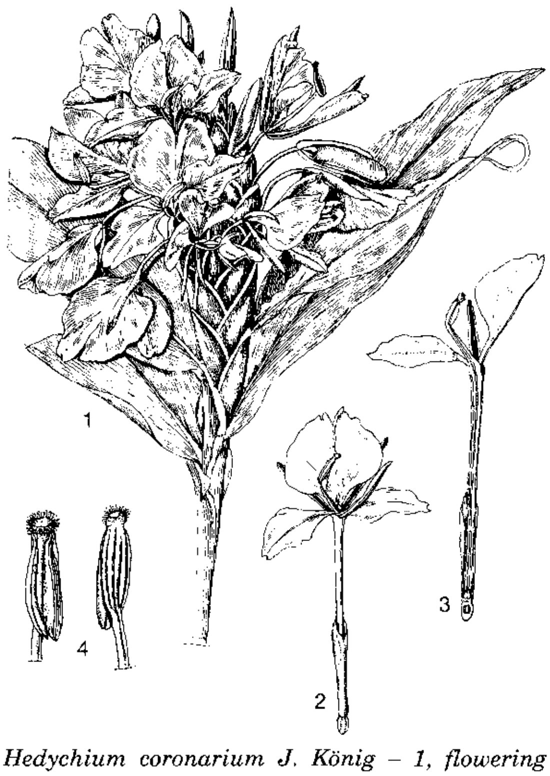
Synonyms *Hedychium flavescens* Carey ex Roscoe (1824).

Vernacular names Common ginger lily, garland flower, butterfly lily (En). Indonesia: gonda-suli (Javanese), gandasoli (Sundanese), Mandasuli (Balinese). Malaysia: gandasuli, suli. Philippines: kamia (Tagalog, Bikol, Cebu Bisaya), banay, katkatan (Bisaya). Thailand: mahaahong (central), tha haan, hun kaeo (northern). Vietnam: b[aj]ch di[eej]p, ng[ar]i ti[ee]n.

Distribution Native of the Himalayas and southern China, now with a pantropical distribution, cultivated and sometimes naturalized, also in southern Africa and South America.

Uses In the Philippines and the Moluccas, a decoction of the basal part of the stem is gargled for tonsilitis, or a part of the stem may be chewed. In Hawaii, the chewed stem is applied to infected nostrils. In Bali (Indonesia) and India, the ground rhizome is used as a febrifuge. In Thailand, boiled leaves are applied to stiff and sore joints.

In Hawaii, China and Brazil, the essential oil from the flowers of *H. coronarium* is a source of high-quality perfume, but other *Hedychium* are also used for the same purpose. The flowers are extensively used in flower garlands in Hawaii and Japan.



Hedychium coronarium J. König – 1, flowering stem; 2, flower; 3, longitudinal section of flower; 4, frontal and dorsal view of anther, with style and stigma.

Observations A stout terrestrial herb, 1–2.5 m tall, rhizome fleshy, 2.5–5 cm in diameter, strongly aromatic; leaves large, oblong to lanceolate, 16–60 cm × 5–10 cm, glabrous above, glabrous or sparsely hairy beneath, ligule up to 3 cm long, bilobed; spike obovoid to rhomboid, 5–20 cm long, rachis concealed, bracts ovate to obovate, up to 5 cm long, closely imbricating, green, each with 2–5 flowers; flower showy, fragrant, white or pale yellow, calyx tubular, cleft on one side, up to 4 cm long, green, corolla tube up to 8 cm long, lobes linear-lanceolate, about 4 cm long, labellum obcordate or obovate, 5–6 cm wide, white or pale yellow with darker yellow spot at base, narrowed at base, lateral staminodes oblong-lanceolate, 3–5 cm long, clawed, fertile stamen not exceeding labellum, anther strongly curved, 1.5 cm long; capsule oblong, glabrous, valves orange-yellow inside, many-seeded; aril red. *H. coronarium* is often cultivated as a garden plant but sometimes escapes and can be found growing along rivers, in swampy areas, open wet locations and the edges of shaded secondary forests, from sea-level up to 2500 m altitude. *H. coronarium* is rather variable in its flower colour and shape of the floral parts. The numerous forms can probably best be regarded as varieties e.g. var. *coronarium* (flowers white), var. *flavescens* (flowers yellow) and var. *chrysoleucum* (Hook.) Hook.f. (flowers yellow but plant slender).

Selected sources 74, 101, 135, 201, 215, 218, 238, 239, 259, 270, 348, 403, 407, 442, 632, 655, 665, 810, 841, 859, 986.

Hedychium longicornutum Griff. ex Baker

in Hook.f., Fl. Brit. Ind. 4: 228 (1892).

Synonyms *Hedychium crassifolium* Baker (1892).

Vernacular names Perched gingerwort (En). Malaysia: tepus hinggap, tepus lada, tepus terbang. Philippines: kamya (Tagalog). Thailand: tapu cha-ching, put duean (peninsular).

Distribution Indonesia (Sumatra), Peninsular Malaysia, peninsular Thailand.

Uses In Indonesia and Peninsular Malaysia, a decoction of the roots added to a bath is traditionally used as a vermifuge, and the decoction is also applied for earache. A decoction of the smaller wormlike rhizomes is a remedy for intestinal worms (doctrine of signatures). In Peninsular Malaysia, the roots are used for syphilis.

Observations An epiphytic herb, rhizome short, thick, grey, fleshy roots, clasping branches of trees and large shrubs near ground level, leafy stems several, up to 70 cm tall; leaves narrowly elliptical, up to 32 cm × 8 cm, glabrous, margins hairy underneath, mid vein below sparsely hairy, ligule 26 cm long, sheath hairy; spike dense, peduncle and rachis about 10 cm long, bracts densely brown, up to 3 cm × 0.5 cm, lower bracts ovate, upper ones narrowly lanceolate, bracteoles tubular, finely hairy; calyx tubular, slender, up to 3 cm long, pink, corolla tube slender, cylindrical, somewhat longer than calyx, lobes narrow, linear, red, edges rolled inward, up to 6 cm × 0.5 cm, labellum about 2.4 cm long, orange, divided nearly to the base into 2 narrow halves, lateral staminodes elliptical, curled backwards, orange, yellow towards base, about 3.2 cm × 0.5 cm, filament of fertile stamen up to 12 cm long, white above, pinkish below, anther linear oblong, 1.2 cm long, orange, slightly curved, stigma longer than stamen, club-shaped, ovary 5 mm long, hairy; capsule up to 2.5 cm long, orange, strongly angled, slightly hairy, dehisced fruit orange inside, many-seeded; aril red. *H. longicornutum* occurs widely scattered in lowland and lower hill forests on stems and branches of small trees which it clasps with its thick mass of fleshy roots.

Selected sources 74, 135, 403, 442, 744, 841.

Halijah Ibrahim

Hedyotis L.

Sp. pl. 1: 101 (1753); Gen. pl. ed. 5: 44 (1754).

RUBIACEAE

x = 8, 9, 11; *H. verticillata*: $2n$ = 32; in general polyploids

Major species *Hedyotis auricularia* L.

Origin and geographic distribution *Hedyotis* occurs predominantly in the tropical and warm subtropical regions of India, South-East Asia, Australia, Micronesia, Polynesia and North America, and the number of species is estimated at up to 250 (including *Oldenlandia* L.).

Uses *Hedyotis* is commonly applied as a poultice to heal wounds, small sores, boils and sore eyes. In Peninsular Malaysia, the Philippines and India, the leaves of *H. auricularia* and *H. philippensis* are rubbed fresh or after boiling on aching parts of the body or applied as a poultice on cracked skin as an emollient. In Peninsular Malaysia, whole plants of *H. pinifolia* Wallich or *H. insularis* (Spreng.) Deb & R.M. Dutta (synonym *H. glabra* R.Br.) are used for this purpose as well. In India, a decoction or extract of the leaves or the whole crushed leaves of *H. auricularia* are a popular medicine for diarrhoea, cholera, dysentery and other intestinal problems. In Fiji, a decoction of the leaves is taken for headache and eye problems, to stop bleeding wounds and to promote healing.

A decoction of the roots of *H. philippensis* or the aerial parts of *H. verticillata* or *H. insularis* are used internally for dysentery, colic, gonorrhoea and as a stomachic and externally to wash small children with stomach-ache or applied as a poultice to scalds.

In Peninsular Malaysia, the roots of *H. costata* (Roxb.) Kurz (synonym *H. vestita* R.Br. ex G.Don) are boiled to make a lotion for rheumatism. *H. leucocarpa* Elm. (synonym *Oldenlandia rigida* (Blume) O. Kuntze) is externally used in Sumatra to treat fever. The leaves of *H. insularis*, mixed with a little ginger and salt, are used for incipient sores, while a decoction is taken for purifying the blood.

Production and international trade *Hedyotis* is only used on a local scale.

Properties The stem and roots of *H. auricularia* contain an unstable alkaloid, hedyotine, and the crystalline bis-indole alkaloid auricularine. The total alkaloid content is about 0.3%. The aerial parts also contain oleanolic acid, ursolic acid, β-sitosterol and stigmasterol. An ethanolic extract showed selective antifungal activity against some important plant-pathogenic fungi using the filter paper disk diffusion technique. The extract also showed antiviral activity against the herpes simplex type-1 (HSV-1) and vesicular stomatitis (VSV) viruses in vitro.

An extract from the leaves and stem of *H. verticillata* showed biological activity in the brine shrimp test (LC_{50} = 22 μM/ml) and some antibacterial tests.

Description Woody herbs or subshrubs, erect or procumbent. Leaves opposite, simple, entire; sessile or petiolate; stipules interpetiolar, adnate to base of petiole, margin with 1–several setae. Inflorescence an axillary or terminal subsessile fascicle or pedunculate corymbiform cyme. Flowers small, 4-merous, bisexual, homostylous or heterostylous; calyx tube subglobose, lobes distinct; corolla white, tube short, not longer than calyx lobes, lobes valvate; stamens 4, normally exserted, filaments attached to corolla between the lobes, anthers dorsifixed; ovary inferior, 2-locular, ovules 5–15 on fleshy hemispherical placentas, placenta peltately attached to septum by short stalk, style filiform, normally exserted, stigma 2-fid. Fruit a hard capsule, splitting septicidally to the base into 2 indehiscent pyrenes or rarely dehiscent; beak mostly absent; seeds numerous. Seed small, depressed obconical or angular, finely reticulate. Seedling with epigeal germination; cotyledons very small.

Growth and development Most *Hedyotis* species are found flowering throughout the year when enough moisture is available.

Other botanical information *Hedyotis* and *Oldenlandia* are very closely related genera, with a long history of taxonomic confusion, and many species have been described with either one of them as a synonym. Recent studies tend to keep the genera separate, mainly on the basis of morphological and embryological evidence, although this is not always clear in all species concerned.

Ecology *Hedyotis* is often found in sunny to shaded, marshy localities, especially on hard or stony soils along roadsides, on walls, in gardens, lawns, fallow fields, dry riverbeds, along watercourses, and as a weed in rainfed and irrigated rice fields. Some species though are primarily found in shaded forests.

Propagation and planting *Hedyotis* is propagated by seed.

Harvesting *Hedyotis* is harvested from the wild whenever needed.

Handling after harvest *Hedyotis* is mainly used fresh.

Genetic resources and breeding *Hedyotis* species are widespread and common throughout South-East Asia as weeds, and there is no risk of genetic erosion.

Prospects Little information is available about the phytochemical and pharmacological activities of *Hedyotis*, or isolated compounds. More research is therefore needed to fully evaluate its possible potential.

Literature |1| Aguilar, N.O. & Lemmens, R.H.M.J., 1999. Oldenlandia L. In: De Padua, L.S., Bunyapraphatsara, N. & Lemmens, R.H.M.J. (Editors): Plant Resources of South-East Asia No 12(1). Medicinal and poisonous plants 1. Backhuys Publishers, Leiden, the Netherlands. pp. 364–367. |**2**| Ali, A.M., Mackeen, M.M., El-Sharkawy, S.H., Hamid, J.A, Ismail, N.H, Ahmad, F.B.H & Lajis, N.H., 1996. Antiviral and cytotoxic activities of some plants used in Malaysian indigenous medicine. Pertanika: 19(2–3): 129–136. |**3**| Deb, D.B. & Dutta, R., 1983. Nomenclatural changes in Hedyotis (Rubiaceae) of South Asia. Taxon 32(2): 284–285. |**4**| Halford, D.A., 1992. Review of the genus Oldenlandia L. (Rubiaceae) and related genera in Australia. Austrobaileya 3(4): 683–722. |**5**| Hamzah A.S., Lajis, N.H. & Sargent, M.V., 1994. Kaempferitrin from the leaves of Hedyotis verticillata and its biological activity. Planta Medica 60(4): 388–389. |**6**| Quisumbing, E., 1978. Medicinal plants of the Philippines. Katha Publishing Co., Quezon City, the Philippines. pp. 908–910.

Selection of species

Hedyotis auricularia L.

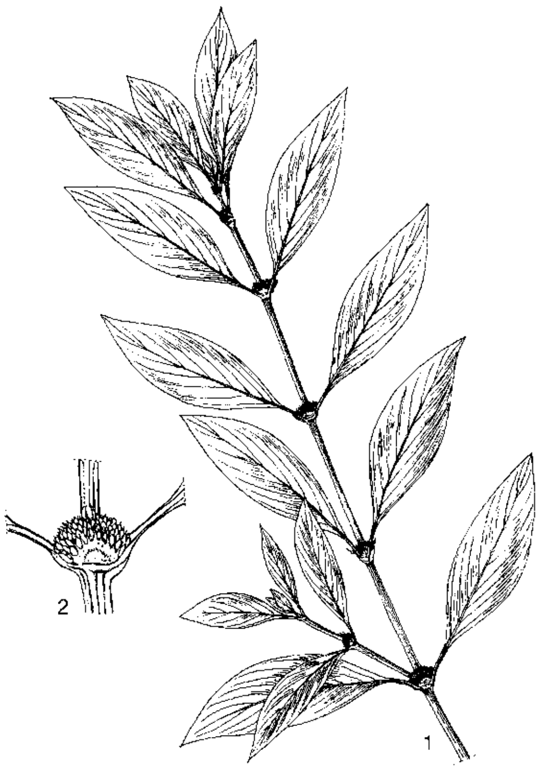
Sp. pl. 1: 101 (1753).

Synonyms *Oldenlandia auricularia* (L.) F. Muell. (1882).

Vernacular names Malaysia: kenikah batu, kerekah batu. Thailand: tong haeng (peninsular). Vietnam: an di[eef]n tai, nh[ix] th[ar]o.

Distribution From the Himalayas to southern China, throughout South-East Asia, Australia and the Pacific.

Uses In Peninsular Malaysia, the boiled leaves are rubbed on aching parts of the body or applied as a poultice on cracked skin. In India, the decoc-



Hedyotis auricularia L. – 1, flowering and fruiting stem; 2, detail interpetiolar stipule and infructescence.

tion or extract of the leaves or the whole crushed leaves are taken for intestinal problems. The leaf juice is applied for diseases of the eyes. A paste of the leaves is considered emollient and applied to abscesses and wounds. In India, the boiled leaves are eaten with rice.

Observations A perennial, suberect to diffuse, hairy herb, 30–100 cm tall; leaves ovate-lanceolate to lanceolate, 4–12 cm × 1–4 cm, upper surface glabrous or scabrid, hairy beneath, petiole 4–15 mm long, interpetiolar stipules triangular, setae 3–7; cyme axillary, small, dense; calyx lobes small, corolla tube glabrous outside, inside pubescent at base, lobes with some short bristles at apex; fruit ovoid, 1.5 mm in diameter, indehiscent, clasped by the persistent calyx.

H. auricularia occurs in thickets, forests, wet grassland, shady roadsides, rubber, tea or cinchona plantations or along water sides, at 10–1600 m altitude.

Selected sources 74, 107, 135, 684, 702, 807.

Hedyotis philippensis (Willd. ex Spreng.) Merr. ex C.B. Rob.

Philipp. Journ. Sci., Bot. 6(3): 222 (1911).

Synonyms *Spermacoce philippensis* Willd. ex Spreng. (1824), *Hedyotis congesta* Wallich & G. Don (1834).

Vernacular names Malaysia: sebueh, bunga kakarang. Philippines: magdadakan (Samar-Leyte Bisaya), dilang-butiki (Tagalog), pulapasagit (Panay Bisaya). Thailand: mae klon, saam nam (peninsular). Vietnam: an di[eef]n philippin.

Distribution Widely distributed from Thailand to Indonesia, the Philippines, Papua New Guinea and northern Australia.

Uses The roots are used internally and externally. Internally, as a decoction, they are given for dysentery, colic and as a stomachic. Externally, the decoction is used to wash listless children, and it is also applied as a poultice to scalds, and in general to any painful part of the body. The aerial parts are eaten with a bitter gourd (*Momordica* sp.) after childbirth.

Observations A perennial, spreading subshrub, up to 1.2 m tall, openly branched, stems slender and often hairy when young; leaves variable, narrowly oblong, 4–11 cm × 1–3.5 cm, glabrous, midvein underneath hairy, shiny above, terminal leaves much smaller, lanceolate, petiole 3–10 mm long, interpetiolar stipules triangular, setae many, up to 7 mm long; cyme axillary, small, crowded; calyx obconical, 1–2 mm in diameter, glabrous, lobes 2.5 mm long, glandular appendage between lobes, corolla slightly longer than calyx, tube 2–3 mm long, lobes oblong, 2–2.5 mm long, spreading; capsule rounded to ellipsoid, 3.5–4 mm long, fleshy, whitish, glabrous. *H. philippensis* occurs on sandy soils, in open forest areas, along streams and seasonally boggy localities at low and medium altitudes.

Selected sources 135, 407.

Hedyotis verticillata (L.) Lamk

Tabl. encycl. 1: 271 (1792).

Synonyms *Oldenlandia verticillata* L. (1767), *Hedyotis hispida* Retz. (1786).

Vernacular names Malaysia: (rumput) sebueh, rumput chengkering, lidah tiong. Philippines: salasik-lupa (Tagalog), bongat (Manobo), bosingau (Iloko). Thailand: tong haeng hin (peninsular). Vietnam: an di[eef]n v[of]ng.

Distribution From India, the Himalayas and southern China, the Andaman and Nicobar Islands and throughout South-East Asia.

Uses In Peninsular Malaysia and India, the aerial parts are made into poultices and applied for headache, and upon the abdomen of small children for stomach-ache. A decoction of the plant is drunk for dysentery.

Observations A perennial, spreading herb, 15–100 cm tall, glabrous or hispid, taproot stout; leaves elliptical, oblong to linear-lanceolate, 1.5–9 cm × 0.2–1.5 cm, pointed at both ends, scabrid, rigid, sessile; cyme axillary, flowers rarely solitary; calyx tube glabrous or pubescent, lobes triangular, corolla 4–5 mm long, lobes on outside with a few hairs at apex; capsule ovoid, 2.5–3 mm long, glabrous, calyx lobes close together at apex. *H. verticillata* occurs in sunny to lightly shaded, dry, less fertile, open localities, on sandy soils, in old clearings, teak forest and thickets, from sea-level up to 1600 m altitude. It is becoming an increasingly important weed in Malaysian plantations.

Selected sources 135.

Isa Ipor

Hibiscus L.

Sp. pl. 2: 693 (1753); Gen. pl. ed. 5: 310 (1754).

MALVACEAE

x = 8, 9, 11, 12, 18, 20, 21; *H. mutabilis*: $2n$ = 84, 92, 110; *H. rosa-sinensis*: $2n$ = 36, 44, 46, 70, 72, 84, 90, 92, 118, 144, 168; *H. sabdariffa*: $2n$ = 36, 72; *H. syriacus*: $2n$ = 80, 90, 92; *H. tiliaceus*: $2n$ = 80, (86), (92), 96

Major species *Hibiscus mutabilis* L., *H. rosa-sinensis* L., *H. tiliaceus* L.

Vernacular names Hibiscus, roselle, rose mallow (En). Roselle (Fr). Indonesia: baru, waru. Malaysia: baru, bebaru bulu (Peninsular), baru laut (Sarawak). Thailand: ehaba. Vietnam: d[aa]m b[uj]t, ph[uf] dung.

Origin and geographic distribution *Hibiscus* (excluding *Abelmoschus*) comprises about 275 species in the tropics and subtropics of the Old and New World; only 2 species occur in the temperate zone. Within the Malesian region 43 species are found.

Uses *Hibiscus* is widely used for ornamental, medicinal, vegetable and fibre purposes. The leaves, root and bark contain much mucilage, and are generally used in decoction (like the flowers) as an emollient and demulcent for ripening abscesses, ulcers, and to treat cutaneous infections, swellings, boils and mumps. In India, Indo-China, China and Malesia, they are also considered resolvent, cooling, expectorant, antidotal to all kinds of poison, anodyne, and are used for burns and scalds that are slow in healing. They are also used as a medication for persistent coughs, bronchitis and other pulmonary complaints, menorrhagia and dysuria. The mucilage is also applied by midwives to facilitate expulsion in labour. Mainly the flowers and leaves are used of *H. mutabilis*, and mainly the flowers and the bark of the stem of *H. rosa-sinensis*. In Indonesia, an infusion of the red flowers of *H. rosa-sinensis* is considered somewhat purgative, and is even said to cause abortion. In India, the flowers are used for their contraceptive properties, and also for irritable conditions of the genito-urinary tract. In Papua New Guinea and Fiji, the juice from the crushed leaves mixed with sea water is drunk to treat stomach-ache. The seeds, pounded into a pulp and mixed with water, are a cure for gonorrhoea, as is the juice of the leaves.

Mainly the bark and root are used of *H. syriacus*. A decoction of these parts is considered to improve the eyesight. An infusion of the dried flowers is used in Malaysia as a diuretic, as well as against skin complaints and itch. The seeds are employed in headaches and colds, and combined with pig marrow, as an application to discharging ulcers. *H. syriacus* is also widely used in Africa.

All parts of *H. tiliaceus* are used. In Papua New Guinea, an infusion of the bark is drunk to relieve coughs and tuberculosis. In Fiji, the leaves are wrapped on bone fractures, and the stem is said to be part of an internal remedy for ulcers and internal injuries. In Indo-China, the leaves are used as a laxative and resolutive. The flowers, boiled in milk, are dropped in the ear against earache. In China, the flowers are used for headaches.

Mainly the calyx, seed and leaves of *H. sabdariffa* are used. The calyx in decoction is reported to be aphrodisiac, cholagogue, digestive, diuretic, purgative, resolvent, stomachic and tonic, and is a folk remedy for abscesses, bilious conditions, cancer, cough, dyspepsia, dysuria, fever, hangover, heart ailments, hypertension, neurosis, scurvy and strangury. The whole plant, and especially the seed, is antiscorbutic. In Burma (Myanmar), the seeds are used for debility, and in Taiwan, they are regarded as a gentle laxative, diuretic and tonic. In the Philippines, the bitter root is used as a tonic. Other *Hibiscus* species occurring in Malesia, including *H. surattensis* L. and *H. elatus* L. and *Abelmoschus esculentus* (L.) Moench are also used as an emollient for skin complaints, for venereal sores and urethritis. *H. trionum* L. is used in southern Africa for roundworm. It is reported to be poisonous to horses. In China, the dried leaves are considered stomachic. The roots of *H. radiatus* Cav. are used to poultice swellings of finger nodes, which remain after framboesia (yaws).

H. mutabilis, *H. radiatus*, *H. rosa-sinensis* and *H. syriacus* are widely planted as ornamentals. The bast fibre is sometimes used as a substitute for jute.

H. rosa-sinensis is also planted as a hedge and fencing, and *H. tiliaceus* is used to reforest eroded land for firewood production, and is suitable as a shade tree, hedge or wind break, along the seashore. In China and India, the sap of petals of *H. rosa-sinensis* is used for blackening eyebrows, or for colouring food, and in Indonesia it has been used for polishing shoes black. In India, the juice of the fresh flowers is believed to increase hair growth. Young shoots and leaves of *H. sabdariffa* are used raw or cooked as a vegetable, and the fleshy calyces are widely used to make red, fresh but sourish beverages and jams. In the Pacific islands, the bark of *H. tiliaceus* is sometimes used as fodder when other food is lacking. In Java, the leaves are used as a food wrapper.

Production and international trade The *Hibiscus* species treated here are only used on a local scale for medicinal purposes. Chinese herbalists in Malaysia import the dried flowers of several species.

Properties The flowers of *H. sabdariffa* contain several flavonoids e.g. gossypetin, hibiscetin, sabdaretin, gossytrin, hibiscin and hibicitrin, as well as anthocyanins e.g. cyanidin-diglucoside and cyanidin-glucosyl-rutinoside. The latter compounds are reported to have diuretic and chloretic effects, to decrease the viscosity of the blood, to reduce blood pressure and to stimulate intestinal peristalsis. All parts of the plant contain large quantities of viscous polysaccharides, the greatest amount being in the calyces. The seeds contain 17–20% edible fatty oil. Callus tissue derived from *H. sabdariffa* seedlings produce two cyanidin glycosides as major anthocyanin pigments, which are used as food colorants. The production of callus and colorants is markedly stimulated by 2,4-D.

An aqueous extract of the calyces inhibited the tone of isolated rabbit aortic strips, but contracted rat uterus, guinea-pig tracheal chain, rat diaphragm and frog rectus abdominis preparations. Intravenous injection of the extract to anaesthetized rats and cats lowered the blood pressure in a dose-response manner. This hypotensive effect was blocked by atropine, so it does not seem to be mediated through inhibition of the sympathetic nervous system but through acetylcholine-like and histamine-like mechanisms, as well as via direct vaso-relaxant effects. Other pharmacological effects of extracts include antimutagenic and chemoprotective activity in a colon carcinogenesis model by the 80% ethanol extract of the aerial parts, chemoprotective effects in a colon carcinogen model in F344 rats with induced aberrant crypt focus formation, and antimutagenic effects (60–90% reduction) towards 9 different colon mutagens in the *Salmonella* mutation assay. In addition, protocatechuic acid, a phenolic acid isolated from the flowers, was evaluated for its topically applied ability to inhibit the TPA-induced promotion of skin tumours of female CD-1 mice. It inhibited the incidence of tumours in mice by 55–80%. The extract of the dried flowers also had a strong inhibitory effect on xanthine oxidase activity as a free radical scavenger. Antioxidant bioactivity was further investigated using a model of t-butylhydroperoxide-induced oxidative damage in rat primary hepatocytes, and found to be significantly protective. Furthermore, in vivo, the aqueous extract of the aerial parts had a significant inhibitory effect on yeast induced pyrexia, and a significant effect on the hot plate reaction time, but not on the carrageenan induced hind paw oedema model in rats. Also 3 polysaccharides isolated from the flower buds showed some tumour-growing-retarding effect on the transplanted tumour sarcoma 180/CD-1 mice. Changes in urine composition of healthy human volunteers after consuming the juice of *H. sabdariffa* calyces in different concentrations and durations were evaluated. The urine showed a decrease of creatinine, uric acid, citrate, tartrate, calcium, sodium, potassium and phosphate, but not oxalate. Interestingly, the low dose of juice caused a more significant decrease in salt output in the urine than did a higher dose. Finally, the oil from the seeds exhibits antibacterial activity against e.g. *Bacillus subtilis*, *Corynebacterium pyogenes*, *Escherichia coli*, *Klebsiella pneumoniae*, *Salmonella typhi*, *Staphylococcus aureus*, *S. albus*,a nd antifungal activity against some species of *Alternaria*, *Aspergillus*, *Colletotrichum*, *Cryptococcus*, *Helminthosporium*, *Trichophyton* and *Trichoderma*.

The flowers of *H. rosa-sinensis* contain flavonoids and anthocyans e.g. hibiscetin, cyanidin diglucoside, and an acidic polysaccharide (L-rhamnose : D-galactose : D-galacturonic acid : D-glucuronic acid; 5:8:3:2), called *Hibiscus*-mucilage RL, was isolated from the leaves. In a test in rats and mice, orally effective antifertility activity was found, when administered from day 1 to 10 of pregnancy. The extract was found not to affect the tubal transport of the zygote, but to inhibit the blastocyst from implanting, causing the termination of the pregnancy. Furthermore, the oral administration of a benzene extract of the flowers (250 mg/kg for 30, 45 and 60 days) affected the spermatogenesis and the endocrine function of the testis in adult male albino rats. Reduction in testicular weight, and that of the epididymis, seminal vesicle, prostrate and pituitary was observed and spermatogenesis ceased. Also a significant reduction in ventral prostrate alkaline phosphatase activity, citric acid content in the seminal vesicles, and fructose content in dorsolateral prostrate was reported. All effects were reversible; 30 days after discontinuation of the treatment organs were fully recovered. Other pharmacological effects of extracts include a partial inhibition of skin-, liver- or colon tumour formation in mice of a flower extract, and antibacterial and antifungal activity of the neutral leaf extract.

The leaves of *H. syriacus* contain a mucilage consisting mainly of L-rhamnose, D-galactose, D-galacturonic acid and D-glucuronic acid (8:1:8:4), and the seeds contain an oil with moderate antimicrobial activity. The water extract of the leaves showed potent inhibition of HIV-1-induced cytopathic effects, while a methanol extract of the leaves and stems showed more than 40% inhibition of protease and α-glucosidase activities at a concentration of 100 μg/ml. Hibispeptin A and B, and the napthalenes syriacusins A–C were isolated from the root bark. The latter compounds inhibited lipid peroxidation, while syriacusin A (2,7-dihydroxy-6-methyl-8-methoxy-1-naphthalenecarbaldehyde) showed cytotoxicity against some human cancer cell lines. Two isolated triterpene caffeates from the root bark inhibited lipid peroxidation and exhibited significant cytotoxicity against a panel of human cancer cell lines.

H. tiliaceus contains sesquiterpenoid quinones and lapachol. The anthers contain gossypetin glucosides, gossypitrin and gossytrin. An acetone extract of the leaves showed antibacterial activity against *Staphylococcus aureus*.

The change in colour of the flowers of *H. mutabilis* is due to the progressive synthesis of flavonoids and anthocyans. In the morning the pigments are isoquercetin, hyperoside, rutin, quercetin-4-glycoside and quercimeritin, and in the evening cyanin, cyanin-3-sambubioside and cyanidin. An aqueous extract was found to be highly effective in an experimental clinical assessment of the anti-HSV-II action.

Adulterations and substitutes *Sida* is used as a substitute for *Hibiscus*, as an emollient for wounds and ulcers.

Description Herbs, undershrubs, shrubs or trees, with stellate hairs and (or) scales. Leaves alternate, simple, often (deeply) lobed, often with extrafloral nectaries; petiole present; stipules present. Inflorescence composed of a raceme or panicle by reduction of the upper leaves, or flowers solitary, axillary, pedicel mostly articulate, at apex rarely thickened into a hypanthium; bracteoles of epicalyx 3–many, rarely lacking, usually free, or short connate, mostly persistent. Flowers bisexual, 5-merous; calyx usually campanulate, 5-lobed to 5-parted, rarely splitting on one side, persistent; corolla with 5 distinct petals, mostly large and showy, often yellow with a dark purple centre; staminal column as long as or shorter than the petals, antheriferous throughout or only in the upper half; ovary mostly 5-celled, style 1, distally 5-branched, stigmas usually discoid, ovules 3–many per cell. Fruit a loculicidally dehiscent capsule, 5(–10)-celled; seeds 3–many per cell, globose or reniform, glabrous or hairy. Seedling with epigeal germination; cotyledons emergent.

Growth and development *Hibiscus* species are strong and profuse growers, and thrive under a wide range of conditions. The flowers of most species last one day, sometimes two days. In *H. sabdariffa*, pinching of the apical bud induces branching. Flowering lasts for about 2 months, but most of the flowers are initiated during the first few weeks. It is a primarily self-pollinating crop. Fruit ripening takes 2–3 months from pollination. *H. tiliaceus* has a rapid growth and in 2–3 years the tree is large enough to provide shade. It flowers throughout the year in Java, but on other Indonesian islands flowering is restricted to 1–3 months/year. Flowers are pollinated by insects and birds. The seeds can float in sea water for several months and are commonly found along the shore.

Other botanical information *Hibiscus* belongs to the tribe *Hibisceae*, to which also the genera *Abelmoschus* and *Gossypium* belong. *Abelmoschus* differs from *Hibiscus* by having a deeply splitting calyx on one side, which falls off together with the corolla, while the calyx of *Hibiscus* is normally 5-lobed to 5-parted, and semi-persistent. *Gossypium* has an undivided style, and 3 epicalyx segments, in contrast to the other 2 genera. *H. schizopetalus* (Mast.) Hook.f. is very closely related to *H. rosa-sinensis*, and is sometimes only considered a cultivar of this species.

Ecology Most *Hibiscus* are heliophilous and prefer low altitudes. Herbaceous species and undershrubs occur particularly in waste places, and along roadsides. *H. rosa-sinensis* requires a relatively dry atmosphere for fruit setting. The arboreous species occur especially in secondary forest, although *H. tiliaceus* prefers coastal areas. When cultivated, *Hibiscus* prefers deep rich soils and a reliable moisture supply. *H. sabdariffa* is a short-day plant and on Java usually no flowering is observed during December–March.

Propagation and planting *H. sabdariffa* and *H. mutabilis* are usually grown from seed, but can also be propagated from stem cuttings. Seed viability of *H. sabdariffa* is about 85%, and the optimum temperature for germination is 25–35°C. *H. rosa-sinensis* propagates readily by softwood cuttings in spring or by hardwood cuttings in fall. It seldom produces seed in cultivation, although it seeds freely in some tropical regions, but not in South-East Asia. Cuttings of *H. rosa-sinensis* treated with indole butyric acid 100 ppm resulted in the highest percentage of rooted cuttings and number of roots per cutting under greenhouse conditions. *H. syriacus* is propagated by seed, by cuttings of ripened wood, and by grafting on common seedling stock. In vitro shoot regeneration, either directly from cotyledons and hypocotyls or through callus showed the best adventitious shoot formation when cultured on a Murashige and

Skoog medium supplemented with 1 mg butyric acid and 0.1 mg naphthalene acetic acid per litre. *H. tiliaceus* is easily raised from seed or stem cuttings. Seed shows 30% germination in 23–48 days.

Diseases and pests Diseases of *Hibiscus* are leaf-spot (*Cercospora hibisci*) and foot rot (*Phytophthora parasitica*). Common pests are cotton stainer bugs (*Dysdercus* ssp.), bollworms (*Earias biplaga*, *E. insulana*), flea beetles (*Podagrica* spp.), white fly (*Bemisia* spp.), woolly aphids and nematodes.

Harvesting The parts used are just picked from the plants, whenever the need arises.

Handling after harvest The harvested plant parts of *Hibiscus* are used fresh or dried.

Genetic resources and breeding Large germplasm collections of *Hibiscus sabdariffa* as a fibre crop are maintained in Australia, India, Bangladesh, Sudan and in the United States. Some *H. radiatus*, *H. tiliaceus* and *H. mutabilis* germplasm is kept in Bangladesh and in the United States. Selection and breeding work has been limited to *Hibiscus* grown for fibre or as ornamentals. Most *Hibiscus* species havea large distribution area, so there seems to be no risk of genetic erosion.

Prospects Referring to their uses and properties, many *Hibiscus* species have good potential as medicinals. Especially *H. sabdariffa* shows this potential, because it combines food products with antioxidant properties. Pharmacological and industrial information is still rather preliminary, and a full evaluation requires more research.

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Selection of species

Hibiscus mutabilis L.

Sp. pl. 2: 694 (1753).

Vernacular names Changeable rose, confederate rose (En). Rose changeante (Fr). Indonesia: waru landak (Javanese), saya ngali-ngali (Ternate). Malaysia: botan, mati laki mati bini, bunga waktu besar. Philippines: amapola, mapula (Tagalog). Thailand: phuttaan (central), dok saamsee, saam phiu (northern). Vietnam: ph[uf] dung, m[ooj]c li[ee]n.

Distribution *H. mutabilis* grows wild and is also cultivated in China. It is now widely cultivated in the tropics, including South-East Asia.

Uses The leaves and flowers of *H. mutabilis* are considered emollient and cooling, and are used on swellings and cutaneous infections. In decoction, they are a remedy for pulmonary complaints.

Observations An erect, robust shrub to small tree, 1.5–4 m tall, densely covered with greyish, stellate hairs; leaves orbicular to broadly ovate, 10–25 cm long, base cordate, apex pointed, mostly 5-lobed, lobes triangular, coarsely serrate-dentate, pubescent; bracteoles of epicalyx 7–10, linear, shorter than the calyx tube, calyx 3–4 cm long, with 5 oblong-ovate lobes, connate below, corolla large, 10–12 cm in diameter, petals 5–7 cm long, single or double, corolla white in the morning, with or without a purple centre, colouring red in the afternoon, stigma yellow or white; seed ovoid, pubescent, hairs 2–4 mm long. The single flowered pink type of *H. mutabilis* is wild in China; the double-flowered type is more common in cultivation.

Selected sources 74, 134, 135, 215, 407, 786, 788, 810, 1127.

Hibiscus rosa-sinensis L.

Sp. pl. 2: 694 (1753).

Vernacular names China rose, shoeflower (En). Rose de Chine (Fr). Indonesia: kembang sepatu (Indonesian), wora-wari (Javanese), waribang (Balinese). Papua New Guinea: wavu wavu (Hula, Central Province), banban (Hisiu, Central Province), hangarou (Keregia, Morobe Province). Philippines: gumamela, antolangan (Tagalog), kayanga (Iloko). Cambodia: dok mai. Laos: kokdok may chiey. Thailand: chabaa (central), baa (peninsular), mai daeng (northern). Vietnam: b[oo]ng b[uj]p, d[aa]m b[uj]t, h[oof]ng c[aaj]n.

Distribution Cultivated throughout the world as an ornamental, in the tropics and subtropics in the open, often for hedges. The origin is uncertain, but possibly from East Africa.

Uses The leaves and flowers are used to ripen boils and ulcers, and in general as an antiseptic. The flowers and bark are considered to have emmenagogic, galactagogue, purgative, even abortifacient properties. In Papua New Guinea, the roots are washed and chewed to treat diarrhoea.

Observations An erect, much branched, glabrous shrub, 1–4 m tall; leaves ovate, 7–12 cm long, margins coarsely toothed, upper surface glossy; epicalyx with 7–9 linear lobes, calyx 2 cm long, bell-shaped, with ovate lobes; flowers about 10 cm in diameter, petals normally red, sometimes orange or white, staminal tube slender and longer than the corolla, red, anthers yellow, stigma red. *H. rosa-sinensis* has an enormous polymorphism, and several varieties have been recognized. *H. schizopetalus* (Mast.) Hook.f., with finely dissected petals, is possibly just a cultivar of *H. rosa-sinensis*.

Selected sources 143, 215, 407, 530, 531, 684, 788, 810, 908.

Hibiscus sabdariffa L.

Sp. pl. 2: 695 (1753).

Synonyms *Hibiscus digitatus* Cav. (1787).

Vernacular names: Roselle, red sorrel (En). Oseille de Guinée, roselle, oseille rouge (Fr). Indonesia: gamet walanda (Sundanese), kasturi roriha (Ternate). Malaysia: asam susur. Philippines: roselle (Tagalog), kubab (Ifugao), talingisag (Subanon). Cambodia: slök chuu. Laos: sômz ph'oox dii. Thailand: krachiap-daeng, krachiap-prieo (central), phakkengkheng (northern). Vietnam: day nh[aaj]t, b[uj]p gi[aas]m.

Distribution *H. sabdariffa* is most probably of African origin, but is now distributed pantropically.

Uses The leaves of H. sabdariffa are emollient, and a poultice is used on abscesses and ulcers. The whole plant, and especially the calyx, is diuretic, tonic and antiscorbutic in decoction.

Observations An erect annual herb, 0.5–3 m tall, stems glabrous, purplish; leaves broadly ovate-orbicular, variable, 6–15 cm long, lobes 3–5, oblong to lanceolate, glabrous or pubescent, purplish, petiole 5–10 cm long; bracteoles of epicalyx 8–12, calyx after anthesis becoming thick-fleshy, 2.5–5.5 cm long, distinctly longer than the fruit, red, corolla 3–5 cm long, not widely open, pinkish to yellow with purple centre; seed reniform, almost glabrous, black brown.

H. sabdariffa is a short-day plant, and drought tolerant.

Selected sources 45, 74, 135, 192, 226, 539, 680, 786, 788, 810, 914, 1015, 1016.

Hibiscus syriacus L.

Sp. pl. 2: 695 (1753).

Vernacular names Syrian hibiscus, rose of Sharon (En). Philippines: gumamelang asul (Tagalog). Thailand: chabaa cheen (central). Vietnam: h[oof]ng c[aaj]n bi[ees]c, m[ooj]c c[aaj]n.

Distribution *H. syriacus* originates in China and Taiwan, but is now cultivated worldwide as an ornamental.

Uses The dried flowers are used as a diuretic, and against skin complaints. The leaves are applied as a stomachic, hypolipidaemic and tonic and the mucilaginous bark and root are used as a demulcent.

Observations A smooth, erect shrub, 2–5 m tall; leaves cuneiform-ovate, up to 8 cm long, 3-lobed, lateral ones short, rounded, the terminal one elongated, pointed, margins toothed, nectary absent, glabrous; calyx 1.5-2 cm long, deeply lobed, flowers normally pale bluish-violet, with a dark centre, sometimes variegated, not opening fully, petals obovate, 3–6 cm long; seed reniform, long hairy. In *H. syriacus*, many cultivars are distinguished, often with double flowers.

Selected sources 786, 788, 810, 1117.

Hibiscus tiliaceus L.

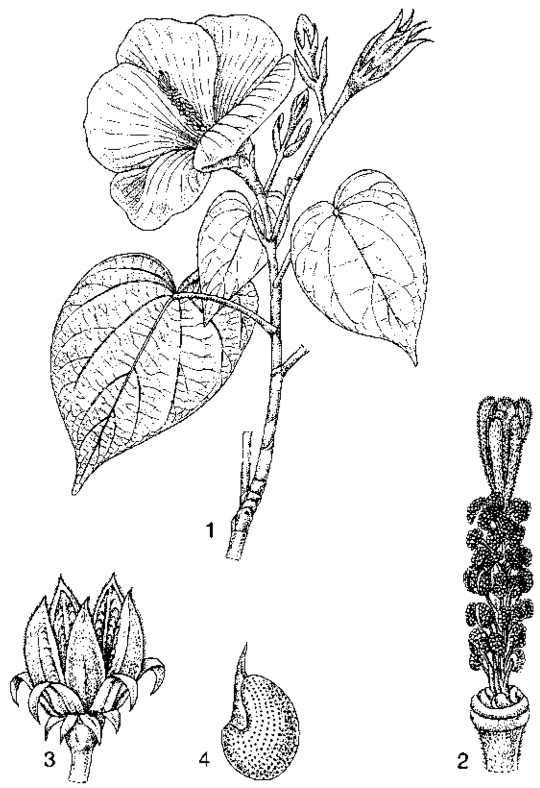
Sp. pl. 2: 694 (1753).

Synonyms *Hibiscus hastatus* L.f. (1781), *Hibiscus similis* Blume (1825), *Hibiscus celebicus* Koord. (1898).

Vernacular names Mahoe, sea hibiscus (En). Indonesia: waru, waru laut, baru. Philippines: malabago (Pilipino, Tagalog), dangliu (Tagalog), ragindi (Bisaya). Papua New Guinea: banj (Gaikorovi, Sepik Province), pow (Lomeoi, Manus Island), valu (Hula, Central Province). Burma (Myanmar): thinban. Laos: hou sua, ta sua. Thailand: khamin naang matsee (north-eastern), po naa (peninsular), po faai (central). Vietnam: tra l[af]m chi[ees]u, b[uj]p tra.

Distribution *H. tiliaceus* is found throughout the tropics on or near sandy shores.

Uses In the Philippines, the fresh macerated bark makes water mucilaginous, and is prescribed in dysentery. In Indo-China, the leaves are used



Hibiscus tiliaceus L. – 1, flowering twig; 2, stamens and styles; 3, fruit; 4, seed.

as a laxative, and the pulverized roots as a vomitive. A decoction of the leaves is emetic. In Papua New Guinea, a decoction of the leaves is taken for sore throat, pneumonia, cough, tuberculosis and diarrhoea. The leaves and root are crushed in water and drunk to ease labour.

Observations A small tree or shrub, up to 15(–30) m tall; leaves suborbicular, or the upper ones ovate, 10–15 cm long, base deeply cordate, apex cuspidate, margin finely toothed, beneath 1–5 central veins with a nectary, upper surface shiny, stipules large, spreading; epicalyx cupular, slightly accrescent, shorter than the calyx, 8–11-lobed, stellate-hairy, calyx campanulate, 5-fid, outside with nectaries, corolla large, 5 cm long, yellow with a purple heart, turning orange-red, staminal column antheriferous throughout, shorter than the petals, yellow, style and stigmas purple; seeds 5–7 per cell, reniform, punctate with tiny warts, black-brown. *H. tiliaceus* is very polymorphic and has been divided into 5 subspecies, differing by the size of the epicalyx, the form and hairiness of the leaves, and the hairiness of the seeds. *H. tiliaceus* is common along the sea shore and beside tidal streams.

Selected sources 122, 143, 786, 788, 810.

Undang A. Dasuki

Illicium anisatum L.

Syst. nat. ed. 10: 1050 (1759).

ILLICIACEAE

$2n = 28$

Synonyms *Illicium religiosum* Siebold & Zucc. (1835).

Vernacular names Japanese star anise, star anise (En). Anis du Japon (Fr). Indonesia: adas jepang, adas cina. Philippines: sanke, sanki (Tagalog).

Origin and geographic distribution *I. anisatum* occurs wild and is also cultivated in Japan, southern China and Taiwan; some state that it was introduced into Japan long ago by Buddhist priests. It does not occur naturally in South-East Asia.

Uses The fruits of *I. anisatum* are imported in considerable quantity, and are found in traditional Chinese pharmacies. *I. anisatum* fruits and leaves are poisonous and the plant has been known to be so since earliest times. It is not prescribed for internal uses, nor applied to the eyes. The fruit, seed oil or leaves are used as a local application in treating toothache, certain forms of dermatitis, and parasites. The plant is used as an insecticide, and as a fish and rat poison. In China a 10–25% aqueous extract is used as an insecticide. The main symptoms of poisoning in man are vomiting, abdominal pains, coma and pulmonary paralysis. Some mention is made of minute quantities included in some Javanese 'jamu'.

In traditional medicine a powder or decoction of the fruits of *I. verum* Hook.f. is used to treat abdominal colic, lumbago arising from a deficiency in the kidneys, vomiting and epigastric pain due to cold in the stomach and diarrhoea. It also has an antidiarrhoeal effect due to its prevention of intestinal fermentation. The fruit is an oestrogenic agent used to increase milk secretion, promote menstruation and facilitate childbirth. The essential oil is officially listed in several Pharmacopoeias. It has stimulant, antiseptic, stomachic, carminative and mildly expectorant properties. It is part of an antitussive formulation and is employed against rheumatism, and also for body lice and bed bugs, but may cause dermatitis in susceptible people. The oil is used as starting material for the production of synthetic oestrogens (e.g. diethylstilbestrol, diethylstilbestrol dipropionate) and perfumes. The leaves of *I. philippinense* Merr. from the Philippines and Taiwan, considered by some to be conspecific with *I. anisatum*, are highly poisonous. In the temperate zone *I. anisatum* is planted widely as an ornamental. In Japan, flowering twigs are a popular cut flower in cemeteries and Buddhist temples.

Production and international trade Wholesale prices for fruits or powder of *I. anisatum* are about US $30/kg.

Properties The fruits and seeds of both *I. anisatum* and *I. verum* contain an essential oil, although its quantity is far more abundant in the latter species; 0.25–1% and 5–9%, respectively. The main components of the oil (60–90 %) include the phenylpropanoids anethole (up to 90%), safrole, methyleugenol and small amounts of terpenes. Myristicin is present in small quantities in the oil of *I. anisatum*, but absent in that of *I. verum*. Anise oil, the essential oil obtained from the fruits of *Pimpinella anisum* L. is practically identical with that from *I. verum*. Since for all pharmaceutical purposes these 2 oils are indistinguishable, many current Pharmacopoeias no longer differentiate between these essential oils, and anise oil may be derived from both species.

The fruits and seeds of *I. anisatum* furthermore contain a series of rearranged, dilactonic, picrotoxin-like sesquiterpenoid lactones (e.g. anisatin, neoanisatin, pseudoanisatin, veranisatin and related compounds). Anisatin and neoanisatin impart convulsive properties to the drug. Similar convulsants are also found in small amounts in *I. verum*, but these amounts are without risk for their medicinal and culinary uses. In mice, at a dose of 3 mg/kg (orally), several veranisatins showed convulsion and lethal toxicity, and at lower doses they caused hypothermia. Veranisatin A and anisatin were tested for other pharmacological activities such as locomotor activity and analgesic effects. Both compounds decreased locomotion enhanced by methamphetamine at oral doses of 0.1 mg/kg and 0.03 mg/kg, respectively, and demonstrated analgesia on acetic acid-induced writhing and tail pressure pain at almost similar doses.

Shikimic acid was first isolated from the fruits of *I. anisatum*, where it is present in large amounts, accompanied by protocatechuic acid. The compound is actually named after the Japanese name of the plant, which is 'shikimi'. The effect of shikimic acid on focal cerebral ischaemic injury after middle cerebral artery thrombosis (MCAT) was studied in rats. Thrombosis was induced by ferric chloride in the rat middle cerebral artery. The effect of shikimic acid on neurological deficit (ND), infarct size (IS), brain oedema and cerebral blood flow (CBF) in the ischaemic region were observed. Shikimic acid (25 and 50 mg/kg, intraperitoneally administered for 3 days before MCAT) attenuated ND, and reduced IS by 51 and 42%, respectively, decreased brain water content from 80.7% to 79.8 and 79.9%, respectively, and increased CBF after ischaemia from 50.2% of the preischaemic level to 75.5 and 73.3%, respectively. Less thrombosis was observed in MCA of rats pretreated with shikimic acid at 25 mg/kg. The extent of brain ischaemia was less than that of the control.

Extracts of *I. anisatum* were furthermore studied for their insecticidal activity against *Culex quinquefasciatus* larvae and for their mode of action on ion channels. The crude methanol extract and its ethyl acetate-soluble fractions were active as insecticide with EC_{50} values of 63.0 μg/ml and 43.7 μg/ml, respectively. The ethyl acetate-soluble fraction was perfused through the bathing solution and the current induced by a brief (10 ms) application of GABA (gamma-amino butyric acid) by pressure ejection through pipette electrode was recorded by the whole-cell patch clamp technique. The extract suppressed GABA-induced currents irreversibly with an EC_{50} value of 0.42 μg/ml. The time constant of current fitted to the single exponential function was shortened by the ethyl acetate-soluble fraction at concentrations ranging from 0.1 μg/ml to 10 μg/ml in a concentration-dependent manner. It was concluded that *I. anisatum* extracts decreased the affinity of GABA for its binding site on the GABA receptor, thereby suppressing GABA-induced currents.

In addition, crude extracts of *I. verum* showed potent antifungal activity against a range of plant pathogens.

Description An evergreen shrub or small tree up to 8 m tall; wood and leaves highly aromatic. Leaves alternate, simple, narrowly ovate to lanceolate, 4–12 cm × 1.5–5 cm, base cuneate, tapering, apex blunt, entire, coriaceous; petiole 0.7–2 cm long; stipules absent. Flowers axillary, sometimes solitary, usually crowded, bisexual, regular, 2.5–3 cm in diameter, perianth lobes 12–15(–30), arranged spirally, slender, acute, 3 mm wide, pale yellow to white; pedicel 0.5–1.5 cm long; stamens (16–)18–20(–25), arranged spirally; carpels 7–9 (–10), arranged in a single row. Fruit a capsule-like follicetum, 2.5–3 cm in diameter, consisting of

Illicium anisatum L. – 1, flowering twig; 2, fruit side view; 3, fruit seen from above.

an aggregate of 7–8 follicles, arranged around a central axis in the shape of a star; each follicle boat-shaped, 1-seeded. Seed obovate-ellipsoid, 6–7 mm long, smooth, glossy, yellowish, containing copious endosperm.

Growth and development Vegetative growth of *I. anisatum* is markedly discontinuous, with periods of dormancy of vegetative buds alternating with active growth. The resumption of growth involves the rapid elongation of buds to produce stems several centimetres long, which bear small caducous leaves; apical pseudowhorls of leaves are then produced, consisting of alternately arranged normal leaves that are tightly clustered together.

Other botanical information *Illicium* comprises about 40 species, 5 in North America and 35 in eastern Asia (7 in Malesia). The common names 'star anise' and 'star anise oil' are generally used for *I. verum* products. Unfortunately, several other *Illicium* species produce similar fruits which are often also named 'star anise', causing confusion and sometimes danger. Most dangerous is the existing confusion with *I. anisatum*. Fruits of *A. anisatum* are smaller than those of *I. verum* and do not form a regular star due to the abortion of some carpels, its follicles are not swollen in the middle and are more pointed at the apex; its odour is balsamic and not anise-like, and the taste is bitter. Botanical drawings do not corroborate the morphological differences in the fruits. To avoid confusion it is proposed to use the scientific names or to use 'Chinese star anise' for *I. verum* and 'Japanese star anise' for *I. anisatum*.

Ecology In its natural habitat *I. anisatum* is found in moist evergreen broad-leaved forest at 1000–2500 m altitude.

Propagation and planting *Illicium* can be propagated from simple layerings or from cuttings. Layerings should be conducted at the beginning of the growing season. Cuttings are preferably green wood cuttings 7–8 cm long taken at the end of the growing season and kept under mist spray or in a closed case to prevent excessive evaporation. Information on propagation by seed is a little contradictory. *I. anisatum* can be sown without pretreatment at the beginning of the growing season. Seedlings are transplanted to individual pots when they are large enough to handle. In temperate regions both cuttings and seedlings are kept in the greenhouse for the first winter. They are planted out in early summer of the following year, and are given some protection for several winters to follow.

Husbandry *I. anisatum* can be grown in full sun or partial shade, and in lime-free, humus-rich soils that are well-drained but moisture retentive.

Diseases and pests In some parts of southern Japan, *I. anisatum* plantations are damaged by the camphor tree weevil (*Dyscerus hylobioides*). The level of infestation increased with age of the plantations and in the vicinity of natural forest. Regular weeding may reduce the level of infestation, apart from the use of insecticides.

Harvesting Assuming a similarity in harvesting in *Illicium*, *I. anisatum* fruits may be harvested before fully ripe, when the essential oil content is highest. Harvesting is carried out by hand picking, or by using a pole with a little hook connected to the end to detach the fruits.

Genetic resources and breeding *I. anisatum* 'Pink Star' is a seedling variant with more anthocyanin pigment in the plant than normal, resulting in crimson new shoot growth and flowers which are distinctly pink in the bud stage and gradually fading to white as flowers open and age. Forms with variegated leaves are also known. There are no known breeding programmes of *I. anisatum*.

Prospects The potential for cultivation Japanese star anise in South-East Asia needs further investigation. Some components show interesting pharmacological activities, but due to their nature of activities, they will only be of interest in research.

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Other selected sources 130, 135, 215, 273, 407, 459, 467, 786, 810.

Undang A. Dasuki

Impatiens L.

Sp. pl. 2: 937 (1753); Gen. pl. ed. 5: 403 (1754).
BALSAMINACEAE

x = (3), 6, 7, 8, (9); *I. balsamina*: $2n$ = (12), 14 (+2B), (18, 20, 24, 28 (+2B), 44, 56 (+2B)); *I. hawkeri*: $2n$ = 48; *I. platypetala*: $2n$ = 12, 14, 16

Major species *Impatiens balsamina* L.

Vernacular names Balsamine (En, Fr).

Origin and geographic distribution *Impatiens* is a large genus with about 600 species, widely distributed throughout the tropics, subtropics and temperate zone of Europe, Asia, Africa, and Central and North America.

Uses In China, Malaysia, Indonesia and the Philippines, the leaves of *I. balsamina* are used as a poultice to heal wounds, chronic ulcers and furuncles. The root and leaves are considered to be expulsive, and are thus described for all sorts of foreign bodies in the throat, such as coins and other metals, as well as for thorns and splinters in the flesh. The roots are also considered antiphlogistic and used for rheumatism. In Thailand, the fresh pounded leaves and stems are used for infections of the nails and ingrowing nails, the leaves and roots for treatment of thorn- or glass-puncture wounds. In China, the aerial parts are used to treat rheumatism, bruises and beri-beri, and in Korea they are used for the treatment of scrofulosis, hard ulcers and dysentery. The flowers are mucilaginous and cooling, and are used for snake bites, lumbago, intercostal neuralgia, to cure broken or torn nails, and infections of the nail base. They are thought to improve the blood circulation and to have fungicidal properties. In Indonesia, the flowers are considered abortive, and are also used against furuncles and dermatitis. In Japan, the squeezed juice from white petals is massaged into the skin for dermatitis. A powder of the seeds, mixed with arsenic acid, is sometimes used to ease the removal of teeth with caries. The seeds are also used in difficult labour or as an emmenagogue. A few seeds cooked with fish help soften the bones. In Indo-China, the seeds are used for amenorrhoea.

In Papua New Guinea, the whole plant of *I. hawkeri* is cooked and eaten by children with stomachache. The juice from the fruit and leaves is rubbed onto the legs of small children who are retarded in their walking. In East Africa, the herb is used as an abortifacient. In Java, the leaves of *I. platypetala* are applied to skin rash, and young leaves mashed with dill are given to children as a diuretic.

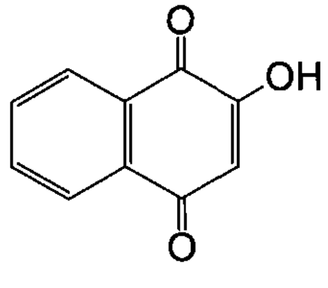
I. balsamina is used in Bali as a vegetable, mixed with other leaves, as they are slightly bitter. The leaves or flowers are widely used to dye the nails red, and in India they are also used for dyeing wool. In Vietnam, a slightly sweet smelling decoction of the leaves is used to wash the head to promote hair growth. The seeds are edible, the oil can be used for cooking and burning in lamps.

Impatiens is widely cultivated as an ornamental in gardens or as a potplant.

Production and international trade *Impatiens* is used for medicinal purposes on a local scale only. Ornamental *Impatiens* is traded internationally on a large scale.

Properties Besides flavonoids, cyanidins and cinnamic acid derivatives, the aerial parts of *I. balsamina* contain the quinone derivatives law-

sone (2-hydroxy-1,4-naphtaquinone) and lawsone-methylether (2-methoxy-1,4-naphtaquinone).
These compounds are also found in several other *Impatiens* species, and also in henna (*Lawsonia inermis* L.), and are responsible for the red colourations of hair and skin.
Lawsone and lawsone-methylether show antifungal activity, and are active in vitro against *Epidermophyton floccosum*, *Trichophyton mentagrophytes*, and *T. rubrum*, which cause ringworm, tinea pedis and athlete's foot. Both cream and ointment preparations containing 1% of a chloroform extract of the plant, were effective against these 3 fungi in vivo, and in vitro also showed equal activity against *Candida albicans* and *Microsporum gypseum*. Studies on the toxicity of *I. balsamina* in mice showed that the LD_{50} of a chloroform extract intraperitoneally injected was 0.67 g/kg. However, the cream preparation containing 1% of the chloroform extract caused irritation of the skin of rabbits and guinea-pigs. In addition, an ether extract of the leaves was found to be effective against the bacteria *Shigella flexneri*, *S. sonnei*, *Staphylococcus aureus* and β-haemolytic streptococcus group A.
The dinaphthofuran-7,12ne derivates balsaminones A and B were isolated, together with lawsone-methylether from the white petals of *I. balsamina*. These compounds exhibited significant antipruritic activity in histamine-treated mice. Mice with a murine hypersensitivity reaction system induced by hen egg-white lysozyme and a rat with a passive cutaneous anaphylaxis (PCA) reaction system were treated with a 35% ethanol extract of the white petals. The extract prevented fatal anaphylactic shock and inhibited heterologous PCA reactions.
Other pharmacological effects of *I. balsamina* include some activity against human epidermoid carcinoma of nasopharynx in vitro (alcoholic extract of the whole plant), and a significant protection and therapeutic activity against rice brown spot (*Helminthosporium oryzae*), when sprayed at



lawsone

intervals of 4–8 days (extract of the aerial parts).
Seeds of *I. balsamina* contain parinaric acid, hosenkosides A–O and baccharane glycosides. In China, the antifertility effect of the seeds was tested on mice. A decoction of 3g/kg for 10 days caused up to 100% contraceptive rate in male and female mice caged together on the 5th day of medication and dissected after 35 days. An anti-implantation rate of 33% was obtained with the decoction at a dose of 80 g/kg; this effect is probably related to suppression of ovulation. Furthermore, a syrup prepared from the seeds had a prominent stimulant effect on isolated mice uteri, increasing the frequency of contraction and enhancing the tone.

Adulterations and substitutes Henna (*Lawsonia inermis*) is used in the same way as *I. balsamina*, for colouring nails red.

Description Annual or perennial herbs, up to 2 m tall, generally with few-branched, fleshy, translucent stems, with swollen joints and watery juice, glabrous, or variably pubescent on the veins when young. Leaves simple, opposite, usually 3-whorled or spirally arranged, margin entire or serrate; petiole present; with or without stipules. Inflorescence axillary, flowers solitary or few together in cymes; flowers 5-merous, zygomorphic; bracts linear-lanceolate, inconspicuous; calyx lobes 3 (or 5), the lateral ones small, the lower one usually spurred, not persistent; corolla lobes 5, often simulating 3 by fusion of the lateral pairs; stamens 5, free from petals, alternate with petals, anthers connate, ultimately rupturing at the base and lifted by the elongating pistil; ovary superior, 5-locular, style 1, stigma 1 or 5, 5–50 ovules per locule, funicle present, pendulous, with dorsal raphe. Fruit a fleshy capsule, dehiscent or not, with usually numerous seeds.

Growth and development *Impatiens* normally flowers throughout the year in the tropics. *Impatiens* shows flower dimorphism: besides the normal flowers, they have small, cleistogamous flowers, which never open and are autopollinated. The normal flowers are entomophilous, but do not regularly produce ripe seed. The mature fruit explodes by curling of the carpels, and the seeds are dispersed at considerable distance.

Other botanical information *Impatiens* has a high degree of endemism of its constituent species, which suggests active recent evolution, and hybridization seems important. Many varieties and cultivars have been recognized in cultivated *Impatiens*, including double-flowered and dwarf forms.

Ecology Wild *Impatiens* grows in tropical and subtropical areas, along streams, wetlands, drainage ditches and in woodland, from sea-level up to 3500 m altitude.

Propagation and planting *Impatiens* is mainly propagated by seeds, sometimes by cuttings. There are 1000–2000 seeds/g, depending on the cultivar. The seeds germinate in 10–18 days, in the light, at 100% relative humidity. Optimum temperature for germination is 25–28°C, and for the seedlings a night temperature of about 20°C is needed for high quality plants. Optimum spacing is 30–40 cm, in order to display the flowers properly.

In vitro production of active compounds Root cultures of *I. balsamina* were analyzed for biologically active compounds, and yielded lawsone (2-methoxy-1,4-naphthoquinone), lawsone-methylether (2-methoxy-1,4-naphtaquinone), methylene-3,3'-bilawsone, spinasterol, and the coumarin derivatives scopoletin, isofraxidin and 4,4'-bi-isofraxidin. In the Philippines, preliminary trials for callus formation in in vitro cultures for medicinal purposes were successful.

Diseases and pests *Impatiens* is susceptible to powdery mildew, often caused by *Sphaerotheca fuliginea*. Fungal blights and rots, bacterial leaf spot and viruses (e.g. *Impatiens* necrotic spot tospovirus, *Impatiens* necrotic spot virus) are also common problems. *Pythium* and *Rhyzoctonia* cause damping-off in seedlings. Pests like aphids, thrips and spider mites cause distorted and stunted leaves, while slugs attack the leaves, and several nematodes attack the roots.

Harvesting The parts of *Impatiens* to be used are usually harvested from cultivated plants.

Handling after harvest The harvested parts of *Impatiens* are used fresh.

Genetic resources and breeding No breeding programmes of *Impatiens* for medicinal purposes are known to exist.

Prospects *Impatiens* species are considered mainly as ornamentals, therefore their value as medicinal plants is not fully exploited. Although limited work has been done so far on some valuable chemicals (e.g. lawsone, lawsone-methylether), more research attention seems justified.

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Selection of species

Impatiens balsamina L.

Sp. pl. 2: 938 (1753).

Synonyms *Impatiens cornuta* L. (1753).

Vernacular names Garden balsam(ine) (En). Balsamine des jardins (Fr). Brunei: banga pacar (Bukit Udal, Dusun), bungar pecar (Sengkurong, Kedayan Malay). Indonesia: pacar air (general), pacar banyu (Javanese), laka gofu (Ternate). Malaysia: bungatabo, inai ayer, keembong. Philippines: kamantigi (Tagalog, Iloko), solonga (Bisaya). Burma (Myanmar): dau dalet. Thailand: thiandok, thian baan, thian suan (central). Vietnam: b[os]ng n[uw][ows]c, (b[oo]ng) m[os]ng tay, n[aws]c n[es].

Distribution Probably native of India and parts of South-East Asia, and found throughout the tropics, subtropics and temperate zone as an ornamental.

Uses The leaves, and sometimes the roots, are used to poultice wounds, inflammations of the skin and torn nails. The flowers are used as a tonic, and have a cooling effect on burns and scalds, and against rheumatism. The red flowers are widely employed to prepare a red dye for finger nails. In Brunei, a decoction of the roots is drunk to treat irregular menses.

Observations An annual herb, 15–60(–80) cm tall, stems erect; leaves spirally arranged, lower leaves occasionally opposite, lanceolate to narrowly elliptical, 3–10(–15) cm × 1.5–3 cm, base cuneate, apex acute, margins serrate, several dark glands towards the base, sessile or shortly petiolate; flowers 1–3 together in leaf-axils, variable in size, up to 3.5 cm long, pedicel slender, 1–1.6 cm long, sepals 3, lower sepal deeply navicular, 13–21 mm long, abruptly constricted into a curved filiform spur 13–24 mm long, dorsal petal cucullate, 10–14 mm long, long-mucronate at apex, lateral united petals 25 mm long, upper petal oblong, 9–11 mm long, obtuse, lower petal suborbicular, 18–27 mm long, unevenly bilobed; corolla red, purple, white, or variegated; capsule broadly fusiform, 12–20 mm × 6–8 mm, densely pubescent. *I. balsamina* occurs in wet, rather open localities or as forest undergrowth, from sea-level up to 1250 m altitude.

Selected sources 74, 135, 297, 407, 417, 424, 739, 788, 810, 1071, 1097.

Impatiens hawkeri W. Bull

Bull's Catalogue: 8 (1886) & Gard. Chron. 25: 760, fig. 168 (1886).

Vernacular names Papua New Guinea: nagatumo (Kabiufo, Eastern Highlands), kolumbata (Marawaka, Eastern Highlands), imda (Asekei, Morobe Province).

Distribution New Guinea, Manus Islands, New Ireland, New Britain and the Solomon Islands, but widely cultivated elsewhere under different names.

Uses In Papua New Guinea, the whole plant is cooked and eaten by children with stomach-ache. Mixed with leaves of *Plectranthus scutellarioides* (L.) R.Br., the leaves are rubbed on the stomach of pregnant women to help relieve labour pains.

Observations A perennial herb, 0.5–1 m tall, stems decumbent to erect, often tinged red; leaves in whorls of 3–7, linear to elliptical to oblong, 4–24.5 cm × 0.5–6 cm, base abruptly cuneate to gradually attenuate, apex acute to long-acuminate, margin shallowly crenate to serrate, the upper teeth ending in a short apiculum, 1–2 mm long, pale to deep green, bronze, reddish or purplish or variegated, petiole slender, 0.5–6 cm long; flowers solitary, pedicel slender, ascending, 4–12 cm long, lateral sepals ovate, long acuminate, 8–15 mm × 3.5–6 mm, lower sepal shallowly navicular, 9–21 mm long, abruptly constricted into a curved filiform spur 3–10 cm long, dorsal petal obcordate to suborbicular, shallowly emarginate, rather flat, 14–29 mm × 16–35 mm, with a shallow crest on the back, lateral united petals 19–42 mm long, shallowly to deeply emarginate, upper pair slightly smaller than lower pair; corolla white, pink, lilac, purple, orange, pale red, scarlet, crimson or magenta; capsule fusiform, 18–33 mm × 5–9 mm, glabrous. *I. hawkeri* grows in moist, shaded or semi-shaded locations in montane or submontane forests, particularly along stream and river margins, at (200–)400–3150 m altitude. It is a very variable species: in addition to the numerous cultivars, 15 groups are recognized in the wild forms, which are differentiated mainly by geographical region, flower colour and leaf-form.

Selected sources 418.

Impatiens platypetala Lindley

Bot. Reg.: 32, t. 68 (1846).

Synonyms *Balsamina sumatrana* Miq. (1846).

Vernacular names Indonesia: pacar leuweung, pacar tere (Sundanese), pacar banyu (Javanese).

Distribution Widely distributed in South-East Asia, common in Malaysia and Indonesia.

Uses In Java, the leaves are used for poulticing skin problems, and as a diuretic for children.

Observations A perennial herb, 30–100 cm tall, erect or decumbent; leaves 3-whorled, sometimes opposite, ovate to ovate-elliptical, 6–11.5 cm × 1–3.5 cm, base attenuate, apex acute to acuminate, margins shallowly serrate, petiole 0.7–2.8 cm long; flowers solitary, pedicel slender, 4–6.5 cm long, lateral sepals lanceolate to ovate, 7–12 mm long, acuminate, lower sepal shallowly navicular, 8–12 mm long, abruptly constricted into a curved, fili-

Impatiens platypetala Lindley – 1, flowering and fruiting stem.

form spur 20–40 mm long, whitish or greenish, petals flat, obcordate, dorsal petal 11–14 mm × 7–9 mm, lateral united petals 19–21 mm long, shallowly emarginate, upper pair slightly smaller than lower pair; corolla pink, rose, purple, violet, white, or white with a coloured eye; capsule fusiform, 16–18 mm × 4–5 mm, glabrous. *I. platypetala* is a variable species, and occurs in lowland and montane forest, growing in gullies, along streams, in damp, shaded and semi-shaded localities, forest clearings, often gregarious, at 100–1600 m altitude.

Selected sources 74, 135, 407.

Rosna Mat Taha

Inula helenium L.

Sp. pl. 2: 881 (1753).

COMPOSITAE

$2n = 20$

Synonyms *Aster helenium* (L.) Scop. (1772).

Vernacular names Elecampane, elfdock, yellow starwort (En). Grande aunée, inule, oeil de cheval (Fr). Vietnam: th[oor] m[ooj]c h[uw][ow]ng.

Origin and geographic distribution *I. helenium* is a native of Central Asia, but is naturalized widely in northern Europe, the United States, China and Japan, and on a small scale in Indo-China. It is occasionally cultivated.

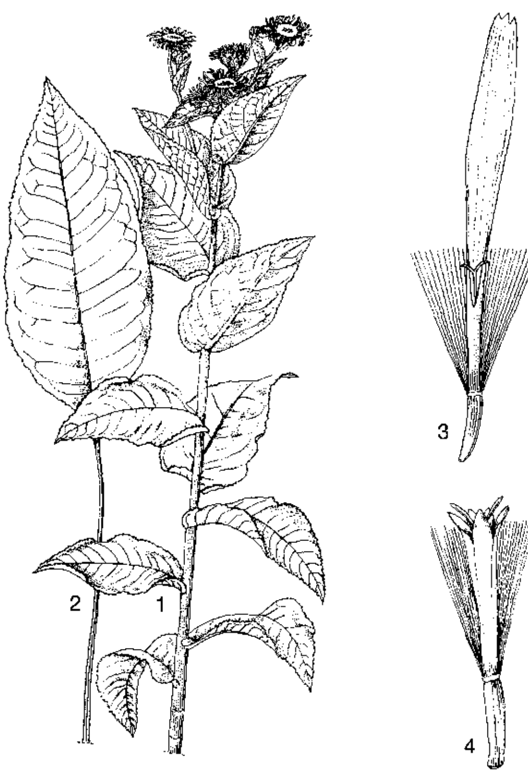
Uses The root oil of *I. helenium* is used in China, Japan, Indo-China, and Peninsular Malaysia as a diuretic, diaphoretic, expectorant and a tonic. In the United States and the United Kingdom, the roots are used as a diuretic and an emmenagogue. It has a warming, salty flavour. It is applied in treating skin and chest diseases such as coughs, colds, asthma, oedema, tuberculosis and eczema. In the past, it was used in Europe in a similar way. In Vietnam and Peninsular Malaysia the root and flower heads of *I. helenium* are imported from China, and are found in Chinese pharmacies.
In China and Japan, the root ('Helenii radix') is also considered vermifugal and germicidal, and may be taken to treat cholera, malaria, inflammation of the intestines, dysentery, and bronchitis. It is used externally against snake and insect bites. In Korea, the root is used to treat ear- and toothache.
I. helenium was cultivated in Europe as a root vegetable in ancient times; nowadays it is still sometimes candied and used to flavour alcoholic beverages, sweets and desserts. The leaves are used for seasoning salads, and also yield a blue dye. It is cultivated in Europe and eastern Asia as an ornamental with large flower heads.

Production and international trade *I. helenium* used to be cultivated on a large scale for its medicinal roots in southern Russia and in Europe, and on a smaller scale in eastern Asia. This trade is no longer very important, but the large area of distribution resulting from former cultivation indicates that it must have been of considerable importance in the past. The dried roots and dried flower heads are traded locally on markets in Central and eastern Asia and in Japan.

Properties As is the case with many *Compositae*, the aromatic and bitter tasting roots of *I. helenium* contain inulin (40–45%), a polysaccharide consisting of D-fructose residues. Triterpenes (e.g. dammaranedienol acetate) and sterols (sitosterol, stigmasterol) have also been found.
Upon steam distillation, *I. helenium* yield a 1–3% crystalline mass, with a little oil. This mass consists of sesquiterpene lactones, mainly the eudesmanolides alantolactone (52.4%), isoalantolactone (33%), dihydroalantolactone, their 11,13-dihydro derivatives and related compounds. The mixture is also known as helenin (in older literature) or inula camphor, although these names are also applied to alantolactone itself.
The root extract and the volatile fraction exert a number of pharmacological effects, which are mainly caused by alantolactone and isoalantolactone. They exhibit significant activity against the Gram-positive bacteria *Staphylococcus aureus* and *Streptococcus pyogenes*, and significant activity against *Mycobacterium tuberculosis*. The compounds also show in vitro antifungal activity against *Microsporum cookei*, *Trichophyton mentagrophytes* and *Trichothecium roseum*. Other activities include antiprotozoal activity against *Entamoeba histolytica* and *Trichomonas vaginalis*, and anthelminthic activity against *Meloidogyne incognita*. Guinea-pigs infected with the nematode *Trichinella spiralis*, which causes trichinelliasis, were treated with helenin to test its effect on the intestinal stages. Those receiving 100 mg/kg helenin daily for 30 days had about 7.5% fewer muscle larvae than their controls; those receiving 300 mg/kg for 10 days had about 62.5% fewer larvae and those given a single, toxic dose of 2500 mg/kg had about 77% fewer larvae. The effect might be caused by nematode muscular activity combined with the stimulation of intestinal peristalsis in the host. The constituents of helenin also have excellent antifeedant properties against phytophagous pests, and are toxic to the mosquito *Aedes atropalpus*. They show allelopathic action against the weeds *Amaranthus retroflexus* L. and *Cheno-*

podium strictum Roth, but also improve root formation in *Vigna radiata* (L.) Wilczek. A lymphocyte transformation test used in vivo and in vitro in mice showed that alantolactone had significant allergenic capacity. Boiled water extracts of *I. helenium* were screened for clonorchicidal activity in rabbits infected with the worm *Clonorchis sinensis*. The extract disclosed significant regressive and progressive changes, such as degeneration, atrophy, necrosis and dilatation of viscera of the worms. The cytostatic action of a 40% ethanol extract of *I. helenium* herbs on cultured human lymphoblastoid cells was studied and was found to suppress cell growth completely at 50–200 µg/ml. *I. helenium* flowers contain the flavonoids quercetin, quercetin-7-triglucoside and 3-methylquercetin.

Description An erect, robust, tomentose perennial, 60–150(–250) cm tall, with a thick root base, short rhizome-like roots, and forked stems in the upper part. Leaves alternate, simple, lower leaves ovate to elliptical, 40–70 cm × 10–25 cm, base rounded, apex acuminate, margins dentate, upper leaves smaller, base cordate, shortly pubescent above, grey-tomentose underneath; lower leaves long petiolate, upper leaves sessile, amplexicaul; stipules absent. Inflorescence a terminal or axillary hemispherical head, solitary or few together, 2.5–7 cm in diameter (large in cultivars), involucral bracts many-seriate, outer bracts ovate, 10–13 mm × 4–5 mm, tomentose, inner bracts smaller, lanceolate, receptacle flat or slightly convex, without scales. Ligulate flowers female, many, corolla 30–40 mm long, 3-toothed at apex, much exceeding the involucre, curled upwards, bright yellow, tubular flowers bisexual, many, corolla 5-toothed, yellow; stamens 5, anthers sagittate; ovary inferior; style bifurcate. Fruit an oblong, striped achene, 3–5 mm long, glabrous; pappus hairs about 30, 5–8 mm long, free. Seedling with epigeal germination.



Inula helenium L. – 1, flowering stem; 2, lower leaf; 3, ligulate flower; 4, tubular flower.

Other botanical information *Inula* belongs to the tribe *Inuleae* and is a little known genus of which the number of species is estimated between 40–90, occurring in the warm and tropical regions of the Old World. The centres of diversity are in Central Asia and in southern Europe, where about 18–25 species are found. None of the species are found in the wild in Malesia, but some occur in Indo-China.

I. brittannica L. (synonym *I. japonica* Thunb.), a widespread, originally European species, is cultivated in China and Japan. The flower heads are found in the Chinese pharmacies in Peninsular Malaysia and have similar uses to *I. helenium*.

Ecology *I. helenium* prefers moist, sunny to half-shady locations, and is found along forest roads, but also in humid pastures and orchards, from sea-level up to 1400 m altitude.

Propagation and planting *I. helenium* is propagated by seed or root cuttings. Germination of 1-year-old seeds is between 93–97% in Moldavia, but reduces to 50% after 4 years. In the Ukraine, seed of *I. helenium* is sown either in autumn (untreated) or in spring (after 1–1.5 months stratification).

Husbandry Best root harvests of *I. helenium* are obtained from 3-year-old plants grown from seeds or 2-year-old plants from root cuttings. In Indo-China, *I. helenium* is still cultivated for medicinal or ornamental purposes.

Diseases and pests *Capitophorus vandergooti*, *Cassida murraea* and *Lygus rugulipennis* are common insect pests on cultivated *I. helenium* in Russia. The insecticide fosfamid (dimethoate) applied at 1.2 kg/ha gives 70–100% control of sucking insects such as thrips, and leaves no residues in the roots. The nematode genera *Aphelenchoi-*

des, *Aphelenchus*, *Cephalobus* and *Panagrolaimus* are commonly found on the roots of *I. helenium*.

Harvesting In China, the open flower heads are collected during July–October. Roots are harvested in autumn.

Yield The fresh root weight of juvenile, mature and senescent plants of different populations of *I. helenium* in Russia is very variable, being 3–40, 73–343 and 64–303 g/plant respectively.

Handling after harvest The flower heads and roots of *I. helenium* are dried in the sun before being stored.

Genetic resources and breeding Small germplasm collections of *I. helenium* are present in Germany, Poland, Portugal, Russia and Canada. There are no known breeding programmes.

Prospects Although *I. helenium* does not occur naturally in Malesia, it has the potential to be cultivated in areas with a sub-humid climate. Its sesquiterpene lactones show interesting pharmacological activities. However, in view of the risks of allergies, their therapeutic use should be limited. Upon further investigation, they might serve as templates in research.

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Other selected sources 14, 125, 130, 131, 135, 146, 309, 401, 564, 675, 739, 750, 786, 957.

Wongsatit Chuakul, Noppamas Soonthornchareonnon, Orawan Ruangsomboon

Ipomoea L.

Sp. pl. 1: 159 (1753); Gen. pl. ed. 5: 76 (1754).

CONVOLVULACEAE

$x = 15$; *I. aquatica*, *I. carnea* subsp. *fistulosa*, *I. congesta*, *I. digitata*, *I. nil*, *I. obscura*, *I. pes-caprae*, *I. triloba*: $2n = 30$, *I. pes-tigridis*: $2n = 28, 30$, *I. purga*: $2n = 24–28$

Major species *Ipomoea digitata* L., *I. nil* (L.) Roth, *I. pes-caprae* (L.) R.Br., *I. purga* (Wender.) Hayne.

Vernacular names Morning glory (En). Liseron (Fr).

Origin and geographic distribution *Ipomoea* comprises about 500 species, (600–700 species according to some authors) and occurs throughout tropical and subtropical regions of both hemispheres, mainly in America and Africa.

Uses Several parts of *Ipomoea* species have purgative properties, and are also taken for dysentery or as a general tonic. In South-East Asia and India, the leaves or young tops of *I. aculeata* var. *mollissima*, *I. batatas* (L.) Lamk, *I. carnea* subsp. *fistulosa* and *I. congesta* are used for these purposes, and of *I. nil* and *I. quamoclit* L. the seeds. The taste of these seeds is at first sweetish, then acrid and disagreeable. The tubers of *I. purga* are used in the Old and New World alike as a purgative. In small doses, they are employed against gastritis, colitis and chronic dysentery. The roots of *I. aquatica*, *I. digitata*, *I. pes-caprae* and *I. pes-tigridis* L. are purgative, as are the seeds of *I. digitata*. The seeds are also a strong pesticide, killing earthworms, leeches, pig tapeworm and other intestinal parasites.

The crushed leaves of many *Ipomoea*, for instance of *I. aculeata* var. *mollissima*, *I. aquatica*, *I. digitata*, *I. obscura*, *I. pes-caprae*, *I. pes-tigridis* and the ornamental *I. quamoclit* are also widely applied on sores, boils, ulcers, piles, haemorrhoids, aphthae, swellings and wounds. In Peninsular Malaysia, the tubers of *I. digitata* and *I. purga* are used for this purpose.

In Indonesia, a decoction of the roots of *I. aquatica* is also used as an antidote against opium or arsenic poisoning or drinking of polluted water. Eating much *I. aquatica* has a nerve-calming effect in case of sleeplessness, stress, headache, general weakness and leucorrhoea. A decoction of the leaves is a remedy for cough. The buds, together with shoots of *Heliotropium indicum* L., are made into a paste to put on ringworm.

In India and the Philippines, the root of *I. digitata* is considered tonic, alterative, aphrodisiac, demulcent, lactagogue and cholagogue, and is useful in fever and bronchitis. The powdered root is given for diseases of spleen and liver, for menorrhagia, debility and fat accumulation. In China, the seeds are regarded as a diuretic, anthelmintic and deobstruant, and are prescribed for dropsy, constipation, to promote menstruation and cause abortion. In the West Indies, a weak leaf decoction is a remedy for asthma and rheumatism. It is also drunk daily in the last month of pregnancy to promote an easy delivery. A strong decoction is taken as an abortifacient. In Nigeria, the dried leaves are applied to burns.

In South-East Asia, Australia, India, Senegal, Brazil and Central America, the leaves of *I. pes-caprae* are considered astringent, alterative, tonic, and diuretic, and are used in an external application for rheumatism, dropsy and colic. In the Philippines, Papua New Guinea, Malaysia, Indo-China and India the seeds of *I. pes-caprae* are used as a remedy for stomach-ache and cramp. A decoction of the root is emollient and diminishes the irritation caused by bladder infections. In Nusakambangan Island, south of Central Java, and in Thailand, the juice from the stem is used to treat the sting of jellyfish and toadfish.

I. triloba L. is used in Peninsular Malaysia in a poultice against headache. In Java, the leaf juice of *I. rumphii* Miq., the identification of which is uncertain, is used against spots on the cornea and against bites from centipedes. The leaves are applied to wounds and ulcers, to ripen them. The plant is sometimes eaten as a vegetable, normally mixed with other herbs. In the Enga Province of Papua New Guinea, cuts or burns are treated with the juice from the heated tuber of *I. batatas*, which dries to a rubber-like gum that holds the skin together. The red-leaved variety is used with wild tobacco leaves to treat eye infections and alone to prevent sores on a baby's skin. It is also taken for diabetes. The pounded leaves of the red-leaved variety are used to stupefy shrimp. In Milne Bay (Papua New Guinea) a decoction of the leaves is drunk against stomach-ache. In Peninsular Malaysia, the tuber is used to make a drink to allay thirst in fever. The finely crushed leaves are smeared on stiff joints and burns, and the stem is bound on stiff rheumatic joints.

In Indonesia, India and Africa, *I. carnea* subsp. *fistulosa* causes severe cases of poisoning in goats and sheep, the symptoms being staggering, weakness of hind legs, dyspnea, depression and pallor of the visible mucous membranes, and anaemia. The pollen is an important aero-allergen in India.

The shoots of *I. aquatica* are commonly eaten as a vegetable in South-East Asia, as aret he leaves of *I. pes-caprae* in Zanzibar. In Brazil the roots are eaten in case of famine, but they cause dizziness when used in excess. In Nigeria, the leaves of *I. obscura* are eaten in soup, and in Kenya as a vegetable.

Ipomoea is also an important genus for providing ornamentals, normally for the large flowers, such as *I. purpurea* (L.) Roth and *I. tricolor* Cav., but also *I. digitata* and *I. carnea* subsp. *fistulosa*. Some are also used as a hedge plant or green manure, such as *I. aculeata* var. *mollissima* in India, and *I. digitata* in Indonesia. Others are also used as fodder: *I. digitata* in Malesia and *I. pes-tigridis* in northern India and the Sahel. In China, the leaves of *I. pes-caprae* are given as a fodder to pigs, but if eaten by dairy cows, the milk is spoiled. In India, the seeds of *I. digitata* are used for coagulating milk.

In India, the leaves of *I. aculeata* var. *mollissima* are used as a substitute for soap to wash clothes. In Ambon (Indonesia), *I. congesta* is used for this purpose, and in Brazil, *I. pes-caprae*.

I. pes-caprae is an excellent sand binder, and is used for checking erosion and drifting of sand. The purple flowers mashed with a little chalk, give a bright green colour, which dries dark blue, like indigo. In Malawi, the long stems are made into ropes for hauling fishing nets, and in Gabon for skipping ropes. The pulped leaves are rubbed on fishing nets, to entice fish.

Production and international trade The tubers of *I. purga* used to be dried and exported to Europe in considerable quantities, where they were used with carminatives such as ginger, cloves or other spices.

Properties From the aerial parts of *I. pes-caprae*, 3 fatty acid glycosides, i.e. pescaprosides A, B and E were isolated, as well as organic acids such as behenic, melissic, butyric, succinic, betulinic, tartaric, fumaric, malic, citric and myristic acid, and flavonoids including hyperoside, isoquercitrin, isoquercitrin monoacetate and quercetin-3-galactoside. The leaves also contain damascenone, which is reported to be an antihistaminic agent in the literature. The root is starchy, and contains saponins.

An aqueous extract of the stems and leaves reversibly counteracts the spasmodic effects and dermatitis of the poison of jellyfish and Portuguese man-of-war. Possibly, the compounds β-damascenone and E-phytol are partly responsible for this effect, their effect being in the same range as papaverine. The extract was also tested for its antagonistic activity against histamine, acetylcholine, bradykinin and barium chloride on isolated guinea-pig ileum, and was found to inhibit the contractions induced by the spasmogens, probably by direct influence on the ileal smooth muscle. The extract was found to contain components which were shown to inhibit the synthesis of prostaglandins, e.g. 2-hydroxy-4,4,7-trimethyl-1(4H)-naphthalenone, (-)-mellein, eugenol and 4-vinylguaiacol. The combination of antispasmodic effects and prostaglandin synthesis inhibition of the extract may explain the use of *I. pes-caprae* leaves for treating jellyfish stings.

A plant extract of *I. pes-caprae* exhibited furthermore significant inhibition of ADP-induced human platelet [14C]5-hydroxytryptamine release and platelet aggregation in vitro. The leaf extract also showed significant dose-dependent effects in the rat ear oedema test, while the methanol, ethyl acetate and aqueous extracts exhibited considerable antinociceptive activity against the writhing- and formalin tests in mice. Compounds responsible for this activity were initially identified as the triterpenes glochidone, betulinic acid and α- and β-amyrin acetate.

The leaves of *I. aquatica* contain hentriacontane, β-sitosterol and its glycoside. A plant extract inhibited prostaglandin and leukotriene biosyntheses in vitro; N-trans- and N-cis feruloyltyramines were found to be responsible for this activity. Furthermore, the fresh aerial parts, intragastrically administered to rats at the dose of 3.4 g/kg body weight showed antihyperglycaemic activity.

The leaves of *I. carnea* ssp. *fistulosa* contain the polysaccharide ipomose, as well as jalapin, saponins and 3-dicaffeoylquinic acid esters. The water extract of the fresh leaves produced a positive inotropic effect on isolated frog heart in vitro, possibly by sodium extrusion or release of the intracellular calcium. It also causes haemolysis and a reduction in blood pressure, when administered intravenously. The ether extract affected the central nervous system, including the respiratory and cardiac regulatory centres. An ethanol extract, as well as succinylcholine as a reference, was tested in vitro on isolated preparations of the frog rectus abdominis muscle and the rabbit perfused heart as well as in vivo in chickens. Both the extract and succinylcholine contracted the frog rectus abdominis muscle, caused bradycardia of the rabbit heart, and produced spastic paralysis in chickens. The plant extract also shows moderate insecticidal, fungicidal, bactericidal and antiviral action, but also allelopathic activity against several crops and weeds. *I. carnea* ssp. *fistulosa* is toxic to goats and sheep. The signs of poisoning are loss of appetite, depression, weakness of hind limbs, dyspnoea, staggering and pallor of visible mucous membranes. It also shows a toxic effect on their livers and kidneys.

Some *Ipomoea* are known to contain alkaloids, e.g. the Mexican *I. hardwegi* Benth. contains ipalbidine, which has shown analgesic activity, and the seeds of *I. obscura* contain the indole alkaloids ipobscurine B and C.

Ipomeamaron, a phytoalexin of the furan-sesquiterpene type, was first found in the tubers of *I. batatas*, which were infected with fungi. Upon this infection, the concentration of ipomeamaron rose fast to a fungitoxic level of about 2%.

Adulterations and substitutes In India, the rhizomes of *Operculina turphetum* (L.) S. Manso are often used as a substitute for tubers of *I. purga*, as a strong purgative.

Description Herbs or shrubs, usually twining, sometimes prostrate, floating or erect. Leaves alternate, simple, variable in size and shape, lobed or divided; petiolate. Inflorescence mostly in axillary, 1–many-flowered cymes; peduncle present; bracts normally small, linear to triangular. Flowers bisexual, regular, small to large; pedicel present; sepals 5, herbaceous or coriaceous, often unequal, often somewhat enlarged in fruit; corolla funnel-shaped or campanulate, 5-lobed, mid-petaline bands well defined by 2 distinct veins, mostly glabrous outside; stamens 5, inserted near the base of corolla tube, normally included, filaments often unequal in length, pollen spinulose; ovary 2(–4)-locular, with 4(–6) ovules; style 1, simple, filiform, normally included. Fruit a globose or ovoid capsule, 4(–6)-valved, 4(–6)-seeded. Seed glabrous or hairy. Seedling with epigeal germination; cotyledons horseshoe-shaped or deeply divided into lobes or slips.

Growth and development *Ipomoea* is sun-loving in general, and the species are known as honey-yielding plants. Many *Ipomoea* species are self-incompatible. The flowers of *I. nil* and *I. triloba* close before noon, those of *I. aculeata* var. *mollissima* and *I. pes-tigridis* open at night.

Other botanical information Several authors have wrongly considered the Malesian specimens of *I. nil* conspecific with the North American *I. hederacea* (L.) Jacq.

Ecology Most *Ipomoea* grow under everwet and seasonal climatic conditions, although some prefer regions with a pronounced dry monsoon, savanna and grasslands. The *Ipomoea* species of the beach can tolerate high temperatures, periodic drought, sea water spray, high pH and low soil nitrogen content.

Propagation and planting *Ipomoea* is normally propagated by seed. The capsules float and can probably be dispersed by water or sea currents. When planted, stem cuttings are used, placed 60–100 cm apart. Whereas *I. aquatica* is propagated by seed and by cuttings, *I. carnea* subsp. *fistulosa* and *I. digitata* are normally propagated only by cuttings. *I. pes-caprae* can also be successfully propagated from nodal explants through Murashige and Skoog (MS) media, supplemented with either 2-isopentenyladenine or zeatin. Quite similarly, *I. triloba* can be propagated through protoplast, petiole or leaf explants, grown on MS media, supplemented with 3-indole acetic acid and 6-benzylaminopurine. *I. purga* is cultivated in Mexico, where seeds are scarified and sown in holes, and sticks are placed near the plants for support. The seeds are planted during the rainy season and harvested about 8 months later.

Diseases and pests Several leaf-spot diseases caused by *Alternaria* sp. and *Xanthomonas* sp. are regularly found in *Ipomoea*. An important disease in *I. aquatica* is white rust, caused by *Albugo candida*. Important pests include the caterpillars *Spodoptera litura* and *Diacrisia strigatula* as well as several thrips and aphids all of which can cause serious damage. *Ipomoea* is also attacked by several nematodes, in particular *Meloidogyne incognita* and *M. javanica*, although tests with extracts of *I. carnea* subsp. *fistulosa* show high mortality of juveniles and adults of these pests.

Harvesting The plant parts of many *Ipomoea* used are simply harvested from the wild whenever needed.

Yield In Mexico, yield of fresh *I. purga* roots is 1.5–2.7 t/ha.

Handling after harvest The roots of *I. purga* lose 75% of their weight by drying. After drying the roots are smoked before being sold.

Genetic resources and breeding Germplasm collections containing *I. batatas* are found all over the world. Large *Ipomoea* germplasm collections are kept in Iquitos and Lima (Peru) and in Griffin (United States).

Prospects Components of several *Ipomoea* species show pharmacological activities, e.g. β-damascenone (anti-spasmodic) and (–)-mellein and 4-vinylguaiacol (inhibition of prostaglandin synthesis). Since these activities are of interest for the development of future medicines, they merit further research in order to evaluate their possible potential.

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Selection of species

Ipomoea aculeata Blume var. mollissima (Zoll.) Hallier f. ex Ooststr.

Blumea 3(3): 574 (1940).

Synonyms *Ipomoea mollissimum* Hallier f. ex Boerl. (1899).

Vernacular names Indonesia: rabet kalorak (Madurese), uluk-uluk (Sundanese).

Distribution In Malesia, occurring in Java, Madura, the Lesser Sunda Islands and the Philippines.

Uses The leaves or young tops are eaten as a purgative, and applied externally to sores and ulcers. The leaves are also used as a substitute for soap to wash clothes.

Observations An annual, pubescent twiner, 10–15 m long, occasionally prostrate, stems woody, fragrant; leaves ovate to orbicular, normally entire, 5–14 cm × 3–10 cm, base cordate to truncate, apex acuminate, mucronulate, lateral veins 5–6, petiole 2.5–8(–12) cm long; flowers solitary or in few-flowered cymes, peduncle short, 2–10(–15) mm long; pedicel 7–15 mm long, in fruit up to 20 mm long, clavate, recurved in bud, erect at flowering, and recurved in fruit, sepals subequal, broadly elliptical or orbicular, 12–18 mm long, corolla salver-shaped, 14–17 cm long, tube long and narrow, white, greenish outside, fragrant, stamens and style exserted, filaments hairy at base, ovary glabrous; capsule ovoid, 15 mm long, mucronate, enclosed by the sepals, valves 4, lacerate or not; seeds 4, 6–8 mm long, densely grey-woolly. *I. aculeata* var. *mollissima* occurs in thickets and open forests, from sea-level up to 700 m altitude. It flowers in Java from May to August. Var. *aculeata* is nearly glabrous, and occurs in North Sumatra, Java and the Lesser Sunda Islands.

Selected sources 74, 407, 786, 1026.

Ipomoea aquatica Forssk.

Fl. Aegypt.-Arab. 44 (1775).

Synonyms *Ipomoea reptans* auct.

Vernacular names Kangkong, water convolvulus, water spinach (En). Patate aquatique, liseron d'eau (Fr). Brunei: kangkong (Bukit Udal). Indonesia: kangkung (general), kalajau (Minangkabau), pangpung (Balinese). Malaysia: kangkung, kankong. Papua New Guinea: kangkong, kango. Philippines: kangkong (Tagalog), galatgat (Iloko). Cambodia: tra kuôn. Laos: phak bong. Thailand: phakbung (general), phak-thotyot (central), kamchon (northern). Vietnam: rau mu[oos]ng, ung th[as]i.

Distribution Native of tropical Asia, possibly India, now circumtropical.

Uses In Brunei, fried leaves are eaten to cool down a fever. In Indonesia, a decoction of the roots is used as a wash against haemorrhoids, and also as a laxative, tonic and antidote against opium or arsenic poisoning or drinking of unhealthy water. The crushed leaves are put on sores and boils. *I. aquatica* is widely used in South-East Asia as a leaf vegetable.

Observations A perennial or sometimes annual, fast growing herb, 2–3 m long, trailing or floating, stem hollow or spongy, succulent, smooth, rooting at the nodes, nodes glabrous or hairy; leaves variable, triangular to lanceolate, 2.5–15 cm × 1–9 cm, base cordate or hastate, basal lobes entire or dentate, petiole 3–20 cm long, green or purple; flowers solitary or in a few-flowered cyme, peduncle 1–12 cm long; pedicel 2–6.5 cm long, sepals subequal, 7–8 mm long, corolla funnel-shaped, 4–7.5 cm long, pink or pale lilac, throat purple or magenta, rarely white, filaments hairy at base, ovary glabrous; capsule ovoid, 7–10 mm long, smooth, brown, partly enclosed by the calyx; seeds 2–4, 4 mm long, angular to rounded, glabrous or velvet, black, greyish pubescent or glabrous. *I. aquatica* occurs in moist, marshy or inundated localities, shallow pools, ditches, rice fields, forming dense masses, and also along roadsides, wild and cultivated, from sea-level up to 1000 m altitude.

Selected sources 74, 135, 215, 407, 647, 786, 914, 1014, 1026, 1070.

Ipomoea carnea Jacq. subsp. fistulosa (Mart. ex Choisy) D.F. Austin

Taxon 26 (2–3): 237 (1977).

Synonyms *Ipomoea fistulosa* Mart. ex Choisy (1845), *Ipomoea crassicaulis* (Benth.) B.L. Robinson (1916).

Vernacular names Shrubby morning glory (Am). Indonesia: kangkungan, klemut, ula (Javanese). Thailand: phak bung farang, phak bung rua (Bangkok). Vietnam: b[if]m b[ooj]ng.

Distribution Native to the Americas, from Florida and Mexico through the Caribbean to Brazil and Paraguay, spread throughout the Pacific and South-East Asia, up to Pakistan. Occasionally cultivated in South-East Asia and India.

Uses The leaves are slightly purgative, and eaten as a vegetable by the Madurese, although they are considered toxic to livestock. In India, the plant is grown as a hedge and green manure, and also as an ornamental.

Observations A perennial, erect or ascending shrub when exposed, 1–3 m tall, twining when shaded, to 5 m long, branches terete or angular, stout, containing a milky juice; leaves ovate to ovate-oblong, 6–25 cm × 4–17 cm, base cordate to truncate, apex acuminate, mucronulate, densely puberulent, subglabrescent; inflorescence a cyme, peduncle stout, 5–10 cm long; pedicel 1–1.5 cm long, puberulent, calyx with 5 nectaries between sepals, sepals subequal, orbicular, ovate to nearly circular, 5–6 mm long, puberulent, corolla tubular or funnel-shaped, 7.5–9 cm long, pink or pale lilac, inside often dark purple towards the base, stamens with very unequal filaments, glabrous; capsule ovoid, 1.5–2 cm long, pale brown, mucronate, finely puberulent basally; seeds 4, 1 cm long, black, brown sericeous. *I. carnea* subsp. *fistulosa* occurs along rivers and canals, sometimes on beaches, locally abundant, from sea-level up to 1000 m altitude. It flowers throughout the year, except during cool periods.

Selected sources 5, 25, 74, 215, 295, 647, 689, 1026.

Ipomoea congesta R.Br.

Prodr.: 485 (1810).

Synonyms *Ipomoea amoena* Blume (1825), *Ipomoea acuminata* Roem. & Schult. var. *burckii* Boerl. (1899), *Ipomoea indica* (Burm.f.) Merr. (1917).

Vernacular names Indonesia: bubgah (Sumatra), pitur (Manado), apukung'a (Talaud). Papua New Guinea: esipota (Sasembata, Northern Province), korokoro (Buin, North Solomons Province). Vietnam: b[if]m t[is]m.

Distribution Circumtropical, throughout Malesia, but not yet collected in Borneo.

Uses On Bougainville Island (Papua New Guinea), Fiji and in India, the sap from the crushed leaves is drunk to relieve dysentery and placed on sores, which are then wrapped with the leaf. In Ambon, the leaves are used as soap to wash clothes. The plant is occasionally cultivated for ornamental purposes.

Observations A herbaceous annual herb, stems twining or sometimes prostrate, and then sometimes rooting at the nodes, more or less densely retrorsely pilose; leaves broadly ovate to orbicular in outline, entire or 3-lobed, 5–17 cm × 3.5–16 cm, base cordate, apex shortly or long-acuminate, petiole 2–18 cm long; umbellate cyme few-flowered, dense, peduncle (0.5–)4–20 cm long, bracts linear to filiform; pedicel 2–5(–8) mm long, sepals equal, 14–22 mm long, hairy or glabrous, corolla funnel-shaped, 5–8 cm long, bright blue or bluish-purple, afterwards more reddish-purple or red, the tube much paler to whitish, filaments hairy at base, ovary glabrous; capsule not seen in Malesian specimens. *I. congesta* occurs in waste places, thickets, forest borders, occasionally on sandy sea-shores, up to 1650 m altitude.

Selected sources 74, 407, 418, 696, 1026.

Ipomoea digitata L.

Syst. nat. ed. 10: 924 (1759).

Synonyms *Ipomoea paniculata* (L.) R.Br. (1810), non Burm.f. (1768).

Vernacular names Malaysia: keledek hutan, akar lanar, akar keremak. Philippines: aurorang gubat, bulakan, malakamote (Tagalog). Cambodia: kantram theari. Thailand: bong len (north-eastern), phak bung rua (Bangkok), man muu (south-eastern). Vietnam: khoai xi[ee]m, t[aaf]m s[es]t.

Distribution Circumtropical.

Uses In Peninsular Malaysia, the root is pounded and applied to swellings. In India and the Philippines, the root is considered tonic, alterative, aphrodisiac, demulcent, lactagogue and cholagogue, and is used for fever and bronchitis. The powdered root is given for diseases of spleen and liver, for menorrhagia, debility and fat accumulation. The plant is also grown for ornamental purposes, and as a fodder for cattle. In India, the seeds are used for coagulating milk.

Observations A large, perennial twiner, sometimes prostrate, stems terete, roots tuberous; leaves orbicular in outline, 6–14 cm × 6–16 cm, palmately divided to or mostly beyond the middle, base cordate or truncate, apex acute or blunt, mucronulate, petiole 3–10 cm long; flowers in a few- to many-flowered cyme, peduncle 2.5–20 cm long, longer than petioles; pedicel 9–25 mm long, sepals subequal, 6–12 mm long, corolla funnel-shaped, tube cylindrical, 5–6 cm long, limb patent, 5–7 cm in diameter, pale red-purple, tube darker inside, filaments hairy at base, ovary glabrous; capsule ovoid, obtuse, 12–14 mm long; seeds 4, black, covered with long, woolly, easily detaching hairs. *I. digitata* occurs in thickets on the beach, but also in waste places, hedges, savanna forests, teak forests and along roadsides, also cultivated, sometimes with variegated leaves, from sea-level up to 700 m altitude.

Selected sources 74, 135, 215, 1026.

Ipomoea nil (L.) Roth

Cat. Bot. 1: 36 (1797).

Synonyms *Convolvulus nil* L. (1762), *Ipomoea scabra* Forssk. (1775), *Ipomoea setosa* Blume (1825).

Vernacular names Blue morning glory (En). Indonesia: areuy jotang bodas (Sundanese), teleng (Javanese). Philippines: bulakan, kamokamotihan (Tagalog). Thailand: waan tam khoei (south-eastern), waan phak bung (Bangkok). Vietnam: h[aws]c s[uwr]u, khi[ee]n ng[uw]u, b[if]m lam.

Distribution Circumtropical including South-East Asia, but not yet found in Borneo.

Uses In Indonesia and Nigeria, the seeds are used as a purgative. In China, the seeds are regarded as a diuretic, anthelmintic and deobstruant and are prescribed for dropsy and constipation, and to promote menstruation. A strong decoction is taken as an abortifacient. A decoction of the root is an emmenagogue. The plant is also widely cultivated for ornamental purposes.

Observations A herbaceous annual or perennial, retrorsely hirsute, stems twining, sometimes prostrate; leaves broadly ovate to orbicular in outline, entire or 3-lobed, 4–14 cm × 3–12 cm, base cordate, apex acuminate, petiole 3–16 cm long;

flowers solitary or in a few-flowered cyme, peduncle 2.5–12 cm long, bracts linear to filiform, 5–8 mm long; pedicel 5–10 mm long, sepals equal, lanceolate, 17–25 mm long, corolla funnel-shaped, 5–6 cm long, pale to bright blue, afterwards red or purple, rarely white, base of filaments with curled hairs, ovary glabrous; capsule ovoid to globular, mucronate, 1 cm in diameter, glabrous, mostly 3-valved and 3-celled; seed 5 mm long, black, grey-puberulent. *I. nil* occurs in hedges, thickets, grasslands, and along roadsides, from sea-level up to 1300 m altitude. Sometimes a weed in sugar-cane plantations.

Selected sources 74, 134, 215, 696, 786, 1026.

Ipomoea obscura (L.) Ker Gawl.

Bot. Reg. 3: t. 239 (1817).

Synonyms *Convolvulus obscurus* L. (1762).

Vernacular names Indonesia: ki papesan (Sundanese), injen-injenan, malingan (Javanese). Philippines: kuskusipa, bang-bangau (Iloko), panggi-panggi (Sulu). Thailand: tong wa (northern), sa uek (central). Vietnam: b[if]m m[owf].

Distribution From tropical Africa, the Mascarene Islands to tropical Asia, throughout Malesia to northern Australia and Fiji.

Uses In Indonesia, a paste of the leaves, together with those of *Argyreia mollis* Chois. and alcohol, is spread on open sores and pustules, to ripen them. The leaves are mucilaginous, with a pleasant smell, and are used crushed or dried and powdered for aphthae. In Nigeria and Kenya, the leaves are eaten as a vegetable.

Observations An annual, slender herb, stems twining or prostrate, 1–2 m long, glabrous or patently hairy, older parts lignescent; leaves ovate, orbicular, to almost kidney-shaped, 2–10 cm × 2–9 cm, base cordate, apex attenuate, acuminate or mucronulate, margins entire or slightly undulate, petiole up to 9 cm long; flowers in a 1–few-flowered cyme, peduncle 1–14 cm long, slender; pedicel 1–2 cm long, clavate and reflexed in fruit, sepals subequal, 3–4 mm long, ovate, often reflexed in fruit, corolla funnel-shaped, 2–2.5 cm long, white or pale yellow with darker midpetaline bands, centre dark purple, filaments unequal, hairy at the base, ovary glabrous; capsule broadly ovoid, 7–8 mm long, mucronate, straw-coloured; seeds 4, 4–4.5 mm long, black, finely grey-puberulent. *I. obscura* occurs in grassland, thickets, hedges, thin forests, waste grounds, along roadsides, occasionally along sandy beaches, from sea-level up to 1300 m altitude.

Selected sources 74, 134, 215, 407, 1026.

Ipomoea pes-caprae (L.) R.Br.

Tuckey, Narr. Exped. Zaire: 477 (1818).

Synonyms *Convolvulus pes-caprae* L. (1753), *Ipomoea biloba* Forssk. (1775), *Ipomoea maritima* (Desr.) R.Br. (1810).

Vernacular names Beach morning glory, horse's footprint, goat's foot creeper (En). Bayhops (Am). Liseron pied de chèvre (Fr). Indonesia: batata pantai (Manado), daun katang (Moluccas), katang-katang (Balinese). Malaysia: batata pantai, tapak kuda. Papua New Guinea: m'buwch (Manus Island), kokolauna (Hula, Central Province), oopurauna (Hisiu, Central Province). Philippines: bagasua (Tagalog, Bisaya), balim-balim (Tagalog), kamkamote (Iloko). Burma (Myanmar): pinlaikazum. Cambodia: trakuon kantek, pak bung tale. Thailand: phak bung thale (central), labuu-lao (peninsular). Vietnam: rau mu[oos]ng bi[eer]n, b[if]m ch[aa]n d[ee].

Distribution Common along all tropical beaches, including South-East Asia.

Uses The plant is mucilaginous and is considered astringent, tonic, alterative, diuretic and laxative, useful in skin affections. In Indonesia, a decoction of the root is considered emollient and diminishes the irritation caused by bladder infections. A paste of the leaves is spread on ulcers and boils, to ripen them. The seed is chewed and swallowed as a remedy for cramp and stomach-ache. In the Philippines, Australia, India and Middle America, a decoction is considered anodynal in rheumatism. Leaf sap is applied to jellyfish stings in Peninsular Malaysia and Thailand. The seeds are taken for stomach-ache in the Philippines, Malaysia, Indo-China and India.

I. pes-caprae is a colonizer of sand dunes and an excellent sand binder.

Observations A perennial, glabrous vine, stems prostrate, sometimes twining, 5–30 m long, containing a milky juice, often rooting at the nodes, taproot thick; leaves often pointing to one side, variable, ovate, elliptical, circular, reniform, 3.5–10 cm × 3–10 cm, base broadly cuneate to truncate, apex emarginate or deeply 2-lobed, 2 abaxial glands at the base of midrib, blade thick, petiole up to 17 cm long; flowers in a 1–few-flowered cyme, peduncle stout, 3–16 cm long; pedicel 1–7 cm long, sepals unequal, somewhat leathery, corolla funnel-shaped, 3–6.5 cm long, purple to reddish-purple, centre with darker inside, filaments hairy at base; capsule globular, 1–1.7 cm in diameter, glabrous, leathery; seeds 4, trigonous-globose, 6–10 mm long, black, densely brownish tomentose. *I. pes-caprae* occurs just behind the flood-line on beaches often colonizing these completely. It also occurs inland, along roadsides and ditches, up to 800 m altitude. Two subspecies are distinguished, subsp. *pes-caprae* with deeply 2-lobed leaves, lobes rounded, corolla about 6.5 cm long, and subsp. *brasiliensis* (L.) Ooststr. with emarginate to truncate leaves, and corolla 3–5 cm long. This later one is most common in South-East Asia.

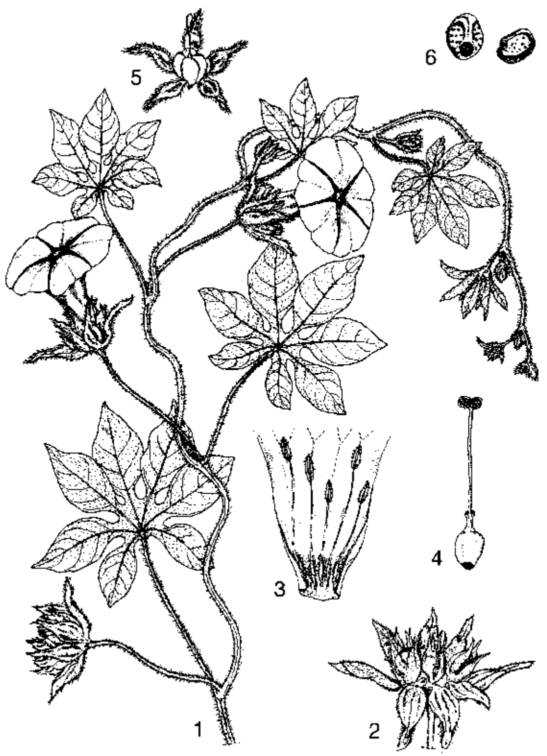
Selected sources 74, 134, 135, 215, 297, 407, 418, 506, 647, 696, 786, 799, 800, 867, 1026, 1071.

Ipomoea pes-tigridis L.

Sp. pl. 1: 162 (1753).

Vernacular names Tiger's footprint (En). Indonesia: gamet (Javanese), samaka furu (Ternate), maka-maka (Tidore). Philippines: bangbangau-ng-buduan (Iloko), malasandia (Panay Bisaya). Thailand: khayum teenmaa (northern), thao saai thong loi (central), phao-la buu-luu (peninsular). Vietnam: b[if]m ch[aa]n c[oj]p.

Distribution From tropical Africa, Mascarene Islands, to continental tropical Asia and throughout Malesia.



Ipomoea pes-tigridis L. – 1, flowering and fruiting branch; 2, fruiting head; 3, opened corolla and stamens; 4, pistil; 5, fruit and calyx; 6, seeds.

Uses In Java, the Philippines, and India the mashed leaves are applied to sores, boils, pimples, and tumours. A decoction of the root is considered purgative and is also administered for haemoptysis. The seed is taken for dropsy. In the Sahel zone of Africa and northern India, the plant is considered a good fodder.

Observations A slender, herbaceous annual, stems twining or sometimes prostrate, 0.5–3 m long, patently hairy with rigid hairs; leaves orbicular or transversely elliptical in outline, 3–7.5 cm × 2.5–10 cm, palmately divided nearly to the base with (3–)5–7(–9) segments, segment oblong to elliptical-oblong, attenuate towards both ends, petiole 1.5–10 cm long; flowers in a few-flowered head, peduncle 2–18 cm long, bracts linear to oblong, 1–3 cm long; sepals slightly unequal, 7–12 mm long, lanceolate, corolla funnel-shaped, 3–4 cm long, the midpetaline bands sparsely hairy, white, filaments unequal, glabrous, ovary glabrous; capsule ovoid, 8 mm long, 1-celled, 4-valved; seeds 4, 4 mm long, sparsely grey-tomentose. *I. pes-tigridis* occurs in grasslands, waste places, fields, thickets, occasionally in teak forests, also in sandy soils near beaches, up to 1300 m altitude. It can be found flowering throughout the year, when sufficient water is available.

Selected sources 74, 134, 135, 215, 295, 407, 647, 786, 1026.

Ipomoea purga (Wender.) Hayne

Getreue Darstell. Gew. 12: 5, t. 33–34 (1833).

Synonyms *Convolvulus purga* Wender. (1830), *Exogonium purga* (Wender.) Benth. (1840).

Vernacular names Philippines: jalapa.

Distribution Originating from southern Mexico to Costa Rica, but has spread to other tropical regions, including South-East Asia. Sometimes cultivated in India as an ornamental and medicinal plant.

Uses The tubers are generally used as a purgative and against inflammations. In small doses, they are employed against gastritis, colitis and chronic dysentery.

Observations A stout, twining herb, roots large, fusiform, tuberous; leaves heart-shaped, 5–11 cm × 3–9 cm, apex pointed, basal leaves with long petiole, upper leaves nearly sessile; flowers solitary or in few-flowered cymes, peduncle 2–4 cm long; sepals equal, small, corolla funnel-shaped, 7–8 cm long, red-purple. *I. purga* grows in thickets, hedges and waste places, from sea-level up to 2000 m altitude.

Selected sources 135, 622, 647, 696, 1026.

Ipomoea triloba L.

Sp. pl. 1: 161 (1753).

Vernacular names Three-lobed morning glory (En). Malaysia: gegasing, kangkong bulu. Philippines: aurora (Sp, Tagalog), bang-ba-ngao (Iloko), muti-muti (Cebu Bisaya). Thailand: yaa dok khon (north-eastern). Vietnam: b[if]m ba th[uf]y.

Distribution Native of tropical America, now a pantropical weed, also in Malesia.

Uses The plant is used in Peninsular Malaysia in a poultice against headache.

Observations An annual herb, stems twining or sometimes prostrate, 1–3 m long, glabrous or sparsely hairy; leaves broadly ovate to orbicular in outline, 2.5–8 cm × 2–7 cm, base cordate, basal lobes rounded or angular to lobed, apex rounded, margins coarsely dentate to more or less deeply 3-lobed, glabrous or sparsely pilose, petiole 3–10 (–18) cm long, slender; flowers solitary or in a few-flowered cyme, peduncle 1–10 cm long, bracts minute; pedicel 2.5–8 mm long, sepals slightly unequal, 7–8 mm long, narrowly oblong, margins fimbriate, corolla funnel-shaped, 18–20 mm long, pink or pale red-purple, sometimes with a darker centre, filaments hairy at base, ovary hairy; capsule subglobular, 5–6 mm long, shortly mucronulate, bristly hairy; seeds 4 or less, 3.5 mm long, glabrous. *I. triloba* occurs in grassland, thickets, hedges, waste places, savanna forests, along roadsides, and occasionally on sandy beaches, from sea-level up to 750 m altitude. It can be found flowering throughout the year.

Selected sources 74, 134, 135, 626, 1026.

Anna L.H. Dibiyantoro & G.H. Schmelzer

Kadsura scandens (Blume) Blume

Fl. Javae: 9 (1830).

SCHISANDRACEAE

$2n$ = unknown

Synonym *Kadsura cauliflora* Blume (1830)

Vernacular names Indonesia: mendulai (Palembang), hunyur buut, ki lembur (Sundanese). Malaysia: belabar, akar dama-dama, kerukol akar.

Origin and geographic distribution *K. scandens* is found in Peninsular Malaysia, Singapore, Sumatra, Java and Bali.

Uses In Sumatra, a decoction of the roots and stem of *K. scandens* is used as an expectorant. The sap of the plant is drunk as a remedy for urinary problems, abdominal pains and diarrhoea. In Java, the fruits are used to alleviate skin problems and the bark is further used to combat fever. In Peninsular Malaysia a decoction of the roots is applied as a lotion for rheumatism. In China, the stem bark is used to treat menstrual disorders and blood deficiency. The ripe fruits are edible and have a sour, somewhat aromatic taste.

Production and international trade *K. scandens* is only used on a local scale.

Properties Detailed research on *K. scandens* is scant. However, some general remarks on the genus *Kadsura* can be made. It is known to biosynthesize and accumulate for example biologically active lignans, the most peculiar being bi-benzocyclo-octadienoid compounds (e.g. kadsurin); biosynthetically these seem to be related to bibenzylbutanoid-type lignans. Further characteristic constituents include series of lanostane-type tetracyclic triterpenic acids, and triterpene lactones (e.g. kadsulactone).

Examples of biological activities of these compounds include for example the triterpene lactone lancilactone (from *K. lancilimba* F.C. How probably *K. renchangiana*), and the di-benzocyclo-octodiene lignans ineteriotherin A and schisantherin D (from *K. heteroclita* (Roxb.) Craib), which showed significant inhibitory activity in vitro against HIV replication in H9 lymphocytes with an EC_{50} value of 1.4 μg/ml and a therapeutic index greater than 71.4, an EC_{50} value of 3.1 μg/ml and a therapeutic index of 13.1 and an EC_{50} value of 0.5 μg/ml and a therapeutic index of 50.6, respectively.

Furthermore, the lignan kadsurenone blocked the Platelet-activating-factor (PAF) induced aggregation and degranulation of isolated human polymorphonuclear leukocytes (PMNs), and several other in vitro models. PAF exhibits potent pro-inflammatory properties, and is secreted by numerous cell types, including e.g. endothelial cells, neutrophils and macrophages. PAF receptor agonists therefore might have potential in the treatment of a vast range of allergic and/or inflammatory based pathophysiological conditions.

Finally, triterpenoid acids from *K. heteroclita* (a species also found in Malesia) and *K. longipedunculata* Finet & Gagnep., collected in southern China, inhibited cholesterol biosynthesis in primary cultures of rat liver cells.

Description A monoecious, woody liana up to 25 m long. Leaves alternate, simple, elliptical to ovate, (9–)10–15(–21) cm × (4.5–)5–9(–15) cm, (1.3–)1.4–2.1(–2.4) times longer than wide, base obtuse to truncate, apex acute to acuminate, margin entire, intercostal venation prominent, papyraceous to coriaceous; petiole (0.8–)1.2–3.0(–4.8) cm long; stipules absent. Flowers usually solitary

Kadsura scandens (Blume) Blume -1, flowering branch; 2, cauliflorous female flowers; 3, gynoecium; 4, androecium; 5, aggregate fruit.

in axils of leaves or in axils of fugaceous bracts, occasionally cauliflorous, unisexual, fragrant; pedicel (4–)8–42(–70) mm long; perianth segments (7–) 11–18, ovate to elliptical, largest up to (7–)9–16 (–19) mm × (5–)7–12(–14) mm, innermost and outermost highly reduced, white, pale yellow or red; male flowers with 24–52 stamens, pink to dark red, anthers almost sessile, closely appressed in a subglobose to ellipsoid androecium, 4–6 mm in diameter, connectives broad with dorso-lateral thecae; female flowers with 50–82(–110) carpels, gynoecium 5–6.5 mm in diameter. Fruit a globose aggregate, about 5 cm in diameter, consisting of 40–100 sessile berries, pericarp greatly thickened distally, ripening red. Seeds 1–2 per berry, pyriform, discoid or reniform, approximately (4.5–) 5.5–8.5(–10) mm × (4–)5–9(–11) mm.

Growth and development *K. scandens* flowers and fruits throughout the year.

Other botanical information *Kadsura* comprises 16 species, with a southern Chinese centre of diversity, extending from Japan in the northeast to the Moluccas, Sulawesi, Java and the Lesser Sunda Islands in the south, and eastern India and Sri Lanka in the west. In Malesia 9 species occur. Formerly *Kadsura*, *Illicium* and *Schisandra* were incorporated in *Magnoliaceae*. Separation into two distinct families *Illiciaceae* (*Illicium*) and *Schisandraceae* (*Kadsura* and *Schisandra*) is supported by morphological and chemical characters. A recent record of *K. scandens* for Brunei may well be a misidentified specimen of *K. acsmithii* R.M.K. Saunders, an endemic in Borneo. The dried fruits of *K. japonica* (L.) Dunal from temperate Asia are the source of 'Fructus Kadsurae'. The drug is used in traditional medicine as a tonic, stimulant, antitussive, beneficial to kidneys and lungs and is prescribed in cough and asthma. The drug is often used as a substitute for *Schisandra chinensis* (Turcz.) Baill. In Indo-China, the roasted fruits of *K. coccinea* (Lem.) A.C. Smith are credited with sedative and hypnotic properties, whereas the seeds are considered a tonic, aphrodisiac and pectoral. Several *Kadsura* species are well-known in traditional Chinese medicine. The stems and roots of plants called *K. lancilimba* F.C. How (possibly *K. renchangiana* S.F. Lan), indigenous to southern China, are used to treat stomach-ache and gastro-enteritis. The stems of *K. heteroclita* (synonym *K. interior* A.C. Smith), indigenous from southern China southward throughout Indo-China, Thailand and Peninsular Malaysia to Sumatra and Borneo, are used in southern China for the treatment of menstrual irregularities, blood deficiencies, and other female disorders.

Ecology *K. scandens* is found in humid lowland to montane forests from sea-level up to 2400 m altitude.

Propagation and planting *K. scandens* can be propagated by seed and most likely by 7–13 cm long semi-ripe stem cuttings. It can possibly be propagated by layering long shoots as well. Plants should be raised in a sheltered location in full sun or partial shade on moderately fertile, well-drained, neutral to slightly acid soils.

Husbandry In the absence of natural supports for *K. scandens* trellis or another sort of framework is essential.

Harvesting Roots, stems and fruits of *K. scandens* are simply collected whenever the need arises.

Genetic resources and breeding The danger of genetic erosion of *K. scandens* appears limited. Although of local occurrence in humid forest it has a wide altitudinal range and its exploitation seems very limited.

Prospects At present, pharmacological research focuses on southern Chinese *Kadsura*. Several lignans, lactones and triterpenoid acids have been identified, which showed interesting pharmacological effects, including anti-HIV-, PAF-antagonistic- and cholesterol biosynthesis inhibitory activities. Related compounds and related activities can be assumed for *K. scandens*, but should be confirmed by research.

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Other selected sources 74, 130, 135, 182, 387, 407, 739, 786, 788, 878, 1027.

J.L.C.H. van Valkenburg & S.F.A.J. Horsten

Kibatalia G. Don

Gen. syst. 4: 86 (1837).

APOCYNACEAE

x = unknown; $2n$ = unknown

Major species *Kibatalia arborea* (Blume) G. Don.

Vernacular names Indonesia: kayu santen (Javanese), ki benteli (Sundanese). Malaysia: jelutong pipit (Peninsular). Philippines: lanete (trade name which includes *Wrightia* spp.). Thailand: ba-du-bu-wae (peninsular). Vietnam: th[aaf]n linh.

Origin and geographic distribution *Kibatalia* comprises 15 species and is restricted to South-East Asia, where it is found from southern China (Yunnan) to Indo-China, peninsular Burma (Myanmar), Thailand, Peninsular Malaysia, Sumatra, Java, Sulawesi, Borneo and the Philippines. Although only 2 species are confined to continental Asia, it is assumed that *Kibatalia* originated from there and spread to the Malesian region afterwards.

Uses In the Philippines, the bark and leaves of *K. blancoi* and *K. gitingensis* are used as a fish poison. A decoction of the root or bark is applied as an abortifacient. In Java, the latex of *K. arborea* is a well-known local anthelmintic. In the Philippines, leaves of *K. maingayi* (Hook.f.) Woodson are externally applied in the treatment of an enlarged spleen. In Vietnam, the latex of *K. macrophylla* (Pierre ex Hua) Woodson (synonym *K. anceps* (Dunn & R. Williams) Woodson) from Indo-China, Thailand and Peninsular Malaysia, is used to arrest bleeding of leech bites.

The wood of *Kibatalia* is used for medium-heavy construction under cover, but more often for small objects such as musical instruments, handicrafts and utensils. The flowers are cooked and eaten as a vegetable.

Properties The major phytochemical characteristic of *Kibatalia* is the occurrence of steroidal alkaloids. The leaves of *K. gitingensis* are relatively rich in these compounds. Among those that have been obtained is gitingensine, which is bis (N-demethyl) kibataline and has spasmolytic properties. The bark of *K. gitingensis* contains numerous alkaloids, among them paravallarine and N-methyl-paravallarine, along with their 20-epimers, and lanitine, or 2α-hydroxy-20-epi-N-methyl-paravallarine, along with its 2-epimers. The chief alkaloid of *K. macrophylla* is the 20-epimer of kibataline. In general, all these alkaloids have the unusual feature of a (18 -> 20S) lactone function. The only alkaloid isolated from *K. arborea* is a simple amino-steroid holafebrine, also present in *Holarrhena pubescens* Wallich ex G. Don. Saponins are present in the leaves of *K. blancoi*, which may explain its use as a fish poison.

Description Evergreen or sometimes deciduous shrubs, or small to large trees up to 45(–65) m tall; bole straight, branchless for up to 30(–40) m, up to 120 cm in diameter, sometimes with short buttresses up to 1.5 m high; bark surface smooth to fissured or sometimes cracked, lenticellate, grey-brown to black, sometimes mottled, inner bark granular, orange to white, often mottled, with copious white latex. Leaves decussate, simple, entire, often with domatia underneath, petioles of a pair connate to form a short cup. Flowers in a terminal or axillary, cymose cluster, 5-merous; calyx lobes imbricate, mostly with colleters inside at base; corolla gamopetalous, white to pale green, with a narrow tube, the lobes overlapping to the right in bud; stamens inserted on the corolla tube, anthers narrowly triangular with a sagittate base, adhering to the pistil head; disk present; ovary superior, 2-carpellate with free carpels and many ovules. Fruit consisting of 2 narrowly ellipsoid or cylindrical follicles with seeds in 2 ranks. Seed pointed or beaked, with a tuft of hairs.

Growth and development Flowering and fruiting in *Kibatalia* seem to occur throughout the year, but in Java *K. arborea* flowers in June–July or October just after the leaves are shed. *Kibatalia* species with seeds bearing a hairy coma are probably wind-dispersed.

Other botanical information Traditionally *Kibatalia* has been placed in the tribe *Nerieae* of the subfamily *Apocynoideae*. It was considered closely related to the liana genera *Vallariopsis*, *Vallaris* and *Beaumontia*. However, recently *Kibatalia* is placed separately in the tribe *Malouetieae*. In the Philippines, reports of *K. blancoi* for Leyte probably are *K. gitingensis*. *K. blancoi*, *K. gitingensis* and *K. elmeri* Woodson, endemic to Luzon, are apparently used indiscriminately in Luzon.

Ecology *Kibatalia* species are found scattered in the canopy or subcanopy layer of lowland and lower montane, primary rain forest on well-drained places like slopes, sometimes along streams or in swamp forest, up to 500(–1200) m altitude. They are found on various soils including sandy soils, limestone and volcanic soils. Occasionally individual *Kibatalia* species are found in freshwater swamp forest and savannas.

Propagation and planting *Kibatalia* can be raised from seed.

Harvesting To obtain the exudate from *Kibatalia*, incisions in the bark are made.

Genetic resources and breeding There are no records of *Kibatalia* species in seed or germplasm banks. Trees are fairly common in the forest and are incidentally grown in botanical gardens. Local utilization can be quite intensive, however, and may deplete particular populations.

Prospects Very little information is available on the pharmacological properties of extracts and purified compounds from *Kibatalia*. More research on this subject will be needed to fully evaluate its potential.

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Selection of species

Kibatalia arborea (Blume) G. Don

Gen. hist. 4: 86 (1837).

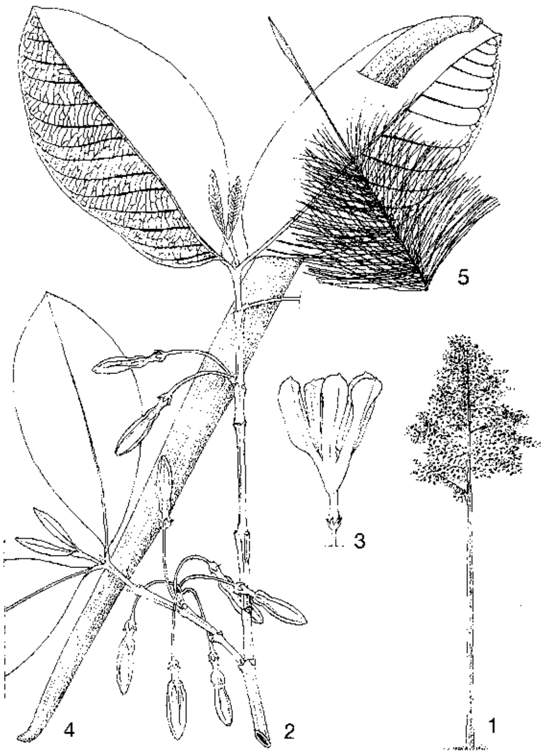
Synonyms *Hasseltia arborea* Blume (1826), *Kickxia arborea* (Blume) Blume (1828), *Tabernaemontana ovalis* Miq. (1862).

Vernacular names Indonesia: lingorumbolia (Sulawesi, Malibi). Malaysia: jelutong beruang, tamadak (Peninsular). Thailand: ba du bu wae (peninsular).

Distribution Peninsular Thailand, Peninsular Malaysia, Sumatra, Java, Sulawesi, Borneo (Sarawak, Sabah) and the Philippines (Palawan).

Uses A few drops of the latex in a glass of water is a well-known local anthelmintic in Java, but it can easily cause inflammation.

Observations A big tree up to 45(–65) m tall; leaves elliptical to obovate, 10–26(–35) cm × (5–)8–13 cm, with 15–60 colleters in the leaf axils; inflorescence a 1–12-flowered, cymose cluster, sepals shortly united, with 70–100 colleters inside, corolla very variable, the lobes 0.2–2.2 times as long as the tube; fruit consisting of 2 paral-



Kibatalia arborea (Blume) G. Don – 1, tree habit; 2, flowering twig; 3, flower; 4, fruit; 5, seed.

lel–divergent mericarps, mericarp very narrowly ellipsoid to very narrowly clavate, 25–35 cm × 1–2.5 cm. *K. arborea* is found in lowland forest, often on stream banks and steep slopes up to 500 m altitude.

Selected sources 135, 283, 672.

Kibatalia blancoi (Rolfe ex Stapf) Merr.

Philipp. Journ. Sci., Bot. 17: 309 (1920).

Synonyms *Kickxia blancoi* Rolfe ex Stapf (1905), *Kickxia merrittii* Merr. (1909).

Vernacular names Philippines: laniting gubat (Tagalog), pasnit (Iloko), baguibonlas (Panay).

Distribution The Philippines (Luzon, Catanduanes, Mindoro, Panay, Guimaras).

Uses In the Philippines, the bark and leaves are used as a fish poison. A decoction of root or bark is used as an abortifacient. The leaves applied externally on the forehead are presumed to relieve headache. The wood is used for making wooden shoes.

Observations A tree up to 20 m tall; leaves narrowly elliptical, (5–)6–11 cm × 1–4 cm, with up to 3 colleters in the leaf axils; inflorescence a few-flowered, cymose cluster, sepals free with 4–15 colleters inside, corolla very variable, the lobes 1.1–4 times as long as the tube; fruit unknown. *K. blancoi* is found on volcanic soils in mountainous areas.

Selected sources 128, 283, 810.

Kibatalia gitingensis (Elmer) Woodson

Philipp. Journ. Sci., Bot. 60: 216 (1936).

Synonyms *Kickxia gitingensis* Elmer (1912), *Vallaris angustifolia* Merr. (1912), *Vallaris gitingensis* (Elmer) Merr. (1915)

Vernacular names Philippines: laniting gubat (Tagalog), laniti (Bisaya).

Distribution The Philippines (Luzon, Catanduanes, Leyte, northern Mindanao).

Uses *K. gitingensis* is used in the same way as *K. blancoi*.

Observation A tree up to 30 m tall; leaves narrowly elliptical to narrowly ovate, 4–10 cm × 0.8–4 cm, with 2–8 colleters in the leaf axils; inflorescence a congested 4–24-flowered cymose cluster, sepals shortly united with 2–4 colleters inside, corolla very variable, the lobes 1–2 times as long as the tube; fruit consisting or 2 mericarps, usually only 1 fully developed, narrowly ellipsoid, 8–26 cm × 0.3–0.4 cm. *K. gitingensis* is found in hill forest at 150–525 m altitude.

Selected sources 283, 810.

Rudjiman

Laportea Gaudich.

in Freyc., Voy. Uranie: 498 (1830).

URTICACEAE

$x = 10$; *L. bulbifera*: $2n = 20, 60$

Major species *Laportea decumana* (Roxb.) Wedd., *L. interrupta* (L.) Chew.

Origin and geographic distribution *Laportea* comprises about 22 species, centred in Africa and Madagascar; 3 species are pantropical. In Malesia, 5 species are found.

Uses The use of leaves or twigs of various *Laportea* in poulticing as an analgesic can be largely ascribed to the irritating hairs. A decoction is taken as a diuretic. In Bougainville Island (Papua New Guinea) the root and stem bark of *L. aestuans* or the closely resembling *L. ruderalis* (J.G. Forster) Chew are externally applied to sores on the sole of feet. In Nigeria, *L. aestuans* is used to treat burns and whitlow. In India, *L. interrupta* is used as a mild irritating rubefacient to treat alopecia by intensifying the capillary blood flow, and keeping the scalp and the hair follicles active.

Production and international trade *Laportea* is only used on a local scale.

Properties Both aqueous and ethanol extracts of the leaves of *L. interrupta* show strong nematicidal activity against *Meloidogyne incognita* larvae.

The methanol extract of *L. aestuans*, before and after filtering through charcoal, and various fractions were assayed against 12 species of pathogenic bacteria and fungi. Extracts were active against 7 of these, especially *Staphylococcus aureus*. In subsequent phytochemical screenings, reactions were positive for steroids, but negative for alkaloids, flavonoids and anthraquinones.

Description Monoecious, rarely dioecious herbs or shrubs with irritant hairs. Leaves alternate, simple, variously dentate, chartaceous; petiolate; stipules intrapetiolar, partially connate, bifid. Inflorescence axillary, paniculate, pedunculate. Flowers in loose glomerules, pedicels winged; male flowers tepals 4–5, stamens 4–5, filaments reflexed, pistillode small; female flowers, tepals 4, the dorsiventral ones unequal, smaller than the lateral ones, ovary superior, ovoid, style linear, rarely bush-like, staminodes absent. Fruit an achene, compressed, ovoid to hemispherical, sessile or stipitate, reflexed.

Growth and development Most *Laportea* species flower and fruit with no particular seasonality.

Other botanical information *Laportea* comprises 2 sections: *Laportea* with 10 species and *Fleurya* with 12 species. In section *Laportea* the female pedicels are winged laterally. *Laportea* is closely related to *Nanocnide*, the latter differs in its erect achenes, and the free and lateral stipules.

Ecology The majority of Malesian species, *L. aestuans*, *L. decumana*, *L. interrupta* and *L. ruderalis*, prefer tropical lowland conditions. However, *L. bulbifera* (Siebold & Zucc.) Chew has a great climatic tolerance and is found from cool temperate northern China throughout South-East Asia to Sumatra and Java, where it prefers highlands above 1000 m altitude.

Propagation and planting *Laportea* can be propagated from seed. In the vicinity of villages plants are sometimes tended for daily use.

Diseases and pests In Costa Rica *L. aestuans* is a host for *Meloidogyne incognita*, a local pest in banana plantations.

Harvesting Leaves or roots of *Laportea* are collected from the wild or from tended plants whenever needed.

Handling after harvest All plant parts of *Laportea* are usually used fresh.

Genetic resources and breeding All *Laportea* species described here have a large area of distribution; several species are common in disturbed habitats, and they do not seem to be at risk of genetic erosion.

Prospects Very little information is available about the phytochemistry (only screening) and pharmacology of *Laportea*. More research is therefore needed in order to evaluate its potential.

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Selection of species

Laportea aestuans (L.) Chew

Gard. Bull. Sing. 21: 200 (1965).

Synonyms *Fleurya aestuans* (L.) Gaudich. (1830).

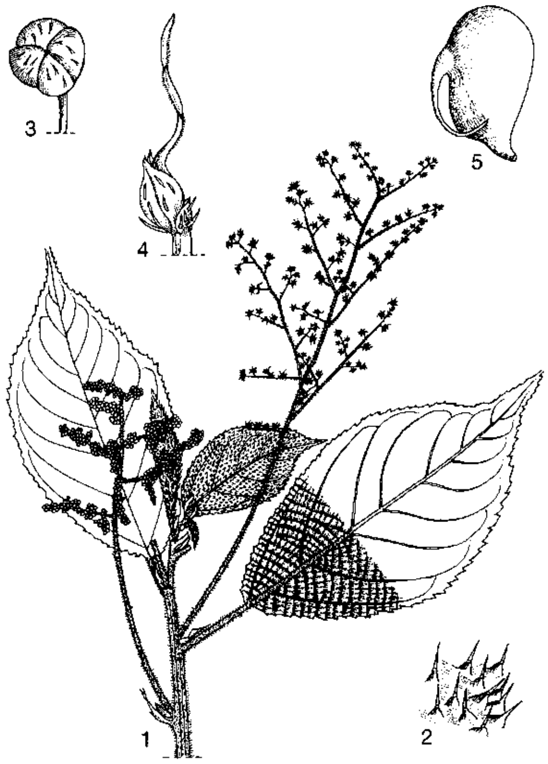
Vernacular names Papua New Guinea: maribean (Kurtatchi, Bougainville Island).

Distribution From tropical America, the West Indies, tropical Africa, Madagascar, Arabia, India to Sumatra, Java and the Lesser Sunda Islands, possibly extending to New Guinea.

Uses In Bougainville Island (Papua New Guinea), the root and stem bark are externally applied to sores on the sole of the feet. In Trinidad, Brazil and Peru, a decoction of the plant is taken as a diuretic.

Observations A monoecious, annual herb up to 1(–)2 m tall, stem fleshy, slightly woody at base, with few branches, glabrescent to densely armed with short irritant hairs and long glandular hairs; leaves ovate to broadly ovate, (3–)10–15(–30) cm × (2–)8–12(–21) cm, base rounded to cordate, apex acuminate, margin dentate, with scattered irritant hairs on the upper surface, petiole (2–) 5–15(–20) cm long, densely covered with irritant and long glandular hairs, stipules up to 1 cm long, with few short irritant hairs; panicle bisexual, well-branched, usually solitary, up to 20 cm × 10 cm, bracteolate, male flowers pedicellate, about 1.5 mm long, with few glandular hairs and very few irritant hairs, filaments reflexed, interfloral bracts very numerous, female flowers pedicellate, pedicel slightly winged dorsi-ventrally, glabrescent, stigma linear, unbranched, about 0.3 mm long, interfloral bracts minute, numerous; achene asymmetrically ovoid, stipitate, 1–2 mm × 1–2 mm, partly surrounded by a narrow membranaceous wing, on each lateral side a triangular ridge enclosing a warty depression, perianth reflexed, pedicel often winged dorsi-ventrally; achene dispersed with perianth and upper portion of pedicel attached. *L. aestuans* is common in disturbed semi-shaded habitats, along roads in abandoned gardens, plantations and shoreline vegetation dominated by *Pisonia grandis* R.Br.

Selected sources 74, 418, 696.



Laportea decumana (Roxb.) Wedd. -1, flowering twig; 2, detail of leaf surface; 3, male flower; 4, female flower; 5, achene.

Laportea decumana (Roxb.) Wedd.

Arch. Mus. Hist. Nat. Paris 9: 127 (1856).

Synonyms *Urtica decumana* Roxb. (1832).

Vernacular names Indonesia: daun gatal besar (Moluccas), afa (Ayawasi, Papua). Papua New Guinea: irongo (Oro Province), ton (Central Province), lang (Wutun, West Sepik).

Distribution From southern Borneo eastward to Sulawesi, the Moluccas and New Guinea. Locally cultivated in New Guinea and the Moluccas.

Uses In many areas of Papua New Guinea the leaves are rubbed on various parts of the body to counteract fever, body pains, fatigue, stomachache and headaches. For the same indications the leaves are merely stroked or gently beaten on the skin in the Moluccas. Locally in the highlands of Papua New Guinea, fresh young leaves are eaten with sweet potato or taro for intestinal pains.

Observations A monoecious, perennial herb, subshrub or shrub up to 2 m tall, stem woody, well-branched, densely armed with irritant hairs; leaves broadly ovate, rarely elliptical, 20–30(–35) cm × (6–)12–18 cm, base rounded to cordate, apex long acuminate, margin serrulate to denticulate, strongly rugose, densely woolly especially at the lower surface, with long irritant hairs on both surfaces, petiole (2–)5–8(–10) cm long, long rigid irritant hairs present, stipules up to 2 cm long, with short irritant hairs; panicle unisexual, well-branched, usually solitary, the male up to (10–)16–20(–25) cm × (4–)6–10(–15) cm, the female up to (20–)30–40(–55) cm × (4–)8–15(–20) cm, bracteolate, male flowers pedicellate, about 2 mm long, glabrous except for a few rather long irritant hairs, filaments reflexed, interfloral bracts present, female flowers pedicellate, glabrous except for a few rather long irritant hairs, stigma linear, unbranched, up to 3 mm long, interfloral bracts present; achene pyriform, stipitate, to 2.5 mm × 2.5 mm, smooth, perianth persistent, stigma persistent, pedicel slightly to strongly winged laterally; achene dispersed free from the perianth. *L. decumana* is common in forest margins and as undergrowth in hedges at low elevations.

Selected sources 74, 83, 407, 416, 418, 419, 420, 422, 427, 428, 432, 433, 434, 435, 436, 437, 438.

Laportea interrupta (L.) Chew

Gard. Bull. Sing. 21: 200 (1965).

Synonyms *Urtica interrupta* L. (1753), *Fleurya interrupta* (L.) Wight (1853).

Vernacular names Papua New Guinea: loogum (Nasingalatu, Morobe Province), o'onu (Delena, Central Province), bobwwiar (Kurtatchi, North Bougainville). Philippines: lipang aso (Tagalog), dalamo, langala (Bisaya). Thailand: kalangtang kai (peninsular), tamyae tuamia (central), haan kai (northern). Vietnam: han, m[as]n.

Distribution Throughout the Old World tropics.

Uses In the Philippines, the leaves are applied to carbuncles, a decoction of the root is taken as a diuretic, and also prescribed as a remedy for coughs and asthma. In Morobe Province (Papua New Guinea), the leaves are rubbed on the head to relieve headache. In coastal regions the leaves are rubbed on the stomach to ease stomach-ache. In Bougainville, the flowers are externally applied to sores on the sole of feet. In the Central Province, the plant is boiled together with *Phyllanthus amarus* Schum., *P. debilis* Klein ex Willd. or *P. urinaria* L. and the solution drunk to relieve whooping cough. In Thailand, the whole plant is used as expectorant and anthelmintic.

Observations A monoecious, annual herb up to 2 m tall, woody at base, with irritant hairs towards the apex; leaves ovate to broadly ovate, (5–)8–12(–18) cm × (3–)5–7(–12) cm, base obtuse, rounded to slightly cordate, apex acuminate, margin serrate, glabrous with few scattered irritant hairs, petiole (3–)5–8(–12) cm long, irritant hairs present, stipules 3–5 mm long, almost glabrous; panicle bisexual, side-branches solitary, often suppressed, up to 30 cm long, flowers fasciculate at intervals along elongated peduncle, male flowers pedicellate, tepals corniculate, few irritant hairs present, filaments reflexed, interfloral bracts present, female flowers pedicellate, pedicel slightly winged dorsi-ventrally, glabrous except for a few irritant hairs, stigma linear, trifid, reflexed, the central branch to 0.5 mm long, interfloral bracts minute; achenes asymmetrically ovoid, sessile, about 1.3 mm long, completely surrounded by a narrow membranaceous wing, on each lateral side a triangular ridge enclosing a warty depression, perianth reflexed, pedicel slightly or not winged dorsi-ventrally; achene dispersed with perianth and upper portion of pedicel attached. *L. interrupta* is common in disturbed habitats under partial shade at low elevations.

Selected sources 74, 128, 241, 418, 421, 429, 810.

J.L.C.H. van Valkenburg

Leea van Royen ex L.

Syst. Nat. ed. 12, 2 : 627 (1767).

LEEACEAE

$x = 12$; *L. aculeata*: $2n = 24$, *L. guineensis*: $2n = 24$, *L. indica*: $2n = 20, 22, 24$, *L. macrophylla*: $2n = 24$

Major species *Leea guineensis* G. Don, *L. indica* (Burm.f.) Merr.

Vernacular names Malaysia: mali-mali (Peninsular). Thailand: katang bai. Vietnam: g[oos]i h[aj]c.

Origin and geographic distribution *Leea* comprises about 34 species, confined to the Old World tropics. Twenty-five species are endemic to Malesia (with a few extending to Queensland (Australia), Micronesia and Fiji), 1 species is found from tropical Africa and Madagascar, throughout South-East Asia to Micronesia (*L. guineensis*).

Uses The roots, tubers and stems of various *Leea* species are mucilageous and astringent. Leaves and twigs have antiseptic properties and are used for poulticing wounds (e.g. *L. aequata*, *L. angulata* Korth. ex Miq.). In the Philippines, the leaves of *L. aculeata* Blume ex Spreng. (synonym *Leea sandakensis* Ridley) are used for purifying bad blood. In Java, the sap of *L. angulata* is used medicinally. In Peninsular Malaysia, the leaves of *L. curtisii* King (synonym *Leea stipulosa* Gagnep.) pounded with tobacco are mentioned as a remedy for baldness. In India, the roots of *L. crispa* van Royen ex L. are used for guineaworm and the leaves are applied to wounds. In some areas of India *Leea* is an important bee plant. Some *Leea* species are well-known garden and pot plants in tropical and subtropical regions e.g. *L. guineensis* and *L. indica*.

Production and international trade *Leea* is only used at a local level.

Properties *L. aequata* yields 0.15% essential oil on steam distillation. The essential oil inhibits the growth of *Mycobacterium tuberculosis* at a concentration of 10 μg/ml in vitro. The oil also inhibits the growth of *Micrococcus pyogenes* at 100 μg/ml, and *Pasteurella pestis* at 50 μg/ml. Steam distillation of wood or leaves of *L. guineensis* also yields an essential oil, consisting of complex mixtures. The essential oil from the wood, however, differs significantly from that of the leaves; in general the wood oil contains more long chain aldehydes and phenylpropanoids, compared to the leaf oil, which is far more rich in terpenoidal compounds. Phytochemical screening of several *Leea* species also showed an abundant presence of phenolic constituents such as flavonoids, leucoanthocyanidins, p-hydroxybenzoic acid, syringic acid and gallic acid which are e.g. present in the leaves of *L. guineensis*, *L. indica*, *L. macrophylla* and *L. rubra*. Tannins may also be present in appreciable amounts in some species.

Further pharmacological effects include a flavonoid sulphate (quercetrin 3-O-α-L-rhamnopyranoside-3'-sulphate) isolated from the leaves of *L. guineensis* which shows antioxidant activity, and an ethanolic extract of *L. indica* which selectively inhibits herpes simplex type 1 (HSV-1) virus at a minimum inhibitory concentration of 0.001–0.1 mg/ml.

Description Herbaceous plants with a woody base, scramblers, creeping or erect shrubs or small trees; stems with spines or unarmed. Leaves distichous, 1-foliolate, 3-foliolate, or 1–4-pinnate, usually imperfectly imparipinnate; petiole expanded to form a stipular structure surrounding the stem apex; stipules narrowly sheathing and subpersistent, or large, obovate and caducous. Inflorescence a leaf-opposed cyme, lax or condensed, erect or pendulous. Flowers bisexual, actinomorphic, 4–5-merous; calyx campanulate, lobes triangular; corolla lobes valvate in bud, apical part of each lobe joined into a keel, reflexed at maturity, basal part joined to each other and the androecium; staminodial tube with an upper portion consisting of 4–5 thickened lobes connate to each other by thinner tissues forming sinuses over which the filaments pass; ovary superior, discoidal, 4–10-locular, each locule with 1 ovule; style short, entire. Fruit a berry, depressed subglobose. Seed triangular-ovoid in cross-section, endosperm ruminate. Seedling with epigeal germination; cotyledons leafy; hypocotyl elongated; all leaves arranged spirally.

Growth and development In general flowers of *Leea* are pollinated by flies and the fruits are dispersed by birds. The inconspicuous, scentless flowers of the greenish-white flowered species are frequented by short-tongued bees and sylphids.

Other botanical information *Leeaceae* is a monogeneric family closely allied to the *Vitaceae* in the order *Rhamnales*, separated because of the development of a complex staminodial tube joined to the corolla, the ovary locules that each have a single ovule, and its pollen morphology.

In the horticultural trade the name *L. rubra* is often used for the reddish-leaved forms of *L. guineensis*. The genuine *L. rubra* is not cultivated. The names *L. coccinea*, *L. manillensis* and *L. sambucina* are still widely used in horticulture. *L. sambucina* has been widely misapplied to *L. guineensis* in the botanical literature; the name is a synonym of *L. indica*.

Distinguishing some forms of *L. indica* from *L. guineensis* can sometimes only be done on the basis of the flower colour.

Ecology The majority of the widespread *Leea* species are found below 100 m altitude, but a few species ascend occasionally to 1500 m (*L. guineensis*) or even to 1700 m (*L. indica*) altitude.

Propagation and planting *Leea* can be propagated by stem cuttings, air-layering or by seed. It is best grown in light shade in moderately fertile and freely draining but moisture-retentive soils.

Husbandry *Leea* grown as ornamental can be pruned to shape. *L. indica* responds well to coppicing.

Diseases and pests In Hawaii cultivated *L. guineensis* is susceptible to *Phytophthora meadii* causing leaf spot, blight, defoliation and death of young plants, and *Calonectria crotalariae* causing collar rot and leaf spot. In France, *Phytophthora nicotianae* var. *nicotianea* may cause problems in *L. guineensis*.

Harvesting Plant parts of *Leea* are collected whenever the need arises. Aboveground parts are obtained by clipping stems, whereas roots are simply dug up.

Handling after harvest Leaves and stems of *Leea* used for poulticing are used fresh.

Genetic resources and breeding All *Leea* species of medicinal importance indicated here have a large area of distribution, either naturally or as a result of cultivation, and do not seem to be at risk of genetic erosion. Apart from living collections in botanical gardens there are no germplasm collections or known breeding programmes of *Leea* for medicinal purposes.

Prospects Too little information is available to evaluate the potential of *Leea* in local medicine, although the anti-viral activity looks promising. More research is therefore needed.

Literature |**1**| Ali, A.M., Mackeen, M.M., El-Sharkawy, S.H., Hamid, J.A., Ismail, N.H., Ahmad, F.B.H. & Lajis, N.H., 1996. Antiviral and cytotoxic activities of some plants used in Malaysian indigenous medicine. Pertanika 19(2–3): 129–136. |**2**| Chuakul, W., Saralamp, P., Paonil, W., Temsiririrkkul, R. & Clayton, T. (Editors), 1997. Medicinal plants in Thailand. Vol. II. Department of Pharmaceutical Botany, Faculty of Pharmacy, Mahidol University, Bangkok, Thailand. pp. 140–141. |**3**| Council of Scientific and Industrial Research, 1962. The wealth of India: a dictionary of

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Selection of species

Leea aequata L.

Syst. Nat. ed. 12, 2: 627 (1767).

Synonyms *Leea hirta* Roxb. ex Hornem. (1813), *Leea hispida* Gagnep. (1910).

Vernacular names Indonesia: ginggiyang (Sundanese), girang (Javanese), mali-mali (Makassar). Vietnam: c[ur] r[oos]i ph[us]n.

Distribution From India and Burma (Myanmar), throughout South-East Asia and Malesia, but absent in New Guinea.

Uses The roots, tubers and stems are mucilaginous and astringent. Leaves and twigs have antiseptic properties and are used for poulticing wounds. In Java, the sap obtained from young shoots is ground with ashes and applied to cleanse wounds.

Observations A shrub, treelet or less frequently a small tree up to 10 m tall, young branches usually densely hairy; leaves 1–3-pinnate, leaflets 5–numerous, rachis 7–20(–25) cm long, petiole (5–)8–14(–20) cm long, stipules oblong-obovate 1.5–4.5 cm × 3–6(–10) cm, pubescent to densely hairy, leaflets ovate to ovate-lanceolate or elliptical to elliptical-lanceolate, (3–)10–22(–30) cm × (1.5–)4–8(–12) cm, base cuneate to truncate, sometimes unequal, apex acuminate, margin serrate, pearl-gland rounded to discoidal, large, conspicuous and brown; cyme 4–14(–20) cm long, rusty pubescent to hairy, bracts up to 8 mm × 5 mm, conspicuous; flowers greenish white, calyx about 4 mm × 4 mm, glabrous to pubescent, usually with pearl-glands, staminodial tube about 2 mm long, upper free part 1.5–2 mm long, lobes deeply notched, sinuses shallow, ovary 4–7-celled; berry 8–15 mm in diameter, orange-red, 5–6-seeded; seed 4–6 mm across. *L. aequata* has a widespread but scattered distribution, in secondary vegetation from sea-level up to 1400 m altitude, usually at lower elevation.

Selected sources 135, 215, 407, 949.

Leea guineensis G. Don

Gen. hist. 1: 712 (1831).

Synonyms *Leea manillensis* Walp. (1843), *Leea coccinea* Planch. (1854), *Leea sambucina* auct. non Willd.

Vernacular names West Indian holly (*L. coccinea*)(En). Philippines: abang-abang (Tagalog), mali-mali (Tagalog, Pampanga). Thailand: kradangngaa daeng (central), khueang khaeng maa (northern), seesa lueat (peninsular). Vietnam: g[oos]i h[aj]c tr[aws]ng, c[or] h[aj]c.

Distribution From tropical Africa, Madagascar, India, Burma (Myanmar), throughout South-East Asia (except New Guinea) to Taiwan and Palau (Micronesia).

Uses In the Philippines, a decoction of the roots, twigs and leaves is considered a vulnerary. In Africa, the leaves are externally applied as poultices on muscular pains, arthritis and rheuma-

Leea guineensis G. Don – 1, fruiting branch; 2, flower at anthesis; 3, variation in stipules; 4, fruit.

tism; roasted they are applied to the head for vertigo. The pounded root is externally applied to rheumatism, localised oedema, as well as to abscesses and furuncles, to mature them, and to wounds as a haemostatic and to promote healing.

Observations A shrub, sometimes with a creeping rootstock, or semi-woody branches or tree, 1–5(–10) m tall, young twigs glabrous; leaves (1–)2 or 3(–4)-pinnate, leaflets numerous, rachis up to 50 cm long, petiole (5–)10–20(–25) cm long, stipules obovate, 2–4(–6) cm × (1–)1.5–3 cm, early caducous, glabrous, leaflets ovate to ovate-lanceolate or elliptical to elliptical-lanceolate, (3–)8–20 (–30) cm × (1.5–)3–8(–14) cm, base cuneate to rounded, apex (long-)acuminate, margin repand to denticulate, pearl-glands small, inconspicuous, caducous; cyme (3–)10–25(–40) cm long, lax or compact, rusty pubescent, bracts ovate to deltoid, up to 3 mm long; flowers red to reddish-orange, calyx about 1–3 mm × 2–4 mm, glabrous to pubescent, staminodial tube red to citrous-white, about 2–3 mm long, upper free part 1.5–2.5 mm long, lobes shallowly retuse, notched or cleft, sinuses shallow, ovary (4–)6(–8)-celled; berry 5–15 mm in diameter, red, 6-seeded; seed 6 mm × 5 mm.
L. guineensis is a complex species of overlapping entities, sometimes having different ecological preferences. It is particularly variable in Madagascar and the Philippines. Within South-East Asia two ecological forms can be discerned, one of shaded forest occurring in Peninsular Malaysia, Sumatra and Java, the other in secondary vegetation occurring in mainland Asia and the Philippines. In the Philippines it appears to replace *L. indica* in secondary vegetation. *L. guineensis* is found in secondary and primary vegetation in Taiwan, the Philippines and Micronesia; throughout the remainder of Malesia it is rather rare in primary forest and shaded localities, but a common component of secondary vegetation in mainland Asia and Africa, from sea-level up to 1500 m altitude.

Selected sources 134, 810, 949.

Leea indica (Burm.f.) Merr.

Philipp. Journ. Sci. 14: 245 (1919).

Synonyms *Leea sambucina* (L.) Willd. (1798), *Leea gigantea* Griff. (1854), *Leea sundaica* Miq. (1859).

Vernacular names Indonesia: ki tuwa (Sundanese), kayu tuwa (Javanese). Malaysia: mali-mali, merbati padang, jolok-jolok (Peninsular). Papua New Guinea: paikoro (Gunantuna, East New Britain), dadoro (Garara, Oro Province), warawa (Navuapaka, Central Province). Philippines: mali (Tagalog), amamali (Bisaya). Thailand: katangbai (northern, Bangkok, south-eastern), bangbaai ton (peninsular). Vietnam: c[ur] r[oos]i den.

Distribution From India, Sri Lanka, throughout South-East Asia, to northern Australia, Solomon Islands, New Hebrides and Fiji.

Uses In Malaysia and East New Britain, the pounded leaves are used for poulticing cuts and skin complaints in general. It is placed upon the head in fever, and as a general anodyne for body pains. In the Central Province in Papua New Guinea, a decoction of the shoots is applied to sores. In the Oro province the body is beaten for some time with leafy shoots to relieve body pains, fevers and sleeplessness. In Malaysia, a decoction of the roots is taken to relieve stomach-ache. In Java, the leaves are applied as a poultice for headache. In the Moluccas, the leaves pounded with coconut oil are heated and applied to cuts and wounds. In Thailand, the root is considered antipyretic and diaphoretic. It is used to relieve muscular pain, and is an ingredient of a preparation to treat leucorrhoea, intestinal cancer and cancer of the uterus. In the Manus Province, Papua New Guinea, young shoots are chewed to relieve a severe cough. In India, the roots are used in diarrhoea, colic, dysentery and as a sudorific. The leaves are roasted and applied to the head for vertigo. The tender shoots are used as a vegetable and the fruits are edible.

Observations A shrub, treelet or small tree 2–10(–16) m tall, many- or single-stemmed, frequently stilt-rooted, stems glabrous to pubescent; leaves (1–)2–3-pinnate, leaflets 7–numerous, rachis (6–)10–35(–60) cm long, petiole (6–)10–25 (–35) cm long, stipules obovate, up to 6 cm × 4 cm, early caducous, usually glabrous, leaflets ovate-oblong to ovate-lanceolate or elliptical to elliptical-lanceolate, (4–)10–24(–45) cm × (1–)3–12(–20) cm, base cuneate to rounded, apex acute to acuminate, margin serrate to shallowly dentate, pearl-glands small, inconspicuous, rapidly caducous; cyme (5–)10–25(–40) cm long, usually lax, sometimes compact, glabrous to pubescent, bracts deltoid to narrowly triangular up to 4(–8) mm long; flowers greenish-white, calyx about 2–3 mm × (2–)3–4 mm, glabrous to pubescent, staminodial tube about 2–2.5 mm long, upper free part about 1–2 mm long, lobes shallowly retuse, notched or cleft, sinuses shallow, ovary (4–)6(–8)-celled; berry 5–10(–15) mm in diameter, purple-black, 6-seeded; seed 5 mm × 4 mm. *L. indica* is widespread and common in primary and secondary forest, and around villages (often coppiced), in wet areas as well as ridges, from sea-level up to 1700 m altitude.

Selected sources 99, 135, 201, 215, 407, 418, 949.

Leea macrophylla Roxb. ex Hornem.

Hort. bot. hafn. 1: 231 (1813).

Synonyms *Leea robusta* Roxb. (1814), *Leea latifolia* Wallich ex Kurz (1875), *Leea parallela* Wallich ex Laws. (1875).

Vernacular names Thailand: phayaa raak lo (central), khueang huu chaang (northern), suea nang rom (south-western).

Distribution India, Burma (Myanmar), Thailand and Indo-China.

Uses In India, the roots are credited with anodyne properties. They are externally applied to wounds and sores and used for guineaworm and ringworm. They are also taken for dysentery and for diarrhoea in cattle. Locally the root paste is consumed with a glass of milk as a single monthly dose for birth control. It is planted in Sri Lanka for the astringent properties of the root. The root contains a red colouring agent for cloth. The leaves are eaten as a vegetable and the fruits are edible.

Observations A herb, shrub, or sometimes a tree, young twigs pubescent, often appearing mealy; leaves 1-foliolate, 3-foliolate or 1–3-pinnate, leaflets 7–21(–numerous), rachis (0–)10–15 (–40) cm long, petiole up to 20 cm long, stipules obovate, 2–6 cm × 1–4 cm, leaflet in 1-foliolate specimens broadly ovate, 20–65 cm × 15–60 cm, base cordate, apex acuminate, margin serrate, in pinnate specimens variable, ovate to ovate-lanceolate or elliptical to elliptical-lanceolate, (8–)14–26 (–35) cm × (2–)4–8(–14) cm, base rounded to subcordate, apex acuminate, margin sinuate to repand or serrate; cyme 12–45(–60) cm long, broad, multi-branched, somewhat lax, finely mealy pubescent, bracts deltoid to narrowly triangular, up to 6 mm long; flowers greenish-white, calyx about 1.5–3 mm × 2.5–4 mm, mealy pubescent, staminodial tube 1.5–2 mm long, upper free part 1.3–1.8 mm long, lobes slightly retuse or shallowly cleft, sinuses 1.3–1.8 mm deep, ovary 6-celled; berry 10–15 mm in diameter, 6-seeded; seed 4 mm × 3 mm. *L. macrophylla* is a complex species with a variety of forms, that are probably ecological. It is found in open vegetation, dry forest and teak forest, particularly forest borders and regrowth, from sea-level up to 2250 m altitude. It may well be cultivated in Malesia.

Selected sources 201, 215.

Leea rubra Blume ex Spreng.

Syst. veg. 1: 670 (1824).

Synonyms *Leea polyphylla* Miq. (1859), *Leea brunoniana* Clarke (1881), *Leea linearifolia* Clarke (1881).

Vernacular names Indonesia: ginggijan beureum (Sundanese), girang (Javanese). Malaysia: mali-mali puchok merah. Thailand: katangbai (Bangkok), khueang (central). Vietnam: g[oos]i h[aj]c t[is]a, ph[is] t[uwr], cu ch[os]i.

Distribution From India, Burma (Myanmar) throughout South-East Asia, to northern Australia.

Uses In Peninsular Malaysia, the ground root mixed with arsenic is externally applied as a poultice against yaws, while the sap of the plant is drunk simultaneously. In Java, the leaves are externally applied for poulticing wounds, the fruits are eaten as a remedy against yaws and dysentery. In Indo-China, a decoction or tincture of the root is taken against stomach-ache, rheumatism and arthritis. In Thailand, the roots are used as an antipyretic and diaphoretic.

Observations A small semi-herbaceous shrub, up to 3 m tall; leaves 2–4-pinnate, leaflets numerous, rachis (2.5–)5–25(–42) cm long, petiole 2–8(–15) cm long, stipules a narrow wing, 2–4 cm × 0.3–0.5 cm, leaflets ovate to ovate-oblong or elliptical to elliptical-lanceolate, (2–)4–8(–14) cm × (0.3–)1.5–4(–6) cm, base rounded to acute, apex acute to shortly acuminate, margin crenate to shallowly serrate, pearl-glands apparently absent; cyme (4–)8–14(–16) cm long, generally compact, rusty pubescent, bracts deltoid-triangular, inconspicuous; flowers bright red, calyx 2–2.5 mm × 1.5–2.5 mm, glabrous, staminodial tube about 1–2 mm long, upper free part 1–1.3 mm long, lobes shallowly retuse or cleft, sinuses deep, ovary 4–6-celled; berry 8–10 mm in diameter, dark red, 6-seeded; seed 4 mm × 4 mm. *L. rubra* is found in dry monsoon forest, savanna and secondary vegetation from sea-level up to 500 m altitude.

Selected sources 135, 407, 739, 949.

Tahan Uji

Leonurus sibiricus L.

Sp. pl. 2: 584 (1753).

LABIATAE

$2n = (16, 18,) 20$

Synonyms *Leonurus japonicus* Houtt. (1778), *Leonurus heterophyllus* Sweet (1826), *Leonurus artemisia* (Lour.) S.Y. Hu (1974).

Vernacular names Lion's tail, Siberian motherwort (En). Agripaume, gros tombé (Fr). Indonesia: ginjean (Javanese), dendereman (Sundanese), si saratan (Sumatra). Malaysia: seranting, tebungaga (Peninsular), kacangma (Sarawak). Philippines: kamariang-sungsong (Tagalog). Thailand: khanchaa thet (south-western), saa saa, saa nam (north-eastern). Vietnam: [is]ch m[aax]u, sung [us]y, ch[os]i d[ef]n.

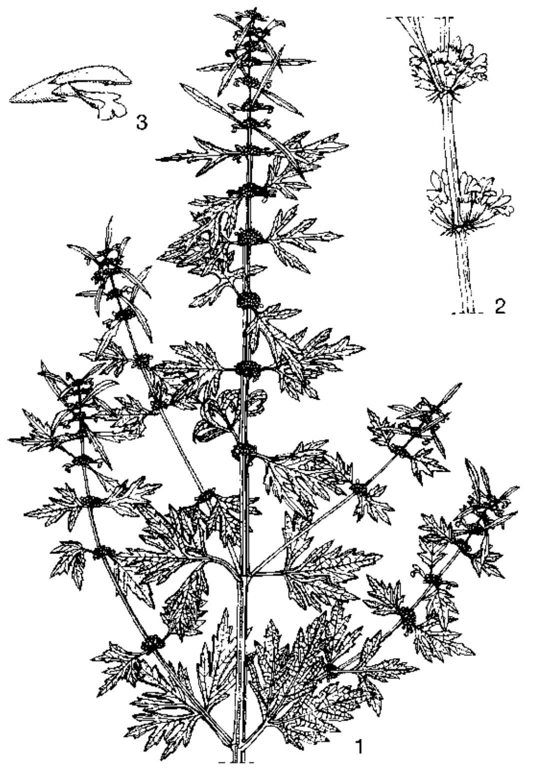
Origin and geographic distribution *L. sibiricus* is a native of temperate Asia, Siberia, China, Korea, and is found from Japan to India and the Mascarenes. It now has a pantropical and temperate distribution. In Malesia, it is distributed from Peninsular Malaysia to Sumatra, Java, Borneo, Bali, Sulawesi, Timor and the Moluccas, and also in the Philippines.

Uses In China and South-East Asia, all parts of *L. sibiricus* are widely used by women for menstruation related disturbances, including the reduction of excessive menstrual flow or menstrual pain and the induction of menstruation. It is used as a restorative after childbirth, to hasten the contraction of the uterus after delivery, and for expulsion of the placenta. It is also used to improve the blood circulation, to stop leucorrhoea, night blindness and dizziness, to cure skin diseases, and to reduce blood pressure. In Sarawak, the leaves are sun-dried, chopped and cooked with chicken, sesame oil and ginger, and served to mothers after delivery. In China, Thailand and the Philippines, the sweet and pungent seeds are also used as a diuretic and a cooling agent. A decoction of the leaves is used as a diuretic as well, while in Java these are taken against bladder stones. In Peninsular Malaysia, the pounded leaves are applied as a poultice for headaches. In Thailand, the fresh or dried aerial parts in decoction are taken for malaria. In northern India, the bitter infusion of the root, leaves and juice may be used as a febrifuge.
In Sarawak *L. sibiricus* is also used as a culinary ingredient, especially by the Chinese.

Production and international trade In Sarawak, *L. sibiricus* is sold dried or bottled as a tonic at local markets and in Chinese pharmacies.

Properties The whole plant of *L. sibiricus* yields 0.05% of the alkaloid leonurine (4-guanidino-n-butyl syringate). Leonurine has a curare-like effect on nerve motor endings. It produces marked diuresis when intravenously injected into rabbit, but in concentrations of 1:1000 it also possesses haemolytic action. Administered to cats in small doses it acts as a respiratory stimulant. Large doses on the other hand cause respiratory paralysis. Furthermore, in China, a decoction of the plant given to normal fertile women increased intrauterine pressure in 41% of the cases, which was probably caused by leonurine. Another alkaloid, stachydrine, is believed to stimulate the release of birth-hastening oxytocin.
The labdane type diterpenes preleoheterin, leoheterin, prehispanolone, hispanolone and galeopsin were isolated from the herb. Preleoheterin and prehispanolone were shown to inhibit ^{3}H-PAF (platelet activating factor) binding to rabbit platelet membranes. Furthermore, prehispanolone increased the proliferation of T- and B-lymphocytes (5–8 times), when used together with concanavalin A, as compared to concanavalin A alone. The fruits, known as 'Leonuri fructus', contain several proline-rich cyclic decapeptides and cycloleonuripeptides A–D. Cycloleonuripeptides B and C showed in vitro cell growth inhibitory action against P-388 lymphocytic leukaemia cells.
Other biological effects attributed to extracts of the plant include a reduction of blood hyperviscosity in a clinical experiment with 105 patients, and a marked stimulating action of a decoction of the leaves on the uterus of mice in vitro. The latter effect is possibly related to stimulation of the histamine-1- and α-adrenergic receptor of the uterus. The aqueous extract of the plant has also been used to treat myocardial ischaemia and oedema in chronic and acute nephritis. Furthermore, chronic ingestion of a 0.5% methanol extract of the herb in drinking water enhanced the development of both pregnancy-dependent mammary tumours (PDMT) and mammary cancers originated from PDMT. By contrast, the treatment markedly suppressed the development of mammary cancers that originated from hyperplastic alveolar nodules (HAN) associated with the decreased formation of HAN. The incidence of uterine adenomyosis was also inhibited in mice given *L. sibiricus*. The urinary excretion of allantoin, creatine and creatinine, and glucose tolerance were stimulated. The cause of discrepancy of the effect on mammary cancers due to their origins is not clear at present. However, the stimulation by the agent of the excretion of any carcinogenic factors may at least partly contribute to its inhibition of mammary cancers originating from HAN.
Finally, the extract of the leaves reveals potent larvicidal and antifeedant activity against the gypsy moth (*Lymantria dispar*).

Adulterations and substitutes Other *Leonurus* species generally have the same medicinal uses as *L. sibiricus*.



Leonurus sibiricus L. – 1, flowering stem; 2, detail of inflorescence; 3, flower.

Description A branched annual or biennial herb, 0.5–1.5 m tall, stem 4-angled, furrowed, pubescent or glabrescent, with an unpleasant smell. Leaves decussate, lower leaves ovate or deltoid in outline, 5–7 cm × 3–4.5 cm, palmately-pinnately partite or dissected, with linear incised segments, upper leaves linear, chartaceous, glabrescent above, glaucous and pubescent on the veins beneath; petiole of lower leaves 2–4 cm long, upper leaves sessile; stipules absent. Inflorescence composed of verticillasters with numerous axillary, bisexual, irregular, sessile flowers; bracts subulate or spinescent, 4–10 mm long; calyx turbinate-campanulate, 4–5 mm long, in fruit 6–7 mm long, 10-veined and 5-toothed, almost equal, glabrous or sparingly pubescent to spinous; corolla 2-lipped, 10–11(–20) mm long, tube slightly shorter than the calyx, when young with an oblique ring of hairs inside, upper lip entire, obovate, erect, convex, pubescent outside, lower lip 3-lobed, midlobe very large, obcordate, pubescent, white, pinkish or red; stamens 4, in 2 pairs, filaments thinly hairy, ascending under the upper lip, anthers 2-celled, glandular; ovary deeply 4-partite, style 2-fid, branches obtuse. Fruit consisting of 4 dry 1-seeded schizocarpous nutlets enclosed in the persistent calyx; nutlets ellipsoid, 2 mm long, truncate at apex, smooth, brown. Seedling with epigeal germination.

Growth and development *L. sibiricus* is a nectar-yielding plant and is pollinated by insects, in Mongolia by short-tongued *Bombus* spp. It grows well at temperatures of 15–20°C and requires a high moisture regime.

Other botanical information *Leonurus* comprises approximately 8 species, mainly distributed in temperate Asia and Europe. *L. sibiricus* has a wide distribution area, and the plants from Siberia to Mongolia and northern China differ slightly from those from southern China, Korea, Japan, India and Malesia. These differences are mainly ecotypical, the leaf-segments of the northern plants being more finely dissected, the corolla larger (up to 2.3 cm long), the lower corolla lip about 1/3 shorter than the upper one, and the middle part of the calyx covered with soft hairs. If these ecotypes were distinguished at species level, the northern type would retain the name *L. sibiricus*, and the southern type would bear the name *L. japonicus*.
In temperate Asia and Europe, *L. cardiaca* L. (common motherwort) is well known as a medicinal plant, with similar uses as *L. sibiricus*.

Ecology *L. sibiricus* is locally common in waste places, along river banks, railway embankments, and also as a weed in arable land. It is sometimes cultivated as an ornamental or for medicinal purposes and also occurs escaped, under both humid and semi-humid climatic conditions, from 0–2000 m altitude. *L. sibiricus* flowers throughout the year.

Propagation and planting *L. sibiricus* is usually propagated by seed. In Vietnam, the best time for sowing is October–November, because the seeds germinate best at temperatures between 20–25°C. It is also propagated by stem cuttings.

Husbandry In China, tests with different fertilizer treatments of *L. sibiricus* gave the best results with P-fertilizer, which caused the highest increase in fresh plant weight, tiller number and leaf growth rate.

Diseases and pests In Korea, white mould (*Ramularia leonuri*) causes leaf spot and blight, mostly in autumn.

Harvesting In Vietnam, the flowers and seeds of *L. sibiricus* are harvested in May.

Handling after harvest Plants of *L. sibiricus* are usually sun-dried or the extract stored in bottles to be used when required.

Genetic resources and breeding Small germplasm collections of *L. sibiricus* exist in Germany, the United Kingdom and Brazil. In China, some breeding is done with *L. sibiricus*.

Prospects *L. sibiricus* is quite a popular medicinal herb and is imported into Malesia as a tonic as well as cultivated locally, although it is underexploited there. Extracts and purified compounds from *L. sibiricus* show interesting pharmacological activities, e.g. on the uterus and the immune system, which merit further research.

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Other selected sources 135, 153, 157, 199, 200, 407, 443, 453, 553, 635, 693, 810, 906, 1110, 1131.

Stephen P. Teo & Chua Hun Pin

Lepidium sativum L.

Sp. pl. 2: 644 (1753).
CRUCIFERAE
$2n = (16,)\ 24, (36)$

Vernacular names Garden cress, pepper cress, cress (En). Cresson alénois (Fr). Indonesia: alim.

Origin and geographic distribution *L. sativum* is grown worldwide as a spicy salad herb. Its origin is not known, but is possibly Ethiopia or Iran.

Uses In Java and China, the seedlings of *L. sativum* are mixed into medicinal preparations of unknown use. In India, the seed oil, like mustard oil, is applied for hiccough and intestinal problems. The pounded seeds are poulticed on the skin, and have a vesicant and soothing action on bruises and sprains. The seeds are also considered galactagogue, emmenagogue, laxative, tonic, diuretic and aphrodisiac. The mucilage of the germinating seeds allays the irritation of the intestines in dysentery and diarrhoea. The aerial parts are used in the treatment of asthma, cough and bleeding piles. Leaves are mildly stimulant and diuretic, and useful in scorbutic diseases and liver complaints. The roots are used in secondary syphilis.

In Ethiopia, a paste of the seeds with water is used on chapped lips, and also against sunburn and other skin problems. The paste is taken internally with honey for amoebic dysentery, and given to animals with stomach problems. The seeds are chewed for sore throat, cough, asthma and headache, but in large quantities also to induce abortion. It is also applied externally as an insect repellent.

In Europe, the herb is used for cough and for vitamin C deficiency, as well as for constipation, as a diuretic and for poor immunity.

The seedlings or young leaves, which taste like radish, are widely eaten in salads, soups and omelets. The whole seed pods can be used, fresh or dried, as a seasoning with a peppery flavour. The seed oil is used for soap making.

In the temperate zone, *L. sativum* is extensively used as a test organism in plant physiological studies, as an indicator organism to examine toxicity levels of environmental pollutants, and in experimental studies assessing diverse pathogens.

Production and international trade Seed of *L. sativum* is widely traded.

Properties The stem and leaves of *L. sativum* contain glucosinolates, the main component being glucotropaeolin (benzylglucosinolate), yielding benzyl cyanide when the plant is bruised, or benzyl cyanide, benzylthiocyanate, benzylisothiocyanate and benzylamine when the plant is extracted with water. Upon steam distillation the herb yields about 0.1% of a colourless essential oil, with a characteristic pungent odour, containing variable amounts of benzyl isothiocyanate and benzyl cyanide. The seeds yield 25% of a yellowish-brown, semi-drying oil with a peculiar, disagree-

able odour. The oil is rich in oleic-, linoleic- and uric acid, and also contains the dimeric imidazole alkaloids lepidine B, C, D, E and F, as well as the imidazole alkaloid lepidine and two monomeric imidazole alkaloids, semilepidinoside A and B. The seed oil has anti-oxidant properties.
Seeds were fed in a toxicity study to Wistar albino rats, and were found to be non-toxic at 2% (w/w), toxic but not fatal at 10% (w/w) and lethal at 50% (w/w) of the diet for 6 weeks, causing depression in growth rate and entero-hepato-nephrotoxicity.
The seed-coat of germinating seeds contains much mucilage, which has an allelopathic substance, lepidimoide, also found in the exudate of germinated seeds of many other species, e.g. sunflower, rice, and lettuce. Lepidimoide promoted the hypocotyl growth of etiolated *Amaranthus caudatus* L. at concentrations higher than 3 μM and inhibited the root growth at concentrations higher than 100 μM. The growth-promoting activity in hypocotyls was 20 or 30 times as much as that of gibberellic acid. The mucilage also contains cellulose (18%), and after hydrolysis it produces arabinose, rhamnose, galactose and galacturonic acid.
The effects of the germinating seeds on the in vitro rate of potato starch hydrolysis were studied to determine the potential for slowing down the hydrolysis of starch to glucose in diabetic persons. The seeds showed a high reduction in starch hydrolysis (42%) and were tested in vivo on 11 non-insulin dependent diabetes mellitus (NIDDM) persons as well as 14 normal healthy persons. It was observed that for both controls and diabetics, the seeds significantly lowered the glycaemic response to a test meal as compared with their response to the meal alone. Furthermore, diabetics showed a higher reduction than the healthy subjects. In the long-term (21 days) treatment of diabetics with 15 g seeds/day, 9 out of 11 subjects showed a reduction in the levels of blood glucose from 10.2 to 8.3 mM at the end of study period. The ethanol extract of the seeds showed significant anti-inflammatory effects against carrageenan-induced rat paw oedema, at a dose of 500 mg/kg.
The seed oil has a pronounced oestrogenic activity. Tests on immature rats receiving 3–4 drops of the oil with their diet showed significantly better development and higher weight of their ovaries than control animals.
The antibacterial action of *L. sativum* has been demonstrated in several tests. The extract of the fresh leaves showed strong antibacterial action against *Bacillus subtilis* and *Micrococcus pyogenes* var. *aureus*, but was less effective against *Escherichia coli*. The antibacterial action depends largely on the age of the plants used. An antiviral effect against the encephalitis virus Columbia SH was demonstrated in a test on mice.
Seeds of *L. sativum* did not show significant in vitro antimalarial activity, however, at the highest concentration used (50 μg/ml), as measured by the inhibition of [^{3}H]hypoxanthine uptake into *Plasmodium falciparum* (strain FCA-2/Ethiopia).
An in vitro study was conducted to investigate the nematicidal effect of some glucosinolates and the products of their myrosinase-mediated enzymatic hydrolysis on second-stage juveniles of the sugar beet cyst nematode *Heterodera schachtii*. The glucosinolates tested were purified from the seeds of *L. sativum* and some other *Cruciferae*, which are hosts of the nematode. The glucosinolates tested in their original form showed no nematocidal effect, whereas the products of the enzymatic hydrolysis at pH 7.0 (essentially the isothiocyanates) of e.g. glucotropeolin, demonstrated a mortality rate that varied as a function of both the concentration of product and the exposure time.
Furthermore, an extract of *L. sativum* was tested for antimutagenic effects on pesticides in the *Salmonella typhimurium* strains TA98 and TA100 with and without the metabolic activation of S9. The extract decreased the mutagenic effects of Captan, Folpet, DDVP, Azinphosmethyl, Bioresmethrin and Trifluralin, and also the antimutagenic effects of glutathione, cysteine and ascorbic acid.
In addition, the antireproductive potential of the leaves was tested with aqueous or 90% ethanol extracts in rats orally dosed for 10 days after insemination, with special reference to effects on foetal development, and showed significant teratologic effect. The continental Asian *L. capitatum* Hook.f. & Thomson showed similar effects in rats.

Description An erect, polymorphic, annual herb, 30–70 cm tall, taproot slender, stems usually much branched, glabrous or with scattered minute hairs. Leaves alternate, membranaceous, ovate-oblong in outline, up to 12 cm × 9 cm, imparipinnati- or bipinnatipartite, with 2–4 pairs of lateral lobes, lobes linear, lanceolate or oblanceolate, up to 3 cm long, uppermost leaves sometimes simple, serrate, glabrous or sparsely pubescent; petiole up to 4 cm long in basal leaves; stipules absent. Inflorescence a terminal or axillary raceme, 1–3 cm long, accrescent to 25 cm when fruiting. Flowers bisexual, rather conspicuous, whitish to violet, pedicel 3–6 mm long in fruit, ascending;

Lepidium sativum L. – 1, flowering stem; 2, basal leaf; 3, flower; 4, seed.

sepals 4, elliptical, 1–1.5 mm long, green, margins membranaceous; petals 4, spathulate to slightly clawed, 1.5–3 mm long, apex rounded; stamens 6, unequal in length, nectaries 6, alternating with filaments; ovary superior, flattened dorso-ventrally, apex emarginate, lateral margins wing-like, style up to 0.5 mm long, stigma capitate, finely pappilate. Fruit an ovoid, flattened silique, 4.5–6.5 mm × 3–4 mm, pale green to yellowish, apical wings prominent, apex emarginate, dehiscing by 2 valves, leaving the replum with thin, white septum; 1 seed per locule. Seed subovoid, flattened, 2–3 mm × 1.5 mm, wingless, reddish-brown. Seedling with epigeal germination; cotyledons trifoliolate, lobes spathulate, lateral lobes smaller.

Growth and development *L. sativum* completes its life cycle in 3–4 months.

Other botanical information *Lepidium* consists of about 140 species with a cosmopolitan distribution, but mainly in the temperate regions.
Some *Lepidium* species other than *L. sativum* are also biologically active, the most interesting being the South American *L. meyenii* Walp. The effect of oral administration of a purified lipidic extract from *L. meyenii* (MacaPure M-01 and M-02) on the sexual behaviour of mice and rats was evaluated by the number of complete matings in normal mice, and on the latent period of erection (LPE) in rats with erectile dysfunction. Oral administration of M-01 and M-02 enhanced the sexual function of the mice and rats, as evidenced by an increase in the number of complete intromissions and the number of sperm-positive females in normal mice, and a decrease in the LPE in male rats with erectile dysfunction.

Ecology *L. sativum* is mainly known from cultivation but escaped, ruderal types occur as well, especially in the temperate regions, more rarely in tropical regions. *L. sativum* prefers full sun or partial shade.

Propagation and planting *L. sativum* is propagated by seed. For sprout production, the seeds are sown thickly in rows, covered lightly with soil or not, and a few days after germination the seedlings are ready for harvesting. Plants can also be thinned if larger plants are preferred. For seed production, a few plants are left till the seeds are fully mature. The plants are then pulled up, dried and threshed so that the seeds fall out.
Germination rate in the first and second year after harvesting was >90%, and decreased slightly after 5–6 years, but remained above 50% for 10 years.

In vitro production of active compounds Significant amounts of lepidine were detected in mature and juvenile explants from both in vivo and in vitro grown *L. sativum* plants. The yield, however, was variable depending upon the source and type of explant used. Mature in vivo plants at vegetative stage exhibited highest yield, after 8 weeks in shoot apex callus on Murashige & Skoog medium supplemented with naphthalene acetic acid at 2 mg/day and benzylaminopurine (benzyladenine) at 5 mg/day. Addition of 900 μM Zn^{2+} or 100 μM Cu^{2+} further enhanced the yield of lepidine.

Husbandry *L. sativum* thrives on any rich, light, moisture-retentive soils, but grows best on moist loams. It can be grown at all elevations throughout the year, but grows best in the cool season in tropical regions. In warm climates the flavour becomes quite peppery.

Diseases and pests *L. sativum* has few diseases and pests. Some fungal and viral infections are recorded, as well as susceptibility to nematodes.

Harvesting In Europe, medicinally used plant parts of *L. sativum* are harvested during or just after the flowering season. For culinary use, the leaves should be harvested before flowering, and for sprout production plants are harvested a few days after germination.

Handling after harvest Most plant parts of *L. sativum* are normally used fresh. The seeds can be stored for future use.

Genetic resources and breeding *L. sativum* is widely grown throughout South-East Asia. Breeding is done for culinary purposes only.

Prospects Glucosinolates and their derivatives after breakdown in general are known to display several interesting pharmacological activities, which merit further research. *L. sativum* is therefore of interest as a source of these compounds. Also, the mucilage from the seeds shows an interesting effect on the rate of potato starch hydrolysis, which might be of use in the treatment of non-insulin dependent diabetes.

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Other selected sources 10, 135, 308, 499, 587, 851, 945.

S. Brotonegoro & W. Wiharti

Leucas R.Br.

Prodr.: 504 (1810).

LABIATAE

$x = 11$; *L. aspera*, *L. lavandulifolia*, *L. zeylanica*: $2n = 22$

Major species *Leucas aspera* (Willd.) Link, *L. lavandulifolia* J.E. Smith, *L. zeylanica* (L.) R.Br.

Vernacular names (Petit) tombé (Fr, Réunion). Indonesia: paci-paci (general), lenglengan (Javanese).

Origin and geographic distribution *Leucas* comprises about 80 species, of which 55–60 occur in southern and tropical Africa and Arabia, and about 25 species from Iran to China, Malesia and the Pacific. The genus has its highest species richness in East Africa.

Uses In general, the crushed leaves of *Leucas* are applied to wounds, sores, especially those of the eyes and nose, chronic skin diseases, such as psoriasis and scabies. The crushed leaves are also used to treat mild fevers, colds, rheumatism and snake bites, and as a decoction against roundworm, mainly for children. The leaves of *L. lavandulifolia* and *L. zeylanica* are also used as a poultice to treat itch, headaches and vertigo. In Indonesia, the leaves may be taken externally or internally as a sedative, useful to treat convulsions, epileptic seizures, coughing spasms, and other nervous disorders. In India, the smoke of burnt dried leaves of *L. aspera* is used as an insecticide. In the Mascarenes, the plant is given for amenorrhoea, but in India the plant may be used for birth control. In Malesia, *L. lavandulifolia* is used as a gargle to remove mucus. A decoction of the leaves is considered a good stomachic, and is applied, internally and externally, to treat colic of children or saccharomycosis of horses. A decoction of the roots is sometimes used for inflamed callosity. Like *L. zeylanica*, it is also considered stimulant and diaphoretic.

Leucas species are aromatic herbs, *L. aspera* and *L. lavandulifolia* are considered fragrant, but *L. zeylanica* has an unpleasant smell and a bitter taste. In India and Malesia, all three species are locally used as a pot herb or grown in the garden for use as a condiment, fresh, dried or fried.

In Malesia, cattle will only eat *L. lavandulifolia* when other food is scarce. The white flowers are offered in temples.

Production and international trade *Leucas* is usually cultivated in home gardens for use in local medicine and as a pot herb, and has not entered international trade.

Properties Only little information can be found in the literature about the phytochemistry of *L. aspera*. The shoots are reported to contain an alkaloid (without further specification) and a series of fatty acids derived from triacontane, e.g. 28-hydroxypentatriacontan-7-one, 28-hydroxypentatriacontan-2-one, 1-hydroxytetratriacontan-4-one, 5-acetoxytriacontane, dotriacontanol and 32-methyltetratriacontan-8-ol. Extracts of *L. aspera*, however, are reported to display several biological activities. An alcoholic extract of the leaves shows anti-bacterial activity against *Micrococcus pyogenes* var. *aureus*, *Escherichia coli*, and several other bacteria. Furthermore, a chloroform extract, in the form of an 0.5% or 10% ointment, was found to be effective in the treatment of *Trichophyton verrucosum* ringworm in cattle. A water-soluble leaf extract was shown to be very effective in inhibiting egg hatch of the nematode *Meloidogyne arenaria*.

The same extract also completely inhibited conidial germination of the fungus *Drechslera oryzae*, in vitro. No antifertility activity was shown in a test with an extract of whole *L. aspera* plants for post-coital antifertility activity in female albino rats. The smoke of the powdered leaves of *L. aspera*, thrown on burning charcoal, was highly repellant and toxic to the mosquitoes *Armigeres subalbatus* and *Culex quinquefasciatus*. The leaf extract significantly reduced larval survival, pupation and adult emergence of the mosquito *Anopheles stephensi* in a dose dependent way, and also significantly increased adult repellence and ovipositional deterrence.

Only general information about phytochemical compounds is available for *L. lavandulifolia*. Without further specification the species is reported to contain alkaloids, steroids, triterpenes, flavonoids and tannins. More information can be found on biological activities of the extracts.

A methanol extract of the herb, in the form of an ointment or as an injection, was examined in rats for its wound healing activity in two types of wounds, the excision and the incision wound models. Both routes of administration showed significant responses in both wound types tested, in terms of contracting ability, wound closure time, tensile strength and regeneration of tissues at the wound site. The methanol extract was also investigated for its effects on a cough model induced by sulphur dioxide gas in mice. It exhibited significant antitussive activity in a dose-dependent manner, when compared with a control. Its effect is comparable to that of codeine phosphate, as a prototype antitussive agent. Furthermore, an ethanol extract of the leaves showed significant inhibitory activity against castor oil induced diarrhoea and PGE2 induced enteropooling in rats. The extract also showed a significant reduction in gastro-intestinal mobility in rats using charcoal meals as test model.

L. zeylanica yields a small quantity of essential oil, reported to contain an alkaloidal substance.

Description Mostly annual, strong smelling, much branched herbs or undershrubs, stems and leaves often villous. Leaves decussate, crenate-dentate-serrate or subentire; petiole short or absent; stipules absent. Inflorescence composed of distant verticillasters with numerous axillary, bisexual, irregular, subsessile flowers, sometimes forming terminal, capitate clusters; calyx tubular-infundibuliform, 8–10-veined, 8–10-toothed, teeth equal or posterior one largest; corolla 2-lipped, upper lip erect, entire, concave, densely villous, lower lip 3-fid, spreading, central lobe very large, tube slender, often not exserted, with a hairy ring inside or not, white, sometimes purple; stamens 4, didynamous, filaments inserted in the corolla tube, upper pair shorter, all ascending under upper lip, hairy, anther-cells nearly in line with each other, confluent, reddish; style subulate, 2-branched, upper branch minute; disk entire or lobed, equal or unequal-sided. Fruit consisting of 4 dry 1-seeded schizocarpous nutlets enclosed in the persistent calyx, nutlets trigonous, obtuse, smooth. Seedling with epigeal germination; hypocotyl densely hairy; cotyledons broadly ovate, 6 mm long, hairy, emarginate; epicotyl 3 mm long, 4-angular, hairy, first leaves 2, elliptical.

Growth and development *Leucas* is pollinated by bees, moths and flies. Flowering is throughout the year, whenever sufficient water is available. *L. aspera* shows a high tolerance to copper and zinc concentrations in polluted soil.

Other botanical information *Leucas* belongs to the subfamily *Lamioideae*, and is closely related to the small genera *Acrotome* and *Leonotis*. The exact number of species in *Leucas* is not clear as no recent revision of all taxa is available.

Ecology *Leucas* occurs in various habitats, from seasonal to perhumid areas, often as a weed of crops or as a ruderal, locally often common, from sea-level to 1500 m altitude.

Propagation and planting *Leucas* is propagated by seed.

Husbandry Of all *Leucas* species, *L. lavandulifolia* is becoming a serious weed in sugarcane fields in Malesia. In banana plantations in India, the application of paraquat at 3 l/ha controls *L. lavandulifolia* sufficiently. *L. aspera* occurs mainly as a weed in sunflower and in rice in India.

Diseases and pests Warty galls often occur on young *L. lavandulifolia* stems and *L. zeylanica* leaves. They are caused by the fungus *Synchytrium rytzii*. *L. aspera* is a host for the fungal pathogen *Septoria bakeri* and also for the root-knot nematode *Meloidogyne javanica*.

Harvesting The leaves or flowers of *Leucas* are collected from gardens, where they often grow as pot herbs. Whole plants are collected from the wild, whenever the need arises.

Handling after harvest The leaves or whole plants of *Leucas* are used fresh or dried and powdered.

Genetic resources and breeding In view of their wide distribution, *L. aspera*, *L. lavandulifolia* and *L. zeylanica* are not endangered or liable to genetic erosion. In addition, they are often cultivated as pot herbs.

Prospects Extracts of *Leucas* show some interesting biological effects, e.g. in the field of treatment of fungal skin infections, wound-healing activity, anti-cough activity and insect repellent activity. More research is needed, however, to isolate the compounds or complexes responsible for these activities, in order to fully evaluate their potentials.

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Selection of species

Leucas aspera (Willd.) Link

Enum. hort. berol. alt. 2: 113 (1822).

Vernacular names Herbe à mouches (Fr). Indonesia: ngangegan (Javanese). Philippines: karukansoli, pansi-pansi (Tagalog), paysi-paysi (Bisaya). Cambodia: phlom ang kep. Thailand: phak hua to, yaa hua to (south-western), yaa nok khao (northern). Vietnam: m[ef] d[aas]t nk[as]m.

Distribution *L. aspera* is distributed from India, the Mascarenes, Burma (Myanmar), Thailand and Indo-China to Peninsular Malaysia, Java, Madura, Sulawesi, the Philippines and Papua New Guinea.

Uses In general, the leaf sap of *L. aspera* is used to treat sores of the eyes and nose. In the Philippines, the bruised leaves are considered to be active against bites of poisonous insects, and in India, the smoke of dried leaves is used as an insecticide and repellant.

Observations An annual herb, 30–60 cm tall, stem and branches hispid, with preading hairs; leaves linear-lanceolate, 4–6 cm × 0.8–1 cm, margin remotely crenate, membranaceous, tomentose on both surfaces, petiole 0.5–1 cm long, densely hispid; inflorescence composed of flowers in terminal verticillasters, forming a globular head, 1.5–2.5 cm in diameter, bracts narrowly lanceolate, 8–10 mm long, ciliate along the margins, calyx tubular, 8–9 mm long, only slightly enlarged in fruit, tube pilose, 10-veined, 10-toothed, mouth strongly oblique, teeth erect, posterior one largest, corolla 15–16 mm long, strongly curved, with a hairy ring inside near the middle, upper lip 2 mm long, densely velutinous, lower lip 6 mm long, sparsely pubescent; nutlets narrowly ovoid, 2.5 mm × 0.8 mm, ventral surface triquetrous, dorsal side rounded, finely granulate or nearly smooth, black. *L. aspera* occurs in various habitats, from seasonal to perhumid areas, mostly grassy plains, as a weed in arable crops, open dry sandy soils, waste places, teak forest, railway embankments, dunes, locally often common, from sea-level up to 500 m altitude.

Selected sources 74, 215, 335, 529, 788, 801, 810, 890, 939, 1001, 1035.

Leucas lavandulifolia J.E. Smith

in Rees, Cycl. 20: sect. 2, pt. 40 (1812).

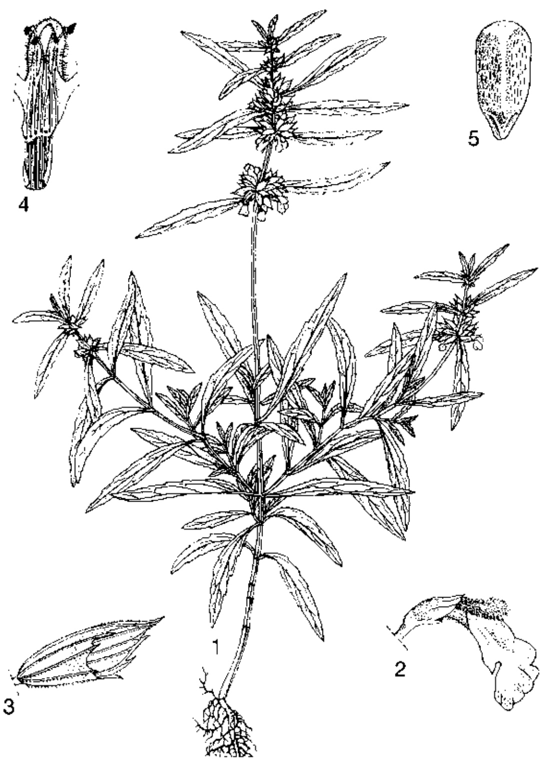
Synonyms *Leucas linifolia* (Roth) Spreng. (1825).

Vernacular names Armoise blanche (Fr). Indonesia: paci-paci (Sundanese), lenglengan (Javanese), laranga (Tidore). Malaysia: ketumbak, ketumbit (Peninsular). Philippines: karukansoli, salita (Tagalog), kaskasumba (Iloko).

Distribution *L. lavandulifolia* is distributed from India, and the Mascarenes to China and southwards throughout Malesia, though rare in Borneo and Papua New Guinea.

Uses In Malesia, *L. lavandulifolia* is said to be used to heal chronic leg sores, dermatosis, as an anthelminthic for roundworms, and for appeasing affections of the nerves. In Java, a poultice is especially applied in veterinary medicine in order to cleanse stinking wounds from fly larvae. In Java, it is also used as a vegetable, and as a fodder for cattle.

Observations An annual herb, 30–80 cm tall, stem and branches subglaucous; leaves linear-lanceolate, 4–6 cm × 0.5 cm, margin subentire or sparingly serrate; inflorescence composed of terminal and axillary, leafy verticillasters, often congested towards the apex, forming a cluster of 1.5–2 cm in diameter, bracts linear, 3–4 mm long,



Leucas lavandulifolia J.E. Smith – 1, flowering plant; 2, lateral view of flower; 3, fruiting calyx; 4, opened corolla with didynamous stamens; 5, nutlet.

puberulous, calyx obliquely turbinate, 5–7 mm long, in fruit 8–9 mm long, glabrescent, mouth oblique, slightly constricted, teeth 7–10, posterior one much longer than the others, corolla 10 mm long, tube with a hairy ring near the middle, upper lip oblong, woolly, lower lip patent; nutlets oblong, 2.5 mm × 1 mm, rounded at apex, inner surface angular, outer rounded, dark brown, pale at base. *L. lavandulifolia* is a weed of open waste places, coconut and other plantations, roadsides, grassland and arable land, fallow land, paddy dams, locally often numerous, from sea-level up to 1500 m altitude. An orthographic variant of *lavandulifolia* is 'lavandulaefolia'.

Selected sources 74, 215, 405, 810.

Leucas zeylanica (L.) R.Br.

Prodr. 504 (1810).

Vernacular names Indonesia: paci-paci (Sundanese, Balinese), brobos (Javanese), daun heran (Moluccas). Malaysia: katumbit, ketumbak, daun luka-luka (Peninsular). Philippines: guma-guma (Sulu), masibulan (Gaddang). Cambodia: man mac. Thailand: thian taak (south-eastern), yaa prik (peninsular). Vietnam: m[ef] d[aas]t, m[ef] hoang, b[aj]ch thi[eej]t.

Distribution *L. zeylanica* is widely distributed throughout South and South-East Asia, but is rather rare in East Asia.

Uses In Malesia, the leaves of *L. zeylanica* may be taken as a sedative, and to heal wounds. The entire plant is rubbed on the abdomen after childbirth. The leaves are also used as an anthelminthic. The whole herb has a bitter taste, but is still locally used as a pot herb.

Observations An annual herb, 20–60 cm tall, stem and branches hispid; leaves lanceolate, 4–5.5 cm × 1–1.3 cm, margins remotely serrate, membranaceous, hirsute on both surfaces, petiole 0.2–0.8 cm long, hispid; inflorescence composed of terminal verticillasters, flowers usually 6–8, forming a globular head, 1.5–2 cm in diameter, occasionally also with axillary verticillasters, bracts linear, 4–5 mm long, spinescent, calyx turbinate, 5–6 mm long, in fruit 7–8 mm, slightly curved, hispid, 10-veined and 8-toothed, posterior one only slightly longer, mouth slightly oblique, corolla 8 mm long, tube with a hairy ring near the middle, upper lip obovate, white-woolly, lower lip patent, 3–4 mm long; nutlets obovoid, 3 mm × 1 mm, apex truncate, ventral surface angular, dorsal side rounded, smooth and shiny, dark brown or black. *L. zeylanica* is a weed of sunny dry localities, often on sandy soils, paddy dams, waste places, roadsides, from the lowland up to 1000 m altitude.

Selected sources 74, 215, 788, 810.

Marfu'ah Wardani

Limnophila R.Br.

Prodr.: 442 (1810).

SCROPHULARIACEAE

$x = 17, 34$; *L. aromatica*: $2n = 34, 68$, *L. indica*: $2n = 34, 68$, *L. repens*: $2n = 68$, *L. rugosa*: $2n = 34$

Major species *Limnophila aromatica* (Lamk) Merr., *L. indica* (L.) Druce.

Origin and geographic distribution *Limnophila* consists of 35–37 species from the Old World tropics and subtropics, with tropical Asia as its centre of distribution. *L. indica* is most widely distributed, throughout the range of the genus. About 15 species occur in South-East Asia, some of them are endemic, and 6 species are endemic to Africa. *L. sessiliflora* (Vahl) Blume has escaped from cultivation in southern North America.

Uses In Malaysia, the more strongly aromatic *Limnophila* are considered medicinal, rather than a condiment. The smell is agreeable and resembles that of turpentine, or a mixture of cinnamon and cloves or cinnamon and citrus. In Indonesia and Peninsular Malaysia, the sap of the leaves of *L. aromatica* is used to clean wounds and sores on the legs although it is considered rather strong. A decoction of the leaves is given in fevers but also to promote appetite, and as an expectorant to clear mucus from the bronchial tubes. In India and Thailand, the plant is used as a cooling agent in fevers, and given to nursing mothers as a galactagogue. In Vietnam, the whole plant is used for its diuretic and anti-spasmodic action, against gravel in the kidneys, as a disinfectant for wounds and for haematuria; also for cough, snakebite and skin diseases. In China, the plant is used for the treatment of intoxication, body pains and for menstrual problems. In Malaysia and Indonesia, *L. erecta* has the same medicinal uses as *L. aromatica*. In the Philippines, an infusion of the leaves of *L. indica* is used for dysentery and dyspepsia. In India, the plant is considered antiseptic, and the juice is rubbed on the body for strong fevers. A liniment is made from the plant with coconut oil and used in elephantiasis. Internally, the juice is given in dysentery, combined with cumin (*Cuminum cyminum* L.) and other aromatic plants. In Indonesia, a decoction of *L. rugosa* is used externally to cure itching eyes, and internally for mild gonorrhoea and impotence.

In Indo-China, Thailand and Indonesia, *L. aromatica*, *L. erecta*, *L. indica* and *L. rugosa* are also eaten as a condiment or sidedish, raw, steamed or cooked. *L. aromatica* is thought to calm the stomach after eating durian (*Durio zibethinus* Murr.). *L. aromatica* can also be grown as an ornamental, because of its attractive flowers.

Production and international trade *Limnophila* is traded on a local scale only, and is found fresh in markets, or dried in Chinese herbalists stores.

Properties *L. aromatica* contains 0.13% essential oil, the terpenes δ-limonene and δ-perillaldehyde being important constituents. The bactericidal activities of this essential oil against *Bacillus subtilis*, *Escherichia coli*, *Pseudomonas aeruginosa* and *Staphylococcus aureus* were similar to those of a streptomycin and chloramphenicol reference. The activities of the essential oil against *Aspergillus niger*, *Candida albicans* and *Rhizopus oryzae*, however, were more marked than those of griseofulvin as reference. Phytochemical analysis also showed the presence of 2 flavonoids, nevadensin (= 5,7-dihydroxy-6,8,4′-trimethoxyflavone) and salvigenin (= 5-hydroxy-6,7,4′-trimethoxy flavone) as well as 2 phenolics, caffeic acid and chlorogenic acid. The related (methylenedioxy type) flavonoid 5-hydroxy-6,8-dimethoxy-3′, 4′-methylenedioxyflavone has also been isolated from *L. indica*.

The essential oil of *L. rugosa* contains linalool (0.1%), estragole (22%), cis-anethole (0.03%), anisaldehyde (0.05%), trans- anethole (75%), anisyl acetone (0.03%), caryophyllene (0.08%), humulene (0.15%) and α-bulnesene (0.01%). Also the compounds 3β-hydroxy-20(29)-en-27-oic acid, nevadensin, and demethoxysudachitin were isolated. The flavonoid nevadensin, administered intravenously (3.1 mg/kg), exhibited a hypotensive effect on both normotensive and spontaneous hypertensive rats under pentobarbital anaesthetization. After administration of nevadensin, the mean arterial pressure decreased by about 50 mm Hg for 30 minutes.

The essential oil of *L. repens* (Benth.) Benth. (synonym *L. conferta* Benth.), an aquatic herb also occurring in South-East Asia, contains α-phellandrene (52.2%) and thymol (38.2%). The antifungal activity of a 1:50 dilution in ethylene glycol was found to be of the same order of magnitude as that of griseofulvin (100 μg/0.1 ml) for *Aspergillus niger*, *Candida albicans* and *Rhizopus nigricans* (synonym *R. stolonifer*). Against dermatophytes (*Trichophyton mentagrophytes* and *Microsporum* *gypseum*), the oil at a concentration of 100 μg/ml inhibited growth whereas miconazole was effective at a concentration of 10 μg/ml. The oil also possessed good anthelmintic activity against *Taenia* sp. and *Ascaris galli*. The crude alcoholic extract showed significant reduction in the epithelization period compared with that of controls in excision wound models. Nevadensin isolated from the plant showed good anti-inflammatory activity in an acute inflammation model and exhibited moderate cytotoxic activity and anti-tubercular activity.

Description Annual or perennial, aquatic or semi-aquatic herbs, often aromatic when bruised, glabrous or hairy; stems erect or prostrate and rooting at the nodes, simple or branched. Submerged leaves verticillate, pinnatifid, glabrous; aerial leaves opposite to verticillate, entire to serrate, laciniate or pinnately divided, punctate; petiolate or not. Inflorescence a lax or compact, terminal or axillary spike or raceme, or flowers solitary and axillary; bracteoles 0 or 2. Flowers bisexual, slightly zygomorphic, 5-merous; calyx tubular, deeply 5-lobed, lobes subequal, tube with 0–5 or 10 prominent veins; corolla tubular or infundibuliform, 5-lobed, bilabiate, adaxial lip outside in bud, entire or 2-lobed, abaxial lip 3-lobed, erect or spreading; stamens 4, included, didynamous, filaments filiform, anthers free, loculi stipitate; ovary superior, glabrous, style filiform, deflexed at apex, stigma bilamellate. Fruit an ellipsoid to globose capsule, septically 4-valved, valves bifid, with numerous seeds. Seed prismatic, small, 0.2–0.3 mm long, both ends truncate.

Growth and development *Limnophila* can be found flowering and fruiting throughout the year. The production of fruits by cleistogamy on submerged stems was found in several *Limnophila* species, including *L. sessiliflora*, but has not been observed in *L. indica*. Hybridization is recorded from tetraploid *L. indica* and *L. sessiliflora*, both common aquarium plants.
Several varieties have been distinguished in *L. indica* by earlier authors, but it was found that factors such as light intensity, daylength, water depth and water flow produced these varieties. In Sri Lanka, the flowers of *L. indica* open between 10.00 h–15.00 h.

Other botanical information *Limnophila* belongs to the tribe *Gratioleae* and subtribe *Stemodiinae*, and is closely related to *Stemodia* and *Morgania*. *Limnophila* is divided into 4 sections: sect. *Limnophila* (e.g. *L. indica*) has finely divided submerged leaves, and aerial leaves with parallel veins, section *Connatae* has similar aerial leaves, but lacks submerged leaves, section *Integrifolieae* (e.g. *L. rugosa*) has pinnately veined leaves and a calyx without striations, while section *Striatae* (e.g. *L. aromatica*, *L. erecta*) has similar leaves as the latter but a striate calyx. Most *Limnophila* species show a large variation in form of the leaves, hairiness and habit.

Ecology All *Limnophila* are aquatic or semi-aquatic herbs occurring in marshes, along riversides or forest paths, mostly at low altitudes. *Limnophila* is also a weed of rice fields.

Propagation and planting *Limnophila* normally propagates by seeds or rooted stems. Also, root tips (1 cm long) from in vitro grown plants of *L. indica* have been cultured in liquid medium with 2% sucrose. The explants floated horizontally on the surface, became green, and their tips started to grow geotropically into the medium. In 4 weeks, 4–6 shoot buds each were differentiated in 84.5% of the cultures. No buds formed at the cut end or near the growing root tip. Histological studies of the roots showed that the buds originated from proliferating cortical cells, which had prominent chloroplasts and starch grains. The shoot buds grew successfully into entire plants.

Husbandry *L. aromatica* is not easily cultivated as it needs a permanent water supply, and the tender, fleshy stems can be easily damaged.

Harvesting Plants of *L. aromatica* are harvested from the wild in Vietnam, when they are at least a year old. Young plants are used as a condiment.

Handling after harvest In Vietnam, the plants of *L. aromatica* are dried before use.

Genetic resources and breeding All *Limnophila* species mentioned here have a large area of distribution, either naturally or as a result of cultivation, and do not seem to be at risk of genetic erosion. There are no known breeding programmes.

Prospects Essential oils and flavonoids of *Limnophila* show interesting pharmacological activities. More research is, however, needed to fully evaluate this potential. The plants might be of interest as a local source of e.g. antifungal or anthelmintic preparations.

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Selection of species

Limnophila aromatica (Lamk) Merr.

Interpr. Herb. amboin.: 466 (1917).

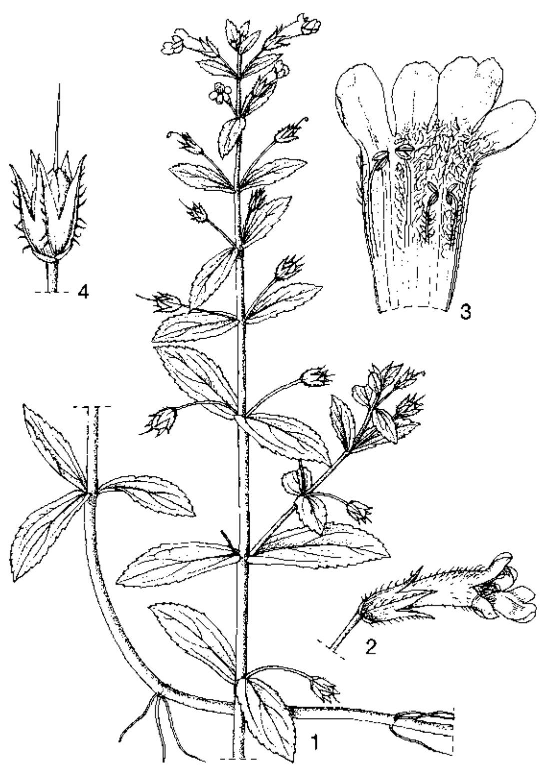
Synonyms *Gratiola aromatica* (Lamk) Pers. (1805), *Limnophila punctata* Blume (1826), *Limnophila gratissima* Blume (1826).

Vernacular names Indonesia: kehkehan (Sundanese), daun kardemom, selaseh ayer kecil (Ambonese). Malaysia: beremi, kerak-kerak. Philippines: angangi (Bontok). Papua New Guinea: poikehkeh (Wapi), ginibok (Keepaukee). Thailand: phak khayaeng (central), phak phaa (northern). Vietnam: rau ng[oom].

Distribution From India and Sri Lanka to Indo-China, southern China, Japan, Taiwan, throughout South-East Asia and northern Australia.

Uses In Indonesia and Peninsular Malaysia, the sap of the leaves is used to clean wounds, and a decoction of the leaves is given in fevers.

Observations A variable, fleshy, annual to perennial herb, 30–100 cm tall, stems simple or shortly branched from the base, glabrous to minutely glandular; leaves decussate or in whorls of 3, ovate-lanceolate to lanceolate, 10–55 mm × 3–15 mm, margins crenate to serrate-dentate, glabrous to densely and minutely glandular, pinnately veined, sessile; flowers solitary and axillary, or a few to many-flowered, terminal or axillary raceme, up to 15 cm long, pedicel 5–20 mm long, bracteoles 2, 1.5–2 mm long, calyx 4.5–7 mm long, hairy, striate at maturity, corolla 10.5–13.5 mm long, pale pink, outside finely glandular, inside densely villous, posterior lobe emarginate, posterior stamens 2.5 mm long, villous, anterior stamens 4 mm long, glabrous; capsule broadly ellipsoid, compressed, 5–6 mm long, brown. *L. aromatica* grows in shallow ponds or marshy localities, from sea-level up to 1000 m altitude. It is closely related to *L. chinensis* (Osbeck) Merr., and some authors consider *L. aromatica* as a subspecies of it.



Limnophila aromatica (Lamk) Merr. – 1, plant habit; 2, flower; 3, opened corolla with stamens; 4, fruit.

Selected sources 135, 407, 747, 810, 837.

Limnophila erecta Benth.

in DC., Prodr. 10: 388 (1846).

Synonyms *Stemodia gratioloides* Benth. (1832), *Ambulia erecta* (Benth.) Baill. ex Wettst. (1891).

Vernacular names Indonesia: kehkehan lembut (Sundanese).

Distribution Burma (Myanmar), southern China, Vietnam, Peninsular Malaysia, Java, Kalimantan.

Uses *L. erecta* closely resembles *L. aromatica* and has the same medicinal and culinary uses in South-East Asia.

Observations An annual herb, 10–30 cm tall, stems erect or ascending, stout to slender, normally much branched, glabrous or densely hairy, reddish; leaves decussate, linear-elliptical to ovate, (5–)10–30 mm × 3–9 mm, margins crenate-dentate, glabrous, pinnately veined, sessile; flowers axillary and solitary or in axillary and terminal racemes, pedicel 2–4 mm long, stout, reflexed at maturity, bracteoles 2, minute, calyx 4–5 mm long, obscurely striate at maturity, corolla 6 mm long, white, glabrous outside, sparsely hairy inside, lobes broadly lanceolate, acuminate, posterior stamens 1 mm long, anterior stamens 2.5 mm long, all glabrous; capsule ovoid, 3.5–4 mm long, pale brown. *L. erecta* grows in shallow ponds or marshy localities, from sea-level up to 1000 m altitude.

Selected sources 135, 311, 747.

Limnophila indica (L.) Druce

Rep. Bot. Exch. Club Brit. Isles 3: 420 (1914).

Synonyms *Hottonia indica* L. (1762), *Limnophila gratioloides* R.Br. (1810).

Vernacular names Philippines: tara-tara (Iloko). Papua New Guinea: narongo (Wapi, Marok). Laos: kh'ai namz.

Distribution Widespread and common, from tropical Africa to Iraq, India, Sri Lanka and Nepal, throughout tropical Asia, Taiwan, South-East Asia and northern Australia.

Uses In the Philippines, an infusion of the leaves is used for stomach problems including diarrhoea and dyspepsia. In India, the juice of the plant is rubbed on the body against strong fevers.

Observations A very variable, amphibious, perennial herb, with sessile or pedicellate glands, aerial stem 2.5–14 cm long, simple to branched, becoming subglabrous, or patent-hirsute (in Australia), submerged stem up to 1 m long, much branched, glabrous; aerial leaves verticillate, variously dissected, 3–12(–22) mm long, 1–3-veined, sessile glandular to subglabrous, rarely all undissected, submerged leaves up to 30 mm long, verticillate, pinnatisect, lobes flattened or capillary; flowers solitary, pedicel 2–10 mm long, slender, bracteoles 2, 2–4 mm long; calyx 3.5–6 mm long, sessile glandular, not striate at maturity, corolla 7–12 mm long, lobes entire, white to pale yellow, or base yellow, pinkish above, posterior stamens 2 mm long, anterior stamens 4 mm long, all glabrous; capsule compressed ellipsoid to subglobose, 3.5 mm long, dark brown. *L. indica* varies from a slender, gregarious plant of about 5 cm tall when growing on mud of river banks and rice fields, to a long, much-branched, submerged herb in deeper water of pools, from sea-level up to 1200 m altitude. *L. indica* is often confused with *L. sessiliflora* (Vahl) Blume, as both species have finely divided leaves in whorls, and are often completely submerged. *L. indica* though, has mostly flowers with pedicel as long as the calyx, 2 bracteoles, and mostly a sub-glandular indumentum on stems and pedicels while *L. sessiliflora* usually has sessile flowers, no bracteoles, and an eglandular indumentum.

Selected sources 311, 810.

Limnophila rugosa (Roth) Merr.

Interpr. Herb. amboin.: 466 (1917).

Synonyms *Herpestis rugosa* Roth (1821), *Limnophila roxburghii* auct. non G. Don.

Vernacular names Indonesia: hades (Sundanese), selaseh ayer (Moluccas), selaseh banyu (Javanese). Philippines: tala (Tagalog), kalaoo (Bicol), tara-tara (Iloko). Papua New Guinea: kraino (Wapi, Morok), poikehkeh (Orne, Walwali). Thailand: phak kachom (central), om kop (northern). Vietnam: h[oof]i n[uw][ows]c, qu[ees] d[aas]t.

Distribution India, Nepal, Indo-China, Thailand, southern China and the Ryukyu Islands, throughout South-East Asia to Fiji and Samoa.

Uses In Peninsular Malaysia a decoction and a steam bath of the leaves serve to cure itching eyes. In Thailand, the leaves are used as an antipyretic. In South-East Asia the leaves and tender stems are a popular side dish with rice, raw or cooked.

Observations An erect, semi-aquatic, fragrant, annual herb, up to 50 cm tall, stem simple or branched, glabrous to hirsute, rooting from the lower nodes; leaves decussate, ovate-lanceolate to ovate-elliptical, 2–12 cm × 1–5 cm, base decurrent into petiole, margin crenate, scabrid above, hirsute or scabrid on major veins beneath, petiole 0.5–3 cm long; flowers solitary and axillary, sometimes in axillary pedunculate clusters with up to 7 sessile flowers, peduncle up to 3.5 cm long; calyx tubular, irregularly but deeply 5-lobed, 6–11 mm long, corolla tubular, 5-lobed, bilabiate, up to 16 mm long, blue, with a yellow spot in the throat, outside pilose, posterior stamens 3 mm long, pilose, anterior stamens 6 mm long, glabrous; capsule broadly compressed ovoid, up to 6.5 mm × 3 mm, pale brown. *L. rugosa* occurs in moist locations along streams, pools and rice fields, from sea-level up to 1500 m altitude.

Selected sources 135, 311, 407, 747, 810.

G.H. Schmelzer

Lindernia All.

Mélang. Philos. Math. Soc. Roy. Turin 3(1): 178 (1766).
SCROPHULARIACEAE
x = 7–12, 14, 18; *L. anagallis*: $2n$ = 18, 22, *L. antipoda*: $2n$ = 36, *L. ciliata*: $2n$ = 18, 24, *L. crustacea*: $2n$ = 28

Major species *Lindernia anagallis* (Burm.f.) Pennell, *L. crustacea* (L.) F. Muell.

Vernacular names Malaysia: akar kerak nasi. Vietnam: l[uw] [owx]i th[ar]o.

Origin and geographic distribution *Lindernia* comprises about 80–100 species, and occurs throughout the tropical and warm regions of the world.

Uses Most *Lindernia* are very bitter. The aerial parts are widely used in poultices for boils, sores and itches. *Lindernia* is also often used to treat dysentery and other intestinal problems. The juice of the aerial parts of *L. crustacea*, mixed with turmeric (*Curcuma longa* L.) and heated with a little water, is applied to infected fingernails. In Peninsular Malaysia, a decoction of the leaves is given after childbirth. *L. hyssopioides* (L.) Haines, *L. montana* (Blume) Koord. (synonym *L. mollis* (Benth.) Wettst.), *L. procumbens* (Krock.) Von Borbas (synonym *L. pyxidaria* L.) and *L. pusilla* (Willd.) Boldingh are used similarly, as is, to a lesser extent, *L. crustacea*.
L. micrantha D. Don is sold on the market in Laos as a condiment.

Production and international trade *Lindernia* is only traded on a local scale and does not enter the international market.

Properties A mixture was isolated from *L. anagallis* consisting of terpenes (e.g. hexatriacontane, lupeol and betulin), together with a mixture of sterol(-glucosides), stigmasterol, β-sitosterol, β-sitosterol-β-D-glucoside and stigmasterol-β-D-glucoside.
A crude extract of *L. anagallis* given to rats or rabbits showed the following pharmacological activities on renal functions and blood pressure: (1) diuretic effect on normal rats, (2) decreasing glomerular filtration rate and renal blood flow on normal kidneys in rabbits, (3) no effects on glomerular filtration rate and renal blood flow on glycerin-induced insufficient kidneys in rabbits, (4) diuretic effects on both normal and glycerin-induced insufficient kidneys in rabbits, (5) inhibition of Na^+ and K^+ reabsorption on normal and glycerin-induced insufficient kidneys in rabbits, (6) hypertensive effect that could be blocked by phenoxybenzamine. In addition, the LD_{50} of this crude extract, given orally or intraperitoneally to rats, was found to be more than 10 g/kg and 4.6 g/kg, respectively.
The analgesic effect was evaluated by acetic-induced abdominal writhing response, hot plate, and tail-pressure pain tests. The anti-inflammatory effect was compared to that of formalin, serotonin, and carrageenin induced oedema in mice or rats. It was found that the analgesic effect was dose-dependent in all three methods tested. The analgesic potency at 0.15 g/kg (p.o.) in the writhing response test and at 0.1 g/kg in the hot plate test were equivalent to 150 mg/kg aspirin administered orally. The anti-oedematous potency against oedema produced by formalin and carrageenin were equivalent to 4 mg/kg of indomethacin administered orally.
L. crustacea contains 2 bitter compounds, but no alkaloids or glycosides were found in the phytochemical screening. From the petroleum ether extract of the whole plant of *L. ciliata* the compounds β-sitosterol, stigmasterol and lup-20(29)-en-3β-ol were isolated. From the whole plants of *L. procumbens*, 2 oleanane-type triterpene saponins, linderniosides A and B were isolated. The total extract showed antitumour activity in vitro.

Description Annual to perennial, branched herbs; stems erect to prostrate, quadrangular, rooting at the nodes. Leaves opposite, simple, entire to crenate; petiole present; stipules absent. Inflorescence with solitary and axillary flowers or terminal and axillary racemes or subumbellate clusters. Flower bisexual, zygomorphic, pedicel accrescent in fruit; calyx deeply to shallowly 5-lobed, -veined, -ribbed or -winged; corolla tubular, bilabiate, upper lip ovate or oblong, emarginate or shallowly bilobed, lower lip 3-lobed, spreading; stamens 2 or 4, didynamous, posterior pair usually fertile, anterior pair fertile, sterile or reduced to staminodes, anterior filaments normally each with a distinct spur near the base, anthers touching in pairs under the lower lip, loculi divaricate; ovary superior, 1-locular, glabrous, style filiform, stigma bilamellate. Fruit a bivalved capsule, with numerous seeds. Seed small, ellipsoid or shortly cylindrical, variously reticulate. Seedling with epigeal germination.

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

Other botanical information *Lindernia* nowadays includes the genera *Bonnaya*, *Ilysanthes* and *Vandellia*. In *Lindernia*, 3 subgenera are recognized, subg. *Lindernia*, subg. *Tittmannia* and subg. *Bonnaya*.

Ecology *Lindernia* occurs in moist, shaded or sunny localities, along ditches, roadsides and in grassy fields, often as minor weeds in rice fields.

Propagation and planting *Lindernia* is propagated by seed, which is mainly dispersed by water, but is also carried externally on birds.

Diseases and pests *L. antipoda* is a host of papaya ringspot virus in Taiwan. *Lindernia* is a host of the nematode *Meloidogyne graminicola*. Resistance against herbicides containing sulphonylurea has been found in *Lindernia* in Japan.

Harvesting *Lindernia* can be harvested for local use throughout the year.

Handling after harvest *Lindernia* is either used fresh or dried for future use.

Genetic resources and breeding The *Lindernia* species treated here are widespread and common throughout South-East Asia as weeds, and therefore certainly not endangered. There are no known breeding programmes of *Lindernia*.

Prospects Extracts of *Lindernia* species showed interesting pharmacological activities in some basic pharmacological screenings assays. Therefore they merit further research in order to evaluate their possibilities in future development.

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Selection of species

Lindernia anagallis (Burm.f.) Pennell

Journ. Arn. Arb. 24(3): 252 (1943).

Synonyms *Ruellia anagallis* Burm.f. (1768), *Vandellia pedunculata* Benth. (1835), *Vandellia cordifolia* (Colsm.) G. Don (1838).

Vernacular names Thailand: nuat plaa duk (northern), yam chui kai kang (central). Vietnam: l[uwx] d[awf]ng cong.

Distribution Throughout continental and South-East Asia and northern Australia.

Uses In Peninsular Malaysia,a decoction of the leaves, like those of *L. crustacea*, is given after childbirth. Taiwanese herbalists use the plant as a diuretic in nephritis, and also for furuncles and carbuncles. In Thailand, the entire plant is used for asthma. In India, it is used as a remedy for gonorrhoea.

Observations An annual herb, up to 40 cm tall, branched from the base, branches short, prostrate and erect; leaves oblong-lanceolate to ovate, 9–45 mm long, base truncate, margins shallowly remotely dentate, subsessile; flowers axillary, solitary, 1 per leaf pair, upper ones forming a raceme, pedicel 6–15 mm long, corolla tube 5–8 mm long, upper lip entire, lower lip 3-lobed, corolla base yellowish, lobes pale bluish purple to white, stamens 4; capsule ellipsoid, attenuate, 1.2 cm long, much extending the calyx; seed ellipsoid, reticulate, acute at both ends. *L. anagallis* occurs in marshy localities, both in savanna and forests, and along rivers, from sea-level up to 1900 m altitude. It is a weed in irrigated and rainfed rice fields.

Selected sources 215.

Lindernia antipoda (L.) Alston

in Trimen, Handb. fl. Ceylon 6, Suppl.: 214 (1931).

Synonyms *Ruellia antipoda* L. (1753), *Bonnaya veronicifolia* (Retzius) Spreng. (1824), *Ilysanthes antipoda* (L.) Merr. (1917).

Vernacular names Indonesia: mata yuyu (Javanese), sawi tanah, tumpangan ayer (Malay). Thailand: maak lin nam khaang (south-western), chang peng no (central). Vietnam: c[os]c m[aw]n, rau choi, m[af]n d[aas]t.

Distribution Tropical and subtropical Asia, from India to southern and central China and Japan, throughout South-East Asia to northern Australia, Micronesia and Polynesia.

Uses In Peninsular Malaysia, the root with the addition of an astringent, is applied to cure diarrhoea. A decoction of the roots and leaves is used as an anthelmintic. In Indonesia, the plant is part of a medicine for vertigo. In Taiwan, the whole plant is considered an emmenagogue.

Observations An annual creeping herb, up to 40 cm long, branches ascending at the ends, stem with air cavities; leaves oblong-obovate, 9–45 mm long, base attenuate, margins shallowly remotely dentate, minutely bristly; flowers axillary, solitary, 2 per leaf pair, pedicel up to 1 cm long, corolla tube 5–8 mm long, widening upwards, upper lip subemarginate, margins recurved, lower lip 3-lobed, middle lobe hairy inside, corolla base yellow, lobes pale blue-purple to white, stamens 2, lilac, staminodes 2, erect, apex club-shaped, bright yellow; capsule erect-patent, linear-lanceolate, 1–1.8 cm long, twice as long as the calyx; seed ellipsoid, reticulate, base acute, apex obtuse or narrowed. *L. antipoda* occurs in sunny or shaded, moist or swampy localities, also near villages and in open forest or ditches, on arable land and irrigated or rainfed rice fields, from sea-level up to 1800 m altitude.

Selected sources 786.

Lindernia ciliata (Colsm.) Pennell

Brittonia 2: 182 (1936).

Synonyms *Gratiola ciliata* Colsm. (1793), *Bonnaya brachiata* Link & Otto (1820), *Ilysanthes ciliata* (Colsm.) Kuntze (1891).

Vernacular names Thailand: phak hom ho paa (south-eastern). Vietnam: m[af]n r[if]a.

Distribution Tropical and subtropical Asia, from India to southern China, throughout South-East Asia to northern Australia and Polynesia.

Uses In Peninsular Malaysia, the sap from the crushed leaves is given after childbirth. In Taiwan, the plant is considered an effective cure for menorrhagia.

Observations A small, annual, erect, or at the base prostrate herb, up to 15 cm tall; leaves oblong to obovate, 10–35 mm long, base attenuate, margins densely sharply serrate, teeth with long bristle, petiole absent; flowers in terminal racemes, 2–8 cm long, 3–13-flowered, pedicel 3–7 mm long, corolla tube narrow cylindrical, 6 mm long, upper lip erect, concave, white with red stripe, lower lip patent, 3-lobed, white-red spotted, stamens 2, staminodes 2, short and curved, base red, apex white; capsule erecto-patent, linear, attenuate acute, 11–15 mm long; seed ellipsoid, 0.3 mm long, reticulately pitted, base acute, apex flattened or rounded. *L. ciliata* occurs on sunny or lightly shaded, often grassy localities, along roadsides, in fallowed fields and rainfed rice fields, generally on light soils, often gregarious, from sea-level up to 700 m altitude.

Selected sources 581, 786.

Lindernia crustacea (L.) F. Muell.

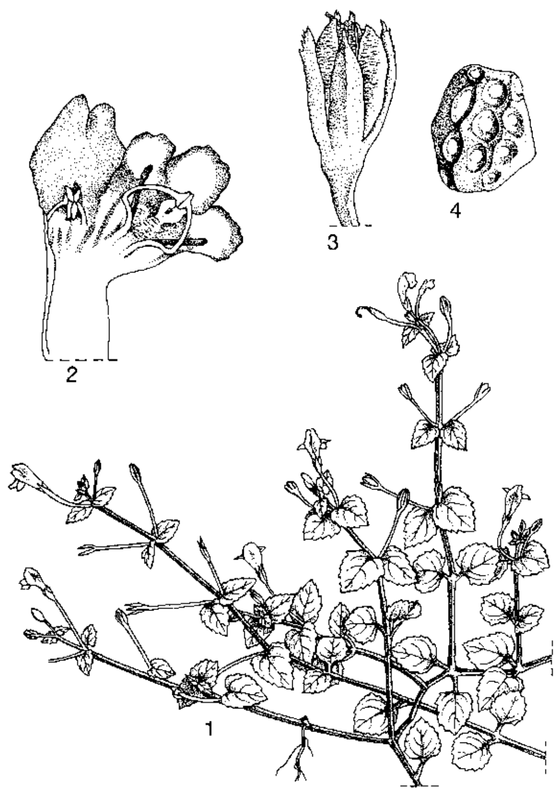
Syst. Census Austral. pl. 1: 97 (1882).

Synonyms *Lindernia gracilis* (Bonati) Bonati (1927), *Vandellia crustacea* (L.) Benth. (1935).

Vernacular names Brunei: kerak nasi. Indonesia: daun sirik betok (Jakarta), jukut mata keuyeup (Sundanese), brobos kebo (Javanese). Malaysia: akar kerak nasi, akar kelurut, rumput jari chechak. Cambodia: (smau) chiĕk to:k. Thailand: yaa kaaphoi tua mia (peninsular), to ti ke kang (central). Vietnam: m[aax]u th[ar]o, d[aa]y l[uw] [owr]i d[oof]ng.

Distribution Throughout West Africa and Asia, including South-East Asia, Japan, northern Australia, Micronesia and Polynesia. It has recently been recorded from Texas (United States).

Uses In Peninsular Malaysia, a decoction of the leaves, or leaves of other *Lindernia* species, is giv-



Lindernia crustacea (L.) F. Muell. – 1, plant habit; 2, opened corolla with stamens; 3, opened fruit in calyx; 4, seed.

en as a medicine after childbirth. In the Moluccas, it is applied to boils and itches, herpes-like sores, and to sores caused by forest ticks. In Indo-China, the plant is considered to have emetic and cathartic properties, and has given good results in treating bilious disorders, dysentery, amenorrhoea, and hepatitis. It is one of the commonest plants in Chinese pharmacies in Indonesia and Malaysia. In Brunei, the powdered herb mixed with rice water is drunk to relieve diarrhoea, vomiting and cholera.

Observations A small, diffusely branched, annual to short-living perennial herb, 5–20 cm tall, stems sharply quadrangular to narrowly-winged, green to purple, pubescent on angles and nodes; leaves ovate, 8–20 mm long, base cordate, margins subentire to serrate, sparingly hairy, petiole 1–18 mm long; flowers axillary and solitary, unilateral or opposite, pedicel 8–20 mm long; corolla 9–12 mm long, tube subcylindrical, dark purple, base pale, upper lip erect, ovate, purple, apex emarginate, pale, lower lip broad, 3-lobed, white or pale purple, yellow spot at base, stamens 4, spurs purple; capsule oblong-ovoid to ellipsoid, 5–6 mm long, as long as the calyx; seed ellipsoid, 0.4 mm long, both ends obtuse, tuberculate, pale brown. *L. crustacea* occurs in moist, open grassy localities, rice fields, sugar-cane fields, river beds, ditches and disturbed soils, from sea-level up to 1500 (–3000) m altitude.

Selected sources 215, 407, 786.

Isa Ipor

Lobelia L.

Sp. pl. 2: 929 (1753); Gen. pl. ed. 5: 401 (1754).

CAMPANULACEAE

$x = 7, 14$; *L. angulata*: $2n = 14, 70$, *L. chinensis*: $2n = 42$, *L. nicotianaefolia*: $2n = 28$

Major species *Lobelia chinensis* Lour., *L. nicotianaefolia* Roth ex Roemer & Schultes.

Origin and geographic distribution *Lobelia* consists of 250–300 species, mostly in the tropics and subtropics, especially in America. In Malesia, 12 species occur in the wild, and 5 species are planted as ornamentals.

Uses *L. angulata* is not very much used in the region. In Java, the pounded leaves are used for sprue. In Vietnam, the fruits are applied to treat scabies, stomach-ache, infected eyes, and difficult urination. In China, the plant is mainly used to treat irregular menstruation, and spermatorrhoea. In Taiwan, the leaves and young tops of *L. angulata* are eaten as a vegetable.

L. chinensis is commonly used medicinally in China, Indo-China and Thailand, but not in Malaysia and Java, where it is not very common. In Indo-China, the roots are considered depurative, antirheumatic and antisyphilitic, and are also taken as an anti-inflammatory and for kidney problems. In Thailand, the whole plant is used in alcoholic macerates as a lung tonic, for tuberculosis, asthma, and in the treatment of bloody vomiting. In China, the plant is applied externally as a poultice on swellings, sores and ulcers and as an antidote for bites of snakes, insects or scorpions. A decoction is taken as a diuretic and cathartic. It stimulates respiration, lowers the blood pressure, stops bleeding and reduces swellings.

L. nicotianaefolia is, like *L. chinensis*, not commonly used in Malesia, although it is found dried in Chinese pharmacies. It is considered poisonous. The dry herb, when handled, is very acrid, and causes irritation to the throat and nostrils like tobacco. The symptoms of poisoning are similar to those of nicotine. In India, an infusion of the leaves is taken as an antispasmodic and externally as a leech repellent. In Vietnam, the crushed leaves or the juice are applied on abscesses and furuncles. The latex causes dermatitis. The seeds are very acrid and used as an insecticide throughout its distribution area.

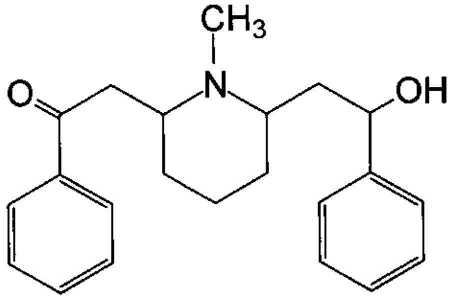
The North American *L. inflata* L. ('Indian tobacco') is well known as a medicinal, and has been planted for this purpose in the hills of India. It has been used to relieve spasm in asthma and chronic bronchitis, and also in respiratory failure resulting from anaesthesia, poisoning by narcotics and noxious gases. It is also applied in some cases of urticaria. Formulations containing lobeline sulphate and vitamin B are used as a smoking cessation agent. Taken as a tea or smoked as tobacco, it has a mild euphoric marijuana-like quality. *L. syphilitica* L., a native of the United States, is cultivated as an ornamental in Peninsular Malaysia but does not grow well there. The North American Indians used a decoction of the roots for syphilis, but later analysis found it valueless. Several other *Lobelia* species, including *L. cardinalis* L., *L. erinus* L. and *L. laxiflora* Kunth are widely planted as ornamentals, and also contain alkaloids.

Production and international trade The South-East Asian *Lobelia* are hardly traded.

Properties *L. inflata* is well known in North America and Europe for its content of piperidine-type alkaloids (0.1–0.6%), which are biochemically derived from the amino acid lysine. The alkaloids can be divided into several groups, the main one being the lobeline-group (e.g. lobeline, lobelanine, lobelanidine), together with the lobinine-group (e.g. lobinine, isolobinine), and other groups which include compounds like 8-10-diethyl lobelidiol, 8-ethyl norlobelol-I, isolobinanidine, lelobanidine I and II, lobelanidinelobelanine, lobinalidine, lobinaline, lobinanidine, 8-methyl-10-ethyl-lobelidiol, 8-methyl-10-phenyl-lobelidiol, norlelobanidine, norlobelanidine and norlobanine. The maximum concentration of alkaloids in *L. inflata* is reached in plants at the middle of the flowering period in India, and the distribution of lobeline in different plant parts was found to be about 1% in the top of the inflorescence and unripe fruits (including the seeds), 0.4% in leaves and stem, and 0.5% in roots. Lobeline can be classified as a nicotinic agonist; the action of lobeline is similar to nicotine, but weaker. Like nicotine, it acts on the central nervous system, autonomic ganglia and the nerve ends in voluntary muscles. It is a primary stimulant and a secondary depressant. In small doses it produces severe vomiting, sweating and general relaxation. Poisonous reactions including rapid and feeble pulse, fall of temperature and collapse with coma, appear when the drug is not rejected by vomiting. Lobeline was also shown to alter presynaptic dopamine (DA) storage by potently inhibiting DA uptake into synaptic vesicles from the rat striatum. D-amphetamine acts at the level of the synaptic vesicle to alter presynaptic function. In contrast to d-amphetamine, which is equipotent in inhibiting DA uptake and promoting release from the synaptic vesicles, lobeline more potently (28-fold) inhibits DA uptake than it evokes DA release to redistribute presynaptic DA storage.

Decoctions of the aerial parts have been used as an expectorant, but this effect cannot be attributed to lobeline, because of its quick degradation in the body. The active compound is probably isolobinine, which strongly irritates the mucous membranes when administered orally. Effects of the triterpene derivative β-amyrin palmitate, isolated from the leaves of *L. inflata*, were studied on the central nervous system of mice and were compared with those of antidepressant drugs, mianserin and imipramine. The results suggest that β-amyrin palmitate has similar properties in some respects to mianserin, and might possess a sedative action.

The aerial parts of *L. angulata* contain related piperidine alkaloids, such as 1-(2-N-methylpiperidyl)-butan-2-one and 1-(2-N-methylpiperidyl)-pentan-2-one, together with flavonoids like diosmin, linarin, apigenin 7-O-rutinoside and luteolin 7-O-rutinoside, and the polyacetylene lobetyolin.



lobeline

L. nicotianaefolia also contains alkaloids of the lobeline group, and samples collected during the rainy season in India contain 0.3–0.4%, while dried samples collected at the end of the rainy season contain 1–1.2% total alkaloids. Lobelanidine is the principal alkaloid, together with nor-lobelanine and to a lesser extent l-lelobanidine. In the Indian Pharmacopoeia, the dried aerial parts of *L. nicotianaefolia* constitute the drug Lobelia or Lobelia Herba.

Little is known about the phytochemistry of *L. chinensis*. However, a hot water extract showed antitumour activity in an in vitro test with Ehrlich ascites tumor sarcoma 180 cells. Furthermore, the effects of several synthetic inhibitors of endothelium-derived relaxing factors and an extract of *L. chinensis*, used in China as antisnake venom, on the biological function of endothelin (ET) are reported. The results showed that inhibiting the production of nitric oxide could stimulate ET release from vascular endothelium, elevate plasma ET and increase blood pressure.

The residues obtained from the ethanol extract of stems, leaves and flowers of *L. laxiflora* were applied in carrageenan- and cobra venom-induced acute inflammation in mice, and a suppression of paw oedema formation at a dose of 100 mg/kg was established.

Adulterations and substitutes *L. inflata* is commonly used as a substitute for other lobeline-producing *Lobelia*.

Description Annual or perennial herbs, sometimes woody below, rarely arborescent, normally lactiferous. Leaves spirally arranged, alternate or in a rosette, simple; petiole present or absent; stipules absent. Inflorescence a terminal raceme or panicle, or flowers solitary and axillary; bracts present or absent. Flowers 5-merous, normally bisexual; calyx lobes valvate; corolla gamopetalous, zygomorphic, with a dorsal slit almost to the base, limb with 2 dorsal lobes, mostly diverging from the lower 3, which form a trifid whole, lobes valvate in bud, connate to a varying degree; stamens 5, alternate with the corolla lobes, free or adnate to the corolla tube, partly connate with the filaments and/or the anthers, forming a tube, anthers basifixed, introrse, 2-celled, cells opening lengthwise, 2 anterior anthers normally with a hairy tuft; disk absent, ovary (partly) inferior, 2-celled, style 1, hairy below the 2 stigmas, during anthesis lengthening through the anther tube, ovules numerous. Fruit a berry or an apically 2-valved capsule, crowned by the persistent calyx lobes; seeds numerous. Seed with straight embryo, albumen present.

Growth and development *Lobelia* can be found flowering throughout the year, under humid conditions. *Lobelia* flowers are protandrous thus promoting outcrossing; by the lengthening of the style, the unopened stigmas grow through the anther tube, pushing the pollen out of the tube. The stigmas become receptive long after the pollen is shed.

Other botanical information *Lobelia* is sometimes classified into a family of its own, the *Lobeliaceae*, but this view is not shared here. The genus *Pratia*, with berry-like fruits, has been merged into *Lobelia*, with capsular, apically 2-valved fruits, because they are closely related, and an intermediate species exists, *L. angulata*, in which intergrading fruit types occur. Many *Lobelia* species show large intraspecific chromosomal variation, although diploidy seems to be predominant.

Ecology *Lobelia* in Malesia grows mainly in the per-humid hills, but some species occur in the lowland where the climate is seasonal.

Propagation and planting *Lobelia* is propagated by seed, and some species also by stolons. *L. chinensis* is normally propagated vegetatively by stolons, which are dispersed by water.

In vitro production of active compounds Hairy roots of *L. chinensis* were induced with *Agrobacterium rhizogenes* ATCC 15834 in vitro, and produced 3 polyacetylene glycosides, lobetyol, lobetyolin and lobetyolinin, in hormone-free Murashige & Skoog, Gamborg B5, Woody Plant (WP) and Root Culture media. The hairy roots produced maximum amounts of the polyacetylenes, particularly in WP medium in the dark.

Diseases and pests From ornamental *Lobelia* some fungal and bacterial diseases are known, caused by e.g. *Alternaria tenuis*, *Coleosporium campanulae* and *Xanthomonas campestris*, but these do not attack the medicinal *Lobelia* treated here. *Lobelia* is susceptible to nematodes.

Harvesting In Vietnam, *L. chinensis* is harvested mainly during the rainy season, *L. nicotianaefolia* and *L. angulata* at the end of the rainy season.

Handling after harvest In Vietnam, *L. chinensis* is used fresh or dried for future use. In India, *L. nicotianaefolia* is usually dried before use. The material is then studded with small spots of resinous exudation, which taste hot and acrid.

Genetic resources and breeding The *Lobelia* species treated here are rather widespread in Asia, but occur less in Malesia. As their preferable habitat is montane forest, there might be a risk of genetic erosion with the destruction of these habitats or through overexploitation.
There are no known breeding programmes of *Lobelia*.

Prospects *L. nicotianaefolia*, and probably other *Lobelia* species as well (e.g. *L. chinensis*), contain interesting alkaloids, similar to those of *L. inflata*. More research is needed to evaluate the composition of alkaloids and their quantity, as well as the optimal growing conditions of the species concerned. The potential for cultivating *Lobelia*, including *L. inflata*, in South-East Asia needs further investigation, since at present the use of the alkaloids mentioned is only very limited.

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Selection of species

Lobelia angulata J.G. Forster

Fl. ins. austr. prodr.: 58 (1786).

Synonyms *Lobelia nummularia* Lamk (1789), *Pratia begonifolia* Lindl. (1830), *Pratia nummularia* (Lamk) A.Br. & Asch. (1861).

Vernacular names Indonesia: ketrus alus, manikan (Javanese), aantingan (Sundanese). Philippines: gubagubai, kanapa (Igorot), tutugi (Bontok).

Distribution From India to south-eastern China, Indo-China, sparsely throughout Malesia, but not recorded from Borneo or the Moluccas. Also in Australia, Tasmania, New Zealand and South America.

Uses In Java, the pounded leaves are sometimes used for sprue. In Indo-China, the fruits or leaves are used to treat stomach-ache, scabies, infected eyes, swellings and boils.

Observations A polymorphous, annual to perennial, branched, creeping or hanging herb, 8–60 cm long, stems terete, rooting at the nodes, glabrous or hairy; leaves alternate, rounded to ovate or reniform, 2–25 mm × 2–35 mm, base cordate, truncate or decurrent, apex acute or rounded, margins dentate to subentire, petiole 0–25 mm long; flowers solitary, axillary, pedicel 0.5–6 cm long; calyx lobes linear-lanceolate to triangular, 1–11 mm long, corolla 4.5–15 mm long, white to pink or purple, outside and inside glabrous or hairy, dorsal lobes 2–14 mm long, connate with lateral ones for 1.5–5 mm, lateral lobes connate to central lobe for 2–12 mm, equal in length, filaments 3–11 mm long, very variable, free for about 3/4 of their length, glabrous or hairy; fruit very variable, an indehiscent or dehiscent capsule or a rather dry to baccate berry, ellipsoid to globose, 6–16 mm × 5–13 mm, reddish-violet, glabrous to hairy, pedicel curved downwards; seed flattened-ellipsoid, about 1 mm long, brown, finely reticulate. *L. angulata* occurs on unshaded to shaded moist soils along rivers, along forest roads and in secondary forest, locally abundant in tea plantations, in Java between 600–2300 m altitude.

Selected sources 74, 135, 407, 413.

Lobelia chinensis Lour.

Fl. cochinch.: 514 (1790).

Synonyms *Lobelia radicans* Thunb. (1794), *Pratia radicans* G. Don (1834).

Vernacular names Indonesia: jukut mata keuyeup, ki tombe (Sundanese). Thailand: phrachan khrueng seek (Bangkok), bua khrueng seek (central). Vietnam: b[as]n bi[ee]n li[ee]n.

Distribution From India and Sri Lanka to China and Japan, southwards to Peninsular Malaysia and Java (Indonesia).

Uses In Indo-China and China, the aerial parts are used internally as a diuretic, externally on skin infections, like boils and swellings, also caused by poisonous insects and animals. The root is considered depurative, antirheumatic and antisyphilitic. In Thailand, the whole plant is used in alcoholic macerates as a lung tonic, for tuberculosis, asthma and treatment of bloody vomiting. In China, a strong decoction is taken as a diuretic and cathartic; it can stimulate respiration, lower the blood pressure, stop bleeding and reduce swellings.

Observations An annual, branched, creeping herb, stem 5–15 cm tall, rooting at the nodes; leaves alternate, lanceolate to ovate-oblong, 1.2–3 cm × 0.2–0.6 cm, base long decurrent, apex acute or rounded, margins subentire to shallowly toothed towards the apex; flowers solitary, axillary, 7–15 mm long, normally 1–2 on each stem, pedicel 0.6–3.5 cm long; calyx lobes narrowly triangular, up to 3 mm long, corolla 5–12 mm long, white to pale purple, outside glabrous, inside hairy, dorsal lobes connate with lateral ones for 4 mm, up to 8 mm long, ventral and lateral lobes equal in length, filaments 5–6 mm long, more than halfway free, 2 anterior ones hairy; capsule obconical, 4–6 mm long, glabrous, pedicel recurved; seed ellipsoid, 0.5 mm long, dark brown, smooth. *L. chinensis* occurs in moist, grassy localities, along water courses and on cultivated land, like rice fields, tea and cinchona plantations, mainly between 500–1600 m altitude.

Selected sources 74, 215, 795, 866, 867, 979, 1004.

Lobelia nicotianaefolia Roth ex Roem. & Schult.

Roemer & Schultes, Syst. veg. 5: 47 (1819).

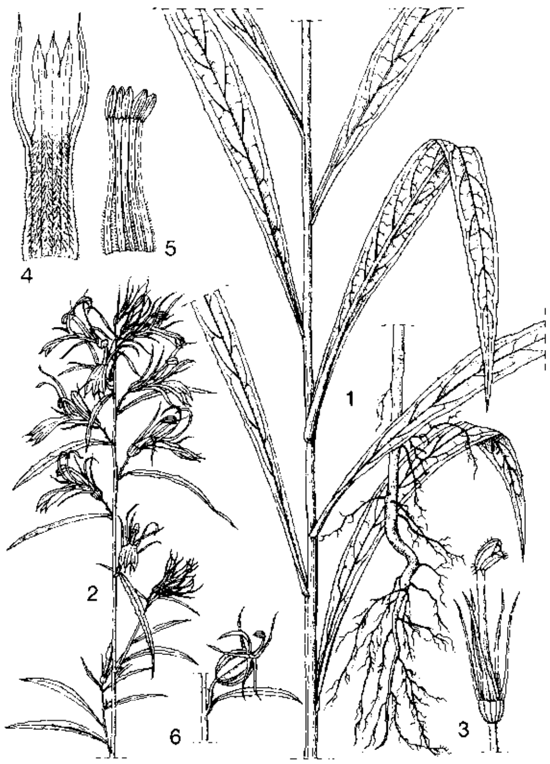
Synonyms *Lobelia pyramidalis* Wallich (1820), *Rapuntium pyramidale* Presl (1836).

Vernacular names Philippines: adlabong, kanyuong (Igorot), balyongyong (Bontok). Thailand: haang kai faa (northern). Vietnam: b[ar] thu [oos]c, s[ow]n c[as]nh kh[us]c.

Distribution From India and Sri Lanka, Indo-China, southern China to the Philippines and Sulawesi (Indonesia).

Uses The seeds are very poisonous, and used as an insecticide. In Vietnam, the crushed leaves or the juice is applied to abscesses and furuncles.

Observations A coarse, biannual or perennial herb, up to 2(–4.5) m tall, stem terete at base, angular above, hollow, simple or apically branched; leaves spirally arranged, crowded when young, oblong to narrowly lanceolate, gradually smaller towards apex, 10–50 cm × 4–8 cm, base long decurrent, apex acuminate, margins serrate, both sides hairy; raceme terminal, up to 45 cm long, at base often panicle-like, pedicel 1–2.5 cm long; flower up to 3.5 cm long, variable in colour, whitish, pink, blue or purple, sepals linear to lanceolate, up to 12 mm long, corolla up to 3 cm long, outside glabrous or hairy, inside hairy, dorsal lobes connate with lateral ones at least for half its length, ventral and lateral lobes equal in length, filaments 1.5–2 cm long, free and hairy at base, upwards puberulous; capsule rounded-cupular, 1 cm × 0.4–0.6 cm, 7–12-veined, glabrous to hairy; seed flattened ellipsoid, small, 0.5 mm long, yellowish-brown, smooth. *L. nicotianaefolia* occurs in open localities on ridges in montane forest, often on grassy mountain slopes and hills, from 600–2300 m altitude. *L. nicotianaefolia* is a very polymorphous species, and microspecies, based on characters like presence or absence of bracteoles, insertion of the bracteoles, branching patterns, hairiness, and size of flowers, do not hold.



Lobelia nicotianaefolia Roth ex Roemer & Schultes – 1, leafy stem and roots; 2, inflorescence; 3, flower, corolla removed; 4, opened corolla; 5, stamens; 6, fruit.

Selected sources 74, 215, 739.

G.H. Schmelzer

Lonicera japonica Thunb. ex Murray

Syst. Veg. ed. 14: 261 (1784).
CAPRIFOLIACEAE
$2n = 18$

Synonyms *Lonicera chinensis* Watson (1825), *Lonicera repens* Zipp. ex Hassk. (1844).

Vernacular names Japanese honey-suckle (En). Chèvre-feuille du Japon (Fr). Thailand: saai nam phueng. Vietnam: kim ng[aa]n, nh[aax]n d[oo]ng.

Origin and geographic distribution *L. japonica* originates from Japan, Korea, China, Taiwan and northern Vietnam, but is widely cultivated as an ornamental in South-East Asia up to 1000 m altitude.

Uses In traditional Vietnamese medicine the flowers are considered diuretic, cooling, depurative and detoxicant. They are prescribed in cutaneous diseases, eczema, measles, boils, carbuncles, and especially in enteritis and dysentery. The leaf-bearing stem is credited with antibacterial and anti-allergic properties. It is recommended in the treatment of boils, impetigo, urticaria, allergic rhinitis, fever, malaria, erythema, measles, diarrhoea, dysentery, syphilis, rheumatism and prickly heat. The drug is taken in the form of a decoction, infusion, extract or alcoholic macerate. In Vietnam, *L. dasystyla* Rehder is used similarly. In traditional Thai medicine a decoction of the fresh stem is used as a diuretic, antipyretic, antidiarrhoeal and antidysenteric; it is used in the treatment of enterocolitis. Although sometimes considered a noxious weed in northern America, *L. japonica* has become an important browse plant for deer in autumn and winter. Several *Lonicera* species (including *L. japonica*) are widely grown as ornamentals for their colourful, fragrant flowers.

Production and international trade Despite its long-standing use in South-East Asia and its omnipresence in traditional Chinese pharmacies as testimony of the trade from more temperate areas to tropical regions, no information is available on trade statistics for *L. japonica*.

Properties The n-butanol fraction of whole plants of *L. japonica* (collected from Korea) was evaluated for its anti-inflammatory activity using several experimental animal models. At oral doses of 100–400 mg/kg, the fraction showed anti-inflammatory activity against acute, granulomatic and chronic inflammation models in mice and rats. Although the activity was not potent compared with prednisolone, these results supported the traditional use of this plant in folk medicine. These results were confirmed using an n-butanol fraction from the aerial parts of *L. japonica* consisting of a mixture of flavanoids, iridoids and triterpenoid saponins. By using acute models (croton oil- or arachidonic acid- induced mouse ear oedema test) or chronic models (adjuvant induced arthritis in rats) of inflammation together with activity-guided isolation procedures, loniceroside A (a hederagenin-saponin), lonicerin (a neohesperidoside flavone) and loganin (an iridoid) were identified as active compounds.

Furthermore, in a screening for phospholipase A_2 (PLA_2) inhibitors of natural origin in order to secure new anti-inflammatory agents, 2 biflavonoids have been isolated from the aerial parts of *L. japonica* which showed strong PLA_2 inhibition in vitro. Their structures were identified as ochnaflavone and its 4′-O-methylether. Ochnaflavone also inhibited rat platelet phospholipase A_2 at an IC_{50} value of about 3 μM. The inhibitory activity was specific against group II phospholipases rather than group I phospholipases. Addition of excess calcium did not antagonize the inhibitory activity, indicating that the inhibition may result from direct interaction with the enzyme.

The butanol fraction of *L. japonica* aerial parts reduced antigen-induced contractions of isolated trachea preparations from sensitized guinea-pigs in a concentration-dependent manner. The butanol fraction also inhibited histamine release from rat peritoneal mast cells induced by antigen or calcium ionophore A23187 (IC_{50} values of 0.26 and 0.32 mg/ml, respectively) in vitro. Eosinophil infiltration into bronchoalveolar lavage fluids induced by aero-allergen challenge in passively sensitized guinea-pigs was inhibited by the butanol fraction at a dose of 800 mg/kg (51.7%). In addition, the butanol fraction inhibited leukotriene B4 production in rat basophilic leukaemia cells (IC_{50} of 0.42 mg/ml) as well as phosphodiesterase 4 (PDE4) isolated from rat brain (IC_{50} of 0.015 mg/ml). At this stage, as a model, the butanol fraction of *L. japonica* may therefore be useful in the treatment of experimental asthma and its mode of action may be related to inhibition of both 5-lipoxygenase and PDE4 enzymes.

An extract of *L. japonica* flowers tested in an experimental model of chronic hepatitis B infection (using the PLC/PRF/5 cell line) suppressed hepatitis B virus surface antigen (HBsAg) secretion without cytotoxicity. The effects on blood pressure of phenolic compounds obtained from dried flowers were investigated in a spontaneously hypertensive rat model. Protocatechuic and methyl caffeate were identified as the major active substances. Chlorogenic acid and five caffeoylquinic acids at higher doses possessed the delay hypotensive effect. Also, at the highest effective dose, all of the compounds also produced hypotension in normotensive rats.

The methanolic extract of *L. japonica* flowers showed no anti-inflammatory activity as measured by its inhibitory effect on interleukin-8 induction in lipopolysaccharide-activated rat macrophages. A saponin fraction extracted from the flower buds showed no skin toxicity in guinea-pigs and suppressed UV-induced erythema in guinea-pigs in a dose-dependent manner.

Aqua-acupuncture is a form of acupuncture that involves the hypodermic injection of e.g. herbal extracts at acupuncture points, purportedly to stimulate them by pressure from the injected substance. *L. japonica* flowers aqua-acupuncture solution (LFAS) and *L. japonica* flowers water-extracted solution (LFWS) were prepared and tested for their chemopreventive potential. Three biomarkers, quinone reductase (QR), ornithine decarboxylase (ODC), and glutathione (GSH), were used to test the chemopreventive potential of LFAS. LFAS was a potent inducer of QR activity in Hepa1c1c7 murine hepatoma cells, whereas LFWS was less potent. LFAS and LFWS also induced QR activities in cultured human hepatoma Hep3B cells. The effects of LFAS and LFWS were also tested on the growth of *Acanthamoeba castellanii*. Proliferation of *A. castellanii* was inhibited by LFAS and LFWS at concentrations of 0.1x, 0.5x, 1x, and 3x the reference. In addition, GSH levels were increased by about 2-fold with LFAS and 1.5-fold with LFWS in cultured murine Hepa1c1c7 cells. LFAS and LFWS were also shown to increase GSH levels in human Hep3B cells.

These results suggest that LFAS has chemopreventive potential by inducing QR activity, inhibiting ODC activity and increasing GSH levels.

Description An evergreen or semi-evergreen, vigorous, scandent shrub or climber up to 3 m tall; branches terete, hollow, glandular, prominently patent pubescent when young. Leaves opposite, simple, entire, ovate-oblong to ovate-lanceolate, 3–8.5 cm × 1.5–4 cm, base rounded to truncate, apex acute or subacuminate, midrib and edges pilose, dark green and shiny above; petiole about 1 cm long; stipules absent. Inflorescence an axillary, 2(–3)-flowered cyme, peduncle 2.5–15 mm long, each pair of flowers subtended by 2 leafy bracts, 10–18 mm × 4–8 mm, and 4 elliptical bracteoles, about 1 mm long, hairy, glandular, ciliate. Flowers intensely fragrant; calyx tube ovoid, glabrous, lobes ciliate; corolla bilabiate, 4–5 cm long, white turning pinkish, fading orange yellow, tube narrow, about 2.5 cm long, soft pubescent outside; stamens 5, exserted, filaments inserted near the apex of the tube; ovary inferior, 2–3-celled, 3–8 ovules per cell, style simple, as long as the corolla, stigma capitate. Fruit a globular berry, 6–7 mm in diameter, few-seeded, black when ripe.

Lonicera japonica Thunb. ex Murray – 1, flowering stem; 2, detail of inflorescence; 3, detail of infructescence.

Growth and development In Vietnam *L. japonica* flowers from March–May, whereas in Java it flowers throughout the year. Flowers open at dusk thereby favouring nocturnal pollinators such as hawkmoths, over diurnal pollinators such as bees. *L. japonica* produces large quantities of seed in more temperate regions, however, in tropical South-East Asia, seed set/fruiting is rather poor. The seeds are disseminated by birds, mammals, and floodwaters. Once established, it reproduces vegetatively by rooting from the nodes of runners.

Other botanical information *L. japonica* has long been a popular ornamental. *L. japonica* var. *repens* (Siebold) Rehder started its career in the Bogor Botanical garden. Some other well-known cultivars include 'Aureo-reticulata', a compact shrub with golden reticulate venation, var. *repens* 'Dart's World' with an overall maroon-reddish appearance, 'Halliana', with deeply divided corolla lobes, 'Hall's Prolific', a vigorous climber with up to 6 m long stems, ' Purpurea' , with leaves tinged purple, and 'Variegata', with variegated yellow leaves.

The flowers of the Eurasian *L. periclymenum* L. are used as a cutaneous and mucous tonic and vulnerary, the leaves in decoction are used for diseases of liver and spleen, and the seeds as a diuretic.

Ecology *L. japonica* can be found in all stages of forest succession. In more temperate areas it will quickly invade following clear cutting, fire, windthrow, or temporary openings in the forest canopy. *L. japonica* is shade-tolerant and will respond to more favourable light conditions with greatly increased growth, dominating the area in a relatively short time. It grows well on clay soils, with a pH ranging from 6.0 to 7.5. Growth is best on well-drained forest soils. In the United States it is highly tolerant of adverse sites and grown successfully on mine spoils.

Propagation and planting *L. japonica* can be easily propagated by seed, stem cuttings and layering. Plants can also be regenerated from leaf and stem calluses. For propagation by seed, stratification for 3 months at 4°C is required.

Husbandry *L. japonica* can be grown as ground cover or on trellis. Left alone it will become more and more bushy, with the inside of the bush containing only dried stems, so severely pruning the old stems is therefore recommended.

Diseases and pests *L. japonica* is susceptible to honeysuckle latent carlavirus and tobacco leaf curl bigeminivirus.

Harvesting The leafy stem parts of *L. japonica* are collected whenever the need arises. The flowers are preferably collected when barely open and still white.

Handling after harvest The flowers or leafy stems of *L. japonica* are dried either partly screened from sun light or gently heated at low temperatures.

Genetic resources and breeding Although largely cultivated as an ornamental and occasionally escaping in South-East Asia, *L. japonica* has a large area of distribution, naturally and as a result of cultivation and naturalization. It is locally considered a harmful weed and does not seem to be at risk of genetic erosion. There are no known breeding programmes of *L. japonica* for medicinal purposes.

Prospects *L. japonica* may have some local therapeutic or cosmetic value formulated as cream, lotion or emulsion to be used topically for skin affections, since several compounds extracted from this plant revealed antimicrobial, anti-inflammatory and anti-aging activities without a skin-irritating effect. The anti-inflammatory effects of several compounds isolated from the n-butanol fraction merit further research in order to evaluate their potential as lead compounds in the development of future medicine.

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Other selected sources 74, 135, 215, 264, 459, 591, 597, 598, 661, 739, 786, 788, 867.

Wongsatit Chuakul, Noppamas Soonthornchareonnon, Orawan Ruangsomboon

Ludwigia L.

Sp. pl. 1: 118 (1753); Gen. pl. ed. 5: 55 (1754).

ONAGRACEAE

$x = 8, 16, 24$; *L. adscendens*: $2n = 16, 24, 32$, *L. hyssopifolia*: $2n = 16$, *L. octovalvis*: $2n = 16, 32, 48$

Major species *Ludwigia adscendens* (L.) H. Hara, *L. hyssopifolia* (G. Don) Exell, *L. octovalvis* (Jacq.) P.H. Raven.

Origin and geographic distribution *Ludwigia* consists of 75 species, and has a cosmopolitan distribution. In the Old World 23 species occur, of which 8 are endemic to Africa, 4 to Asia and Malesia and 1 is common to both. In Malesia, 6 species occur in total.

Uses The aerial parts of *Ludwigia* are mucilaginous and considered antiseptic and emollient. They are widely used in Asia, including Indonesia and Malaysia, for poulticing headache, wounds, burns, boils, ulcers, impetigo, pimples and other skin complaints. In Indo-China, crushed young shoots of *L. adscendens* are mixed with castor oil (*Ricinus communis* L.), and used to treat ringworm. Because of its antiseptic properties, *Ludwigia* is also used in ophthalmia, fever, sore throat, and bites of snakes and dogs. In Peninsular Malaysia, a cold infusion of the roots of *L. hyssopifolia* is also drunk for syphilis, while in China, a decoction of the aerial parts of *L. adscendens* is used. In decoction, *Ludwigia* is considered astringent and diuretic and commonly used in the region for diarrhoea and dysentery, as a carminative and as a laxative. In China and Indo-China, a decoction of the aerial parts of *L. adscendens* or *L. octovalvis* is prescribed for rheumatic pains. In Peninsular Malaysia, India and Nigeria, *L. octovalvis* is also used for nervous diseases and also as a vermifuge.

Ludwigia is widely stocked by Chinese herbalists in South-East Asia.

In Indo-China, the young parts of *L. adscendens* are eaten as a salad, and those of *L. hyssopifolia* are used in soup. In Malaysia, *L. hyssopifolia* is cooked and eaten as a vegetable.

In Indonesia, *L. adscendens* is said to be dangerous for cattle as it is supposed to induce gastroenteritis. In Indo-China and Africa though, it is considered a good fodder. In Peninsular Malaysia, *Ludwigia* is ploughed under in rice fields as a green manure. In the Philippines, *L. hyssopifolia* is used to make a black dye.

Production and international trade *Ludwigia* is only used on a local scale and does not enter international trade as a medicinal.

Properties An ethanol extract of *L. hyssopifolia* showed strong in vitro antitumour-promoting activity using the inhibition of Epstein-Barr virus activation in Raji cells induced by phorbol-12-myristate-13-acetate and sodium-n-butyrate as a model. The cell viability of the Raji cells was significantly reduced as well. In addition, when sprayed on 2-day-old fruit flies, the extract showed only slight toxicity.

In several broad screening experiments, crude extracts of *L. octovalvis* were active, including a more than 50% inhibition against cytotoxicity, induced by carbon tetrachloride and D-galactosamine in rodents, and antibacterial activity against the carcinogenic bacteria, *Streptococcus mutans*. For the latter, the extract showed significant growth-inhibiting activity of serotypes c and d at a concentration equal to or lower than 7.8 mg/ml. In the presence of 5% sucrose, the antibacterial activity did not change for type c, but decreased for type d. The extract also showed antibacterial activity against *Streptococcus aureus* ATCC 25933 and *Yersinia enterocolitica* 03, and some non-pathogenic bacteria. A crude methanol extract was screened for its effect in immunoglobulin A nephropathy, by testing its effect on human mesangial cell proliferation. The extract inhibited human cell proliferation activated by interleukin-1β (IL-1β) and IL-6 at 50 μg/ml, and decreased IL-1β and tumour necrosis factor-α (TNF-α) production. The antidiarrhoeal potential of a methanol extract of the aerial parts was studied with several experimental models of diarrhoea in rats at doses of 100, 200 and 300 mg/kg. Rats treated with the extract showed significant inhibitory activity against castor oil induced diarrhoea and prostaglandin E2 (PGE2) induced enteropooling. It also significantly reduced gastro-intestinal motility following a charcoal meal. The same extract was also evaluated for its antipyretic potential on normal body temperature and yeast-induced pyrexia in albino rats. Following subcutaneous injection, a yeast suspension (10 ml/kg body weight) increased the rectal temperature after 19 hours. The extract, at doses of 100, 200 and 300 mg/kg, showed significant reduction in normal body temperature and yeast-provoked elevated temperature in a dose-dependent manner, and the effect extended up to 5 hours after drug administration. The anti-pyretic effect of the extract was comparable to that of paracetamol (150 mg/kg). In addition, the dried methanol extract was evaluated for its central nervous system activity in rats and mice. General behaviour, exploratory behaviour, muscle relaxant activity and phenobarbitone-induced sleeping time were evaluated, and the extract was found to cause a reduction in spontaneous activity, a decrease in exploratory behavioural pattern in the Y-maze and Head dip tests and a reduction in muscle relaxant activity in rotarod, 30° inclined screen and traction tests. The extract also significantly potentiated the phenobarbitone-induced sleeping time. These preliminary tests indicate that the extract in doses of 200–400 mg/kg, has significant psychopharmacological activity.

Description Erect to creeping herbs, rooting at the nodes, or large shrubs; underwater parts often swollen and spongy, or with white spongy aerophores. Leaves alternate or opposite, simple, entire; petiole present; stipules absent or reduced, deltoid. Flowers mostly 4-merous, solitary, axillary, sometimes terminal and racemose; bracteoles absent or conspicuous, near base of ovary. Sepals 3–7, persistent; petals as many as the sepals or absent, caducous, yellow or white, contorted at aestivation; stamens as many as the sepals or twice as many, and then epipetalous ones smaller, anthers usually versatile, sometimes basifixed, pollen shed in tetrads or singly; disk flat to conical, normally with depressed, hairy nectaries, surrounding the base of each epipetalous stamen; ovary inferior, 4–5-celled, ovules numerous, style simple, stigma hemispherical or capitate, often lobed, upper part receptive. Fruit a capsule, irregularly dehiscent, or by a terminal pore, or by flaps separating from the apex; seeds numerous. Seed rounded or elongate, raphe usually visible, sometimes as long as the seed; endosperm absent; embryo straight. Seedling with epigeal germination.

Growth and development *Ludwigia* flowers and fruits throughout the year, under (sub)tropical conditions.

Other botanical information The former genera *Jussiaea* (stamens twice the number of sepals) and *Ludwigia* (stamens as many as the sepals) have been merged into 1 genus, *Ludwigia*, because they show a reticulate pattern of relationships.

Ecology *Ludwigia* grows under dry to everwet climatic conditions, in and along marshes, ponds and rice fields. It is often abundant and weedy.

Propagation and planting *Ludwigia* is propagated by seed and runners. The seeds of *L. adscendens* are corky and float for some weeks, after which they germinate. Germination of *L. hyssopifolia* seeds, however, is completely inhibited by submergence or by burial in the soil. In the Philippines, a single plant of *L. hyssopifolia* was found to produce about 265 000 seeds.

Diseases and pests Several insects are currently being screened for their potential as biological control agents for weedy *Ludwigia* throughout the world. In Thailand and India, the chrysomelids *Altica foveicollis* and *A. cyanea* are promising for the control of *L. adscendens*, while in Bangladesh, *A. foveicollis* is active on *L. octovalvis*. In India, a fruit-infesting weevil (*Nanophyes nigritulus*) is also being screened. Several snails, which are vectors of serious diseases, feed on *Ludwigia*.

Harvesting In Vietnam *Ludwigia* is harvested from June–September.

Handling after harvest *Ludwigia* is either used fresh or dried in the sun or stove for future use.

Genetic resources and breeding *Ludwigia* is widespread and common as a weed throughout South-East Asia, and therefore certainly not endangered. There are no known breeding programmes for *Ludwigia*.

Prospects General pharmacological screening reveals a multitude of interesting pharmacological effects of the methanol extract of *L. octovalvis*. These merit further research, to evaluate their potential, and this should focus on the phytochemistry to define (bio-)markers related to the pharmacology shown. The toxicological aspects should be investigated thoroughly as well.

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Selection of species

Ludwigia adscendens (L.) H. Hara

Journ. Jap. Bot. 28: 290 (1953).

Synonyms *Jussiaea repens* L. (1753), *Jussiaea adscendens* L. (1767).

Vernacular names Water primrose (En). Indonesia: buang buang (Sumatran), krangking (Javanese), ganggeng landeuh (Sundanese). Malaysia: tinggir bangau, inai pasir (Peninsular). Papua New Guinea: agidahano (Kutubu). Philippines: sigang-dagat (Tagalog), gabi-gabi (Magindanao), tabagan (Ifugao). Thailand: phak pot nam (northern), phak phang phuai, phak phaeng phuai (central). Vietnam: rau d[uwf]a n[uw][ows]c, rau d[uwf]a tr[aa]u, du long th[as]i.

Distribution Native of continental Asia, Sri Lanka, southern China, Japan, and throughout South-East Asia to northern Australia. Introduced as a weed in tropical Africa.

Uses In Peninsular Malaysia, China and Indo-China, the aerial parts are used for poulticing skin complaints, like boils, ulcers and impetigo. In decoction, they are used for dysentery, fever, cough and ophthalmia. In Taiwan, the aerial parts, when pounded with ash of bamboo leaves and leaves of *Osmanthus fragrans* (Thunb. ex Murray) Lour., are applied to swellings. In Papua New Guinea, the leaves and stem are considered to have contraceptive properties.

Observations A robust, prostrate or ascending herb, much branched, up to 60 cm tall, floating stems up to 4 m long, tops above water, glabrous, aerophores conspicuous on nodes, spindle-shaped, white; leaves broadly oblong-elliptical, 0.4–7 cm × 0.7–4 cm, base narrowly cuneate, apex acute or obtuse, veins 6–13 pairs, petiole 1–2 cm long; sepals 5, deltoid, 5–11 mm long, petals 5, obovate, 9–18 mm × 6–10 mm, apex rounded, creamy white, yellow at base, stamens 10, filaments 2.5 mm long, pollen single, style 4–8 mm long; capsule 1.2–2.7 cm × 0.3–0.4 cm, normally glabrous, thick-walled, irregularly dehiscent, conspicuously 10-ribbed, pale brown, seeds evident, pedicel 2.5–5.5

cm long; seeds uniseriate in each cell, ellipsoid, flattened, each firmly embedded in a cube of woody endocarp, endocarp fused to capsule wall, dark brown. *L. adscendens* is very common in fresh water pools, swamps, fallow and planted rice fields, and in ditches, from sea-level up to 1600 m altitude. Plants growing under dry conditions have small, crowded leaves, are densely hairy and flower rarely.

Selected sources 74, 134, 135, 264, 739, 788.

Ludwigia hyssopifolia (G. Don) Exell

Garcia de Orta 5: 471 (1957).

Synonyms *Jussiaea linifolia* Vahl (1798).

Vernacular names Willow herb (En). Indonesia: jukut anggereman, mainang (Sundanese), meligai (Bangka). Malaysia: lakum air, inai paya, maman pasir (Peninsular). Philippines: pasau na hapai (Tagalog), barigaua (Bikol), manakatud (Iloko). Thailand: tien na. Vietnam: rau m[uw][ow]ng, rau l[uws]c.

Distribution Throughout the tropics, including Micronesia and northern Australia.

Uses In Peninsular Malaysia, a cold infusion of the roots is drunk for syphilis. In Sulawesi (Indonesia), the infusion is used for poulticing pimples, boils and other infections. In Indo-China, the plant is taken for diarrhoea and dysentery, enteritis and sprue.

Observations An annual herb, 5 cm tall (dwarf) or up to 3 m tall, with elongate pseudoaerophores from submerged roots, young parts minutely puberulent; leaves lanceolate, 1–9 cm × 0.2–3 cm, base narrowly cuneate, apex acuminate, veins 11–17 pairs, petiole 2.5–18 mm long; sepals 4, lanceolate, 2–4 mm long, 3-veined, petals elliptical, 2–3 mm × 1–2 mm, yellow, fading orange-yellow, stamens 8, filaments 0.5–2 mm long, pollen single, style 1–1.5 mm long; capsule 1.5–3 cm × 0.1–1.2 cm, subterete, enlarged in the upper part, thin-walled, subsessile; seeds dimorphous, lower seeds uniseriate in each cell, oblong, brown, each firmly embedded in a cube of relatively hard endocarp, raphe about one third of the length of the seed, seeds in upper, inflated part multiseriate, free, ovoid, pale brown, raphe narrow. *L. hyssopifolia* is a common weed of pools, ditches, rice fields, fallow gardens and rice fields, both on clay and sandy soils, from sea-level up to 1000 m altitude.

Selected sources 62, 74, 134, 135, 788.

Ludwigia octovalvis (Jacq.) P.H. Raven

Kew Bull. 15: 476 (1962).

Synonyms *Jussiaea suffruticosa* L. (1753), *Jussiaea pubescens* L. (1762), *Jussiaea angustifolia* Lamk (1789).

Vernacular names Willow herb, primrose willow (En). Indonesia: cacabean (Sundanese), salah nyowo (Javanese), lakum air (Malay). Malaysia: buyang samalam, lakom ayer, pujang malam (Peninsular). Philippines: tayilakton (Tagalog), talangkau (Iloko), pachar pachar (Sulu). Thailand: thian nam (peninsular), yaa raknaa (northern). Vietnam: mu[uw][ow]ng d[aas]t.

Distribution Pantropical, between 32° North and 30° South.

Uses In Java, the plant is sometimes used against ulcerations of the nose. In India and Peninsular Malaysia, the mucilaginous leaves are used for poulticing many complaints, including headache, orchitis and swollen glands. They are drunk in decoction for diarrhoea, nervous diseases and as a carminative and vermifuge. In Nigeria, the plant is pulped and boiled and taken as a ver-

Ludwigia octovalvis (Jacq.) P.H. Raven – 1, flowering and fruiting branch; 2, flower; 3, flower, perianth removed; 4, fruit; 5, seed.

mifuge and laxative. It is considered to have analgesic properties, and together with other herbs, is given for rheumatic pains.

Observations A perennial, robust, much branched herb, sometimes woody at base, 2(–4) m tall, lower part of stem sometimes with aerenchyme, pseudo-aerophores present in inundated conditions, normally with appressed or spreading hairs; leaves narrowly lanceolate to narrowly ovate, 2–14 cm × 0.5–4 cm, base narrowly cuneate, apex attenuate, veins 11–20 pairs, old leaves reddish, petiole up to 1 cm long, bracteoles reduced or 1 mm long; sepals 4, ovate or lanceolate, 6–15 mm long, petals broadly obovate or cuneate, slightly emarginate, 17 mm × 2–17 mm, yellow, stamens 8, filaments 1–4 mm long, pollen in tetrads, style 1.5–3.5 mm long; capsule 1.7–4.5 cm × 0.2–0.8 cm, terete, thin-walled, pale brown, 8 darker ribs, irregularly splitting, pedicel up to 10 mm long; seeds pluriseriate in each cell, free, rounded, raphe as long as the seed. *L. octovalvis* occurs in humid localities, damp grasslands, rice fields, along ditches, in swamps, pools, river beds, on floating islands in lakes and in coconut plantations, from sea-level up to 1500 m altitude. Two subspecies are distinguished, subsp. *octovalvis* and subsp. *sessiliflora* (Micheli) P.H. Raven.

Selected sources 74, 134, 135, 181, 574, 708, 709, 788, 1099.

Isa Ipor

Lunasia amara Blanco

Fl. Filip. ed. 1: 783 (1873).
RUTACEAE
2*n* = unknown

Synonyms *Pilocarpus amara* (Blanco) Blanco (1845), *Rabelaisia parvifolia* Planch. (1845).

Vernacular names Indonesia: kemaitan (Javanese), pingsang (Sulawesi), bungkus kusu (Moluccas). Philippines: lunas (Tagalog), bunglai (Bikol), paitan (Bisaya, Iloko).

Origin and geographic distribution *L. amara* is found throughout the Philippines, Borneo and eastern Java eastward to south-eastern New Guinea and Cape York in Australia.

Uses *L. amara* is well known in native medicine of the Philippines and Indonesia. In Indonesia, a decoction of the bark and leaves is rubbed on swollen limbs and is also used as a treatment for skin diseases. In Central Sulawesi, sap from the bark is used as eyedrops for inflamed or irritated eyes. In the Philippines and Thailand, the bark is mentioned as a remedy for snakebites and stomach problems. Bark and leaves or seeds are taken for digestive disorders. Sometimes mention is made of the use of *L. amara* in arrow poison.

Production and international trade *L. amara* is only used on a local scale.

Properties Fresh leaves of *L. amara* yield 0.1–0.15% of an essential oil which is almost entirely sesquiterpenoid in nature. The principal sesquiterpenes are γ-elemene (0.7–19%), germacrene-D (18–51%) and bicyclogermacrene (7–26%). There are lesser amounts of bicycloelemene (1–2%), β-bourbonene (0.7–3%), β-elemene (4–9%), α-farnesene (1–3%) and δ-cadinene (3–5%).
Furthermore, some 13 alkaloids have been identified from several parts of *L. amara*. From the bark, 9 furoquinoline type alkaloids, i.e. hydroxylunacridine, hydroxylunacrine, hydroxylunidine, hydroxylunine, kokusaginine, lunacridine, lunacrine, lunine and skimmianine, and 4 quinoline type alkaloids, i.e lunamarine, 4-methoxy-2-(3',4'-methylenedioxy-phenyl)-quinoline, eduleine and 4-methoxy-2-phenylquinoline are reported in the literature. Biochemically, both types of alkaloids are strongly related, and formally derived from the anthranilic acid unit, which is common to all of them.
Lunacrine, which is the principle alkaloid found in the leaves, and lunasin, a related quaternary furoquinoline, both show a distinct action on muscles, evidenced by a continually increasing tone and a rapid diminution of the power of response of the muscle to stimulation. This action on muscular tone is seen not only upon isolated voluntary and smooth muscles but also upon the blood vessel walls, where a distinct contraction occurs, and upon the heart where a distinct diminution in the contractions was observed. The lethal effect of both alkaloids is due to stoppage of respiration simultaneously with that of the circulation. Blood pressure experiments upon anaesthetized, decerebrated and decapitated animals show a sudden drop which is principally due to the action on the heart muscle. Lunasine, however, causes a rise in the decapitated preparations, showing considerable action on the vasomotor centre which is not seen by lunacrine.

Adulterations and substitutes (Furo-)quinoline alkaloids are found in many other species belonging to *Rutaceae*. Especially the alkaloids skimmianine and kokusaginine seem to be distributed very widely. Some of the many examples containing the alkaloids include: *Acronychia baueri* Schott(both), *Casimiroa edulis* Llave & Lex.

(both), *Eriostemon* spp. (skimmianine), *Glycosmis pentaphylla* (Retz.) A.DC. (both), *Ruta graveolens* (both) and *Zanthoxylum* spp. (skimmianine).

Description A dioecious, evergreen, sparsely branched shrub or small tree up to 12 m tall; all parts covered with scale-like and/or stellate trichomes. Leaves alternate, simple, crowded towards the tip of branchlets, oblanceolate to obovate, elliptical or lanceolate, 5.5–60 cm long, base cuneate to narrowly rounded or cordate, apex rounded to acuminate, margin subentire to sinuate, chartaceous to coriaceous, with scattered oil dots; petiole 1.5–15 cm long, conspicuously swollen just below the insertion of the blade; stipules absent. Inflorescence an axillary panicle, with head-like clusters of trimerous flowers. Male inflorescence up to 28 cm × 8 cm; sepals ovate, 0.5 mm long; petals obovate, 1 mm long, greenish-yellow to white; stamens 1 mm long; rudimentary gynoecium pulvinate. Female inflorescence up to 25 cm × 2 cm; sepals broadly ovate, 1–1.5 mm long; petals ovate, 2–2.3 mm long, greenish-yellow to white; staminodes 3; gynoecium about 0.5 mm × 1 mm, 3-carpellate. Fruit consisting of 1–3 follicles; follicle obovate, truncate, 6–15 mm × 5–10 mm, transversely ribbed, 1-seeded, 2-valved, dehiscent along the apical and adaxial edges, pericarp dry, endocarp cartilaginous and discharged from the follicle with the seed. Seed obovoid, dark brown to reddish-brown, with fleshy oily cotyledons, endosperm absent.

Lunasia amara Blanco – 1, flowering and fruiting branch; 2, detail of fruits.

Growth and development *L. amara* can be found flowering and fruiting throughout the year.

Other botanical information *L. amara* is the only species retained in the genus *Lunasia*. It is extremely variable in certain vegetative features. Trichomes vary from flat, scale-like structures composed of as many as 60 connate, radiating cells to stellate structures, composed of as few as 2 separate ascending cells. However, a gradation exists from scale-like to stellate. This gradation is found within a single individual and between populations. Likewise, leaves are exceptionally variable in size, texture, number of lateral veins and irregularities of the margin. Based on these differences many taxa have been described. However, as the variations are repeated, in varying degrees of similarity, without a particular pattern, all taxa have been united in a single taxon.

Ecology *L. amara* is found on soils ranging from ultramafic to limestone in well-drained rain forest, moist to rather dry thickets, gallery forest and secondary growth, from sea-level up to 900 m altitude.

Propagation and planting *L. amara* is only occasionally planted and propagated by seed.

Harvesting Bark, leaves and fruits of *L. amara* are collected whenever the need arises.

Genetic resources and breeding *L. amara* is widespread and locally common throughout its distribution area, and apparently well adapted to disturbance and therefore not endangered. Apart from collections in botanical gardens no breeding programmes exist.

Prospects Not much is known about the biological activities of isolated alkaloids from *L. amara*. Therefore, more research will be needed in order to fully evaluate its potential as a medicine.

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Other selected sources 74, 241, 380, 407, 873, 949, 1028.

Muhammad Mansur

Melanolepis multiglandulosa (Reinw. ex Blume) Rchb.f. & Zoll.

Acta Soc. Regiae Sci. Indo-Neerl. 1: 22 (1856).
EUPHORBIACEAE
$2n$ = unknown

Synonyms *Melanolepis angulata* Miq. (1860), *Melanolepis moluccana* (L.) Pax & K. Hoffm. (1914), *Mallotus multiglandulosus* (Reinw. ex Blume) Hurus. (1954).

Vernacular names Indonesia: daun kapur (Malay, Moluccas), ngalu (Halmahera, Tidore), tutup (Javanese). Malaysia: chawan, jarak kayu (Peninsular). Papua New Guinea: avima (Nangananga, East New Britain). Philippines: alim (Tagalog), alok (Bikol, Bisaya). Vietnam: c[as]nh di[eef]u, h[aws]c l[aa]n nhi[eef]u tuy[ees]n.

Origin and geographic distribution *M. multiglandulosa* is widespread over Taiwan, Ryukyu Islands, Marianas, and from southern Thailand throughout Malesia to Papua New Guinea (Bismarck Archipelago). The species is unknown from Sarawak and Brunei and has never been cultivated outside its area of natural distribution.

Uses In Peninsular Malaysia and Indonesia the leaves of *M. multiglandulosa*, sometimes in a mixture with ginger, are used as a poultice against different kinds of scurf. In Peninsular Malaysia and Sumatra (Lampung), a decoction of the leaves, often in a mixture, provides a vermifuge. As a tea the leaves are employed in Sulawesi (Minahasa) against cough; for the same purpose the bark is used in Sabah. In the Philippines, the bark, leaves, and flowers, fresh or slightly heated, are applied to the skin as a sudorific against chest pain and fever. In East New Britain (Papua New Guinea), crushed dried leaves mixed with cold water are drunk to treat constipation, chest complaints and tuberculosis.

The ashes of old leaves are used as an additive to *Arenga pinnata* (Wurmb) Merr. tinder. These ashes were formerly used as additive to *Bixa orellana* L. in dyeing. In Sumatra (Lampung) leaves are mixed with tapé (a product of fermented flour from cereals) to sweeten the taste of the tapé. The wood makes good firewood.

Properties Although in general the bark and leaves of *M. multiglandulosa* are used, the only phytochemical information available is for the roots. From the roots have been isolated common triterpenes, e.g. friedelin, α-amyrinacetate, oleanic acid, olean-12-en-3-β,28-diol, as well as steroids including campesterol, stigmasterol, β-sitosterol, campesterol-3-O-βD-glucoside, stigmasterol-3-O-βD-glucoside, β-sitosterol-3-O-βD-glucoside, 5α-stigmastan-3,6-dione, stigmast-4-en-3-one, stigmast-4,22-dien-3-one and 6β-hydroxystigmast-4-en-3-one. The roots are also known to contain sucrose. At present, no information is available about pharmacological activities supporting the traditional uses of *M. multiglandulosa*. A test on antibacterial activity gave negative results.

Adulterations and substitutes Allied species of the genera *Macaranga* and *Mallotus* are often used in the same way as *M. multiglandulosa*, e.g. as a poultice for scurf, and in decoction as a vermifuge.

Description A shrub or tree, up to 20 m tall; young parts covered with whitish to brown stellate hairs; flowering twigs with a broad soft pith; bark smooth to shallowly longitudinally fissured with many minute lenticels to flaky; latex milky, sticky. Leaves spirally arranged, simple, ovate, sometimes 3-lobed, usually symmetric, 5–38 cm × 5–34 cm, base cordate to cuneate, with a group of protruding glands on the upper surface, apex acute to acuminate, margin dentate, with glands in teeth and smaller ones along the margin, papery, venation palmate with 5(–7) major veins, lower surface often with 2 basal black glandular areas and additional smaller glandular areas along the veins; petiole 2.4–31 cm long; stipules deltoid, 1.2 mm × 0.8 mm, caducous. Inflorescence a terminal panicle, very laxly branched, usually with either staminate or pistillate flowers, erect, up to 26(–54) cm long, side-branches up to 41 cm long; staminate flowers up to 5 together, pistillate

Melanolepis multiglandulosa (Reinw. ex Blume) Rchb. f. & Zoll. – 1, twig with male inflorescence; 2, female flower; 3, male flower; 4, infructescence; 5, underside leaf with glands along the margin.

flowers single or 2 together. Flowers actinomorphic, sepals (4–)5, valvate, petals absent; staminate flowers 7–13 mm in diameter, sepals ovate, stamens 200–250, free, anthers with apidorsal gland on the connective, disk and pistillode absent, pedicel 5–6 mm long; pistillate flowers 4.5–5.5 mm in diameter, calyx tube about 1 mm long, lobes 1.7–3 mm × 1.2–1.8 mm, ovary 2–3-locular, 1 ovule per locule, style 0–0.6(–2) mm long, stigmas erect, not or slightly split, pedicel 3–6 (–13) mm long, accrescent. Fruit a lobed capsule, obcordate in outline, 9–15 mm × 7–9 mm, densely tomentose to subglabrous, greyish-green. Seed 5.5–6 mm × 4.5–5.5 mm, creamy to purplish-magenta; aril grey to orange.

Growth and development Trees of *M. multiglandulosa* are monoecious, but usually only show unisexual inflorescences. It is not known whether both sexes occur at the same time on the same plant or not. A distinct flowering or fruiting season is unknown; flowering and fruiting specimens may be encountered during the whole year. The seeds are distributed by birds.

Other botanical information *Melanolepis* comprises 2 species, of which *Melanolepis vitifolia* (O. Kuntze) Gagnep. is restricted to Cambodia. No infraspecific taxa are recognized in *M. multiglandulosa*, but the species is somewhat variable in its range. Towards the north (West Pacific Islands) and to the east (Bismarck Archipelago) there is a tendency to more glabrous leaves, while in New Guinea two basal glands at the upper surface protrude further than the other glands and at the lower surface there are always two basal black glandular areas. The latter are usually absent in specimens from other areas.

Propagation and planting Seed of *M. multiglandulosa* shows canopy-induced facultative dormancy but germinates readily under sunny conditions, completing germination within 5 weeks.

Ecology *M. multiglandulosa* is rare to usually locally common and is considered to be an invader. It is mainly found in secondary places such as roadsides, regrowth thickets, depleted open secondary forest, forest edges in savanna, coconut plantations, old gardens, but also in primary forest, *Barringtonia* swamp forest, *Eucalyptus deglupta* Blume dominated forest, monsoon (deciduous) forest and along mangroves, at altitudes varying from sea-level up to 300(–1335) m. It is often found in poorly drained and/or temporarily inundated alluvial sands, clay, coral(sand), red loam, and volcanic soils.

Husbandry *M. multiglandulosa* is widely cultivated in Taiwan and the Ryukyu Islands, but there is no information on cultivation within Malesia.

Harvesting Leaves can be collected year round, except in drier areas where the plants may be deciduous and leaves can be collected in the wet season only.

Genetic resources and breeding In view of its widespread distribution and preference for disturbed habitats, *M. multiglandulosa* does not seem to be seriously threatened by genetic erosion. No germplasm collections or breeding programmes are known to exist

Prospects At present, phytochemical and pharmacological information on *M. multiglandulosa* is very limited. Only a thorough pharmacological testing and identification of the active constituents may change the intensity with which the tree is used and cultivated.

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Other selected sources 128, 207, 418, 779, 810, 831.

P.C. van Welzen

Melastoma L.

Sp. pl. 1: 389 (1753); Gen. pl. ed.5: 184 (1754).

MELASTOMATACEAE

$x = 9–12$; *M. malabathricum*: $2n = 24$ (also polyploids and aneuploids)

Major species *Melastoma malabathricum* L., *M. sanguineum* Sims.

Vernacular names Indonesia: senduduk. Malaysia: sendudok (Peninsular).

Origin and geographic distribution *Melastoma* comprises 22 species and is centered in South-East Asia, but extends to India, southern China, northern Australia and Oceania.

Uses *Melastoma* is used throughout South-East Asia for its astringent properties. In Indonesia *M. malabathricum* is predominantly used whereas in Malaysia *M. sanguineum* is preferred. In Cambodia, the roots of *M. sanguineum* are further considered a stimulant and tonic. In the Moluccas, the pounded roots of a plant called 'birurang merah' or 'ligura banga', possibly *M. cyanoides* Sm. (synonyms *Osbeckia annamanica* Guill., *Osbeckia papuana* Cogn., *Otanthera cyanoides* (Sm.) Triana) or *M. moluccana* Blume (synonyms *Otanthera moluccana* (Blume) Blume, *Otanthera nicobarensis* Teijsm. & Blume, *Otanthera novoguineensis* Baker f.) are taken to prevent a miscarriage. The fruits are given to children to prevent bed-wetting. The roots, leaves, flowering tops or berries of several *Melastoma* from Indo-China e.g. *M. dodecandrum* Lour. (synonym *Melastoma repens* Desr.), *M. saigonense* (Kuntze) Merr. and *M. septemnervium* Lour. (synonym *Melastoma candidum* D. Don) are used in the same way as *M. sanguineum* in diarrhoea, leucorrhoea, and dysentery for their astringent properties.

The fruit of M. *malabathricum* yields a black or purple dye, the leaves and roots yield a pink dye. The ashes from the plant can be used as a dye mordant. The fruits of various *Melastoma* are eaten as a snack.

Production and international trade *Melastoma* is only used at the local level and fresh or dried shoots or leaves are on sale in local markets.

Properties In general, *Melastoma* species are rich in tannins of the hydrolysable type. Most of them are di- and trimers, with reported bactericidal and antiviral activities.

From the acetone extract of dried leaves of *M. malabathricum*, purchased from a market in Sukabumi (Indonesia), 14 tannins including malabathrins B, C and D, the dimers nobotanins B, G and H and the trimer nobotanin J, were isolated. Nobotanin B is reported active against human immunodeficiency virus (HIV) in vitro. Furthermore, *M. malabathricum* shows a broad spectrum antibacterial activity against gram positive bacteria, thereby supporting its use in cut, burn and wound treatment. It is further capable of suppressing established concentrations of *Staphylococcus aureus*, thereby supporting its use for abscesses, boils and swellings caused by infections.

A leaf extract of *M. malabathricum* showed a strong inhibition in the tetradecanoylphorbol acetate (TPA)-induced ear oedema test, at a dose of 2 mg per ear.

An extract of *M. dodecandrum* with 80% aqueous acetone (MDL) inhibited nitric oxide (NO) production by a murine macrophage-like cell line, RAW 264.7, activated with lipopolysaccharide (LPS) and recombinant mouse interferon-gamma (IFN-gamma). The majority of the inhibitory activity was recovered in the 50% methanol extracts, which contained hydrolysable tannins. Among the latter, casuarinin, casuarictin, pedunclagin and nobotanin B exhibited strong inhibitory activities toward NO production, with ID_{50} values between 2.0 and 5.1 μM. Both MDL and the purified tannins significantly reduced the induction of the inducible nitric oxide synthase (iNOS) protein in the course of macrophage activation with LPS and IFN-gamma. In addition, the NO production by macrophages preactivated with LPS and IFN-gamma for 16 h was also inhibited by these tannins, with IC_{50} values around 30–130 μM, but not by MDL. These results suggest that MDL has the pharmacological ability to suppress NO production by activated macrophages and that the hydrolysable tannins have major inhibitory activities.

Three active principles were isolated from the leaves of *M. septemnervium* using the screening of hypotensive effects in the spontaneously hypertensive rat model (SHR). Intravenous injection of castalagin, procyanidin B-2, or helichrysoside into SHR lowered the mean blood pressure in a dose-dependent manner, with helichrysoside being the most potent compound. Plasma noradrenaline (NA) levels, both basal in SHR and elevated in normal rats through cold-stress stimulation, were attenuated by these compounds in a way which was not influenced by adrenalectomy. Decrease of NA release from sympathetic nerves was assumed to be responsible. Moreover, the hypertensive effect of various vasoconstrictors in anaesthetized rats was reduced by helichrysoside. The same results were also observed in castalagin or procyanidin B-2 treated animals. The results indicate that the three principles possess the ability to lower blood pressure through a decrease of sympathetic tone as well as due to direct vasodilatation in SHRs.

Description Erect or procumbent shrubs or small trees up to 10 m tall. Leaves opposite, simple, lanceolate to ovate, base acute, rounded to cordate, apex acute or acuminate, margin entire, 3-, 5-, 7- or 9-veined, almost glabrous, strigose or subvillose to villose; petiolate; stipules absent. Inflorescence terminal or in distal leaf axils, usually cymose, bracteolate. Flowers bisexual, 5(–8)-merous, diplostemonous; hypanthium campanulate, moderately to densely covered with scales, bristles or complex emergences; sepals triangular to lanceolate, deciduous; petals obovate; stamens normally dimorphic; ovary hemi-inferior, adnate to the hypanthium by 10 septa, 5-locular and apically bristly, many-seeded. Fruit a campanulate dry capsule, opening apically, or a fleshy capsule, splitting irregularly transversally or longitudinally, or an indehiscent berry. Seed minute, cochleate, embedded in the pulp. Seedling with epigeal germination; cotyledons leafy; hypocotyl elongated; leaves simple, opposite.

Growth and development Pollination of *Melastoma* is by bees or bumble-bees. Dispersal of the seed is enhanced by frugivorous birds. *Melastoma* can be found flowering and fruiting throughout the year. In general *Melastoma* is not the first to colonize clearings; field observations suggest that germination is more successful in light shade, provided by grasses or sedges, with slightly increased relative humidity. Recent laboratory tests, however, indicate a preference for full daylight. As a weed in pineapple on peat soil *M. malabathricum* started flowering when 2 m tall and 5 months of age, and may grow up to 3 m in 2 years.

Other botanical information The genus *Othanthera*, traditionally placed close to *Melastoma* because of its indehiscent fleshy fruits, isomorphic stamens and different inflorescences has been included here. Most important for species delimitation are the leaf and hypanthium indumentum. Character combinations and quantitative characters have to be used for species delimitation due to the variation of most vegetative and flower characters. In many species, especially *M. malabathricum*, morphological characters vary locally, which has resulted in the taxonomic recognition of numerous geographically restricted species here considered synonyms.

Ecology Most *Melastoma* are pioneers with a high dispersal capacity. *M. malabathricum* can germinate and grow in fields of *Imperata cylindrica* (L.) Raeuschel and finally smother this grass.

Propagation and planting *Melastoma* is propagated by seed. In a seedling trial in Malaysia seeds of *M. sanguineum* germinated in 25–50 days. Trials with various media for *M. malabathricum* in Singapore gave 65% germination within 10–15 days and up to 80% germination within 30 days.

Diseases and pests *M. malabathricum* can be a serious weed in pastures, pineapple and other crops on peat soils. It is also a serious weed in oil palm, rubber and coconut. Locally it can be a weed in cassava, sugar cane, tea and upland rice.

Harvesting *Melastoma* roots, shoots, leaves or fruits are harvested throughout the year, whenever the need arises.

Handling after harvest In general leaves and roots are used fresh, but they may be dried and powdered for storage for later use.

Genetic resources and breeding All *Melastoma* species treated here have a large area of distribution and are favoured by human disturbance. They do not seem to be at risk of genetic erosion.

Prospects The tannins isolated from *Melas-*

toma show several in vitro, (e.g. antibacterial, antiviral, inhibition of NO production) and in vivo (antihypertensive) effects, which are very interesting. These effects merit further research in order to evaluate their possibilities in the future development of new lead-compounds or medicines.

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Selection of species

Melastoma malabathricum L.

Sp. pl. 1: 390 (1753).

Synonyms *Melastoma affine* D. Don (1823), *Melastoma denticulatum* Labill. (1824), *Melastoma polyanthum* Blume (1831).

Vernacular names Brunei: kuduk kuduk, kemungting uman (Iban). Indonesia: harendong (Sundanese), senggani, kemanden (Javanese). Malaysia: Singapore rhododendron, senduduk (Peninsular, Sabah). Philippines: malatungau (Ibanag), bubtoi (Sambali), yagomyum (Cebu Bisaya). Thailand: khlongkhleng khee nok (south-eastern), mang khre (peninsular), chuk naaree (Bangkok). Vietnam: mua da hung, mua se.

Distribution From the Indian Ocean Islands throughout South and South-East Asia, China, Taiwan, Australia and South Pacific Ocean.

Uses In Peninsular Malaysia, a decoction of the leaves alone or in a mixture is used for diarrhoea. A decoction of roots and leaves is given to women after childbirth. Powdered leaves and roots may be sprinkled on wounds. They are used in an application for haemorrhoids apparently for their astringent properties. Roots are simply sucked or may be used for making a gargle in toothache. In Sumatra, the ground leaves are applied as a compress to cuts, wounds and swellings. In Java, a decoction of the leaves or sap from the pounded leaves affords a remedy for diarrhoea, dysentery, and leucorrhoea. In East Kalimantan, a strong decoction of the leaves is externally applied on painful arthritic joints. Likewise the decoction is applied to weeping sores caused by stinging insect hairs, to aid extraction of the hairs. The same preparation is applied to disinfect other types of weeping wounds. In other parts of Borneo, roots and fruits are sucked for toothache and flowers are rubbed on small cuts. A decoction of the leaves is drunk to treat stomach-ache. In Thailand, the whole plant is used for diarrhoea, dysentery and as an astringent. The leaf juice is used for indigestion. In Fiji, a decoction of the leaves is used to treat stomach complaints and thrush. Chewed leaves are applied as a poultice on wounds. The bark is used to treat dysentery and toothache. In Java, the young shoots are eaten as a fresh or cooked vegetable. It is locally cultivated as an ornamental.

Melastoma malabathricum L. – 1, flowering twig; 2, fruiting twig.

Observations A shrub or small tree up to 5 m tall, young branches quadrangular, covered with appressed, spreading or erect scales and/or bristles, bark brown, old branches terete, glabrescent; leaves elliptical to lanceolate, (4–)6–15 cm × (0.6–) 2–6.5 cm, base rounded to acute, apex acuminate, 5- or 7-veined, above and beneath strigose to pilose; cyme terminal, 3–12-flowered; flowers normally 5-merous, hypanthium campanulate 5–11 mm × 1–10 mm, covered with long golden to red scales, sepals lanceolate, intersepalar emergences present, petals obovate, 15–35 mm × 10–22 mm, violet, seldom white, stamens dimorphic (seldom monomorphic), anther of longer outer stamens violet, connective prolonged, filaments 6–12 mm long, anther of inner stamens yellow, connective not prolonged, filaments 5.5–9.5 mm long, ovary shorter than hypanthium, crowned by bristles; capsule fleshy, 7–11 mm × 6–10 mm, opening irregularly transversely at maturity, exposing the soft dark blue pulp with orange seeds. *M. malabathricum* is found in disturbed locations, on fallow land, or in grasslands from sea-level up to 3000 m altitude. On the basis of the indumentum on leaves and branches two subspecies are recognized: subsp. *malabathricum* with strigose to slightly pilose leaves beneath and branches covered with scales, and subsp. *normale* (D. Don) K. Meyer with pilose leaves beneath and strigose branches. The latter subspecies has a more northern distribution and is confined to higher elevations in tropical areas.

Selected sources 143, 252, 372, 373, 407, 440, 588, 786, 1070.

Melastoma sanguineum Sims

Bot. Mag. 48: t. 2241 (1821).

Synonyms *Melastoma decemfidum* Roxb. ex Jack (1823).

Vernacular names Malaysia: sendudok, sendudok gajah (Peninsular). Cambodia: prea, kenchea das. Thailand: mang khre khon, mang khre chaang, bre chaang (peninsular). Vietnam: mua b[af].

Distribution From Burma (Myanmar), Thailand, southern China, Indo-China to Malaysia, Sumatra, Borneo, the Lesser Sunda Islands and the Moluccas.

Uses In Malaysia, the plant is sometimes considered superior to *M. malabathricum*, but actually both species are used indiscriminately. In Vietnam, leaves, roots and fruits are used in folk medicine for their astringent properties in diarrhoea and leucorrhoea.

Observations A shrub or small tree up to 10 m tall, young branches quadrangular, covered with adpressed or spreading, red to brown scales or bristles, bark brown or grey; leaves lanceolate or elliptical, seldom ovate, 3–17 cm × 1–6 cm, base rounded or acute, apex acute or acuminate, glabrous or strigose, 5- or 7-veined, pale green or tinged red beneath; cyme terminal, 3–5-flowered or flowers solitary; flowers normally 5-merous, hypanthium campanulate, 7–15 mm × 5–14 mm, covered with reddish bristles, sepals lanceolate or triangular, intersepalar emergences present, petals cuneate-obovate, 33–46 mm × 22–33 mm, violet, stamens dimorphic, anther of longer outer stamens violet, connective prolonged, filaments 8–12 mm long, anther of inner stamens yellow, connective not prolonged, filaments 5–8 mm long, ovary slightly shorter than hypanthium, crowned by golden bristles; capsule fleshy, 8–19 mm × 8–18 mm, opening irregularly longitudinally at maturity, exposing the solid yellow pulp with orange seeds. *M. sanguineum* is found in disturbed forest, along streams and roads, in open locations and savanna from sea-level up to 2300 m altitude. Based on differences in indumentum of the petiole and hypanthium three varieties are recognized.

Selected sources 730, 739, 786.

J.L.C.H. van Valkenburg & N. Bunyapraphatsara

Merremia Dennst. ex Endl.

Gen. Pl., Suppl. 1: 1403 (1841).

CONVOLVULACEAE

$x = 15$; *M. dissecta*: $2n = 30, 32$; *M. emarginata*: $2n = 28, 30$; *M. hederacea*, *M. peltata*, *M. tridentata*, *M. tuberosa*, *M. vitifolia*: $2n = 30$.

Major species *Merremia hederacea* (Burm.f.) Hallier f., *M. mammosa* (Lour.) Hallier f., *M. peltata* (L.) Merrill, *M. umbellata* (L.) Hallier f. subsp. *orientalis* (Hallier f.) Ooststr., *M. vitifolia* (Burm.f.) Hallier f.

Vernacular names Malaysia: ulan.

Origin and geographic distribution *Merremia* consists of about 80 species, widely distributed in the drier or humid tropics of both hemispheres. Approximately 23 species occur in South-East Asia.

Uses The tubers, roots or stems of several *Merremia* species are used as a purgative. The tubers of *M. tuberosa* are known as a drastic purgative in India and Java, and this is their only use. The tubers of *M. mammosa* in Indonesia and Malaysia, *M. peltata* in the Philippines, *M. umbellata* in India, and *M. tridentata* subsp. *hastata* in Indo-China are mildly laxative and are widely taken for dysentery. The sap from the stems of *M. peltata*, the leaves of *M. emarginata* and the aerial parts of *M. tridentata* subsp. *hastata* are also applied as a laxative in Indo-China and India.

The leaves or stems of *Merremia* are a popular medicine for chest problems. In Indonesia, an infusion of the leaves of *M. emarginata* mixed with lumps of sugar is a remedy for cough, and in the Philippines, the sap from the stem of *M. peltata* is used for this purpose. In Africa, an infusion of the leaves of *M. dissecta* is taken as a sedative for chest complaints, and a poultice of fresh, crushed leaves is applied as a resolutive. In Indonesia and Malaysia, the sap of the fresh tubers of *M. mammosa* is widely drunk in affections of the throat and respiratory organs.

Merremia is also widely used against inflammations of various kinds. In the Philippines, the leaves of *M. peltata* are applied as maturative for inflammation of the breasts, and as a poultice on superficial wounds. In Fiji, a decoction of the leaves of *M. peltata* is used to treat boils, infections and appendicitis. A decoction of the roots is used to treat stomach muscular rigidity. A drink made from the juice of the leaves of *M. peltata* is reputed to be taken for the treatment of hernia, and the heated leaves are applied as a poultice. A decoction of the leaves together with the leaves of *Colocasia esculenta* (L.) Schott is used for the treatment of cysts. In Papua New Guinea, the leaf, part of the stem or the sap of *M. peltata* is put on wounds, sores and swellings. In the Philippines and India, a decoction of the roots of *M. tridentata* is used as a mouthwash for toothache. In India, a paste or powder made of the root of *M. umbellata* is applied to swellings. In Peninsular Malaysia and the Moluccas, pounded leaves of *M. umbellata* are used to poultice burns, sores and scalds. In India, the whole plant or the roots of *M. tridentata* are used for hemiplegia, piles, swellings and urinary disorders. The seeds of *M. umbellata* yield a mucilage used in India as an aperient and alterative in cutaneous diseases. The juice of the aerial parts of *M. emarginata* is dropped into the ear to cure sores. In Indonesia, Fiji and India, diluted sap from the young stems of *M. peltata* is used as eye or ear drops.

In Peninsular Malaysia and Thailand, a poultice of the leaves of *M. hederacea*, together with turmeric (*Curcuma longa* L.) and broken rice, is used to heal cracks in the hands and feet. In Indonesia, *M. umbellata* is used for this purpose.

In the Philippines and Thailand, a decoction of the leaves and tops of *M. emarginata* is sometimes used as a diuretic. In India, the decoction acts as a diuretic and alterative, and is used for rheumatism, neuralgia, and headache. The roasted seeds of *M. tridentata* are diuretic and antibilious. In the Philippines, a decoction of the roots of *M. umbellata* is drunk as a remedy for haematuria. In India, *M. vitifolia* is used for strangury and urethral discharges. The juice of the plant is considered cooling and diuretic. In the Philippines, the tubers of *M. peltata* are used to treat uterine haemorrhage.

In Peninsular Malaysia, a poultice of the leaves of *M. tridentata* is applied to the head for fever. In the Philippines, the roots of *M. peltata* are used in infusions to treat chills. The leaves of *M. petaloidea* (Choisy) Burkill from India, but sometimes planted in Peninsular Malaysia, are used for poulticing the head for fever. The sap of the fresh tubers of *M. mammosa* is widely drunk for fever or applied as a poultice on the head. In Peninsular Malaysia, an infusion of *M. vitifolia* is drunk for high fever. In Cambodia, an infusion of the stem is used internally and externally for malaria and small pox.

In the Philippines, sap from the stem of *M. peltata* or the roasted seeds of *M. tridentata* are taken as an anthelminthic.

In Indonesia and Malaysia, the tubers of *M. mammosa* used to be widely used in the treatment of diabetes, but this use is no longer common, as it has been shown that the plant does not posses suitable properties.

Several *Merremia* species are planted as ornamentals, e.g. *M. dissecta* and *M. vitifolia* in India and *M. tuberosa* in Africa. In India, the leaves of *M. emarginata* are eaten as a pot-herb, and in India and Peninsular Malaysia, the young leaves of *M. umbellata* are eaten as a vegetable. In Malesia, the tubers of *M. mammosa* and *M. peltata* are eaten, although they tend to have a purgative effect. The leaves of *M. dissecta* smell like bitter almonds and are used in India for making liquor.

The stems of *M. mammosa* yield a fine, strong fibre, with a satin shine, which is made into cloth. The clothes made have to be dried in the shade after washing them, to prevent loss of this shine. In the Philippines, the stem of *M. peltata* is sometimes used for tying purposes.

M. dissecta is poisonous to cattle in India. The hairs on the leaves of *M. vitifolia* are irritating. *M. hederacea* however, is eaten readily by cattle, which thrive on it even if given nothing else to eat.

Production and international trade *Merremia* species are mainly cultivated and traded on a local scale, for medicinal purposes.

Properties The tubers of *M. mammosa* contain a resin, of which the greater part consists of glycosides of hydroxy fatty acids (sometimes referred to as glycoretins) e.g. jalapinolic acid, convolvulinolic acid, ipurolic acid and 3,11-dihydroxyhexadecanoic acid. The resin also contains the ether-insoluble jalapins woodrosin I and II, and the ionophoric resin glycosides, merremosides, and mammosides A–G, H1 and H2. In general, these glycosides are responsible for the laxative effects of the resin.

An ethanol extract of the tubers of *M. mammosa* inhibited the growth of the tumour Crown gall in potato disks, inoculated with *Agrobacterium tumefaciens*, in vitro. Tuber extracts also significantly decreased the blood glucose levels in male white rats.

The roots of *M. tuberosa* contain 12–25% resin of which 5–6% is soluble in ether. The resins show, as do the resins of the roots of *M. dissecta*, allelopathic activity on the radicle growth of *Amaranthus* sp., wheat and oats, but had no antibacterial activity against *Bacillus subtilis* and *Escherichia coli*.

The leaves of *M. dissecta* contain cyanogenic glycosides, which on hydrolysis yield hydrocyanic acid (with a characteristic odour of bitter almonds). In addition, the seeds contain amygdalin acyl derivatives (cyanogenic glycosides), prunasin and prunasin-6'-malonate, and the roots tropane alkaloids (known as merresectines). The leaves of *M. vitifolia* also contain a glycoside, which on hydrolysis yields hydrocyanic acid and benzaldehyde.

The seeds of *M. emarginata* contain caffeic acid, p-coumaric acid, ferulic acid and sinapic acid. The extract exhibits antibacterial activity against *Bacillus* sp., *Pseudomonas* sp. and *Typhimurium* sp.

In a general screening, the leaves of *M. peltata* showed antimicrobial activity, and gave a positive reaction for alkaloids. An MeOH extract of *M. peltata* showed anti-HIV activity, inhibiting HIV-1 reverse transcriptase and gp120-CD4 binding, in vitro.

The flavonoids diosmetin, luteolin, diosmetin-7-O-β-D-glucoside and luteolin-7-O-β-D-glucoside have been isolated from the aerial parts of *M. tridentata*. The ethanol extract of the aerial parts of *M. tridentata* subsp. *hastata* also showed significant larvicidal activity on the larvae of the tick *Boophilus microplus*.

Adulterations and substitutes In India, the root of *Ipomoea purga* (Wender.) Hayne is used as an adulterant of *M. tuberosa* root.

Description Annual or perennial herbs or shrubs, usually twining, but also prostrate and rooting at the nodes, erect herbs or low, erect shrubs; sometimes with tuberous roots. Leaves alternate, variable in size and shape, entire, dentate, lobed or palmately or dentately partite or compound; petiole present; stipules absent. Inflorescence axillary, few- to many-flowered, variously ramified, large to small; peduncle present to almost absent; bracts usually small. Flowers bisexual, regular, small to large, pedicel present; sepals 5, usually subequal, often somewhat enlarged in fruit; corolla funnel-shaped or campanulate, slightly 5-lobed, mid-petaline bands well-defined, white, yellow to orange; stamens 5, inserted near the base of corolla tube, included, filaments often unequal in length, anthers often contorted, pollen glabrous; ovary 2–4-celled, with 4 ovules, style 1, simple, filiform, included, stigma 2-globular. Fruit a globose or ovoid capsule, 4-valved, 4-seeded. Seed glabrous, pubescent or villose, especially at the margins. Seedling with epigeal germination; cotyledons often deeply divided into lobes or slips.

Growth and development In Java, most *Merremia* species can be found flowering throughout the year. *M. hederacea* is found flowering from April to November, and *M. vitifolia* from May to November. The flowers of *M. dissecta* open in the evening and remain open till the following afternoon; of many other *Merremia* species the flowers open well after dawn.

The tubers of *M. mammosa* are bunched, and on sandy soil long and thin; on clayish soil however, they can become as large as coconuts.

Other botanical information *Merremia* and *Ipomoea* are taxonomically closely related. The main differences are the spiralled anthers and the smooth pollen in *Merremia*, as well as campanulate corollas, which are commonly yellow, while yellow is rare in *Ipomoea*.

Ecology *Merremia* grows on disturbed sites, such as roadsides, grasslands, cultivated areas, and along forest borders, sometimes covering entire shrubs and trees. Several *Merremia* species are serious weeds in tree plantations, and can be reduced by burning or cattle grazing.

Propagation and planting *Merremia* is mainly propagated by seed, sometimes from stem cuttings. *M. mammosa* and *M. vitifolia* are propagated by stem cuttings. They are fast growing, and suitable for covering walls, trellis and pergolas. The seeds of *M. dissecta* germinate within one week.

Husbandry Tubers of *M. mammosa* will grow bigger when planted in fertile soil. Before planting, the soil is well tilled, and raised beds are made, 50–60 cm high, to prevent waterlogging. Fertilization with potassium is especially beneficial for tuber growth.

Diseases and pests *M. dissecta* and *M. emarginata* are highly susceptible to the fungus *Albugo ipomoeae*, resulting in irregular growth. The Coleoptera *Mylabris pustulata* and the Chrysomelid *Aspidomorpha furcata* feed on flower buds of *M. tuberosa*.

Harvesting In Java, the tubers of *M. mammosa* are harvested when the plant has dried out, more than 1 year after planting.

Handling after harvest In Ambon, the tubers of *M. mammosa* are cooked whole, in Bali they are first peeled thickly before cooking and afterwards they can be mashed. In India, the root of *M. tuberosa* is cut into slices of 5–8 cm in diameter and 0.5–1 cm thick before drying.

Genetic resources and breeding As many *Merremia* species are widespread and have a weedy habit, there seems to be little risk of genetic erosion. A small ex situ collection of *M. mammosa*, originating from Indo-China, is present in the Bogor Botanical Gardens in Indonesia.

Prospects The use of *Convolvulaceae* resins as a laxative, e.g. from *Ipomoea*, is quite well established due to the presence of glycosides of hydroxy fatty acids. Some of the resins found in several *Merremia* species are of similar composition and may therefore be of local importance. In general, more information on the pharmacology and phytochemistry is needed to fully evaluate other potential uses of the species.

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Selection of species

Merremia dissecta (Jacq.) Hallier f.

Bot. Jahrb. 16(4–5): 552 (1893).

Synonyms *Convolvulus dissectus* Jacq. (1767), *Ipomoea sinuata* Ortega (1798).

Vernacular names Noon-flower (En).

Distribution Native to the New World, from Florida to Argentina and Uruguay, but introduced into West tropical Africa, India, the Pacific islands and South-East Asia.

Uses In Cuba, an infusion of the leaves is taken as a sedative in chest complaints. A poultice of crushed fresh leaves is applied as a resolutive and sedative for inflammations. In Africa, a cold infusion is a remedy for giddiness, snake bites or intoxication. In Curaçao, a hot infusion is taken to relieve urinary infection. Reports from India suggest that it is poisonous to cattle. In South-East Asia it is sometimes cultivated as an ornamental, and occasionally escapes. Medicinal use is not known from this region, although it certainly has some potential.

Observations A perennial, slender twiner, 3–6 m long, patently hirsute with yellow hairs, adult parts woody, glabrescent and warty; leaves rounded in outline, palmately divided nearly to the base, segments 5–7, middle segment 2.5–10 cm × 0.5–3 cm, lateral ones smaller, apex mucronulate, margin coarsely dentate to irregularly pinnately lobed, petiole 2.5–7 cm long; flowers few together, peduncle 5–10 cm long; flower-buds narrowly ovoid, acute, pedicel 1.5–2 cm long, sepals subequal, 2–2.5 cm long, ovate-lanceolate, acute, margin scarious, enlarged in fruit, corolla funnel-shaped, 3–3.5 cm long, white, throat rose-purple, midpetaline bands distinct, anthers spirally twisted; capsule globose, glabrous; seed glabrous, black. *M. dissecta* occurs in open grasslands and along roadsides, from sea-level up to 300 m altitude.

Selected sources 142, 647, 696.

Merremia emarginata (Burm.f.) Hallier f.

Bot. Jahrb. 16(4–5): 552 (1893).

Synonyms *Evolvulus emarginatus* Burm.f. (1768), *Ipomoea reniformis* Choisy (1833).

Vernacular names Indonesia: embun, pegagan utan (Javanese). Philippines: kupit-kupit (Iloko), bato-bato (Tagalog). Thailand: uek, sa uek klet hoi (central).

Distribution Tropical Africa, Asia and Malesia.

Uses In Indonesia, an infusion of the leaves added to lumps of sugar is a remedy for cough. In the Philippines, a decoction of the leaves and tops is sometimes used as a diuretic. In India, it is considered purgative, diuretic and alterative, and used in rheumatism and neuralgia. In India, the plant is eaten as a pot-herb.

Observations A perennial, prostrate herb, 30–75 cm long, sparsely hairy to glabrescent; leaves kidney-shaped to broadly ovate, 0.5–3.5 cm × 0.7–3.5 cm, base cordate, lobes rounded, apex obtuse to slightly emarginate, margins entire to coarsely crenate, petiole 0.2–3.7 cm long; flowers in a 1–few-flowered cyme, peduncle almost absent; flower-buds globular, pedicel 2–4 mm long, sepals subequal, obovate to orbicular, outer ones 2.5–3 mm long, obtuse with cucullate, mucronate apex, inner ones deeply emarginate, corolla tubular-campanulate, 5–9 mm long, yellow with a paler base, mid-petaline bands distinctly 5-veined, purplish, hairy inside, filaments hairy at base; capsule subglobular, 5–6 mm in diameter, glabrous, brown-black, partly enclosed by sepals, base of style present; seed 2.5 mm long, greyish brown, glabrous, dotted. *M. emarginata* occurs in regions with a pronounced dry season, in open grasslands and fields, along railroads and waste places, on rather heavy soils, from sea-level up to 200 m altitude. The plant is sometimes confused with *Centella asiatica* (L.) Urb., which has the same habit.

Selected sources 215, 407, 570, 786.

Merremia hederacea (Burm.f.) Hallier f.

Bot. Jahrb. 18 (1–2): 118 (1894).

Synonyms *Evolvulus hederaceus* Burm.f. (1768).

Vernacular names Indonesia: lawatan (Javanese), tatapajan (Sundanese), kelemibiet (West Kalimantan). Malaysia: ulan pelandok. Thailand: cha uek, ma uek (eastern), thao sa uek (central). Vietnam: b[if]m hoa v[af]ng.

Distribution Tropical Africa, Mascarene Islands, tropical Asia, from the Himalayas southwards to Sri Lanka, and eastwards to Burma (Myanmar), southern China, Indo-China and Thailand, and southwards throughout Malesia to northern Australia.

Uses In Peninsular Malaysia, a poultice of the leaves, together with turmeric (*Curcuma longa* L.) and broken rice, is used to heal cracks in the hands and feet. It is a good fodder for cattle.

Observations An annual, twining or prostrate, slender herb, 1–2 m long, glabrous to sparsely hirsute; leaves ovate in outline, 1.5–5 cm × 1.2–4 cm, base broadly cordate, apex obtuse and mucronulate, margin entire or crenate to shallowly or deeply 3-lobed, petiole 0.5–6 cm long; flowers few to several, first ramification dichasial, subsequent ones often monochasial, peduncle 1–10 cm long, bracts narrow-obovate, 3 mm long, caducous; flower-buds oblong, pedicel 2–4 mm long, sepals concave, broadly obovate to spathulate, 4–5 mm long, broadly notched at the apex, mucronulate, corolla campanulate, 6–10(–12) mm long, outside glabrous, inside with long hairs, yellow, base of filaments hairy; capsule broadly conical to depressed-globular, 5–6 mm high, wrinkled; seed 2.5 mm long, pubescent or nearly glabrous. *M. hederacea* occurs in thickets, open grasslands, and on sandbanks, from sea-level up to 250 m altitude. Two forms can be distinguished: f. *pubescens* Ooststr., with shortly pubescent seeds, and f. *barbata* Ooststr., with seeds having reddish-brown long hairs on the hilum and margins when ripe.

Selected sources 134, 215, 786.

Merremia mammosa (Lour.) Hallier f.

Teysmannia 7: 164 (1897).

Synonyms *Convolvulus mammosus* Lour. (1790), *Ipomoea gomezii* Clarke (1883).

Vernacular names Indonesia: blanar, widara upas (Javanese), hailale (Ambon). Malaysia: widara upas. Philippines: angcoa. Vietnam: b[if]m v[us].

Distribution India, Andaman Islands, Indo-China, introduced and cultivated in Java for the edible roots, formerly also in Bali, the Moluccas, Papua New Guinea and the Philippines; locally naturalized in Madura.

Uses In Indonesia, the sap of the fresh tubers is widely drunk in affections of the throat and respiratory organs, dysentery, fever, and externally applied for snakebite, burns, fevers, dysentery, poisoning, chest and throat affections and oedema. It is mildly purgative. In Malaysia, it is often cultivated in gardens as a medicinal or for the edible tubers.

Observations A perennial, glabrous twiner, 3–6 m long, stems annual, terete, finely striate in the older parts, tubers fusiform to globose, fasciculate, 10–25 cm long, with a milky juice; leaves broadly ovate to orbicular, 6–12 cm × 4.5–12 cm, base cordate, apex abruptly acuminate, margin entire, petiole 6–10 cm long; flowers 1–3 together, peduncle 3–15 cm long, bracts linear-lanceolate, caducous; flower-buds narrowly ovoid, acute, pedicel 12–15 mm long, clavate, sepals subequal, 24–30 mm long, concave, outer ones broadly ovate-elliptical, corolla broadly funnel-shaped, 7–8 cm long, white, minute glands outside, mid-petaline bands distinctly veined, base of filaments hairy, anthers spirally twisted; capsule ovoid, about 1,5 cm in diameter, enclosed by permanent calyx; seed 8 mm long, greyish to black, with long, brownish hairs along the margins. *M. mammosa* occurs in Java from sea-level up to 500 m altitude.

Selected sources 215, 407, 647, 762, 816.

Merremia peltata (L.) Merr.

Interpr. Herb. amboin.: 441 (1917).

Synonyms *Convolvulus peltatus* L. (1753), *Merremia nymphaeifolia* Hallier f. (1896).

Vernacular names Indonesia: areuy carayun (Sundanese), hailale (Ambon), kuge (Ternate). Malaysia: akar ulan, akar ulan gajah (Peninsular). Papua New Guinea: palai (Lomeoi, Manus Province), dawe (Koropak, Madang Province), balala (Sililio, Morobe Province). Philippines: bulakan (Tagalog, Bisaya), budakin (Bagobo), tampinita (Subanun). Thailand: yaan len, en luen (peninsular).

Distribution From Madagascar, Mascarene Islands, Seychelles, throughout Malesia, to North and East tropical Australia and Polynesia.

Uses In Indonesia and Fiji, diluted sap from the young stems is used as eye or ear drops. In the Philippines and Papua New Guinea, sap from the stem and tuber is considered a purgative, and a remedy for cough, diarrhoea and worms. The leaves are applied as a maturative for inflammation of the breasts. The tubers are purgative in decoction, and are used to treat uterine haemorrhage. In Fiji, a drink made from the juice of the leaves is reputed to be taken for the treatment of hernia, and the heated leaves are applied as a poultice. In Indonesia, the leaves of *M. peltata* are often used for washing hair, as they are cooling, improve growth and prevent hair loss.

Observations A large perennial twiner, 5–30 m long, rarely precumbent, stems terete, fistulose or pithy, glabrous, with milky juice, tuber large; leaves peltate, broadly ovate to orbicular, 7–30 cm in diameter, base rounded, apex acuminate, mucronulate, petiole 3–20 cm long; flowers in a 2-many-flowered corymb up to 40 cm long, peduncles 1–2 together, stout, bracts caducous; flower-buds narrowly ovoid, acute, pedicel 1.5–2.5 cm long, clavate in fruit, sepals subequal, 15–25 mm long, outer ones broadly ovate, apex obtuse, corolla broadly funnel-shaped, 4.5–6 cm long, shallowly lobed, white, sometimes yellow, corolla inside above the insertion of filaments with a semi-circular thickening, filaments dilated and hairy in lower part, anthers spirally twisted, hairy; capsule ovoid; seed densely yellowish to dark brown, tomentose. *M. peltata* occurs along edges of primary and secondary forests, clearings, and thickets, from sea-level up to 700 m altitude. Yellow-flowered specimens appear to be restricted to West Malesia, the white-flowered ones to East Malesia.

Selected sources 407, 418, 786.

Merremia tridentata (L.) Hallier f. subsp. hastata (Desr.) Ooststr.

Blumea 3: 317, f. 2 (1939).

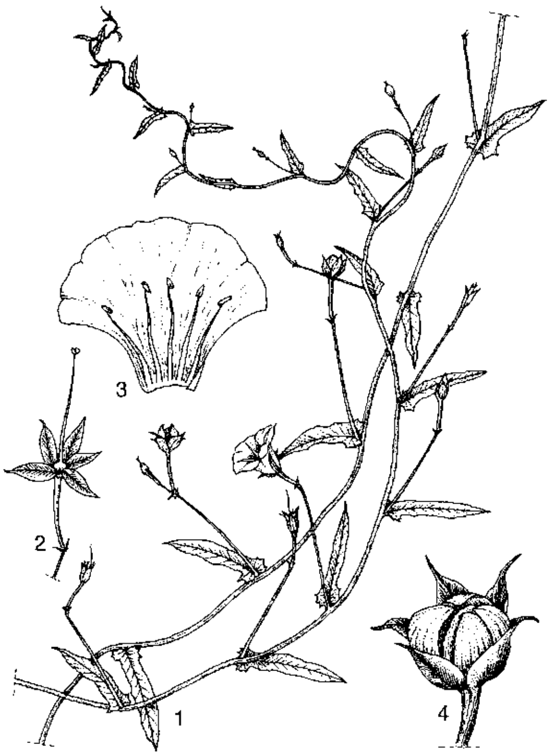
Synonyms *Merremia hastata* Hallier f. (1893).

Vernacular names Indonesia: irit-iritan, rangitan (Javanese), jala ma tubu (Ternate). Malaysia: akar keremak, karok relia, pungulang (Peninsular). Philippines: maragta, talanuk (Tagalog), karadkad (Igorot). Thailand: thao tot maa (south-western).

Distribution From tropical Africa to tropical Asia, India, and Sri Lanka, eastwards to China, and southwards throughout Malesia, and northern Australia.

Uses In Indo-China, all parts are considered purgative. The roasted seeds are anthelminthic, diuretic and antibilious. In Peninsular Malaysia, a poultice of the leaves is applied to the head for fever, and on snakebites. In the Philippines and India, a decoction of the roots is used as a mouthwash for toothache. *M. tridentata* is bitter, astringent and tonic. In northern Nigeria, a decoction of the whole plant of *M. tridentata*, together with natron, is taken for gonorrhoea.

Observations An annual twiner, occasionally prostrate, 0.6–2 m long, stems slender, glabrous, root stout; leaves linear-oblong to narrowly linear, 2.5–10 cm × 0.5–2 cm, more or less contracted above the base, lobes more or less stem-clasping, basal lobes dentate, apex attenuate, acute to obtuse, mucronulate, margin entire or slightly undulate, petiole 1–3 mm long; flowers in 1-few-flowered cymes, peduncle 1–8 cm long, bracts minute; flower-buds narrowly conical, acute, pedicel 6–8 mm long, in fruit clavate, up to 15 mm long, tips of sepals curved outwards, sepals subequal, 6–7 mm long, ovate-lanceolate, acuminate, corolla funnel-shaped, 12–20 mm long, pale yellow or white, centre purple or dark brown, filaments sparsely hairy



Merremia tridentata (L.) Hallier f. subsp. hastata (Desr.) Ooststr. – 1, flowering and fruiting stem; 2, calyx and pistil; 3, corolla and stamens; 4, fruit.

at base; capsule globose to ovoid, pericarp papery, glabrous; seeds 2.5–3 mm long, dull black, glabrous. *M. tridentata* subsp. *hastata* occurs on rather light soil, in open grasslands, waste places, teak forests, and along roadsides, from sea-level up to 1200 m altitude. Subsp. *tridentata* differs from subsp. *hastata* in that the outer sepals are mostly obtuse to emarginate, the corolla is 10–12 mm long, the filaments are inserted about 1.5 mm from the base, and the apex of the leaves is obtuse, truncate or emarginate.

Selected sources 134, 215, 568, 786.

Merremia tuberosa (L.) Rendle

Fl. Trop. Afr. 4(2): 104 (1905).

Synonyms *Ipomoea tuberosa* L. (1753), *Operculina tuberosa* (L.) Meissn. (1869).

Vernacular names Wood rose, Brazilian jalap (En). Indonesia: areuy kawoyang (Sundanese). Vietnam: b[if]m c[ur].

Distribution Probably of Central American origin, now distributed throughout tropical Africa, the Mascarene Islands, India and Sri Lanka; in India and Malesia cultivated as a medicinal and sometimes escaped from cultivation.

Uses In South-East Asia, the tuber is used as a drastic purgative. The plant is also planted as an ornamental in Africa. The woody fruits are used in flower arrangements in Europe.

Observations A perennial, glabrous twiner, 3–5 m long, stems robust, finely striate, tuber large; leaves orbicular in outline, 6–16 cm × 6–16 cm, palmately divided to far below the middle, segments 7, oblong-lanceolate, apex acuminate, base narrowed, entire, the middle segment larger than the lateral ones, petiole 6–18 cm long; flowers in a few-flowered cyme, peduncle 4–15 cm long, bracts triangular, small; flower-buds oblong, apex pointed, pedicel 15–18 mm long, in fruit clavate, up to 5 cm long, sepals subequal, outer ones 25 mm long, ovate, obtuse, inner ones oblong, in fruit 5–6 cm long, enclosing the capsule, corolla funnel-shaped, 5.5 cm long, yellow, anthers twisted; capsule subglobose, 3.5 cm in diameter, pericarp thin, splitting irregularly, and loosening circumsessile at base; seeds 17 mm long, black, black pubescence on sides. In Indonesia, *M. tuberosa* occurs from sea-level up to 600 m altitude. The loosening of the capsulewall is different from that of *Operculina*, where the wall shows 2 layers, and the outer one is fleshy in the upper part, forming an operculum.

Selected sources 134, 647.

Merremia umbellata (L.) Hallier f. subsp. orientalis (Hallier f.) Ooststr.

Fl. Males. ser. I, 4: 449 (1953).

Synonyms *Convolvulus umbellatus* L. (1753).

Vernacular names Indonesia: lawatan kebo (Javanese), areuj geureung (Sundanese), daun bisul (Moluccas). Malaysia: andur nasi (Peninsular), ulan tapak pelandok. Philippines: kalamitmit (Tagbanua), bangbangau (Iloko), kamokamotihan (Tagalog). Thailand: chingcho khaao (northern), thao dok baan tuum (south-eastern), en (peninsular). Vietnam: b[if]m t[as]n.

Distribution *M. umbellata* subsp. *orientalis* occurs from tropical East Africa, Seychelles, India, Sri Lanka eastwards to China, Indo-China, Thailand, and southwards through Malesia to northern Australia. Subsp. *umbellata* occurs in America from Mexico to Paraguay, in the West Indies and in tropical West Africa.

Uses In Peninsular Malaysia and the Moluccas, pounded leaves are used to poultice burns, sores and scalds. In Indonesia, a poultice of the leaves, together with Curcuma powder (*Curcuma longa*

L.) is applied on cracks in the soles of the feet. The seeds yield a mucilage used as an aperient and alterative in cutaneous diseases. In Indo-China, the latex of the root is taken as a purgative. In the Philippines, a decoction of the roots is drunk as a remedy for haematuria.

Observations An annual twiner, 1–3 m long, sometimes prostrate, terete, softly pubescent or glabrescent, young parts with milky juice; leaves ovate to oblong, 4–12(–16) cm × 1–6.5(–9) cm, base cordate, rounded or truncate, basal lobes rounded or angular, apex acuminate, both sides sparsely to densely hairy, petiole 1.5–6 cm long; cymes few- to many-flowered, umbelliform, peduncle 1–4(–7) cm long, bracts minute, caducous; flower-buds ovoid, pedicel 5–9 mm long, sepals subequal, concave, broadly elliptical or orbicular, 5–7 mm long, corolla funnel-shaped, 2–3 cm long, white, rarely yellow to orange, middle part mid-petaline bands hairy, anthers straight; capsule ovoid to conical, 10–12 mm high, mucronate by style-base, glabrous or sparsely hairy at top; seeds 5 mm long, densely hairy with soft, patent hairs. *M. umbellata* occurs in thickets, along edges of forests, in plantations, in grasslands, along fields and roadsides, from sea-level up to 1100 m altitude. Subsp. *umbellata* (synonym var. *occidentalis* Hallier f.) differs from subsp. *orientalis* in its more robust habit, with larger leaves, longer peduncles, more and larger yellow flowers, a subglobose capsule, with broader, ovate valves, and seeds shorter pubescent.

Selected sources 134, 215, 407, 786.

Merremia vitifolia (Burm.f.) Hallier f.

Bot. Jahrb. 16(4–5): 552 (1893).

Synonyms *Convolvulus vitifolius* Burm.f. (1768), *Ipomoea vitifolia* Blume (1825).

Vernacular names Indonesia: ginda purang utang (Javanese), areuy kawoyang (Sundanese), dewulu (Madurese). Malaysia: akar lulang bulu, ulan raya (Peninsular). Philippines: lakmit (Tagalog), kalalakmit (Sulu). Cambodia: var moba mek. Thailand: ching chaw. Vietnam: b[if]m l[as] nho.

Distribution From India, the Andaman Islands and Sri Lanka to Indo-China and throughout Malesia.

Uses In Peninsular Malaysia, an infusion of the plant is drunk for high fever. In Cambodia, an infusion of the stem is used internally and externally for malaria and varioles. In India, the plant is used for strangury and urethral discharges. The root is eaten raw in India, as a stomachic. The hairs on the leaves are irritating.

Observations A large twiner, 2–5 m long, stems terete, older ones striate, glabrous or patently white hirsute; leaves orbicular in outline, 5–18 cm × 5–16 cm, base cordate, palmately lobed, lobes 5–7, broadly triangular to lanceolate, apex acuminate to obtuse, margin coarsely dentate to crenate, sparsely to densely hairy, petiole 2–15 cm long; flowers 1–3(–5) together, peduncle 1–15 cm long, bracts tiny; flowerbuds narrowly ovoid, acute, pedicel 8–20 mm long, clavate in fruit, sepals oblong to ovate-oblong, with glandular pellucid dots, 12–20 mm long, in fruit 20–25 mm long, thick, subleathery, whitish inside, corolla funnel-shaped, 4–6 cm long, lobes obtuse, mid-petaline bands distinctly 5-veined, bright yellow, paler towards the base, anthers spirally twisted; capsule subglobose, 12 mm high, papery, straw-coloured; seeds 6–7 mm long, dull black, glabrous. *M. vitifolia* occurs in regions with or without a strong dry season, in open grasslands, thickets, hedges, along fields, in teak forests, along edges of secondary forests, on river-banks and roadsides, from sea-level up to 900 m altitude.

Selected sources 215, 788.

Muhammad Mansur

Micromelum minutum (J.G. Forster) Wight & Arn.

Prodr. fl. Ind. orient.: 448, 468 (1834).

RUTACEAE

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Synonyms *Micromelum pubescens* Blume (1825), *Micromelum ceylanicum* Wight (1840), *Micromelum compressum* (Blanco) Merr. (1918).

Vernacular names Lime berry (En). Indonesia: sesi (Lampung), ki mangkok (Sundanese), mentanen (Javanese). Malaysia: chememar, cherek, kematu (Peninsular). Philippines: piris (Tagalog), makabangon (Bikol), basar basar (Iloko). Thailand: samui (chaang) (peninsular), saam sok (northern), sabaek (eastern). Vietnam: cam n[us]i, kim s[uw][ow]ng.

Origin and geographic distribution *M. minutum* is found from India throughout South-East Asia to Australia and the Pacific.

Uses In Peninsular Malaysia, the pounded leaves of *M. minutum* are an ingredient of a poultice used to relieve skin irritation. A poultice of boiled roots is applied for ague. Magical powers are also attributed to it for warding off evil spirits. In the Philippines, the young shoots are heated with oil and used as a medicine for infantile convulsions. The leaves and roots are used as a febrifuge. The roots in decoction or infusion are given for diarrhoea in children, and as a carminative. The roots are also good for toothache. It is further reported as a remedy for stomach-ache and headache. In southern Sumatra, pieces of the root are chewed with betel for coughs. In Indo-China the leaves are rubbed on the skin to relieve irritations caused by scabies. In Fiji the leaves or inner bark of the twigs are used in various ways for headache and stomach-ache, to cure coughs and a sore tongue, to arrest profuse menstruation, to treat gonorrhoea, and as a remedy for thrush. The leaves are further taken as a general tonic. The wood is used for furniture and handles, but is of little economic interest.

Production and international trade *M. minutum* is an ingredient of herbal supplements traded in Malaysia and the Middle East. Production and trade statistics, however, are not available.

Properties *Micromelum* species are well known for the presence of coumarins, especially of the 6- or 8-prenylated-7-methoxy type. For example, from an acetone extract of the bark of *M. minutum*, 12 coumarins were isolated: micromarin A, B, C, F, G and H, micromelin, murralonginol-isovalerate, microminutinin, 6-methoxymicrominutinin, microminutin and murrangatin. Furthermore, the hexane/diethyl ether extract of the bark yielded the coumarin phebalosin. Micromelin, microminutinin and 6-methoxymicrominutinin are also reported to be present in the leaves and twigs of this species collected in Malaysia, together with 1,2-seco-dihydromicromelin. Additionally, the aboveground parts of *M. minutum* collected in India yielded coumarins including osthol, micromelin, murralongin, murrangatin, dihydromicromelin-A and -B and acetyldihydromicromelin A. Furthermore, the furoquinoline alkaloid flindersine has been reported for *M. minutum*.

Of the isolated compounds, both micromelin and microminutin showed in-vivo activity in the P-388 lymphocytic leukaemia assay. In addition, the coumarin phebalosin showed significant toxicity in the brine shrimp lethality assay (LC_{50} 47 ppm) and significantly inhibited the development of crown gall tumours on potato discs. However, insignificant cytotoxic activity was observed in the 9KB and 9 PS cell lines (ED_{50}> 20 μg/ml, ED_{50} 27 μg/ml, respectively), and no activity was observed in the 9ASK astrocytoma reversal assay. In the P-388 in vivo murine leukaemia system, phebalosin was inactive in doses up to 25 mg/kg, but insufficient material was available for testing at higher doses.

Extracts of *M. integerrimum* (Buch.-Ham.) Roem. have been fractionated based on in-vivo activity by using the P-388 lymphocytic leukemia assay in mice. Subsequent chomatography led to the isolation of the coumarins micromelin and scopoletin, which both demonstrated antitumour activities as crystalline compounds. Micromelin was furthermore converted into the corresponding butenolide (deoxymicromelin), which was inactive in the 9KB assay however.

Adulterations and substitutes The alkaloid flindersine has been found in other *Rutaceae*, including *Zanthoxylum australe* (Cunn.) G. Don. Phebalosin was previously isolated from *Phebalium drummondii* Benth.

Description A small to medium-sized, unarmed tree up to 20 m tall, with stem up to 15 cm in diameter; twigs and buds densely short-hairy. Leaves alternate, imparipinnate, up to 30 cm long including petiole with 9–15 alternate leaflets; stipules absent; leaflets ovate-lanceolate, 3–12 cm × 1.5–6 cm, base obtuse and asymmetrical, apex attenuate-acuminate, rarely obtuse or emarginate,

Micromelum minutum (J.G. Forster) Wight & Arn. – 1, fruiting twig.

margin entire to irregularly undulate-crenate; petiolule 3–5 mm long. Inflorescence terminal, cymose-paniculate, (3–)15–20 cm long. Flowers bisexual, 5-merous, calyx cupular, shallowly 5-toothed; petals valvate, linear-oblong, 7 mm × 1.5 mm, pale green to yellowish-white, densely appressed hairy outside; stamens 10; ovary superior, cylindrical, hairy, 5-celled, cells bi-ovulate, with a twisting of the radial follicle walls. Fruit an ellipsoid, oblong berry, 6–10 mm long, with 1–3 developed locules, each one-seeded. Seed glabrate, yellow to red when ripe, with flat and folded cotyledons. Seedling with epigeal germination; emergent cotyledons green; hypocotyl elongated.

Growth and development *M. minutum* flowers and fruits throughout the year. However, in areas with a pronounced dry season, flowering is restricted to the wet season.

Other botanical information *Micromelum* belongs to the tribe *Clauseneae*, together with *Clausena*, *Glycosmis* and *Murraya* but is classified on its own in the subtribe *Micromelinae*. *Micromelum* comprises some 9 species distributed from West Pakistan, India, Sri Lanka to southern China and throughout South-East Asia to Australia, New Caledonia and the South Pacific. The circumscription of the species varies among specialists of this group. Here, a broad circumscription of *M. minutum* is adopted, including many variable forms distinguished as separate species by others. In Peninsular Malaysia, the leaves of *M. hirsutum* Oliv. are an ingredient of a poultice to relieve skin irritation caused by caterpillars. It is, however, more linked to magical powers to ward off evil spirits. In Indo-China the leaves are rubbed on the skin to relieve irritations caused by scabies. *M. falcatum* (Lour.) Tanaka (synonym *M. octandrum* Turcz.) from southern China, Indo-China, Thailand, Burma (Myanmar) and the Andaman Islands, is used in folk medicine in Indo-China. A decoction of the leaves and roots is used as an emmenagogue, analgesic and anti-arthritic. The leaves are applied as a wound disinfectant. A tincture prepared from the leaves or roots is also prescribed in embrocation for rheumatism and arthritis. The bark of *M. integerrimum*, a closely related species from northern India, Burma (Myanmar) and the Andaman Islands, is used for pulmonary affections.

Ecology *M. minutum* is found on a wide range of soils in both primary and secondary forest, from sea-level up to 1000 m altitude.

Propagation and planting In a seedling trial in Peninsular Malaysia seeds of *M. minutum* germinated in 12–47 days.

Harvesting Bark, leaves and fruits of *M. minutum* are collected whenever the need arises.

Genetic resources and breeding *M. minutum* is widespread and common throughout South-East Asia, and therefore not endangered. Apart from collections in botanical gardens no breeding programmes exist.

Prospects Cytostatics and antitumour treatments constitute a dynamic field of modern pharmaceutical research, which traditionally has been strongly based on natural products. There is always a need for new constituents with potential activity, to serve as lead compounds for future developments. Therefore, the coumarins from *Micromelum* which showed activity in the P-388 in vivo assay merits further research, in order to fully evaluate their potential.

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Other selected sources 74, 128, 135, 207, 215, 220, 231, 407, 523, 671, 730, 739, 786, 788, 810, 819, 976.

M.A. Nor Azah

Millettia Wight & Arn.

Prodr. fl. Ind. orient. 1: 263 (1834).
LEGUMINOSAE
$x = 10, 11$; *M. extensa*, *M. pachycarpa*: $2n = 22$; *M. pinnata*: $2n = 20, 22$

Major species *Millettia pinnata* (L.) Panigrahi, *M. sericea* (Vent.) Wight & Arn.

Origin and geographic distribution *Millettia* consists of about 150 species found in the Old World tropics and subtropics, and 5 species in California and Mexico. One species (*M. pinnata*) extends from India to northern Australia and the West Pacific.

Uses Roots or seeds of many *Millettia* species are traditionally employed as a fish poison throughout South-East Asia. Roots and seeds of *M. pachycarpa* Benth. from India, Burma (Myanmar), Thailand and China, are used likewise to poison fish and birds, and possess considerable insecticidal activity. The plant is locally employed as a tonic and to treat swellings. Roots of *M. racemosa* Benth. from India, Burma (Myanmar), Thailand and the Philippines, are used as a fish poison and applied to cattle sores.

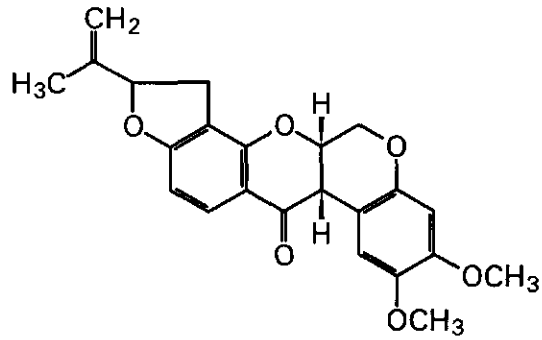
M. ichtyochtona Drake from Vietnam and *M. piscidia* (Roxb.) Wight & Arn. from India are both used as fish poison, the former species is even being locally cultivated for its piscicidal properties. In Peninsular Malaysia, pounded leaves of *M. xylocarpa* Miq. (syn. *M. hemsleyana* Prain) are placed in a hollow tooth to relieve toothache. The West African *M. thonningii* (Schumach. & Thonn.) Baker is effectively applied as a molluscicide and cercaricide. In Sudan, the dried whole plant is used as an antimalarial. Leaves and branches of *M. extensa* and *M. pinnata* are applied as green manure or as fodder. The bark of various *Millettia* species is used for rough cordage. Sometimes *Millettia* is planted as an ornamental, for its showy drooping inflorescences.

Production and international trade *Millettia* is of local importance only, therefore no information on production and international trade is available.

Properties Many *Millettia* species are characterized by the presence of isoflavones and rotenoids, which are isoflavone derivatives. For instance, *M. ichtyochtona* contains isoflavones in the leaves, and rotenone in the seeds. The latter compounds are also isolated from the roots and seeds of *M. pachycarpa*, which also contains isoflavones in the fruits, and other aerial parts. *M. extensa* is known to contain isoflavones and rotenoids in roots and seeds, *M. thonningii* in the seeds and roots, and *M. racemosa* isoflavones in the stem. Rotenone is a powerful mitochondrial inhibitor of the electron transport. It exhibits a considerable degree of selective toxicity; for example it is very toxic to insects, but only slightly to mammals.

Preliminary studies with ethanolic seed extracts of *M. pinnata* exhibited an anti-inflammatory effect in rats. *M. pinnata* seed extracts prepared with several other solvents were also evaluated for anti-inflammatory effects in chemically (bradykinin and PGE-1) induced hind paw inflammations in the rat; the predominant action appears to be a modulation of eicosanoid-events in inflammation. In contrast, minimal effects were seen against histamine and 5-HT-induced inflammations.

M. pinnata roots have been advocated in Ayurvedic medicine for treatment of various inflammatory and infective conditions including ulcers. Sequential petroleum ether, benzene, chloroform, acetone and ethanolic extracts of *M. pinnata* roots, when administered at a dose of 50 mg/kg intra peritoneal (i.p.) in rats, were found to have anti-inflammatory and analgesic activity. Pentobarbitone-induced 'sleeping time' was reduced by all the extracts except for petroleum ether, which enhanced it. The extracts were also found to possess anti-ulcer effects when administered either by i.p. (45 min before) or oral route (45 min before or for 4 days) against restraint-stress or pylorus-ligated gastric ulcers in rats, the maximum protection being afforded by petroleum ether and ethanol extracts. The mechanism of the anti-ulcer effect could be due to decrease in acid-pepsin secretion and augmentation of mucin secretion as observed with the ethanol extract, while the petroleum ether extract might be producing the effect by virtue of its anti-stress activity.



rotenone

The traditional Indian use of *M. pinnata* seeds for treatment of clinical lesions of skin and genitalia, prompted an evaluation of antiviral properties against herpes simplex virus type-1 (HSV-1) and type-2 (HSV-2) by in vitro studies in Vero cells. A crude aqueous seed extract of *M. pinnata* completely inhibited the growth of HSV-1 and HSV-2 at concentrations of 1 and 20 mg/ml (w/v), respectively, and cytopathic effects were completely absent.

Other pharmacological effects of compounds and extracts of *Millettia* include: inhibition of the interleukin-1 production by pongapinone A, a phenylpropanoid isolated from the bark of *M. pinnata*, and inhibition of murine retroviral transcriptase and human DNA-polymerase by extracts from *M. pachycarpa*.

The inedible fatty seed oil of *M. pinnata* which has a disagreeable odour, and is difficult to refine, was tested as an antifeedant and insecticide against several insects, e.g. *Oryzaephilus surinamensis* and *Tribolium castaneum* (both storage pests of rice) and *Nephotettix virescens* (a vector of the virus causing tungro disease in rice).

Adulterations and substitutes Rotenoids are also obtained from the roots of other legumes such as *Derris*, *Lonchocarpus*, *Paraderris*, *Piscidia* and *Tephrosia* species. Other insecticides of plant origin used in South-East Asia are present in the seeds of *Croton tiglium* L., roots of *Derris* and *Paraderris* species, stem and roots of *Tinospora* species, leaves of *Vitex negundo* L., *Nicotiana tabacum* L. and *Azadirachta indica* A.H.L. Juss. Other piscicidal plants include *Croton tiglium*, *Derris* species, *Myrica esculenta* Buch.-Ham., *Paraderris* species and *Sapindus saponaria* L.

Description Shrubs, lianas or trees up to 25 m tall. Leaves alternate, imparipinnate; stipules small, caducous; leaflets (sub)opposite, 1–35; stipellae absent or present. Inflorescence terminal or axillary, pseudopaniculate or pseudoracemose. Flowers bisexual, 5-merous; calyx tube usually truncate with 4–5 teeth or short lobes or with 4–5 distinct valvate lobes; corolla papilionaceous, much longer than the calyx, white, pink, blue or violet, standard broadly ovate to obovate, glabrous or silky pubescent outside, wings adherent to keel petals and equally long, (sub)falcate; stamens 10, upper filament free or adnate; ovary superior, 1-loculate, 1–7(–11)-ovuled. Fruit a flattened, sometimes inflated pod, without wings or with 2 wing-like crests, tardily dehiscent, 1–more seeded. Seed generally flat, lens-shaped or quadrate, in a few species ellipsoid.

Other botanical information *Millettia* is placed in the tribe *Millettieae* within the subfamily *Papilionoideae*. It seems closely related to *Aganope*, *Derris*, *Lonchocarpus*, *Ostryocarpus* and *Paraderris*. *Millettia* differs from *Derris* and *Paraderris* in the pods being wingless and dehiscent. *Millettia* can be easily distinguished from *Callerya*, the latter having large paniculate inflorescences and a diadelphous staminal tube. The Malesian *M. dasyphylla* (Miq.) Boerl. has been recombined in *Callerya dasyphylla* (Miq.) Schot. The Chinese and Indo-Chinese *M. dielsiana* Harms ex Diels, *M. reticulata* Benth. and *M. speciosa* Champ. have been recombined in *Callerya cinerea* (Benth.) Schot, *C. reticulata* (Benth.) Schot and *C. speciosa* (Champ.) Schot, respectively. *C. cinerea* is used as an anti-anaemic in China. *C. reticulata* is applied to cure wounds and as an insecticide. The roots of *C. speciosa* are used for their reconstituent and antitussive properties. They are utilized in the form of a decoction or powder in the treatment of general debility, anorexia, headaches, coughs and dysuria.

Ecology *Millettia* species are generally found in rather open habitats. *M. pinnata* is very tolerant of saline conditions and also tolerant of alkalinity. It nodulates and fixes atmospheric nitrogen with *Rhizobium* of the cowpea group.

Propagation and planting Most *Millettia* species are propagated by seed. *M. pinnata* can easily be propagated by seed and cuttings. Germination takes 10–30 days. Seedlings reach a height of 60 cm about 1.5 years after sowing and are easy to transplant. Direct sowing is common and mostly successful.

Husbandry Trees of *M. pinnata* coppice well and can also be pollarded.

Diseases and pests *Millettia* hosts a large number of fungi and insects, but serious damage has not been observed. Flowers and flower buds of *Millettia* species of section *Fragiliflora* (e.g. *M. pinnata*) often suffer from gall formation: the section can be easily identified by this phenomenon.

Harvesting Leaves of *Millettia* can be picked whenever the need arises, whereas pods are collected when mature. Tuberous roots are harvested from plants at least 1 year old.

Yield Pod production in *M. pinnata* starts 5–7 years after sowing. Individual trees yield 9–90 kg of pods annually. Mature trees yield 8–24 kg seed annually. Air dried roots of *M. pachycarpa* contain 0.9–1.6 % rotenone and 2.8–4.3% ether extractives, roots less than 2.5 cm in diameter being richer in rotenone. Average yield of rotenone-rich roots amounts to 1 kg/plant. The seeds contain up to 0.65% rotenone and deguelin and 12% ether extracts.

Handling after harvest Ripe pods of *Millettia* are collected and subsequently dried in the sun. Seeds are extracted by light hammering or by splitting the pod with a knife along the sutures and winnowing them out of the husks. Tuberous roots are washed, sliced and dried for further storage.

Genetic resources and breeding Medicinally important *Millettia* have a preference for relatively open habitats, and tend to be adapted to disturbance. Therefore the risk of genetic erosion is likely to be limited. However, the natural distribution of a considerable number of species is rather limited.

Prospects The presence of rotenoids in *Millettia* may be of interest for their application as an insecticide in local communities, being cheap, simple and convenient. The anti-inflammatory, antiulcer and antiviral effects might be of interest for development of future lead compounds, and thus merit further research.

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Selection of species

Millettia extensa (Benth.) Benth. ex Baker

Fl. Brit. India 2: 108 (1876).

Synonyms *Otosema extensa* Benth. (1852), *Millettia auriculata* Baker ex Brandis (1874).

Vernacular names Thailand: kwaao khruea (northern).

Distribution From India eastward to Burma (Myanmar), Thailand and Indo-China.

Uses The root is used as a fish poison and credited with insect repellent properties. The root bark is given daily for 5 days following menstruation as an anticonceptive. An infusion of powdered roots is rubbed on cattle and horses to keep off flies. The root is used to kill maggots in cattle sores. Leaves and twigs are used for cattle fodder.

Observations A sub-erect shrub or more often a liana up to 20 m in length with glabrescent stems up to 25 cm in diameter; leaves very variable, petiole 15–40 cm long, stipules oblong, 7 mm long, persistent, leaflets 7–9, oblong to obovate, 6–16 cm long, base obtuse to cordate, apex acuminate or mucronate; inflorescence an axillary pseudopanicle, 10–30 cm long, flowers in groups of 2–4, calyx 3 mm long, shortly dentate; corolla yellowish green to pink, standard orbicular, stamens monadelphous, ovary superior, 8-ovuled; pod strap-shaped, 15 cm × 2–3 cm, thin-walled, glabrescent, 8-seeded; seed 1.5 cm × 1 cm, black. *M. extensa* is found in relatively open forest including semi-deciduous forest up to 1200 m altitude.

Selected sources 215, 331.

Millettia pinnata (L.) Panigrahi

in G. Panigrahi & S.K. Murti, Fl. Bilaspur Distr. 1: 210 (1989).

Synonyms *Pongamia pinnata* (L.) Pierre (1899), *Millettia novo-guineensis* Kanehira & Hatusima (1942), *Derris indica* (Lamk) J.J. Bennett (1971).

Vernacular names Pongam, Indian beech (En). Pongame oil tree (Am). Arbre de pongolote (Fr). Indonesia: bangkong (Javanese), ki pahang laut (Sundanese), kranji (Madurese). Malaysia: mempari, kacang kayu laut (Peninsular), biansu (Sarawak). Philippines: bani (general), balikbalik, balok (Tagalog). Laos: (do:k) ko:m ko:y. Thailand: khayi, yi-nam (peninsular). Vietnam: d[aa]y m[aas]u, d[aa]y lim, kh[oor] s[aa]m hoa.

Distribution *M. pinnata* occurs naturally or locally naturalized from Pakistan, India and Sri Lanka throughout South-East Asia to north-eastern Australia, Fiji and Japan. It has been introduced in Egypt and the United States (Florida, Hawaii).

Uses Extracts from the leaves, bark and seed are applied as antiseptic against skin diseases and rheumatism. Pounded and roasted seeds can be used as a fish poison. In rural areas, dried leaves are stored with grain to repel insects. The seed-oil is applied as a lubricant, as a leather dressing in the traditional Indian tanning industry, and in manufacturing soap, varnish and paint. The leaves, flowers and seed-cake are used as green manure; the leaves and seed-cake also as fodder. The wood is used for temporary shelters, and twigs are occasionally used as a toothbrush. In India, *M. pinnata* is used as a host of the lac insect and of the hemiparasite sandalwood *Santalum album* L. It is occasionally planted as an ornamental because of its attractive flowers.

Observations An evergreen or briefly deciduous, glabrous shrub or tree with spreading branches, 15–25 m tall, trunk up to 80 cm in diameter; leaflets 5–9, ovate, elliptical or oblong, 5–25 cm × 2.5–15 cm, base rounded to cuneate, apex obtuse-acuminate; inflorescence pseudoracemose, axillary, 6–27 cm long, each node bearing a pair of strongly fragrant flowers; calyx campanulate, 4–5 mm long, truncate, finely pubescent, corolla white to pink, purple inside, often with green central blotch, brownish veined outside, standard rounded obovate, 1–2 cm long, with basal callosities, thinly silky hairy, wings oblong, oblique, slightly adherent to obtuse keel, stamens monadelphous, vexillary one free at base, joined to the tube in the middle; pod oblique-oblongoid to ellipsoid, flat, 5–8 cm × 2–3.5 cm × 1–1.5 cm, smooth, thick-leathery to subwoody, beaked, short-stalked, tardily dehiscent, 1–2-seeded, mesocarp fibrous; seed compressed ovoid, 1.5–2.5 cm × 1.2–2 cm × 0.8 cm, with a brittle coat. *M. pinnata* occurs on a wide range of soils in lowland forest on limestone and rocky coral outcrops on the coast, along the edges of mangrove forest and along tidal streams and rivers from sea-level up to 1200 m altitude. Pods may be transported by sea currents, but germination takes place in non-saline conditions.

Selected sources 74, 295, 1038.

Millettia sericea (Vent.) Wight & Arn.

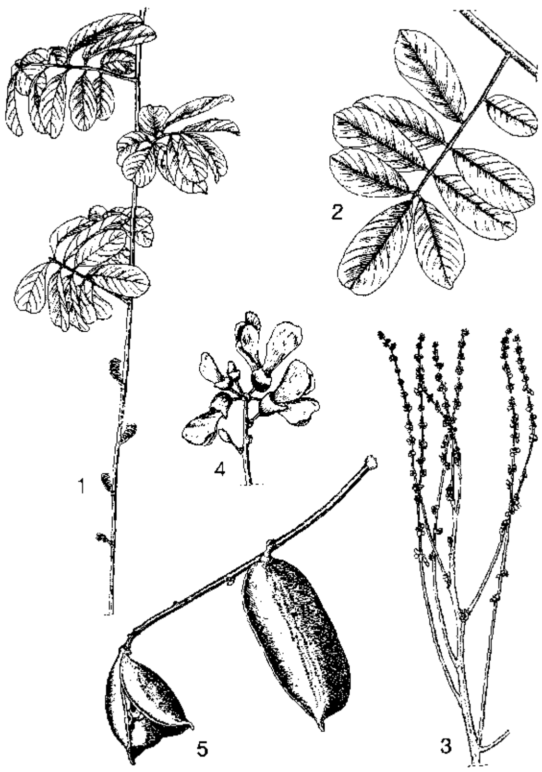
Prodr. fl. Ind. orient. 1: 263 (1834).

Vernacular names Indonesia: tuwa laleur (Sundanese), akar tuba, bori akar. Thailand: chanai-kho, paa-tuu, no-roh (peninsular). Vietnam: th[af]n m[as]t l[oo]ng t[ow].

Distribution Northern Vietnam, Peninsular Thailand, Peninsular Malaysia, Sumatra and Java.

Uses In Peninsular Malaysia, pounded leaves are placed in a hollow tooth to relieve toothache. The leaves are used for poulticing sore eyes. A decoction of the leaves is drunk for fever, urinary disorders and after chilbirth. In Indonesia, bark powder or pounded dry leaves in small dosage are used as a vermifuge for children. The juice of the roots is employed in animal medicine to cleanse neglected wounds in horses and cattle. In the Moluccas, pounded roots are employed as a fish poison. A piece of root is also used to retard fermentation of palm wine. Young leaves and shoot tips can be eaten in salads.

Observations A large liana up to 30 m long; leaflets 5–9, oblong or oblong-obovate, 7–25 cm × 3.5–11 cm, base rounded to cordate, apex shortly acuminate or rounded, coriaceous; inflorescence an axillary or terminal pseudopanicle, 15–50 cm long, flowers in groups of 7–8; calyx campanulate, 3–4.5 mm long, truncate, corolla violet, standard



Millettia sericea (Vent.) Wight & Arn. – 1, young shoot; 2, leaf; 3, inflorescence; 4, detail of inflorescence; 5, infructescence.

orbicular with a green basal blotch, auricles absent, callosities absent, sericeous outside, wings elliptical, adherent to the keel petals, stamens diadelphous, vexillary one free at base, joined to the tube in the middle; pod very thick with narrowed base and top, 5–7.5 cm × 1.5–3.5 cm, densely brown hairy, glabrescent, 1–2-seeded; seed transverse-ellipsoid, thick, 2.5–3.5 cm × 1–2.5 cm × 0.4–1.3 cm. Recently, 3–4-seeded collections from Peninsular Malaysia with pods up to 14 cm × 5 cm have been distinguished as a separate *M. chrysamaryssa* Adema, characterized by flat pods and seeds. *M. sericea* is found scattered on river banks and in forest fringes from sea-level up to 1200 m altitude.

Selected sources 11, 74, 331, 407, 747, 788.

J.L.C.H. van Valkenburg

Mitragyna speciosa (Korth.) Havil.

Journ. Linn. Soc., Bot. 33: 69 (1897).
RUBIACEAE
$2n$ = unknown

Synonyms *Nauclea speciosa* Miq. (1857).

Vernacular names Indonesia: kadamba (Kalimantan), puri (Batak Toba). Malaysia: ketum, kutum, biak-biak. Philippines: mambog (Tagalog), lugub (Mandaya), polapupot (Ibanag). Thailand: bai krathom, ee-thaang (central), thom (peninsular). Vietnam: giam d[ef]p, giam l[as] nh[or].

Origin and geographic distribution *M. speciosa* is found from Peninsular Malaysia, Sumatra, Borneo, to the Philippines and New Guinea. It is cultivated in southern Vietnam, peninsular Thailand and Burma (Myanmar).

Uses In Peninsular Malaysia, the pounded leaves of *M. speciosa* are widely used to poultice wounds, or to expel worms from children. The leaves, heated with those of *Blumea balsamifera* (L.) DC., *Morinda citrifolia* L. and *Oroxylum indicum* (L.) Kurz, are applied hot to an enlarged spleen. In the Philippines, the aerial parts are used as a local anaesthetic. It is also considered an antihypertensive plant and has been used for chronic cases of hypertension and diabetes mellitus. In Peninsular Malaysia and Thailand, the leaves are taken for diarrhoea, dysentery or stomach-ache and are also used for their analgesic and stimulant properties. Overdoses can cause vomiting and diarrhoea. In Peninsular Malaysia, Thailand, Vietnam and Burma (Myanmar), the leaves are chewed as a substitute for opium, as they cause hallucinations and euphoria. Extended use leads to anorexia, weight loss, darkened and dry skin, and in some cases even to psychosis. They are habit-forming, and reputed to act as a stimulant to help one endure fatigue and go long periods without food. In addition to chewing the leaves or drinking the infusion, the residue may be dehydrated and smoked, or the syrup smoked in a pipe. In Burma (Myanmar), the leaves are known to induce stupor when taken in case of an overdose.

The wood can be used for triplex and boxing.

Production and international trade *M. speciosa* is used on a local scale only.

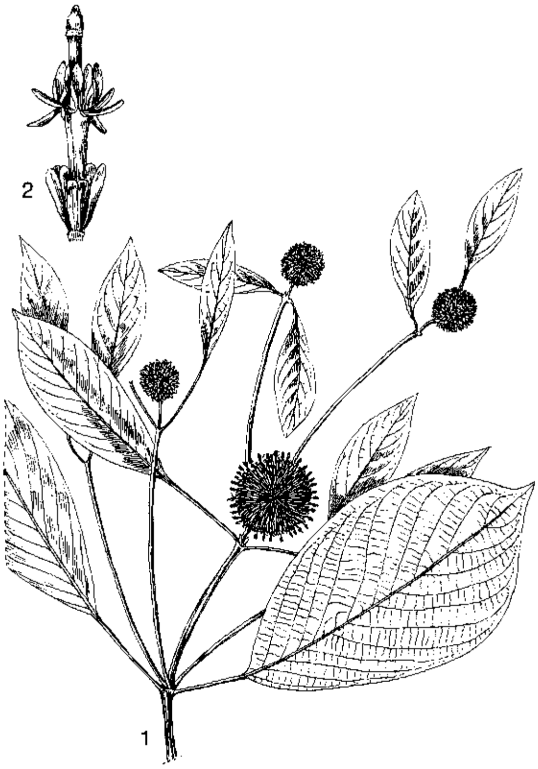
Properties *M. speciosa* is well known for the presence of a series of (monoterpenoid) indole alkaloids, which are biochemically derived from the amino acid tryptophan. The best known compounds, isolated from the leaves, are (–)-mitragynine and mitraphylline. Others include e.g. speciogynine, corynantheidaline, speciociliatine, mitraciliatine, 7-α-hydroxy-7H-mitragynine, mitragynalinic acid, corynantheidalinic acid, 3-dehydromitragynine and 3,4,5,6-tetradehydromitragynine. In young *M. speciosa* plants the major single indole alkaloid present was the C-3H-α-alkaloid speciogynine, but most of the indole alkaloids were of the C-3H-β-type, viz. isocorynantheidine, isopaynantheine and mitraciliatine. Rhynchociline, ciliaphylline, specionoxeine and isospecionoxeine were also obtained from the stem and root bark but not from the leaves. Besides indole alkaloids, several flavonoids were isolated from the leaves, e.g. apigenin, astragalin, cosmosin, hyperoside and also the polyphenols kaempferol, quercetin and rutin.

The pharmacological activities of mitragynine have been quite well investigated. Its antinociceptive activity, after oral administration, was compared to that of morphine and paracetamol, by using the acetic acid induced writhing model, the hot tail flick- and the cold tail flick tests in mice. Mitragynine, at 200 mg/kg, and morphine, at 5 mg/kg, reduced writhing significantly, but paracetamol did not. All 3 compounds produced significant analgesia in the hot tail flick test, but only morphine and mitragynine also did so in the cold tail flick test.

Furthermore, mitragynine (1–10 μg), injected intracerebroventricularly, exerted a dose-dependent antinociceptive activity in both the tail-pinch and hot-plate tests in mice. The mechanisms of the actions were evaluated using different opioid receptor antagonists. These results indicate that mitragynine can induce antinociception by acting in

the brain, and that the supraspinal opioid systems are at least partly involved in the antinociceptive action of mitragynine in mice.
Mitragynine and morphine also inhibited the electrically stimulated contraction of guinea-pig ileum in vitro through the opioid receptor in a concentration-dependent manner. Mitragynine was 10 times less potent than morphine, and furthermore did not show any effect on the smooth muscle contraction induced by acetylcholine or histamine.
In addition, the effects of mitragynine were evaluated for the 5-HT-2A receptor-mediated head-twitch responses in mice. Intraperitoneal injection of mitragynine (5–30 mg/kg), as well as intraperitoneal injection of the 5-HT-2A receptor antagonist ritanserin, inhibited the 5-methoxy-N,N-dimethyltryptamine (5-MeO-DMT at 16 mg/kg)-induced head-twitch response in a dose-dependent manner. In contrast, mitragynine affected neither head-weaving caused by 5-MeO-DMT, nor drug-free spontaneous motor activity. Stimulation of postsynaptic α2-adrenoceptor, blockade of 5-HT-2A receptors, or both, seem to be involved in suppression of 5-HT-2A receptor-mediated head-twitch response by mitragynine.
Effects of a related compound, mitragynine-pseudoindoxyl, on electrically stimulated contractions in guinea-pig ileum and mouse vas deferens, and on its binding affinity in the guinea-pig brain membranes were also studied in vitro. Mitragynine-pseudoindoxyl inhibited the electrically stimulated ileum and mouse vas deferens contractions in a concentration-dependent manner. In the ileum, the effective concentration is 100- and 20-fold smaller than those of mitragynine and morphine, respectively. In the vas deferens, it is 35 times smaller than that of morphine. It was demonstrated that the compound acts on opioid receptors, leading to a potent inhibition of electrically stimulated contraction in the ileum through the μ-receptors and in mouse vas deferens through δ-receptors.
In Malaysia, an extract of the leaves of *M. speciosa* was found to have strong enzyme inducing properties (cytochrome P450). Therefore, patients with chronic conditions taking these plants should be warned of possible drug interactions which may lead to a decrease in the effectiveness of drugs taken concurrently with such plants.

Description A large tree, 10–30 m tall; bole 60–100 cm in diameter, bark greyish, shallowly sculptured and with pustular lenticels; each node with 2 serial buds; terminal vegetative bud ellipsoid, slightly flattened. Leaves opposite, simple, entire, oblong-ovate, 8–15 cm × 4–10 cm, base broadly rounded, apex abruptly acuminate, glabrous or veins beneath puberulous, veins 12–15 pairs; petiole (1–)2–5 cm long; stipules lanceolate, 2 cm long, pubescent, with 9 veins, inside with colleters at base. Inflorescence terminally on lateral branches, composed of 3(–7) globose heads, 1 head subsessile between 2 others on long peduncles, 5 cm long; head 2.5 cm in diameter when flowering, 1.5 cm when fruiting, receptacle hairy, leafy bracts up to 4 cm long, petiolate, interfloral bracteoles up to 3.5 mm long. Flowers bisexual, 5-merous, sessile; calyx cup-shaped, up to 2 mm long, 5-lobed; corolla yellowish-white turning deep yellow, funnel-shaped, 5–8 mm long, lobes 5, 3 mm long, thickened at apex, margin revolute, a conspicuous ring of hairs inside at base of lobes; stamens 5, on intersection with lobes, anthers lanceolate, cordate, conspicuously protruding from the corolla; ovary inferior, 2-celled, style exserted, 13 mm long, stigma rounded, 2 mm long. Fruit composed of 2 cocci, exocarp thin, splitting loculicidally along its length, 10-ridged; seeds numerous. Seed shortly winged on 2 sides, lower wing shortly bifid or notched.



Mitragyna speciosa (Korth.) Havil. – 1, flowering branch; 2, flower with bracteoles.

Growth and development In Thailand, *M. speciosa* was grown in orchards until this was prohibited. *M. speciosa* flowers in March–April.

Other botanical information *Mitragyna* comprises 10 species from the Old world Tropics, of which 4 species occur in continental Africa and 6 species in continental and South-East Asia.

Ecology *M. speciosa* generally occurs rather sparsely in open savanna and secondary forest, at low altitudes. In Borneo, it is usually encountered in swamp and riverine forests which are periodically flooded, where it is one of the dominant species observed as colonizing vegetation on old ox-bow riverbeds.

Propagation and planting *M. speciosa* is propagated by seed.

Harvesting The leaves of *M. speciosa* are harvested throughout the year.

Handling after harvest In Peninsular Malaysia, the leaves of *M. speciosa* are dried in the sun until they are crisp. After that there are several possibilities for further use. The leaves can be powdered between the hands, the coarser parts removed, and the rest stored for later use. A small amount of this powder can be swallowed daily to twice daily in a cup of cold water or drunk as a hot infusion. The dry leaves can also be boiled, and the infusion is boiled down to a syrup. This syrup can be kept for a long time. The syrup can be mixed with hot water and drunk or it is put on the tongue and washed down with water. The syrup can also be mixed with finely shredded leaves of the palm *Licuala paludosa* Griffith, and the resulting sticky pellet is smoked in a bamboo pipe. In southern Thailand, the syrup may also been taken with betel leaf (*Piper betle* L.).

Genetic resources and breeding There is possibly some danger of genetic erosion, because most leaves are picked from natural *M. speciosa* populations in South-East Asia. On the other hand, leaf collection does not seem to be deleterious for the plant. The tree is preserved even when forest is cleared, but information on regeneration is lacking. Many botanical gardens in the region seem to have planted several trees.
There are no known breeding programmes of *M. speciosa*.

Prospects Mitragynine shows interesting in vitro and partly in vivo effects on several receptor systems including opioid receptors (antinociceptive activity, pain) and 5-HT-2A (antagonism, anxiolytic, antidepressant). These effects merit further research on *M. speciosa*, to fully evaluate the potential of mitragynine or its derivatives for either future medicine, or as biochemical tools in modern pharmacological research.

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Other selected sources 46, 201, 393, 407, 409, 523, 656, 657, 786, 796, 904, 905, 1056, 1066.

L.S.L. Chua & G.H. Schmelzer

Mollugo pentaphylla L.

Sp. pl. 1: 89 (1753).
AIZOACEAE
$2n = (18), 36$

Synonyms *Mollugo stricta* L. (1762), *Mollugo sumatrana* Gand. (1918).

Vernacular names Carpet weed, African chickweed (En). Mollugine, olsine (Fr). Indonesia: jampang kulut, jukut taridi (Sundanese), galingsa (Javanese). Malaysia: tapak burong, rumput belangkas, bunga karang. Philippines: malagoso (Tagalog), sulangkang (Subanun), lepouo (Bontok). Thailand: soi nok khao (southeastern), yaa nok khao (central), yaa khai hao (northern). Vietnam: c[or] b[uj]ng cu, b[if]nk cu.

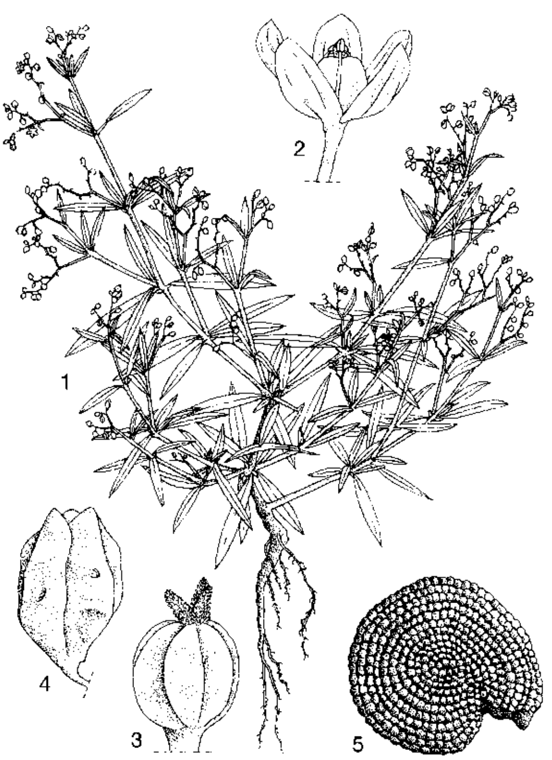
Origin and geographic distribution *M. pentaphylla* is distributed throughout the tropics and subtropics of the Old World, from India to New Caledonia and Micronesia, but is rare in Australia.

Uses In Peninsular Malaysia, the leaves of *M. pentaphylla* are applied for poulticing sore legs. In Java, they are used for sprue and mouth infections. In India, the whole plant is used as a mild laxative medicine, also as a stomachic, antiseptic and emmenagogue. In China, it is made into a soup to promote appetite, while a decoction of the roots is used to treat eye diseases. In Thailand, the entire plant is used as an antipyretic.
In the Solomon Islands, the whole plant is burnt to make a mosquito repellent. The leaves are eaten as a bitter pot herb in India, Thailand and Java, but they are less popular than those of *Glinus oppositifolius* (L.) DC. (synonym *Mollugo oppositifolia* L.), which are larger.
Other *Mollugo* species are used in a similar way as *M. pentaphylla*.

Production and international trade *M. pentaphylla* is only occasionally traded on local markets by herbalists.

Properties Very little is known about the phytochemistry and biological activities of extracts and isolated compounds from *M. pentaphylla*. Two triterpenes were isolated from the aerial parts. Mollugogenol A exhibited antifungal activity against *Cladosporium cucumerinum*, while mollugogenol B is inactive. Furthermore, mollugogenol A also exhibits spermicidal action by damaging the sperm membrane through increased lipid peroxidation.
Other components isolated include the flavonoids apigenin-8-C-glucoside and 6,8-di-C-pentosylapigenin, and the anthocyanin pelargonidin.
M. pentaphylla is a component in an important folk medicine in Taiwan, which is used as an anticancer, antitoxic and diuretic agent.

Description An erect or prostrate, glabrous annual, often much and widely branched from the base, 2–35 cm tall, with a thin taproot, stems thin, angular, when old often tinged brownish-red. Leaves in false whorls of 3–5(–9) or partly opposite, the basal ones in a rosette, oblong-obovate-spatulate, upper leaves smaller, linear-lanceolate, 10–50 mm × 1.5–10 mm, both ends narrowed, margins entire, midrib prominent beneath; petiole short or absent; stipules minute. Inflorescence a lax axillary or terminal cyme, often with long racemiform branches; bracts small, persistent; pedicel 1.5–6 mm long, persistent and recurved till long after the fall of the fruiting perianth. Flowers bisexual, with 5 free, oval-oblong tepals, 1–2 mm long, apex obtuse, inside white, outside green with white margins, during anthesis widely patent, afterwards connivent to a globe; stamens



Mollugo pentaphylla L. – 1, plant habit; 2, flower; 3, pistil; 4, capsule; 5, seed.

3, alternate with the carpels, filaments short; styles 3, free, very short, white; ovary superior, 3-locular. Fruit a capsule with 3 carpels, broadly ellipsoid, 2 mm long, thin-walled. Seeds numerous, reniform, 0.8 mm in diameter, finely granulate, dark brown. Seedling with epigeal germination; hypocotyl 3.5–5 mm long, cotyledons 3 mm × 1.5 mm, apex acute, petiole short; first leaf elliptical to ovate, petiolate, glabrous, midvein distinct.

Other botanical information *Mollugo* contains 15–20 species, distributed over the warmer regions of the world. In Malesia only 1 species is known. *Mollugo* is closely related to *Glinus*, and they are differentiated by the presence of a filiform appendage and conspicuous caruncle on the seed, and in the dense stellate pubescence of *Glinus*. The *Aizoaceae* have been split into 2 families by some authors: *Molluginaceae*, with a free perianth, and *Ficoidaceae*, with a gamophyllous perianth. Other authors merge *Aizoaceae* with *Portulacaceae*.

Ecology *M. pentaphylla* occurs in semi-arid to humid regions, mostly locally abundant as a minor weed in cultivated areas, including rice fields and open grasslands, but also in sandy or stony localities, at low and medium altitudes.

Propagation and planting *M. pentaphylla* is propagated by seeds, which are dispersed by water.

Harvesting *M. pentaphylla* is collected from the wild whenever the need arises.

Genetic resources and breeding *M. pentaphylla* is widespread in anthropogenic habitats, and is therefore probably not at risk of genetic erosion.

Prospects *M. pentaphylla* remains of local importance, because little is known of the biologically active compounds.

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Other selected sources 135.

N.O. Aguilar

Nymphaea nouchali Burm.f.

Fl. indica: 120 (1768).

NYMPHAEACEAE

$2n = 28, 56, 84$

Synonyms *Nymphaea stellata* Willd. (1800).

Vernacular names Water lily, lotus lily (En). Nénuphar bleu (Fr). Indonesia: tunjung. Malaysia: kelipok, teratai kechil. Philippines: lauas, pulau (Tagalog), talailo (Bisaya). Cambodia: rum' châng, pralit, mum phlong. Laos: hua bua, bwà khiiz bèèz, bauna neai. Thailand: bua-phan, bua khaap (central), nirobon (Bangkok). Vietnam: s[us]ng lam, b[oo]ng s[us]ng, c[ur] s[us]ng.

Origin and geographic distribution *N. nouchali* is distributed from Africa to India, and throughout South-East Asia to Australia, both wild and cultivated.

Uses Especially the rhizomes, but also the other parts of *N. nouchali* (and other *Nymphaea* species), are considered astringent and tonic in South-East Asia, and a decoction is given for diarrhoea. In Vietnam, the rhizomes are also used for treating backache and stomach-ache, and in Cambodia for treating colic. In India, the powdered rhizome is prescribed as a demulcent for piles, and also for dysentery and dyspepsia. An infusion of the fresh rhizomes is considered emollient and diuretic, and used for blennorrhagia and infections of the urinary tract.

In the Philippines, the slightly bitter juice of the leaves and petioles is used for gonorrhoea. The juice possesses mildly narcotic properties, and is rubbed on the forehead and temples to produce sleep. In Cambodia, the juice from the leaves or the macerated leaves are an ingredient of a lotion applied to the skin for fever. In India and Thailand, the flowers are taken as a cardiotonic because of its astringent properties.

The rhizomes of *N. nouchali* are edible and rich in starch, like those of other *Nymphaea* species, though less appreciated than those of *Nelumbo nucifera* Gaertner (*Nelumbonaceae*, formerly in *Nymphaeaceae*). Seeds, young leaves and petioles of many other *Nymphaea* species are eaten as well. *Nymphaea* is often consumed as a famine food, but especially in Africa, it is part of the normal diet for certain tribes. The rhizomes are considered poisonous unless boiled.

In West Africa, the rhizome of *N. lotus* L. is sometimes chewed as a substitute for kola nut (*Cola* spp.). In India, the rhizomes of *N. nouchali* have been used for tanning purposes. Most *Nymphaea* species, including *N. nouchali*, are widely cultivated in the tropics as an ornamental.

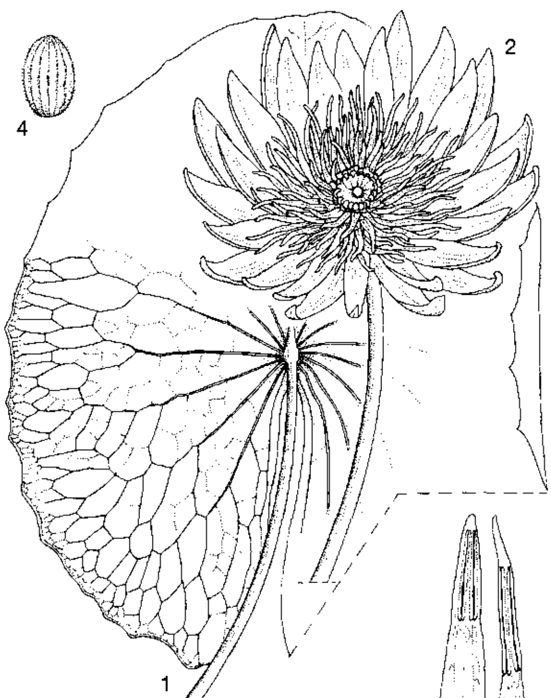
Production and international trade *N. nouchali* is widely cultivated and traded as an ornamental. No statistics on medicinal trade are available.

Properties All parts of *N. nouchali*, except for the seeds, contain the alkaloid nymphaeine. This alkaloid is toxic to frogs and produces tetanus-like symptoms. Alcoholic extracts of the rhizome, containing the alkaloid, have a mild sedative and spasmolytic action. They do not significantly depress the heart; in large doses though, they have a paralysing effect on the medulla. Another alkaloid, coclaurine, was also found in the leaves and stem.

Nymphaea species contain several flavonoids e.g. kaempferols, quercetins and myricetins, especially in the flowers, and also a glycoside, nymphalin, which has a digitalis-like action.
The extract from the rhizomes did not cause a significant growth of mammary glands, when injected into immature female mice at 2 g/day for 5 days.
N. lotus contains the alkaloids nupharine, nymphaeine, nelombine and nupharidine, which are respiratory excitants. An overdose may cause death by lung poisoning, as has been seen in mice, dogs and fish. An extract of the leaves of *N. pubescens* Willd. was screened for its antifungal activity and caused 85% inhibition of spore germination in *Fusarium solani*, but not in *Drechslera spicifera*.

Adulterations and substitutes *Nelumbo nucifera* has similar medicinal, culinary and ornamental use as *Nymphaea* species.

Description A perennial, aquatic herb, rhizome cone-like, tuberous. Leaves simple, ovate-orbicular, 10–30 cm × 8–25 cm, floating, base incised, cordate or hastate, lobes (nearly) overlapping, blade narrowly peltate, margins entire, sinuate, dentate or lobulate, upper side green, glabrous, lower side green, red or purple or spotted purple, mostly glabrous, sometimes finely pubescent, veins palmate; petiole long; stipules present. Flowers solitary, 8–18 cm in diameter, held 5–20 cm above the water, pedicel up to 1.5 m long, reddish, spongy; sepals 4, adnate at base to base of receptacle, inside the same colour as corolla; petals 10–35, many-seriate, the inner diminishing in size, normally blue, but also white, purplish blue or pinkish, slightly fragrant; stamens numerous, the outer with broad petaloid filaments; receptacle with cup-shaped apex, carpels 10–16, immersed, forming a numerous-celled syncarpous ovary, stigmas radiate, yellow. Fruit a depressed globose syncarp, berry-like, 2–4 cm in diameter, spongy, ripening under water, irregularly dehiscent, seeds numerous. Seed narrowly ovoid, 1–1.5 mm long, greyish-white, with longitudinal ridges, floating due to air-containing sack-like, pulpy aril, perisperm present. Seedling with only one cotyledon.



Nymphaea nouchali Burm.f. – 1, leaf; 2, flower; 3, stamens; 4, seed.

Growth and development *N. nouchali* can be found flowering throughout the year. The flowers open during the day, but some other *Nymphaea* flower during the night. Flowers are generally protogynous, and first-day flowers open less wide than on later days. Insect pollinators are attracted by the colour and the odour of the flowers and include mostly *Hymenoptera*, although *Coleoptera* and *Diptera* may also be present. Pollen-covered insects which visit first-day flowers effect cross-pollination. The flowers open during a period of 3–4 days. Natural hybridization occurs wherever several species grow together in the same pond; the hybrids may be fertile or sterile. When plants become overcrowded, flowers are smaller and fewer and foliage is lifted out of the water. Dense infestation can be cleared out of ponds manually or with herbicides, after which grass carps can be introduced to keep the number of plants down.

Other botanical information *Nymphaea* is a taxonomically difficult group, consisting of 35–45 species, and occurring widely in temperate and tropical regions throughout the world. Five subgenera are recognized, and only the subgenus from the New World has been revised thoroughly. *N. nouchali* belongs to subgenus *Brachyceras*, which has incompletely fused carpels. There is considerable confusion about the status of *N. nouchali*, *N. caerulea* Savigny and *N. capensis* Thunb., but the last 2 species are nowadays often considered as varieties of *N. nouchali*. Five varieties are distinguished in Africa, of which (at least) 2 also occur in South-East Asia. Var. *caerulea* (Savigny) Verdc. (synonyms *N. caerulea*, *N. capensis*) has leaves with entire to slightly undulate margins, while var. *zanzibariensis* (Casp.) Verdc. has lobulate margins, and is recorded as nocturnal and homogamous.

Formerly *N. lotus* was considered to occur both in Asia and Africa, but the Asian plants are now referred to as *N. pubescens*. The true relationships between the African and Asian taxa is still unclear, however, and difficult to elucidate from herbarium material. The size and form of the leaves and flowers can vary widely, even in one locality.

The name sacred lotus has often been misapplied to several species. In effect, the Egyptian sacred lotus is *Nymphaea lotus*, while *Nelumbo nucifera* (synonym *Nelumbium nelumbo* (L.) Druce) is the Indian sacred lotus.

Ecology *N. nouchali* is common throughout its distribution area, and is found in shallow ponds, ditches and lakes up to 500 m altitude.

Propagation and planting *N. nouchali* is propagated by seed and by division, or by pieces of rhizome with a sprouting eye. Some *Nymphaea* species produce viviparous plantlets in the leaf-blade axil, by which they can be propagated as well. Seed can be gathered after about 10 days of immersion, or immediately when it resurfaces, and can be planted into finely graded propagating mix, with about 2.5 cm of water. When the first floating leaves appear the water level can gradually be raised.

Diseases and pests Leaf spot is caused by *Cercospora* spp. and *Ovularia* spp. and affected leaves need to be removed quickly in order to prevent spreading of the disease. Crown rot can be a serious problem, and seems to be a stress-related, multifactorial syndrome. Several fungi and bacteria have been identified, but no satisfactory solution has yet been found. *N. nouchali* can be extensively damaged by caterpillars of the moths *Nymphula stagnata* and *N. nympheata*, which feed on the leaves and flowers.

Harvesting Leaves, flowers and seeds of *N. nouchali* are harvested from the water surface from land or by boat, but rhizomes are more difficult to dig up. This is sometimes done by pulling the whole plant up by the leaves. In periodically flooded areas, rhizomes are harvested when the water level has dropped.

Yield In Sri Lanka, *N. nouchali* has been cultivated for its edible rhizomes in rice fields during the monsoon period, and up to 2500 kg/ha can be harvested annually.

Handling after harvest The parts of *N. nouchali* harvested are normally used fresh.

Genetic resources and breeding *N. nouchali* is widespread and common throughout South-East Asia, and therefore certainly not endangered. There are no known breeding programmes for medicinal purposes.

Prospects Some interesting information is available on constituents displaying biological activity from *Nymphaea* species, including *N. nouchali*. However, more research will be needed for instance on toxicological aspects, in order to fully evaluate their possible potential.

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G.H. Schmelzer

Ochrosia A.L. Juss.

Gen. pl.: 144 (1789).

APOCYNACEAE

$x = 10, 11$; *O. oppositifolia*: $2n = 22$

Major species *Ochrosia oppositifolia* (Lamk) K. Schum.

Origin and geographic distribution *Ochrosia* s.l. comprises about 40 species and is found from the Mascarenes to the Pacific and Northern Australia including South-East Asia. New Caledonia is particularly rich in endemics.

Uses In the Moluccas, the root or the seeds of *O. oppositifolia* are used in bilious disorders, in particular as an antidote to the effect of eating poisonous fish or crabs. In Vietnam, the bark is used as a febrifuge and stomachic. Cups made from the wood will give a bitter taste to drinks when allowed to stand for some time. The drinks are then taken as a stomachic. The leaves are also used for their attributed tonic and febrifugal properties. In Lubang Island (Mindoro Province), the Philippines, the plant is used for minor ailments and also as firewood and as a shade tree. In the Philippines, the bark of *O. glomerata* (Blume) F. Muell. (synonym *Paralstonia clusiacea* auct. non Baillon) is used to reduce swellings. In China, 3 species are cultivated for their use in traditional Chinese medicine: *O. borbonica* J.F. Gmelin, *O. coccinea* (Teijsm. & Binnend.) Miq. and *O. elliptica* Labill. However, the identity of *O. borbonica* is somewhat doubtful. The seeds of *O. ackeringae* (Teijsm. & Binnend.) Miq. (synonym *O. littoralis* Merr.) are edible both cooked and raw. The timber of some species is locally used (e.g. *O. acuminata* Trimen ex Valeton, *O. oppositifolia* (Lamk) K. Schum.). *O. elliptica* is widely distributed as an ornamental; it shows startling bright red fruits and dense clusters of cream flowers produced throughout the year on an open spreading leafy canopy.

Properties Research on active constituents in *Ochrosia* has focused on anticancer compounds following the isolation of the alkaloid ellipticine (5,11-dimethyl-(6H)-pyrido(4,3-bicarbazole) from *O. elliptica*. Many *Ochrosia* spp., in particular those from New Caledonia, have since been subjected to investigations of their alkaloid content.

The major alkaloids isolated from *O. elliptica* are ellipticine, elliptinine, 9-ellipticine, 9-methoxy-ellipticine and isoreserpiline, which are all of the indole type, derived from the amino acid tryptophan. In addition, the bark of *O. coccinea* from the Moluccas contains the indole alkaloids ellipticine, 9-methoxy-ellipticine and reserpiline. The main base present in the bark of *O. oppositifolia* is isoreserpiline, which is accompanied by a considerable quantity of its stereoisomer reserpiline. The quaternary ammonium base corresponding to isoreserpiline and reserpiline, ochropposine, is also a major constituent. The principal constituent of the leaves is isoreserpiline. Numerous other indole alkaloids have been recorded, including epirauvanine and bleekerine.

Ellipticine and its derivatives possess anticancer properties against several experimental neoplasms as well as towards some human cancers. Substitutions on the C-9 and N-2 positions of the dimethyl-pyrido-carbazole nucleus result in the formation of semisynthetic derivatives which are even more effective. Two additional sites of action of these drugs have been reported: (i) ellipticine and 9-methoxy-ellipticine disturb biological membranes in their enzymatic functions, or in their role as permeability barriers, and (ii) ellipticine derivatives or its analogs are reversibly non-competitive inhibitors of cholinesterases and interact with muscarine receptors.

So far, only one ellipticine derivative, celiptium® (N-methyl-9-hydroxy ellipticine, as the acetate salt) has been introduced onto the market for treatment of metastatic breast cancer. This drug shows significant activity against leukaemia L 21210, leukaemia L 388, melanome B16 ependymoblastoma, lymphosarcoma of Gardner and tumour of Shay. Furthermore, it shows intermediate activity against pulmonary carcinoma of Lewis, and no activity against lymphosarcoma of Yoshida, lymphoma LLx 15 and myeloid.

Description Shrubs or trees with white latex. Leaves in whorls of 3–5 or rarely opposite, simple, entire to rather undulate, variable in size and shape; petiolate. Inflorescence terminal or axillary, in whorls or solitary, pedunculate. Flowers bisexual, 5-merous, sepals ovate to broadly so, or rarely orbicular, obtuse, without colleters inside; corolla lobes overlapping to the right in bud, salver-shaped, lobes oblong, apex obtuse to rounded, white or whitish; stamens included, free from the pistil head, disk present or not. Fruit a drupe, apocarpous to syncarpous, consisting of 2 mericarps, mesocarp fibrous or not, endocarp with or without 2 lateral cavities, 1–3 seeds in each carpel. Seed flat, suborbicular to elliptical. Seedling with epigeal germination, cotyledons leafy, hypocotyl elongated, first leaves opposite.

Growth and development The fruits of *Ochrosia* species from shoreline habitats float with their thick fibrous mesocarp after the pulp has worn off and are dispersed by sea currents. Likewise, *Ochrosia* species float because of additional cavities in the endocarp, which facilitates their dispersal by fresh water or sea currents. The seeds germinate readily when washed ashore. However, *O. oppositifolia* fruits planted without removal of the pulp germinate poorly and only after about 8 months.

Other botanical information There is considerable dispute about whether *Ochrosia* and *Neisosperma* are distinct genera. There has still been no monographic revision covering all species concerned. Chemical constituents seem to support a separation. In *Ochrosia* s.s. ellipticine-base compounds are present, whereas in *Neisosperma* corynane-base compounds are present.

Ecology *Ochrosia* species are found in shoreline habitats, periodically inundated forest, as well as rain forest or lower montane forest up to 800 m altitude.

Propagation and planting *O. elliptica* is usually propagated by seed but can also be propagated by ripe wood cuttings. Under glasshouse conditions in temperate climates ripe wood cuttings in early spring are rooted in moist sand in a closed case with bottom heat.

In vitro production of active compounds Young seedlings of *O. elliptica* are a good source for developing callus cultures. The callus of cotyledon origin was found best for developing a rapidly growing system. B5 medium containing a combination of kinetin at 0.1 mg/l, 2,4-D at 10 mg/l, coconut water at 5% and sucrose at 20 g/l is most suitable for callus induction. A short subculture period of 7 days in liquid medium was necessary to maintain the cultures in healthy condition. Tissues grown on B5 medium supplemented with kinetin at 0.1 mg/l, 2,4-D at 1 mg/l and naphthalene acetic acid (NAA) at 0.5 mg/l produced maximum ellipticine content.

Husbandry *O. elliptica* should preferably be grown in full light but also tolerates partial shade. Preference is given to fertile moist but well-drained loams with additional leaf mould.

Genetic resources and breeding The widespread natural distribution of *O. oppositifolia*, and its tolerance for disturbed habitats, makes the risk of genetic erosion limited. Cultivation of *O. elliptica* as an ornamental also diminishes this risk of genetic erosion.

Prospects The indole alkaloids isolated from *Ochrosia* species possess an interesting pharmacology in the field of anti-neoplastic activity. So far, one semisynthetic derivative has successfully been introduced onto the market. The bioproduction of the ellipticine base skeleton of *Ochrosia* may therefore have some potential for the pharmaceutical industry.

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Selection of species

Ochrosia elliptica Labill.

Sert. Austro-Caledon.: 259, t. 30 (1824).

Synonyms *Ochrosia calocarpa* (Hassk.) Miq. (1869).

Vernacular names Pokosola (En).

Distribution *O. elliptica* occurs naturally in New Caledonia and surrounding islands, New Hebrides, and Australia (New South Wales, Queensland). Cultivated elsewhere e.g. Indonesia, Hawaii, the Caribbean and China.

Uses *O. elliptica* has no traditional medicinal use in South-East Asia, but it is planted as ornamental. However, it is cultivated for its medicinal use in China. In the Loyalty Islands, east of New Caledonia, it is traditionally used for its diuretic and purgative properties. An infusion of the bark is used as a febrifuge. The latex is applied on bruises and cuts.

Observations A treelet or tree up to 4–6(–12) m tall; leaves in whorls of 3–4 or rarely opposite, obovate to elliptical, 4.5–18 cm × 3–7 cm, base decurrent onto the petiole, apex usually obtuse or emarginate, rarely acute, petiole 0.5–2 cm long; inflorescence terminal and axillary cyme, in whorls of 2–3, rarely solitary, a dense corymb, peduncle 0.5–3.0 cm long; flowers fragrant, shortly pedicellate, sepals 2.6–2.8 mm long, membranous, corolla tube 10–14 mm long, corolla lobes narrowly elliptical, 10–11 mm × 3.5–4 mm, stamens included; fruit consisting of 2 separate mericarps, mericarps ellipsoid, 3.5–4 cm × 2–2.3 cm, dorso-ventrally compressed, mesocarp not fibrous, endocarp with 2 lateral cavities, green and turning bright red when ripe; seed suborbicular, narrowly winged. *O.*

elliptica is found along the seashore, on coral outcrops as well as sandy habitats.

Selected sources 117, 318, 459, 1090.

Ochrosia oppositifolia (Lamk) K. Schum.

Engl. & Prantl, Nat. Pflanzenfam. 4(2): 156 (1895).

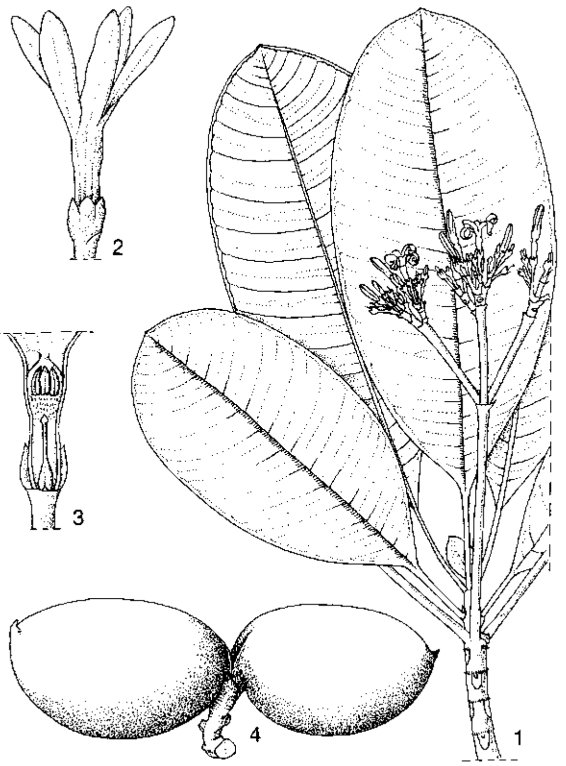
Synonyms *Ochrosia salubris* (Raf.) Blume (1850), *Ochrosia borbonica* auct. non J.F. Gmelin, *Neisosperma oppositifolia* (Lamk) Fosberg & Sachet (1977).

Vernacular names Bois jaune (Fr). Indonesia: upas laki-laki (Malay, Moluccas), songgo langit (Javanese), lau lite (Ambon). Philippines: ginlin (Sulu). Vietnam: chai lang, chai b[oo]ng.

Distribution *O. oppositifolia* is found throughout South-East Asia, on the islands of the Pacific and Indian Oceans and the coast of tropical Asia.

Uses In Vietnam, bark, wood and leaves are credited with febrifugal and stomachic properties.

Observations A shrub or tree up to 45 m tall, trunk up to 50 cm in diameter; leaves in whorls of 3–4(–5), usually obovate, rarely elliptical, (4.5–) 8–36 cm × (1.5–)3–18 cm, base decurrent onto the petiole, apex often rounded to obtuse, sometimes apiculate, rarely truncate or shallowly retuse, petiole 1–6.5 cm long; inflorescence axillary and terminal cyme, in whorls of 2–4, peduncle 0.5–13.5 cm long, congested, many-flowered; flowers fragrant, pedicellate, sepals ovate, 1–2.2 mm × 0.7–1.6 mm, obtuse, thick, green, corolla tube (4–)5–10 (–12) mm long, corolla lobes narrowlyelliptical, (4–)5–9(12) mm × 2–3 mm, stamens included; fruit consisting of 2 separate mericarps, mericarps ellipsoid or ovoid, 5–8 cm × 3–5.5 cm, mesocarp fibrous, united with the stone, green and turning yellow when ripe; seed suborbicular to elliptical, 25 mm × 20 mm, thin, winged. *O. oppositifolia* is found along the seashore, in coastal forest, less often inland, often on limestone, but not in the mangrove.



Ochrosia oppositifolia (Lamk) K. Schum. – 1, flowering branch; 2, flower; 3, dissected flower; 4, fruit.

Selected sources 74, 117, 133, 672, 730, 786.

J.L.C.H. van Valkenburg & R. Hendrian

Operculina turphetum (L.) S. Manso

Enum. subst. braz.: 16 (1836).

CONVOLVULACEAE

$2n = 30$

Synonyms *Convolvulus turphetum* L. (1753), *Ipomoea anceps* Roem. & Schult. (1819).

Vernacular names Indian jalap, turpeth-root, wood rose (En). Turbith végétal (Fr). Indonesia: areuy jotang (Sundanese), sampar-kedung, balaran (Javanese). Philippines: bangbangau, laplapsut (Iloko), kamokamotihan (Tagalog). Thailand: chingcho liam (northern). Vietnam: ch[if]a v[oo]i, b[if]m n[aw]p.

Origin and geographic distribution *O. turphetum* is distributed in the Old World tropics from East Africa, the Mascarene Islands and Seychelles, through India to South and South-East Asia, tropical Australia and Polynesia. It has not yet been recorded from Sumatra, and is rare in Peninsular Malaysia and Borneo.

Uses The rhizome of *O. turphetum* is officially recorded in many pharmacopoeias, especially in South America and India.I n India, China, Thailand and Indo-China, the rhizome is used as a powerful purgative and as a diuretic, as well as in the treatment of articular pains, fevers, gout, jaundice, bilious disturbances in general, intestinal worms and rheumatism. In India, distinction is made between white rhizomes, which are mildly purgative, and black rhizomes, that give drastic, often poisonous results. The heated stem is applied to the abdomen after parturition to cure colic and to aid in the contraction of the tissues. In Fiji, the leaves or young stems are used to prepare a tea which is drunk frequently as a remedy for bladder stones and against pains in the abdomen or stomach. A decoction of the leaves is used as a tonic after childbirth. In Java, the plant does not seem to be used, despite its frequent occurrence.

In the Philippines, the stems are used for tying purposes. *O. turphetum* is considered a good browse plant for cattle.

Production and international trade *O. turphetum* is cultivated and locally traded in India, Sri Lanka and Indo-China.

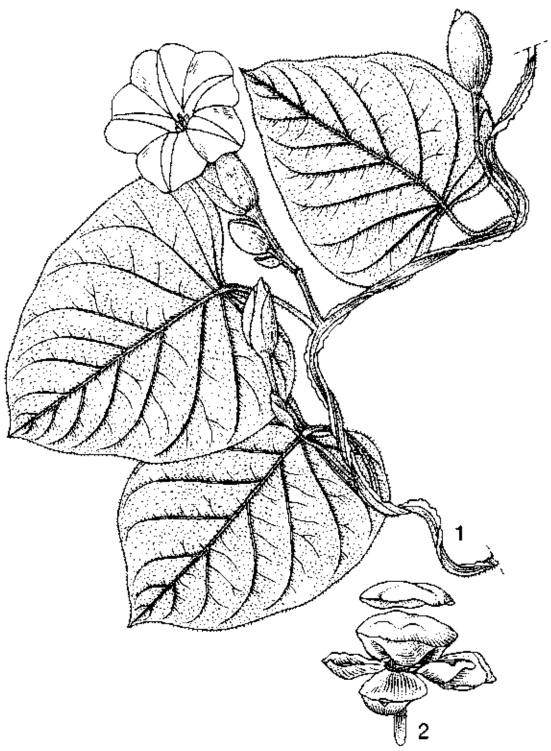
Properties The rhizome bark in particular contains up to 10% of a brownish yellow glycosidic resin, called turphetin, which is analogous to jalapin (the resin from *Ipomoea purga* (Wender.) Hayne).

The main glycosidic acids (glycosides from hydroxy fatty acids, which are responsible for the laxative effects of the resin) from the alcohol-soluble resin fraction were identified as gluco-gluco-gluco-rhamnosides of 11-hydroxy-palmitic acid (jalapinolic acid), 3,12-dihydroxy-pentadecanoic acid (operculinolic acid), 3,12-dihydroxy-palmitic acid, 4,12-dihydroxy-pentadecanoic acid and 4,12-dihydroxy-palmitic acid.

Treatment of susceptible host plants with extracts from the leaves induced systemic resistance to subsequent challenge from sun hemp rosette virus, tobacco mosaic tobamovirus, datura shoestring potyvirus and tomato spotted wilt tospovirus.

Adulterations and substitutes In India, the tubers of *Ipomoea purga* or *Rheum* spp. (*Polygonaceae*) are often used as a substitute for *O. turphetum* rhizomes, as a strong purgative. *Marsdenia tenacissima* (Roxb.) Moon (*Asclepiadaceae*) is sometimes applied as an adulteration of *O. turphetum*.

Description A perennial twiner, stems 2–4 m long, narrowly 3–5-winged, sulcate or angular, glabrous or pilose at the nodes, rhizomes long, fleshy, much branched. Leaves alternate, simple, very variable in shape, orbicular, broadly ovate, ovate to lanceolate, broad leaves 5.5–15 cm × 4–14 cm, narrow ones 5.5–7.5 cm × 1–2.5 cm, base cordate to hastate, apex acuminate, acute or obtuse, mucronulate, margin entire or rarely coarsely dentate to shallowly lobed, upper surface glabrous or appressed pilose, lower surface pubescent, midrib and 8–11 veins on either side prominent underneath; petiole 2.5–7.5 cm long, terete, sometimes winged. Inflorescence a few-flowered cyme; peduncle 2–18 cm long, terete or sometimes winged, glabrous or pubescent. Flowers actinomorphic, 5-merous, pedicel angular, 12–15(–35) mm long, pubescent, in fruit clavate up to 40 mm long, bracts oblong or elliptical-oblong, mucronulate, 1.5–2 cm long, pubescent, caducous; sepals 5, free, ovate or broadly ovate, acute, outer ones 1.5–2.5 cm long, pubescent outside, inner ones 2 cm long, glabrous, calyx in fruit broadly cup-shaped, up to 6 cm in diameter; corolla broadly funnel-shaped, 3–4.5 cm long, white, sometimes with yellowish base, glabrous, rarely with yellowish gland hairs outside; stamens 5, inserted, filaments adnate to the corolla, sparsely pubescent below. Fruit a capsule, depressed-globose, 1.5 cm in diameter, with up to 4 seeds; epicarp circumscissile in or above the middle, the upper part (operculum) more or less fleshy, separating from the lower part and from the endocarp; endocarp scarious, splitting longitudinally, irregularly. Seed trigonous to globular, 6 mm long, glabrous, dull black.



Operculina turphetum (L.) S. Manso – 1, flowering stem; 2, fruit.

Growth and development *O. turphetum* can be found flowering throughout the year when sufficient water is available.

Other botanical information *Operculina* consists of about 20 species, present in the tropics. Three species occur in Malesia, *O. turphetum*, *O. brownii* Ooststr. and *O. riedeliana* (Oliv.) Ooststr. *O. brownii* is closely related to *O. turphetum*, the main difference being the sepals, which are broadly rounded and glabrous, and the large seeds, 15 mm long. It occurs in tropical Australia, and probably also in the dry savanna regions of southern New Guinea. *O. riedeliana* differs from *O. turphetum* in that the stem is wingless, the corolla pale yellow, the mid-petaline bands densely pilose and the capsule up to 3 cm in diameter. It occurs widely in South-East Asia.

Ecology *O. turphetum* is weedy, and occurs in open forest, teak forest, hedges, thickets, roadsides and waste places, occasionally in sugar-cane plantations, restricted to regions with a medium or strong monsoon, from sea-level up to 1300 m altitude.

Propagation and planting *O. turphetum* is propagated by seed.

Diseases and pests In India, *O. turphetum* is attacked by *Pseudocercospora operculinae* which causes leaf-spot disease. In nurseries in India, *O. turphetum* seedlings are attacked by the larvae of *Helcystogramma* sp. and *Papilio demoleus* (Lepidoptera), which feed on the young leaves and cause 30–100% loss.

Harvesting In India, whole plants of *O. turphetum* are uprooted, to obtain the rhizomes.

Handling after harvest In India, the rhizome and basal stem of *O. turphetum* plants are cut into cylindrical pieces, 1.5–15 cm × 1–5 cm, often with the central woody portion removed by splitting the bark on one side. The surface is longitudinally furrowed, grey-reddish, giving it a rope-like appearance. The pieces have a distinct, unpleasant or musty odour, and are powdered before use. The taste is somewhat bland or nauseating at first, then slightly acrid.

Genetic resources and breeding *O. turphetum* is a weedy species, occurring in anthropogenic habitats, and does not seem to be threatened by genetic erosion.

Prospects The laxative properties of several so-called *Ipomoea* resins (jalapin, turphetin) are quite well established. They can therefore be used as local substitutes for the better known anthranoid laxatives e.g. *Senna* or *Frangula* in communities where these preparations are not available. *O. turphetum* therefore has some potential for cultivation in the region.

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Other selected sources 74, 135, 215, 829.

N.O. Aguilar

Ophiorrhiza L.

Sp. pl. 1: 150 (1753); Gen. pl. ed. 5: 74 (1754).
RUBIACEAE
$x = 11$; *O. mungos*: $2n = 22$

Major species *Ophiorrhiza mungos* L.

Vernacular names Snake root (En).

Origin and geographic distribution *Ophiorrhiza* comprises about 150 species and occurs from eastern India and Sri Lanka throughout continental Asia to southern China, Japan, Malesia, Micronesia, the Fiji Islands and the Society Islands. The genus reaches its greatest diversity in New Guinea and south-eastern Asia. One species occurs in northern Australia.

Uses The leaves and young stems of medicinally used *Ophiorrhiza* are normally crushed and applied as a poultice to soften skin and ripen boils.

The roots of *O. mungos* are intensely bitter and are official in the French and Spanish Pharmacopoeias. They are applied as a treatment of cancer and are also widely known in Malesia for treating snakebites, although this is incorrect. This misconception seems to be based on its resemblance to *Rauvolfia serpentina* (L.) Benth. ex Kurz. In India, a decoction of the leaves, roots and bark make an agreeable, bitter tonic and stom-

achic. Laxative and sedative properties are attributed to the bark of the root.
O. singaporensis Ridley, from southern Peninsular Malaysia, like *O. communis* used for poulticing boils or for leprosy. The leaves of *O. laxa* A. Gray, endemic to Fiji, are chewed to stop blood in the urine. A decoction of the mashed leaves of *O. leptantha* A. Gray, occurring in Fiji and one of the Horne Islands, is taken for stomach-ache.
In India, a paste made of the scrapings of the stem of *O. mungos* is used in the production of scabbards and guitars.

Production and international trade *Ophiorrhiza* is mainly used on a local scale, although its occurrence in European Pharmacopoeias indicates that international trade exists.

Properties The aerial parts of *O. mungos* contain several alkaloids, e.g. the indole[2,3-a]-quinolizidine alkaloid (-)-ophiorrhizine (also in *O. major*), as well as the chinolin alkaloids camptothecin and 10-methoxycamptothecin.
In limited trials, camptothecin showed a broad spectrum anti-tumour activity, but its toxicity and poor solubility caused several problems. The natural 10-hydroxy-camptothecin is more active than camptothecin, and is used in China against cancers of the neck and head. More promising are the analogues 9-amino-camptothecin and several semi-synthetic derivatives. These compounds are tested in clinical trials and showing good responses in a number of cancers, including colon, lung, ovarial and cervical cancers. The agents act by inhibition of the enzyme topo-isomerase I, which is involved in DNA replication and reassembly, by binding and stabilizing a covalent DNA-topo-isomerase complex. Camptothecin has also been shown to have potentially useful activity against pathogenic protozoa such as *Leishmania donovani* and *Trypanosoma brucei*, which cause Leishmaniasis and sleeping sickness, respectively. Again, this is due to topo-isomerase I inhibition. Camphothecin and 10-methoxycamphtothecin also possess antivirus activity against Herpes simplex virus.
The aerial parts of *O. communis* yield strictosidinic acid and harman, as well as isomalindine-16-carboxylate. The alkaloid harman-2-oxide was isolated from *O. rosacea* Ridley of Peninsular Malaysia. The alkaloids palicoside and 3,14-didehydro-19-methylnormalindine were isolated from *O. kunstleri* King, occurring in southern Thailand. *O. blumeana* Korth. from Java, yields the alkaloids bracteatine, ophiorrhizine-12-carboxylate, blumeanine, and ophiorrhizine. The Chinese *O. pumila* Champ. ex Benth. contains deoxypumiloside, pumiloside and chaboside.

Adulterations and substitutes Camptothecin and derivatives can also be obtained from *Camptotheca acuminata* Decne. (*Nyssaceae*), *Mappia foetida* Miers (*Icacinaceae*), *Nothapodytes foetida* (Wight) Sleumer (*Icacinaceae*) and *Tabernaemontana heyneana* Wallich (*Apocynaceae*).

Description Annual to perennial, procumbent or erect herbs, branched or not, sometimes woody at base, 30–150(–300) cm tall. Leaves opposite, simple, elliptical-lanceolate, lanceolate to ovate, base slightly unequal; petiole present; stipules interpetiolar, variable in shape and size, entire or lobed, persistent or not. Inflorescence terminal, umbelliform to corymbiform, composed of several cymes; branches spiciform to cincinniform, short at anthesis, elongate or not afterwards. Flowers bisexual, 5-merous, white or pink, small, subsessile; bracts absent, small or forming an involucrum; calyx tube very small, usually turbinate, lobes 5, tiny; corolla tube cylindrical or funnel-shaped, glabrous or puberulous, lobes 5, valvate in bud; stamens 5, usually included, inserted in the tube, corolla tube swollen at insertion, filaments minute, anthers linear, opening by longitudinal slits; disk large, 2-lobed, fleshy, glabrous, ovary inferior, 2-celled, ovules numerous, style filiform, stigmas 2, linear or oblong, included or exserted. Fruit a coriaceous, flattened capsule, subcordate, broader than long, dehiscing at the apex by 2 broad valves, with numerous seeds. Seed minute, 0.5 mm long, angular, glabrous.

Growth and development The flowers of *Ophiorrhiza* species with an elongate corolla tube are probably pollinated by *Lepidoptera*, while the ones with a short tube can be pollinated by other insects as well. In Indo-China, *O. mungos* fruits in January.

Other botanical information *Ophiorrhiza* is a large, taxonomically complex and most likely polyphyletic genus, of which a worldwide revision is badly lacking. Several authors place *Ophiorrhiza* in subfamily *Rubioideae*, because raphid crystals have been found in several species, and also because of its albuminous seeds and valvate aestivation.

Ecology Most *Ophiorrhiza* prefer humid upland forest, but some have a wider altitude range, and even occur on the beach.

Propagation and planting *Ophiorrhiza* is propagated by seed.

In vitro production of active compounds Cell cultures of the Chinese *O. pumila* yielded a series of anthraquinones and a gluco-camptothecin, 9-β-D-glucosyloxy-camptothecin.

Harvesting *Ophiorrhiza* plants are normally pulled up completely for use.

Handling after harvest *Ophiorrhiza* is usually used fresh.

Genetic resources and breeding Many *Ophiorrhiza* have a restricted area of distribution, but are locally often rather common. As they are not extensively used the risk of genetic erosion seems to be limited.
No breeding programmes of *Ophiorrhiza* are known to exist in the Malesian region.

Prospects Camptothecin and its derivatives show good prospects in the development of new anti-cancer drugs. Several semi-synthetic derivatives have already entered clinical trials. Therefore, although camptothecin can be obtained from several natural sources, there might be future potential for *Ophiorrhiza* as a supplier of synthetic starting materials.

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Selection of species

Ophiorrhiza communis Ridley

Journ. Roy. As. Soc. Straits Br. 61: 16 (1912).

Vernacular names Malaysia: pokok peparu, penberak nasi. Thailand: pen-berak naa-si (Malay, peninsular).

Distribution Peninsular Malaysia and peninsular Thailand.

Uses In Peninsular Malaysia, the soft and easily pulped plant is used for poulticing enlarged spleens or the chest for treating cough.

Observations An almost unbranched, herb, pubescent or hairy, up to 30 cm tall; leaves ovate or lanceolate, 8–15 cm × 2.5–3.5 cm, base equal, apex acuminate, glabrescent above, veins and sometimes the whole surface beneath pubescent, petiole 2.5 cm long, stipules setaceous; branches of cyme slender, up to 2.5 cm long, glabrous or puberulous, peduncle 2.5 cm long; flowers white, rarely pink, pedicel as large as calyx, calyx ovoid, lobes short, blunt, corolla tubular, lobes short; capsule transverse oblong, upper margin straight, slightly puberulous. *O. communis* is common in secondary forest, from sea-level up to 2000 m altitude, except in the southernmost area of Peninsular Malaysia, where *O. singaporensis* replaces it.

Selected sources 135, 786.

Ophiorrhiza major Ridley

Fl. Mal. Pen. 2: 36 (1923).

Distribution Peninsular Malaysia.

Uses In Peninsular Malaysia, the aerial parts are used in a poultice for the head to treat vertigo. The fresh aerial parts are also applied for eczema and other skin diseases.

Observations A slender, woody, hairy herb, 30–90 cm tall; leaves elliptical-lanceolate or narrowly elliptical, 10–17.5 cm × 2.5–10 cm, base unequal, apex acuminate, veins prominent beneath, often mealy-pubescent, leaf glabrous above, petiole 1.2–3 cm long; cymes terminal and axillary, peduncle 2.5–5 cm long, puberulous; flowers white, lobes pink, or all dark pink, pedicel as long as the calyx, calyx sub-globose, obscurely ribbed, teeth short, corolla cylindrical, 6–7 mm long, lobes short; capsule narrowly ovoid, 1–2 mm long, 4–5 mm in diameter, glabrous. *O. major* is quite common in secondary forest at low altitudes.

Selected sources 135, 325, 786.

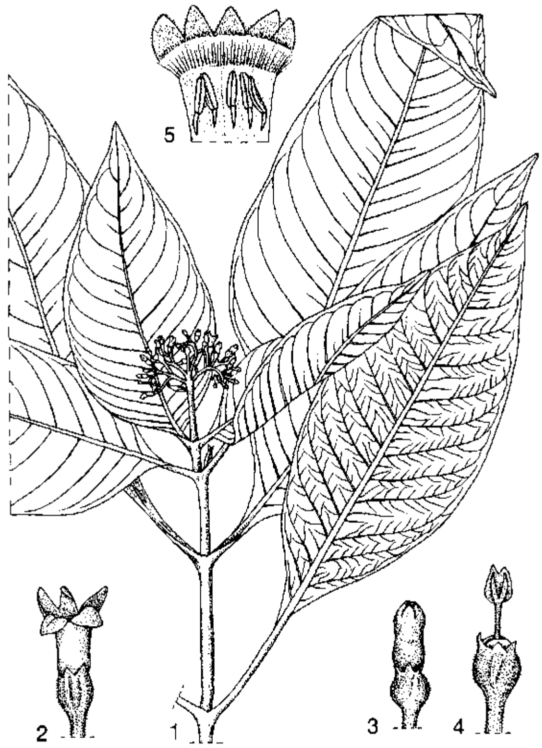
Ophiorrhiza mungos L.

Sp. pl. 1: 150 (1753).

Vernacular names Mongoose plant (En). Malaysia: pokok sumpu badak. Philippines: payang payang gubat (Tagalog), kayotimokan (Bagobo), lumai (Bikol).

Distribution From India, Sri Lanka, to Indo-China, Thailand, Peninsular Malaysia, Sumatra, Java and the Philippines.

Uses In Peninsular Malaysia, the plant is used as a poultice for keeping the skin moist and soft. In India, a decoction of the leaves, roots and bark is made into a bitter tonic and stomachic. The species name is from the story that mongoose eat this plant when bitten by a snake; however, its anti-snakebite activity is unfounded.



Ophiorrhiza mungos L. – 1, flowering branch; 2, flower; 3, flower bud; 4, flower, corolla removed; 5, opened corolla.

Observations A semi-woody, erect, normally glabrous herb, 10–50(–80) cm tall; leaves elliptical to elliptical-lanceolate, 4–12 cm × 2–6 cm, base and apex pointed, petiole 8–25 mm long, stipules 4–5 mm long, linear, caducous; cyme more or less flat-topped, 2–12 cm in diameter, branches sub-umbellate, spreading, hairy or glabrous, bracts absent; pedicel short, calyx teeth very short, corolla white, tube 7–8 mm long, lobes short, obtuse, keeled; capsule 2–3 mm long, 6–8 mm in diameter. *O. mungos* occurs in primary and secondary forest, in moist localities, up to 400 m altitude.

Selected sources 74, 135, 215, 225, 542, 786, 838.

G.H. Schmelzer & N. Bunyapraphatsara

Oroxylum indicum (L.) Kurz

For. fl. Brit. Burma 2: 237 (1877).
BIGNONIACEAE
$2n = 28, 30$

Synonyms *Bignonia indica* L. var. α (1753), *Bignonia pentandra* Lour. (1790), *Calosanthes indica* (L.) Blume (1826).

Vernacular names Midnight horror (En). Indonesia: pongporang (Sundanese), kayu lanang, mungli (Javanese). Malaysia: beka, bonglai, kulai. Philippines: pingka-pingkahan (Tagalog), abong-abong (Bisaya), kamkampilan (Iloko). Cambodia: pi ka. Laos: lin may, ung ka. Thailand: phe kaa (central), litmai (northern), lin faa (north-eastern). Vietnam: n[us]c n[as]c, ho[af]ng b[as] nam, m[ooj]c h[oof] di[eej]p.

Origin and geographic distribution *O. indicum* is found from India eastward to southern China and the Philippines, and throughout South-East Asia; in Indonesia eastward to Sulawesi and the Lesser Sunda Islands. Locally cultivated near human settlements.

Uses Throughout its distribution area, the bitter bark is employed for intestinal complaints. It is credited with astringent and tonic properties, and widely used for diarrhoea and dysentery. In Malaysia, a decoction of the leaves is drunk for stomach-ache. Externally it is employed in cholera, fever, childbirth and rheumatic swellings. The boiled leaves are employed as a poultice during and after childbirth, and in dysentery as well as for an enlarged spleen. Leaf poultices may be further applied for toothache and headache. In Java, the pounded bark mixed with water is taken in gastritis and to purify the blood. In northern Sulawesi, the inner bark is used to arrest bleeding. In the Philippines, a decoction of the root is credited with antirheumatic, antidysenteric and diuretic properties; the leaves are used in antirheumatic baths. In Thailand, the root and root bark are used for diarrhoea and dysentery, while the stem bark is applied for ulcers and abscesses. In Vietnamese folk medicine, a decoction of the seeds is used for cough, bronchitis and gastritis. Externally the seeds are applied to ulcers. A decoction of the dried root bark or stem bark is used in the treatment of allergic diseases, urticaria, jaundice, asthma, sore throat, laryngitis, hoarseness, gastralgia, diarrhoea and dysentery. An alcoholic maceration of the fresh bark is externally applied on allergic dermatitis. In Thai folk medicine, the root is employed as a tonic and antidiarrhoeal, whereas the seed is used as a laxative and expectorant. Throughout South-East Asia, cooked flowers, buds and young pods are highly esteemed as a vegetable. In Java, flowers, young shoots and the stem bark are consumed fresh as a side dish. The wood can be used as a firewood although it is of poor quality.

Production and international trade *O. indicum* is only used at a local scale.

Properties The various parts of *O. indicum* are rich in flavonoids. The leaves contain the flavonoids baicalein (5,6,7-trihydroxyflavone), scutellarein (4',5,6,7-tetrahydroxyflavone), and their glycosides baicalin (baicalein-7-glucuronide) and scutellarin (scutellarein-7-glucuronide). The stem and root bark contain e.g. baicalein, scutellarein, oroxylin A (5,7-dihydroxy-6-methoxyflavone), chrysin (5,7-dihydroxyflavone) and p-coumaric acid. Baicalein and oroxindin (wogonin-7-O-β-D-glucuronide) have been isolated from the seeds.

Other compounds mentioned in the literature include the prenylated naphthoquinone lapachol, and the anthraquinone derivative aloe-emodin.

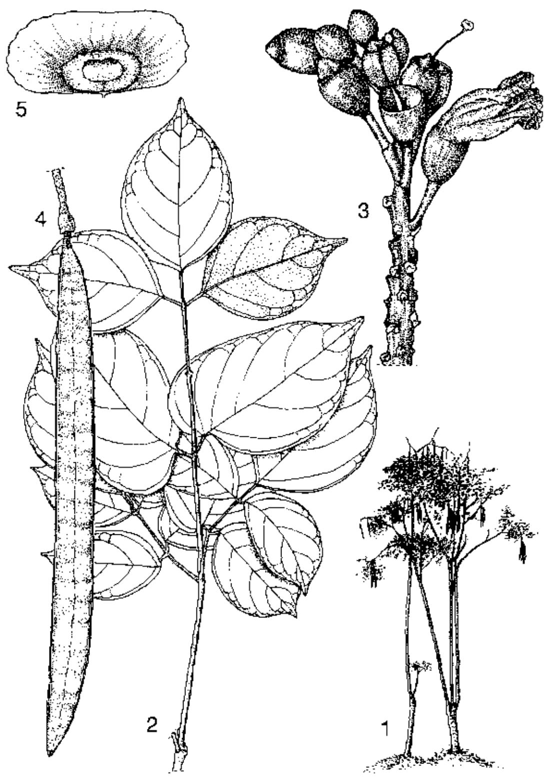
Dichloromethane extracts of the stem bark and root of *O. indicum* were found to have antimicrobial activities against Gram-positive bacteria (*Bacillus subtilis* and *Staphylococcus aureus*), Gram-negative bacteria (*Escherichia coli* and *Pseudomonas aeruginosa*) and a yeast (*Candida albicans*). Bioassay-guided chromatographic fractionation led to the isolation of flavonoids (e.g. baicalein, chrysin and oroxylin A) and lapachol as active constituents. Lapachol was found to be active against the Gram-positive bacteria; 5 μg gave a zone of inhibition equivalent to that shown by 5 μg of streptomycin, whereas 5 μg of chrysin gave inhibition zones of equal size to that of 5 μg of streptomycin against *Pseudomonas aeruginosa*.

The inhibitory activity of lapachol from *O. indicum* root against soya bean 5-lipoxygenase (IC_{50} 0.79 μg/ml) was equivalent to that of the positive control (the flavonoid fisetin; IC_{50} 0.97 μg/ml), whereas 50 μg/ml of the dichloromethane extract of the root bark gave 100% inhibition of leukocyte lipoxygenase. These activities might indicate an anti-inflammatory effect for the dichloromethane extract, mainly due its lapachol content.

The isolated flavonoid baicalin also showed inhibitory effects against the human T cell leukaemia virus type 1, and the human immunodeficiency virus (HIV-1). Baicalein furthermore showed antiproliferative activity in cultured rabbit vascular muscle cells, and lipoxygenase activity in vitro. Other pharmacological activities of baicalin and baicalein include anti-inflammatory activity of baicalin in the rat adjuvant arthritis model, inhibition of LPS-induced IL-1 production by both flavonoids, and inhibition by baicalein of leukotriene C-4 biosynthesis by rat resident peritoneal macrophages. The methanol extract of the young perianth exhibited strong antitumour-promoting activity when tested against 12-O-tetradecanoylphorbol-13-acetate (TPA) induced Epstein-barr virus early antigen activation.

Adulterations and substitutes Baicalin, baicalein and related flavonoids also occur in *Scutellaria* (*Labiatae*). The naphthoquinone lapachol is also present in other *Bignoniaceae*, such as *Paratecoma peroba* (Record & Mell) Kuhlm. from South America and *Tectona grandis* L.f. (*Verbenaceae*).

Description A semi-deciduous, sparingly branched tree up to 27 m tall; trunk up to 40 cm in diameter, bark grey, with prominent leaf scars, twigs thick, pithy, later hollow, lenticellate. Leaves crowded, imparipinnate, 3–4 times pinnate, 0.5–2 m long; petiole long, rachis swollen at points of insertion; stipules absent; leaflets ovate to oblong, 4–11(–15) cm × 3–9 cm, base cuneate or mostly oblique, apex acuminate, entire, with scattered glands on the lower surface. Inflorescence an erect raceme, terminal, 25–150 cm long, peduncle and rachis partitioned. Flowers bisexual, pedicel 2–4 cm long, bracteolate; calyx coriaceous, campanulate, containing water in bud, 2–4 cm



Oroxylum indicum (L.) Kurz - 1, habit; 2, detail of leaf; 3, part of inflorescence; 4, fruit; 5, seed.

long, 1.5–2 cm in diameter, brown or dirty violet, becoming almost woody in fruit; corolla funnel-shaped, about 10 cm long, lobes 5, subequal, margin wrinkled, reddish outside, yellowish to pinkish inside; stamens 5, inserted in the throat, hairy at the base; ovary superior, 2-celled, many-ovuled. Fruit a pendent capsule, sword-shaped, 45–120 cm × 6–10 cm, valves flat, almost woody, finally black. Seed 5–9 cm × 2.5–4 cm, including the membranous and transparent wing. Seedling with epigeal germination; hypocotyl elongated; cotyledons leafy.

Growth and development The terminal inflorescences of *O. indicum* induce a sympodial growth and the leaves are crowded near the end of the stem or branches, giving a mature tree an open irregular crown. When an inflorescence has finished flowering, the leaves below it fall off and the leafless stem is left as a pole, with a few pods dangling from its extremity. After 3–4 weeks in a leafless state, one or more lateral buds start developing into side-branches, and the cycle can be repeated. Its architecture represents Chamberlains's model. Branches on the same tree may flower, fruit or produce new shoots independently. Trees can be found flowering and fruiting throughout the year. In some areas a peak in flowering is observed at the beginning of the dry season, whereas fruits are present on trees in a leafless state during the dry season. The flowers are nocturnal and 1–2 flowers open in the course of one night; before sunrise the corolla falls off. They are pollinated by bats attracted by the foetid smell. The winged seeds are wind-dispersed as the pods open.

Other botanical information *Oroxylum* is a small genus and a second species, *O. flavum* Rehder, has been described based on a specimen raised from seed collected in southern China.

Ecology *O. indicum* is a short-lived nomad tree, nowhere gregarious, always encountered in canopy openings, secondary growth and thickets. It tolerates a wide range of both climatic and soil conditions, and occurs mostly below 1000 m altitude.

Propagation and planting *O. indicum* can be propagated by seed or stem cuttings. As opened fruits will have lost part of their seeds and seed may be affected by fungal attack, seed should collected from closed fruits. Seed germination is about 50% in 19–25 days. Germination success is enhanced by soaking for 24 h prior to sowing and planting at 0.5 cm depth.

Harvesting Seed from ripe fruits, stem bark and root bark of *O. indicum* are collected all year round.

Handling after harvest Stem bark and root bark of *O. indicum* are generally dried prior to use.

Genetic resources and breeding *O. indicum* is widespread and common in disturbed habitats throughout South-East Asia, and therefore not endangered. There are no known breeding programmes of *O. indicum*.

Prospects The flavonoids and lapachol isolated from *O. indicum* show interesting pharmacological activities in the fields of virus-inhibition and anti-inflammatory activity. These merit further research in order to evaluate their possibilities and potential for future medicine.

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Other selected sources 74, 128, 207, 240, 263, 407, 523, 730, 747, 867, 949, 1080.

M.A. Rasadah

Paederia foetida L.

Mant. pl. 1: 52 (1767).
RUBIACEAE
$2n = 44$, (55), 66, sometimes aneuploid

Synonyms *Paederia tomentosa* Blume (1826), *Paederia chinensis* Hance (1878), *Paederia scandens* (Lour.) Merr. (1934).

Vernacular names Chinese moon creeper, Chinese fevervine, kings tonic (En). Indonesia: sembukan (Javanese), kahitutan (Sundanese), bintaos (Madurese). Malaysia: akar sekentut, daun kentut, kesimbukan. Philippines: kantutai (Tagalog), bangogan (Bikol), mabolok (Pampangan). Cambodia: vear phnom. Laos: kua mak ton sua. Thailand: kon, choh-ka-thue mue (northern), yaan phaahom (peninsular). Vietnam: d[aa]y m[ow] l[oo]ng, d[aa]y m[ow] tr[of]n, m[ow] tam th[eer].

Origin and geographic distribution *P. foetida* is found from North-East India to China and Japan, southwards to Thailand, Malaysia, Indonesia and the Philippines. It has been introduced into North America (North Carolina, Texas, Louisiana), Hawaii, Christmas Islands, Mauritius and Reunion as an ornamental and escaped.

Uses The leaves of *P. foetida* are widely used in Asia and South-East Asia for the treatment of intestinal complaints such as colic, cramps, flatulence, dysentery and also for rheumatism and gout. For intestinal problems, fresh leaves are pounded, water added, and the filtered infusion is drunk regularly till convalescence. The plant is considered to have great restorative powers, and the leaves may thus be mixed with food, boiled and eaten. The leaves can be mixed in omelettes as well for intestinal mucus. In India, the leaves are often boiled in soup to lessen their smell. In Peninsular Malaysia and Java they are applied to swellings and bruises in general. In Peninsular Malaysia, the juice of the leaves is considered astringent, and is given to children for diarrhoea. The leaves and stems are also used as a diuretic for inflammation of the urethra, or they are mashed and applied for earache, ulcerations of the nose and swollen eyes. In Java, the leaves are applied as a poultice for a swollen belly, distension, herpes or ringworm.

In the Philippines, the bark or the root is considered emetic, and the leaves are used in antirheumatic baths. The boiled and mashed leaves are applied to the abdomen as a diuretic, and also as a solvent for vesical stones. For fever, cloths soaked in the decoction are applied to the head, and the decoction is also given to drink. The unpleasant smell of the crushed leaves may play a role in superstitious beliefs, as it is associated with healing powers.

In India and Indo-China, the stem, leaves and seeds are applied specifically for rheumatism, alone or in mixtures with other plants. The root is also used as an emetic. In India, the juice of the root is also prescribed in piles, inflammation of the spleen, and pain in the chest and liver. It may help to eliminate poisons collected in the system. The leaves are also used to treat hepatic disorders and rheumatism.

In China, *P. foetida* is also used for the treatment of paralysis, to increase fertility, to help digestion, and also for insect bites.

In some parts of India, the fruit is used to blacken teeth, and it is also considered a medicine to prevent toothache.

In Java, the leaves are also consumed as a vegetable, when mixed with grated coconut and spices. The stem yields a strong and silky fibre, but it is not commercially exploited.

Production and international trade *P. foetida* is used on a local scale only. It has been found in Chinese herbalist shops in Peninsular Malaysia.

Properties Several iridoid glucosides containing an intramolecular lactone ring, i.e. asperuloside, scandoside and paederoside were isolated from the aerial parts of *P. foetida*. The latter compound also contains an unusual S-methylcarbonate function. Bruised aerial parts of the plant have the fetid odour of indole (methyl-mercaptan). Damage to the tissue releases an enzyme which splits off this sulphur-containing group from paederoside, and is therefore responsible for the unpleasant odour.

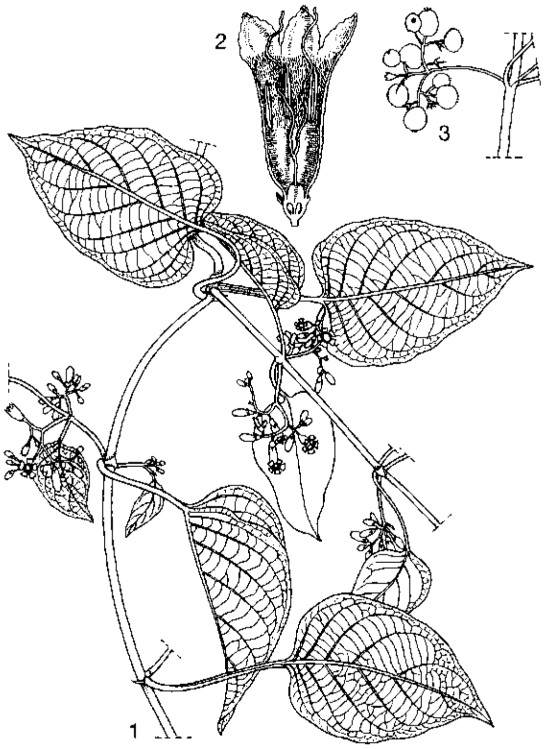
The presence of alkaloids (α- and β-paederine, aerial parts) and an essential oil have also been recorded. Monoterpenes such as linalol constitute the major components in the oil. The most abundant sulphur-containing compound was dimethyl disulphide.

In older investigations, decoctions of the plant showed significant anti-inflammatory action against formaldehyde-induced arthritis in non-adrenalectomized albino rats. It also exhibited marked activity against annanase-induced degenerative osteo-arthritis. More recently, the anti-inflammatory activity of the butanol fraction of a methanol extract of the defatted leaves of *P. foetida* was tested. This fraction produced a significant inhibition of granulation tissue formation in cotton-pellet implanted rats. It decreased liver aspartate transaminase activity without affecting serum aspartate transaminase activity. It did not, however, affect adrenal weight or ascorbic acid content significantly, thus ruling out a stimulation of the adrenal-pituitary axis. The extract antagonized hyposaline-induced haemolysis of human red blood cells and an elevation of rat serum acid phosphatase activity, indicating the presence

of a membrane stabilizing activity. It also inhibited the elevation of serum orosomucoid levels in rats, suggesting the possibility of the presence of disease-modifying antirheumatic activity.
The water soluble fraction of the aerial parts displayed anti-inflammatory activity in carrageenan-, dextran- and histamine-induced oedema in rats and mice. Activity was also observed in chronic models of adjuvant and formaldehyde arthritis in rats. However, the status remained unaltered in carrageenan-induced oedema in adrenalectomized rats. In the carrageenan pleurisy test in rats, it reduced the pleural exudate volume and inhibited the migration of leucocytes into the inflammatory site. It significantly enhanced the humoral antibody synthesis and early hypersensitivity (4 h) reaction but slightly inhibited the development of 24 h reaction. It failed to exhibit any analgesic or antipyretic action and showed no ulcerogenic potential. LD_{50} was found to be greater than 2 g/kg in rats and mice upon oral as well as intraperitoneal treatments.
Other biological activities include in vitro anticancer activity by an ethanolic extract of the leaves against human epidermoid carcinoma of the nasopharynx in tissue culture. Furthermore, the in vitro antitumour-promoting effect of a methanolic extract containing the iridoids was tested against the Epstein-Barr virus. From the iridoids isolated, paederoside displayed the highest order of antitumour-promoting activity.
The hepatoprotective potential of a leaf methanol extract has been assessed against CCl_4-induced liver damage in the rat model. The extract showed effectiveness in reversing 6 out of 12 common biochemical (enzymatic) parameters assessed.
In addition, scandoside was found to promote the growth of lettuce seedlings. Paederoside showed a similar inhibitory activity to that of asperuloside and daecetyl-asperulosidic acid in a plant growth inhibition test and in an antimicroorganism activity test. Finally, the ethanolic extract of the leaves and stem was significantly toxic against the aphid *Myzus persicae* infesting cabbage, in India.

Adulterations and substitutes Asperuloside was also isolated from other *Rubiaceae*, including *Asperula odorata* L. and several *Coprosma* species.

Description A slender, perennial, stinking twiner, 1.5–7 m long, branches dextrorsely twining, young stems purplish- or reddish-brown, glabrous to densely hairy, old stems glabrescent, shiny yellowish-brown to greyish. Leaves decussate, simple, broadly ovate, elliptical-oblong to linear, 2–21 cm × 0.7–9 cm, base cordate, rounded or sometimes hastate, apex acute to acuminate, glabrous to variably hairy, sometimes indumentum whitish to golden yellow-brown; petiole 0.5–6(–9) cm long; stipules interpetiolar, rounded or ovate to triangular, 1.5–5 mm × 2–3 mm, usually entire, glabrous or hairy. Inflorescence a terminal or axillary cymose panicle, extremely variable, from widely branched paniculate, over 1 m long to rather reduced, 10 cm long; bracts foliaceous or small and linear, with few to numerous flowers, often in lax scorpioid cymes; peduncle 2–30 mm long. Flowers bisexual, usually 5-merous, dirty pink or lilac, or purplish, corolla lobes pinkish to whitish inside, throat dark purple; calyx campanulate, 5-lobed, lobes triangular, up to 1 mm × 0.6 mm, normally glabrous; corolla cylindrical to bell-shaped, 5–17 mm × 2–5 mm, throat and inside of tube densely long-hairy, lobes 5, oblong to triangular, 1–3 mm × 1.5–3 mm, margins wavy, inflexed; stamens 5, inserted in the middle of the tube, included, anthers 2–2.5 mm long; ovary inferior, 2-celled, 2-ovuled, disk small, style and stigmas 4–15 mm long, joined style part up to 2 mm



Paederia foetida L. – *1, flowering branch; 2, flower, vertical section; 3, infructescence.*

long, stigma branches 2, filiform, irregularly twisted, mostly included. Fruit a drupe, (sub)globose, 4–6 mm in diameter, walls thin, dry, brittle, crowned by the persistent sepals, shiny pale brown to yellowish- or reddish-brown; pyrenes 2, semi-orbicular or semi-ellipsoidal, plano-convex or compressed, slightly smaller than fruit, without conspicuous wings, black, often conspicuously covered with raphides. Seedling with epigeal germination; cotyledons broadly rounded, veins prominent; first pair of leaves elliptical, apex acuminate.

Growth and development *P. foetida* can be found flowering and fruiting throughout the year in tropical and subtropical conditions; in other localities, it flowers during the rainy season, and fruits early in the dry season. *P. foetida* is protandrous and self-incompatible; stigmas remain receptive for a short period only. Individual flowers are short-lived, open early in the morning and fall off after 2 days; entire inflorescences, however, bear flowers for a long period of time. Bees and butterflies have been observed to visit the flowers.

Other botanical information *Paederia* is a small genus of 30 species distributed in Asia and South-East Asia (16 species), Africa and Madagascar (12 species) of which 11 are endemic to Madagascar, and America (2 species).

Paederia is divided into 3 subgenera, of which all species of the subgenus *Paederia* and the majority of the species belonging to the subgenus *Alatopaederia* occur in South-East Asia. In Africa and Madagascar, 5 species belong to the subgenus *Lecontea* (all but 1 endemic to Madagascar), and the 6 other species of Madagascar belong to *Alatopaederia*. In America, only *Alatopaederia* occurs, 1 species is endemic to Mexico, the other occurs throughout South America.

The name *P. foetida* has been used for 2 different species, which are very similar vegetatively and in flower, but are strikingly different in fruit. *P. foetida* has (sub)globose fruits and a very wide distribution in South-East Asia while *P. cruddasiana* Prain has laterally compressed-ovoid fruits, which are distinctly winged, and which occurs from northern India, Bangladesh, Nepal, Bhutan to south-western China and Thailand.

Ecology *P. foetida* occurs commonly as a ruderal in thickets and woodland, but also along forest edges, in secondary evergreen to deciduous forest and clearings in primary forest. It also grows in montane vegetation up to 3000 m altitude, on steep, forested slopes, or on sandy or rocky sea coasts.

Propagation and planting *P. foetida* is mainly propagated by seed. Despite its weediness, *P. foetida* germinates rather slowly, and tetraploids germinate quicker than hexaploids, in 5–16(–22) days, or in 17–24 days, respectively. Sometimes, shoots produce adventitious roots when they come in contact with the soil, and can thus be propagated as well.

Micropropagation is also successful. Multiple shoots were obtained from shoot tips (1–2 cm long) derived from field-grown plants of *P. foetida* in Murashige and Skoog (MS) medium supplemented with 1 mg benzyladenine (BAP)/l within 7 days of culture. Root induction was observed in MS media supplemented with 0.25 mg BAP + 0.5 mg indole butyric acid (IBA) within 12 days of culture. About 70% of these plantlets were successfully transferred to soil.

Diseases and pests In India, *P. foetida* is attacked by *Uredo paederiae* causing rust, and also by *Puccinia zoysiae* causing leaf spot. It is a host for the root-knot nematode *Meloidogyne* sp.

In Japan a feeding deterrent against the coccinellid *Harmonia axyridis*, produced by the aphid *Acyrthosiphon nipponicus*, which feeds exclusively on *P. foetida*, was identified as a paederoside.

Harvesting *P. foetida* is harvested from the wild whenever needed.

Handling after harvest Parts of *P. foetida* are mainly used fresh, but can be dried for later use.

Genetic resources and breeding *P. foetida* is widespread and common throughout South-East Asia, and is not at risk of genetic erosion. There are no known breeding programmes of *P. foetida*.

Prospects Extracts of *P. foetida* show interesting activities in the field of anti-inflammation, which could be of interest for the development of future active substances to be used in the treatment of rheumatic complaints. Especially the disease-modifying component merits attention. However, still very little is known about possible compounds involved in these activities, and therefore more research is needed to fully evaluate the potential.

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Other selected sources 74, 135, 173, 215, 236, 250, 264, 331, 407, 552, 786, 788, 803, 810, 841, 926, 1076.

N.O. Aguilar

Pangium edule Reinw.

Sylloge Plant. Ratisb. 2:: 13 (1825).

FLACOURTIACEAE

$2n$ = unknown

Synonyms *Pangium rumphii* Voigt (1845), *Hydnocarpus polyandra* Blanco (1845), *Pangium ceramense* Teijsm. & Binnend. ex Boerl. (1899).

Vernacular names Indonesia: picung (Sundanese), pucung (Javanese), pangi. Malaysia: kepayang, payang. Papua New Guinea: puga (Agenehembo, Oro Province), ola (Bayer river, Western Highlands Province). Philippines: pangi (Samar-Leyte Bisaya, Panay Bisaya, Bikol), salingkumut (Mandaya).

Origin and geographic distribution *P. edule* is found throughout Malesia, from the Philippines, Malaysia, Indonesia to Papua New Guinea, and extending eastward to the Bismarck Archipelago, the New Hebrides and Micronesia; small-scale cultivation is found throughout its natural range.

Uses Most of the medicinal and poisonous applications of *P. edule* are based on the presence of hydrocyanic acid in all parts of the plant, ranging from seeds, fruits, leaves, bark or roots. Fresh leaves, leaf sap, pounded leaves or ground fresh seeds are externally applied as an antiseptic and disinfectant to cleanse ulcerations, infested wounds, and to treat scurf. Likewise they can be used as an insecticide against head lice and ticks and as an insect repellent in general.

Fresh leaves can be used to preserve meat or game for several days. The freshness of the meat is retained and insects are repelled. Mention is made of meat already infested with maggots being rendered palatable as a result of the leaves killing the maggots. The ground immature seeds, more precisely the kernels, can be used to preserve fish for several days. The ground kernels are either applied in layers alternating with the freshly caught fish, or the intestines of fish are removed and replaced by the ground kernels. The ground kernels can be removed before preparing the fish for consumption. The pounded bark or immature seeds can be used as a fish poison, whereas pounded leaves are used to stupefy shrimp. The difference is apparently a matter of dosage of the hydrocyanic acid. In the Philippines, all parts are considered an efficient anthelmintic. In Papua New Guinea the fruit is sliced and the juice applied to sores and cuts. All parts are sometimes credited with narcotic properties, an overdose resulting in sleepiness, headache and a sort of intoxication or attack of delirium, which may result in death. These effects may result from the consumption of inadequately prepared seeds. The poisonous agent can be deactivated by extensive washing, soaking, roasting or fermenting. The oil extracted from fresh or cooked kernels can be used as a good substitute for coconut oil in cooking; application for illumination or soap making is also possible but in general the oil is considered of poor quality for these applications. For medicinal use cold pressed oil is preferred, as this still contains hydrocyanic acid. The seed oil is the most important preservative used in traditional weaving of the Iban in Borneo. After an elaborate preparation the mature seeds are sold as 'kluwak', a condiment for 'bumbu rawon', an Indonesian mixture of spices and condiments and as an ingredient of 'sayur kluwak'. The sapwood and heartwood is yellow, with a disagreeable odour, rather hard, but not very durable, used occasionally for local construction and suitable for match sticks.

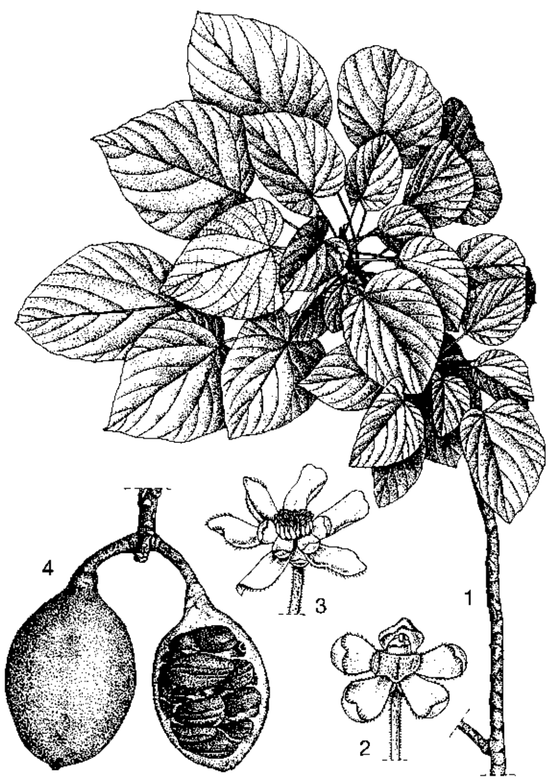
Production and international trade Although statistics on international trade are not available for *P. edule*, local economic importance is evident. Mature 'processed' seeds are for sale as 'kluwak' in markets throughout Indonesia, in particular in Java or in regions with many Javanese or Sundanese migrants, at a price of about US$ 1/kg.

Properties All parts of *P. edule* contain a high percentage of gynocardine, a cyanogenic glycoside of the unsaturated alicyclic aglycone type. For example upon crushing or damaging (e.g. by insects) the plant material, the enzyme gynocardase is liberated, which catalyzes the hydrolysis of gynocardine in its sugar (glucose) and aglycone (a cyano-

hydrin) part. Subsequently, the very unstable cyanohydrin decomposes, and liberates toxic hydrocyanic acid. The hydrocyanic acid thus can be responsible for a range of biological activities, including antibacterial, antifungal, and insecticidal effects.
Gynocardine can be easily eliminated from fresh or dried plant material by sufficient washing or heating (the latter destroys the enzyme gynocardase).

Adulterations and substitutes Cyanogenic glycosides are found throughout the plant kingdom, in at least 70 families. Perhaps the best known tropical species in this respect is cassava root (*Manihot esculenta* Crantz (*Euphorbiaceae*), which may contain up to 0.4% of the cyanogenic glycoside linimarin.

Description A dioecious, more rarely andromonoecious, medium-sized tree, up to 40 m tall, with a dense crown and drooping branches; trunk up to 1 m in diameter, buttresses present. Leaves spirally arranged, simple, ovate-cordate, (10–)12–30(–60) cm × 8–20(–40) cm, entire, 5–7-veined from the base, dark green, glabrous, shining above, dull beneath; petiole 7–30(–50) cm long; stipules absent. Flowers usually unisexual, but the terminal flowers of the male inflorescence sometimes bisexual, rather fragrant; male flowers in few-flowered pseudo-racemes, 6–24 cm long, including 5–12 cm long peduncle, pedicel 2.5–4 cm long, female flowers mostly solitary in the axils of the upper leaves, pedicel 6–9(–12) cm long; calyx closed before anthesis, nearly globose, disrupted irregularly in 2–3(–4) segments, lobes reflexed about 1(–2) cm long, petals (4–)5–8(–9), imbricate, ovate-oblong, 1.5–2.5 cm, somewhat fleshy, bright pale green; male flowers with 20–25(–31) stamens, 0.8–1.3 cm long, free; female flower with as many staminodes as petals and alternating with them, rarely 20–25, ovary superior, ovoid, sessile, with 2–4 many-ovuled placentas, stigma sessile. Fruit an indehiscent, asymmetrical oblong to ovoid drupe, 15–25 (–30) cm × 7.5–12(–15) cm, bluntly to distinctly sharp tipped at both ends, brownish, rather scurfy and rough, hanging from a curved stalk, containing about (13–)20(–40) irregularly shaped closely packed, interlocked seeds, pericarp coriaceous, 0.5–1 cm thick, becoming soft an mushy in the ripe fruit. Seed almost triangular, (3–)4–6 cm × 2–3(–4) cm, enclosed by a white oily and fleshy, sweet, aromatic, edible aril, greyish white when fresh, blackish when weathered, leathery. Seedling with epigeal or hypogeal germination; cotyledons emergent or non-emergent; hypocotyl elongated; all leaves arranged spirally, conduplicate.



Pangium edule Reinw. – 1, twig; 2, female flower; 3, male flower; 4, detail of fruiting twig, pericarp and pulp of one fruit removed halfway.

Growth and development In a seedling trial of *P. edule* in Malaysia 9 out of 14 non-scarified seeds germinated after 20–32 days; germination resembles that of durian (*Durio zibethinus* Murray). Saplings can maintain themselves in the forest. Trees usually start fruiting from about 15 years, but occasionally a tree may start fruiting at 6 years. Trees can be found flowering throughout the year, fruiting appears to be concentrated at the beginning of the rainy season. Flowering starts immediately after every new flush of leaves. Fruiting can happen 1–4 times a year, with smaller fruits during massive fruiting. The development of the trees accords with Aubréville's model, so-called 'pagoda trees' or 'Terminalia branching': growth is determined by a monopodial trunk with rhythmic growth, bearing whorled branch tiers, and branching plagiotropic by apposition. Leaves are crowded at the end of branches. The biggest leaf in each cluster is thrust out on the underside, and the other leaves are placed to overshadow it as little as possible. The seed of *P. edule* can float for a long time and can thus be distributed by rivers and sea currents.

Other botanical information *Pangium* is a monotypic genus, that was formerly included in the family *Bixaceae*. In Sarawak, considerable variation in fruits and seeds has been observed. The typical form is called 'kepayang lenga', and fits most descriptions so far published. The fruits are oblong to oblong-oval, 18–23 cm × 10–14 cm, tips almost rounded, blunt, about 0.5 cm long; about 25–30 seeds per fruit; seed 3.5–4.0(–6.0) cm long. A second form is called 'kepayang papan'. The fruits are subglobular to ellipsoidal, 16–24 cm × 11–16 cm, tips oblong-triangular, sharp, 1.5–2 cm long; about (13–)20–24(–19) seeds per fruit: seed 3.5–5.5 cm long. A third form is called 'kepayang bubur'. The fruits are ellipsoidal to oval, 18–20 cm × 12–14 cm, tips almost rounded, blunt, about 0,5 cm long; 25–30(–40) seeds per fruit; seed 2.5–3.0(–4.0) cm long.

Ecology *P. edule* is found in primary rain forest and secondary forest, in many regions chiefly in deforested localities, always as isolated specimens though locally common, wild or semi-cultivated, also along river banks, in teak forest, on both dryland and temporarily inundated places, on stony or clayey soils, chiefly below 300 m altitude but sometimes up to 1000 m altitude.

Propagation and planting In view of the hard seed coat of *P. edule*, scarification followed by immersion in water for 24 hours prior to sowing is preferred. A seed bed consisting of sand facilitates transplanting. Germination takes about 1 month, seedlings are transplanted to individual pots when 2–3 leaves have developed. Potting medium consists of equal amounts of compost and sand. After 4 months the seedlings can be transplanted to the garden.

Diseases and pests *P. edule* does not appear to suffer from serious diseases or pests.

Harvesting Fruits are in general not harvested until they have fallen from the tree. To obtain the seeds the fruits are often left rotting for 10–14 days as this facilitates removal of the seeds.

Yield Fruits on average weigh 1 kg, but may weigh up to 2.5 kg. A mature tree yields approximately 300 fruits a year. An annual production per tree of about 250 kg processed seeds seems feasible.

Handling after harvest For fish preservation the seed coat of *P. edule* is removed and the kernels are finely cut and dried in the sun for 2–3 days. Seeds for cooing oil extraction are generally cooked for several hours. The seed coat is removed and the kernels are put in running water for 24 hours, or directly dried in the sun. Following this the oil is extracted by pressing.

Genetic resources and breeding *P. edule* is widespread and common throughout Malesia, semi-cultivated in some areas and therefore not endangered. Locally natural regeneration may be hampered by overexploitation. There are no known breeding programmes of *P. edule*.

Prospects Knowledge of the numerous uses of *P. edule* has become rare. Very little information is available on the pharmacological properties of extracts and purified compounds from *P. edule*. More research is needed to evaluate its potential. The tree is a true multi-purpose species that deserves to be promoted in view of its potential as a natural pesticide and food preservative in remote areas in the absence of electricity.

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Other selected sources 53, 207, 287, 368, 418, 730, 779, 786, 810, 1029, 1066, 1067.

Roemantyo & Ervizal A.M. Zuhud

Parameria laevigata (A.L. Juss.) Moldenke

Rev. Sudamer. Bot. 6: 176 (1940).

APOCYNACEAE

$2n$ = unknown

Synonyms *Parameria barbata* (Blume) K. Schum. (1895), *Parameria glandulifera* (Wallich ex G. Don) Benth. ex Kurz (1877).

Vernacular names Indonesia: gembor, ragen (Javanese), akar gerip putih (Malay); pegat sih (Javanese, the bark only), kayu rapet (Sundanese, the bark only). Malaysia: akar serapat puteh, akar gerip puteh, akar serau; kayu rapat (the bark only). Philippines: tagulauai, prugtong-ahas (Tagalog). Cambodia: var ang kot. Thailand: khruea khao muak (northern), khruea suut, som lom (central, eastern). Vietnam: d[oox] tr[oj]ng nam.

Origin and geographic distribution *P. laevigata* is found in India (Andaman Islands) and southern China, throughout Burma (Myanmar), Indo-China, Thailand, Peninsular Malaysia, Singapore, Sumatra, Java, the Lesser Sunda Islands, Sulawesi, Borneo and the Philippines.

Uses In Malaysia and Java, a decoction or a wash made of the bark of *P. laevigata* is given after childbirth to make the uterus shrink. In Java and Bali the latex is used to heal wounds. Some of these uses stem from the observation that strands of latex exuded when a piece of bark is broken off will contract so as to make the wound invisible afterwards. This 'holding' is likewise the reason to include a piece of bark in a mixture given to newly wedded brides so as to consolidate marriage. In the Philippines, the bark macerated in coconut oil is well-known as a cicatrizant. An infusion of the leaves is taken internally as an emmenagogue. The bark macerated in oil is further applied to heal wounds and taken internally to treat tuberculosis. In Indo-China the latex is used as a stomachic, febrifuge and general tonic. In Thailand, the stem is used as an antidiarrhoeal and for wound healing. In traditional Chinese medicine all parts of the plant are used in the treatment of rheumatism, nephritis and injuries. *P. polyneura* Hook.f. is found from Burma (Myanmar) southward to peninsular Thailand, Peninsular Malaysia, Sumatra and Borneo. It is used in Malaysia in the same way as *P. laevigata*. Both *P. laevigata* and *P. polyneura* yield a good quality rubber. However, the small quantities that can be obtained are not commercially exploitable.

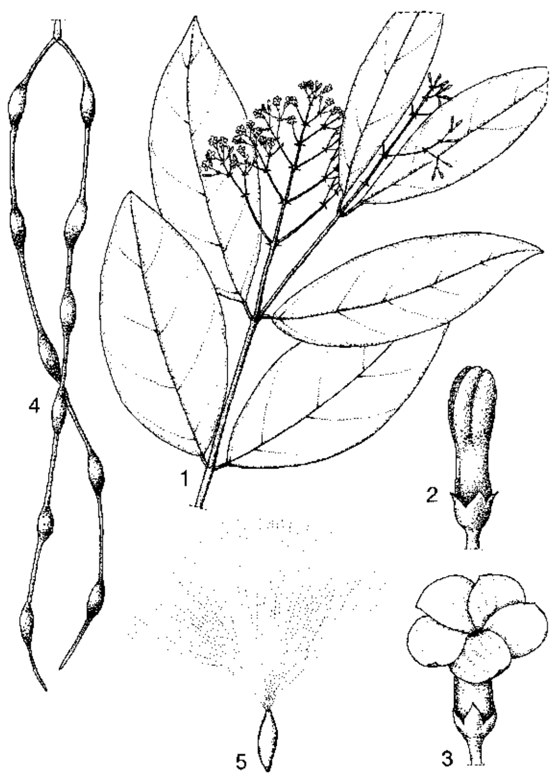
Production and international trade Fragments of the bark or small branches of *P. laevigata*, smoked and dried, are on sale in local markets in China and Indo-China.

Properties Very little is known about the phytochemistry and pharmacology of *P. laevigata*, nor have its traditional uses been confirmed by investigations.

An aqueous extract of the leaves showed partial inhibition of the bacteria *Micrococcus aureus* and *Escherichia coli* in the modified filter paper disk / agar plate assay. Inhibition of HIV-1 protease was detected in a biological screening experiment.

Adulterations and substitutes *Eucommia ulmoides* Oliv. (*Eucommiaceae*) and *P. laevigata* are traded under the same name in Cambodia and Vietnam and used for renal affections and rheumatism.

Description A perennial climber up to 10 m long, branches often lenticellate, glabrous to densely puberulent. Leaves opposite (rarely in whorls of 3), simple, elliptical to obovate, 1.5–15 cm × 0.7–6.3 cm, 1.5–4 times longer than wide, base obtuse to cuneate, apex acute to caudate, with 3–6 pairs of secondary veins, blade papery; petiole 1–5 mm long, with glands in axils; stipules absent. Inflorescence a terminal panicle or shorter cymes scattered along the stem, 2–16 cm long, puberulent, many-flowered. Flowers 5-merous, actinomorphic, fragrant; sepals ovate, 0.5–1.3 mm × 0.4–0.9 mm, pubescent to glabrous; corolla lobes



Parameria laevigata (A.L. Juss.) Moldenke – 1, flowering branch; 2, flower in bud; 3, flower; 4, fruit; 5, seed.

in bud overlapping to the left, open corolla salverform, tube narrow, 1.2–2.5 mm long, lobes falcate to the left, 1.7–4 mm long, white; stamens completely included; disk of 5 separate lobes; ovary consisting of 2 separate carpels united into a common style, superior, ovules numerous. Fruit a paired follicle, distantly tortulose, 12–32 cm × 0.4–0.7 cm, glabrous. Seed elliptical, 5.7–12 mm × 1.1–4 mm, brown, hirsute.

Growth and development In Indo-China *P. laevigata* flowers from August–April, fruiting from January–April. In Java flowering takes place from March–September, and fruiting from January–November.

Other botanical information *Parameria* comprises 3 species and is distributed from India (Assam, Andaman Islands), southern China, southward to Burma (Myanmar), Thailand, Indo-China, Malaysia, Indonesia (Sumatra, Java, Lesser Sunda Islands, Kalimantan, Sulawesi) and the Philippines. *Parameria*, *Urceola* and *Aganoneiron* constitute a closely related group within the subfamily *Apocynoideae*. *Parameria* can be easily distinguished by the aestivation of the corolla lobes which is to the left, whereas it is to the right or valvate in *Urceola*, and to the right in *Aganoneiron*. *P. laevigata* is an extremely variable species; there is, however, no clear line to distinguish the extremes. *P. polyneura* can be distinguished by its densely pubescent corolla lobes and its weakly tortulose fruits.

Ecology *P. laevigata* is found in primary and secondary forests and thickets from sea-level up to 1500 m altitude.

Propagation and planting *P. laevigata* is easily propagated by cuttings or seed.

Harvesting *P. laevigata* stems are cut, the bark and small branches removed and the plant is allowed to resprout.

Handling after harvest Pieces of bark and small branches of *P. laevigata* are simply dried for future use.

Genetic resources and breeding *P. laevigata* is common in thickets and open forest in Indo-China and the Philippines. Apparently it adapts well to disturbed habitats, therefore it does not seem to be seriously threatened by genetic erosion. However, *P. laevigata* is reported rare in Indonesia.

Prospects *P. laevigata* has hardly been investigated, and only few data are available. Therefore more research is needed to fully evaluate its possible prospects for medicine.

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Other selected sources 128, 215, 407, 672, 766.

J.L.C.H. van Valkenburg

Parkia R.Br.

in Denham & Clapp., Narr. Travels Africa, Bot. App.: 234 (1826).

LEGUMINOSAE

$x = 12, 13$; *P. speciosa*: $2n = 24, 26$

Major species *Parkia sumatrana* Miq., *P. timoriana* (DC.) Merr.

Origin and geographic distribution *Parkia* is a pantropical genus with about 35 species, most of them found in tropical America, especially in the Amazon basin. In Asia, *Parkia* occurs from north-eastern India and Bangladesh eastward through the whole of the South-East Asian region, with more isolated species in Micronesia and Fiji. About 6 species occur within Malesia. Peninsular Malaysia and Sumatra have 4 species, Borneo has 5 species. *P. timoriana* has the largest area of distribution, occurring from India to New Guinea.

Uses The seeds of *P. speciosa* and *P. timoriana* are considered beneficial in the treatment of hepatalgia, oedema, nephritis, diabetes and colic, probably as a result of their diuretic and relaxing activity. They are also used as an anthelmintic. The leaves are used against jaundice. In Indo-China, the bark of *P. sumatrana* is used medicinally. In Kalimantan, the inner red bark of *P. speciosa* is applied as a dressing on burns, followed several hours later by an infusion of the pounded white wood, which is used to wash the skin. The wood of *Parkia* is used locally for non-durable or indoor applications. *P. speciosa* and *P. timoriana* are sometimes used as shade tree for coffee and nurseries. The fresh or cooked seeds of various *Parkia* species, most importantly *P. speciosa*, are relished as a sidedish or condiment.

Production and international trade In 1984, 145 t *P. timoriana* seeds were used locally for medicinal purposes in Java, whereas export was only marginal. In 1990 production was about 142 t from nearly 14 000 trees. It is expected to rise to 180 t by 2000 to fulfill the needs of the 'jamu' industry in Indonesia in which *P. timoriana* seeds play an important role.

Properties The seeds of *P. speciosa* and *P. timoriana* contain several non-protein sulphurous amino acids, e.g. djenkolic acid (S,S'-methylenebis-L-cysteine), N-acetyl-djenkolic acid, and glutalyl-cystine. Cyclic poly-sulphides also occur in the seeds of *P. speciosa*, which contribute to the foul smell. After boiling, seeds of *P. timoriana* and *P. speciosa* contain thio-proline at a concentration of 0.54 ± 0.2 and 0.14 ± 0.02 mmol/100g, respectively.

Furthermore, lectins with haemagglutinating activity have been isolated from the seeds of *P. speciosa* and *P. timoriana*. Purified *P. timoriana* lectin showed 2 bands using SDS-PAGE; both of them appeared to be single polypeptide chains with molecular weights of 47 900 and 45 700. The purified lectin could agglutinate red blood cells of rabbits and rats, but not those of humans, sheep or goose. Its haemagglutinating activity was completely inhibited by methyl-α-D-mannosamine and mannose. In addition, Ca^{2+}, Mn^{2+} and Mg^{2+}, but neither ethylenediaminetetraacetic acid (EDTA) nor agtazic acid (EGTA), were effective activators of the purified lectin.

Oral administration of the chloroform extracts of *P. speciosa* seeds to alloxan-induced diabetic rats produced a significant depression in blood glucose levels. Extraction, isolation and structure elucidation of the hypoglycaemic fraction (called S-9.4) gave a mixture of β-sitosterol (66%) and stigmasterol (34%). Fraction S-9.4 produced 83% hypoglycaemic activity at 100 mg/kg body weight (BW) compared with 111% activity of glibenclamide at 5 mg/kg BW dosages. The minimum effective dose which produced a statistically significant hypoglycaemic effect was 25 mg seeds/kg BW. When tested individually β-sitosterol and stigmasterol showed no hypoglycaemic effects, indicating that synergism between β-sitosterol and stigmasterol was necessary to effect the hypoglycaemic activity. The hypoglycaemic effect was not observed in healthy rats.

In addition, administration of the chloroform extracts of *P. speciosa* empty pods to alloxan-induced diabetic rats produced a significant reduction in blood glucose levels. A hypoglycaemic assay guided extraction, isolation and structure elucidation gave stigmast-4-en-3-one. Stigmast-4-en-3-one produced 84% activity at 100 mg/kg BW compared to 111% activity of glibenclamide at 5 mg/kg BW dosages. The minimum effective dose which produced statistically significant hypoglycaemic effect was 50 mg pericarp/kg. Hypoglycaemic effects were not observed in healthy rats.

Description Deciduous, medium-sized to large trees up to 50 m tall; bole up to 100(–250) cm in diameter, buttresses present or absent. Leaves alternate or opposite, bipinnate with up to 30(–42) pairs of pinnae; petiole and rachis usually with extrafloral nectaries; stipules small, caducous; leaflets opposite, sessile. Inflorescences compound, consisting of a stout twig to 50 cm long, sparsely branched or unbranched, bearing 2–10(–more) flexible peduncles, each to 50 cm or more long. Flowers in a long-stalked, pendulous, pyriform to clavate, dense head, sterile flowers at base of the head, male ones in middle portion and bisexual ones at apex, 5-merous; calyx long-tubular or funnel-shaped with imbricate lobes; corolla longer than calyx; stamens 10, connate below, shortly exserted; ovary superior, short-stiped, style exserted. Fruit a linear to strap-shaped or oblong pod, stalked, leathery or woody, usually indehiscent, many-seeded, usually several pods together in a pendent infructescence with swollen receptacle. Seeds in 1 row, ellipsoid, with a pleurogram. Seedling with epigeal germination; cotyledons fleshy, peltate; epicotyl with a scale leaf and subsequently bipinnate leaves.

Growth and development *P. speciosa* and *P. timoriana* show a synchronized annual cycle of flowering, fruiting and leaf fall; the trees are without leaves for 2–3 weeks each year. They start flowering when 10–15 m tall, but vegetatively propagated *P. speciosa* starts flowering and fruiting a few years after planting. The flowering heads are usually pollinated by bats, but are also visited by insects and birds. They produce a fetid odour and a copious nocturnal supply of nectar. Hornbills, monkeys, squirrels, deer, elephants and wild pigs feed on the fruits and probably disperse the seeds. In Java, *P. timoriana* flowers in April–July and most fruits are found in June–August.

Other botanical information *Parkia* is classified in the tribe *Parkieae* of the subfamily *Mimosoideae*, together with *Pentaclethra*, which is confined to tropical Africa and America.

P. timoriana is often cited as *P. javanica* (Lamk) Merr., especially in Malaysian literature. Although the latter name is older and would therefore have priority, it has been superseded because the correct identity of the species concerned cannot be recovered. The status of *P. intermedia* Hassk. is uncertain, but it is probably a hybrid between *P. speciosa* and *P. timoriana*; it is found almost exclusively in Java. *P. sherfeseei* Merr. from the Philippines (Mindanao) is possibly conspecific with *P. sumatrana*.

Ecology *Parkia* occurs scattered in lowland rain forest and sometimes also in tall secondary forest, on sandy, loamy and podzolic soils, also in waterlogged locations, in freshwater swamp forest and on river banks, up to 1000(–1400) m altitude. *P. sumatrana* and *P. timoriana* also occur in dry evergreen forest, often along streams.

Propagation and planting *Parkia* can be propagated by seed and by vegetative means. Seeds of *P. timoriana* are hand-picked from underneath mother trees. The hard, indehiscent pods need to be opened with a chopping knife. *P. timoriana* has 1000–1400 dry seeds/kg. The germination rate of the hard seeds of *P. timoriana* is about 55% in 8–103 days; mechanical scarification is recommended. In a test in Thailand, 3-year-old seed had a germination rate of only 8.5% whereas nicked seed had a germination rate of 90.5% in only 4–8 days. A pretreatment with concentrated sulphuric acid for 15 minutes gave a germination rate of 95%. Whereas *P. speciosa* can be propagated by stem cuttings and budding, attempts with *P. timoriana* have failed. Seedlings of *P. timoriana* can be stumped with 10–20 cm shoot and 20–40 cm root length, and survival after planting is 100%. In Java, growth during the first 5 years was fast, but then slowed down. Ample space and light are necessary for optimal growth.

Diseases and pests *Parkia* species have a number of pests in common with other leguminous trees and shrubs. The stem and bark borers *Xystrocera festiva* and *Cossus subfuscus* can cause severe damage in *P. speciosa*, especially at lower elevations in Java. Other pests are the pod borers *Cryptophlebia ombrodelta* and *Mussidia pectinicornella*, and the caterpillars of the leaf feeders *Polyura hebe*, *Eurema blanda* and *E. hecabe*. The seeds are relished by a great number of arboreal mammals.

Harvesting Mature pods of *Parkia* are collected by climbing the trees and using long poles. Climbing is sometimes facilitated by pegs in the trunk.

Yield A population of about 100 mature *P. timoriana* trees in East Java yielded on average 12 kg of seeds/tree; 70% of the trees were fruiting and the yield ranged from 4–45 kg of seeds/tree.

Handling after harvest Seeds of *Parkia* can be dried in the sun to improve storability and to facilitate transport over long distances.

Genetic resources and breeding Within Malesia no seed or germplasm collections of *Parkia* are known to exist and no breeding programmes are being carried out. The *Parkia* species of medicinal importance have a fairly wide area of distribution and are also cultivated, suggesting that it is unlikely that they are threatened.

Prospects Extracts and isolated compounds from *Parkia* species exhibit an interesting anti-diabetic effect, which merits further research. Lectins may have possibilities as tools in research. In view of the increase in the human population, local demand for *P. timoriana* seeds is expected to rise. Therefore efforts should be made to cultivate *Parkia* in order to sustain market demand.

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Selection of species

Parkia sumatrana Miq.

Fl. Ind. Bat., Suppl. 1, Sumatra: 284 (1861).

Synonyms *Parkia macrocarpa* Miq. (1861) p.p. excl. leaves, *Parkia streptocarpa* Hance (1876), *Parkia dongnaiensis* Pierre (1899).

Vernacular names Brunei: kupang amas, petai belalong. Indonesia: soga (Sulawesi). Malaysia: buah putai, kedaung (Iban, Sarawak), petai nering (Peninsular). Burma (Myanmar): mai-ka-tor (Shan), thit lein. Cambodia: royôông (Kampot), ta sek (Kompong Speu). Laos: 'hua 'lôn (Savannakhet), 'sôm po:y 'luang (Louang Prabang). Thailand: i-thao (south-eastern), luk ding (central). Vietnam: th[us]i, c[awj]c heo, bung r[es]o.

Distribution Southern Burma (Myanmar), Indo-China, Thailand, Peninsular Malaysia, Sumatra, Borneo and Sulawesi.

Uses In Indo-China, the powdered bark is used as a leech repellent. In Cambodia the macerated bark is applied in medicinal baths.

Observations A tree up to 35 m tall; leaves alternate or rarely opposite, primary rachis including petiole 36 cm long, pinnae (5–)7–11(–18) pairs, secondary rachis up to 9.5 cm long, leaflets (12–)14–20(–37) pairs per pinna, oblong, (10.5–)11.5–21(–25) mm × (3–)4.5–8 mm, base weakly auriculate, apex rounded or slightly retuse; peduncle 14–44 cm long, head clavate, 4–5 cm long, 3 cm in diameter; bisexual flowers, calyx up to 11 mm long, corolla up to 12 mm long, lobes up to 2 mm long; infructescence consisting of up to 8 strap-shaped pods per head, pod up to 45(–52) cm long (including stipe) and 2 cm or 4.2–5.4 cm broad, variably pubescent, rarely twisted, stipe up to 10 cm long; seeds 10–13 per pod and lying diagonally or 26–33 per pod and lying horizontally across the width of the pod. Based on pod characters and number of leaflets two subspecies with a non-overlapping distribution are distinguished. Subsp. *sumatrana* is found in Sumatra, Borneo, Sulawesi, (and the Philippines) and subsp. *streptocarpa* (Hance) H.C.F. Hopkins is found in Burma, Thailand, Indo-China and Peninsular Malaysia. Specimens collected in Borneo and Sumatra showing intermediate character states, even with *P. singularis* Miq., have recently received species rank as *P. paya* H.C.F. Hopkins. *P. sumatrana* is found scattered in evergreen forest, often along streams, on sandy, stony or clayey soils from (0–)100–600 (–900) m altitude.

Selected sources 207, 319, 740, 1066.

Parkia timoriana (DC.) Merr.

Philipp. Journ. Sci., Bot. 5: 33 (1910).

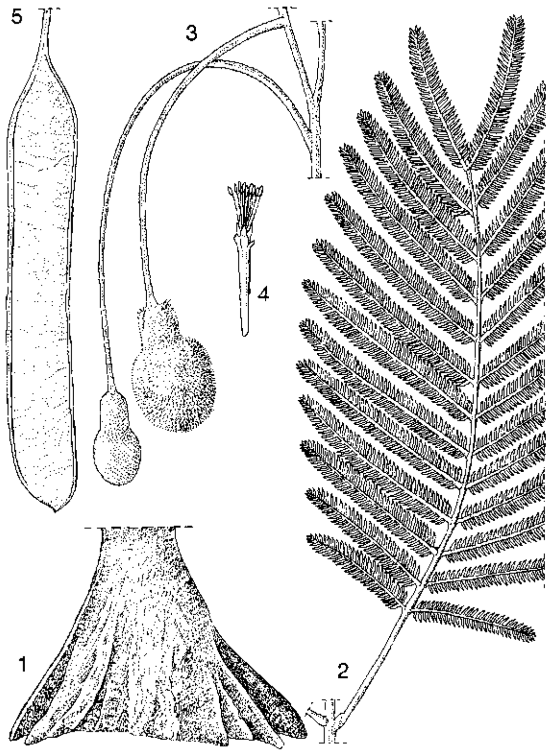
Synonyms *Parkia roxburghii* G. Don (1832), *Parkia biglobosa* auct. non (Jacq.) R.Br. (1830), *Parkia javanica* auct.

Vernacular names Indonesia: alai (Sumatra), kedawung (Javanese), peundeuy (Sundanese). Malaysia: kedaung (Sarawak), kupang (Sabah), petai kerayong (Peninsular). Philippines: kupang (Pilipino), amarang (Palawan). Burma (Myanmar): mai-karien (Shan). Thailand: kariang, riang (peninsular).

Distribution India, Bangladesh, Burma (Myanmar), Thailand and throughout the Malesian region (except Papua New Guinea).

Uses The ripe seeds, either roasted or boiled and powdered are taken in decoction as a well-known remedy for colic. Leaves and/or bark are externally applied to clean wounds and ulcers and to cure scabies. The pods pounded with water are used as a hair shampoo.

Observations A tree up to 50 m tall; leaves alternate, primary rachis including petiole 18–42 cm long, pinnae 14–31 pairs, secondary rachis



Parkia timoriana (DC.) Merr. – 1, base of trunk; 2, leaf; 3, flowering heads; 4, flower; 5, fruit.

8.7–11.5 cm long, leaflets 52–72 pairs per pinna, somewhat sigmoid, 6–10.5 mm × 1–2 mm, base auriculate on proximal side, apex acute; peduncles 5–7 per compound inflorescence, 8.5–33 cm long, head somewhat biglobose at anthesis, 5.5–6.7 cm long, apical part 3–4.5 cm in diameter; bisexual flowers, calyx up to 10.5 mm long, corolla up to 11 mm long, the lobes up to 2 mm; pod strap-shaped, up to 50 cm long (including stipe) and 4–5.5 cm broad, valves woody, rarely twisted, stipe of 6–15.5 cm long; seeds 12–19 per pod, lying horizontally across the width of the pod. *P. timoriana* is found in lowland rain forest, mixed deciduous and dry evergreen forests, often along streams or the upper part of slopes, sometimes common, preferring fertile soils with a pH of 5–7, from 0–600(–1300) m altitude.

Selected sources 135, 207, 215, 407, 480, 647, 810, 1066.

Umi Kalsom Yusuf & Ervizal A.M. Zuhud

Pavetta indica L.

Sp. pl. 1: 110 (1753).

RUBIACEAE

$2n = 22$

Synonyms *Ixora indica* (L.) Kuntze (1891), *Pavetta tomentosa* Roxb. ex Smith (1810).

Vernacular names White pavetta, bride's bush (En). Bois de pintade (Fr). Indonesia: soka (Sundanese). Malaysia: jarum-jarum, nyarum-nyarum, gading-gading. Philippines: gusokan (Cebu Bisaya), pangapatolen (Iloko), kotbu (Igorot). Laos: kho som kang, kho som kao. Thailand: khem paa (central, northern). Vietnam: thanh t[as]o r[uwf]ng, d[oj]t s[af]nh, c[awr]ng g[af].

Origin and geographic distribution *P. indica* is widely distributed from the Andaman Islands, India and the north-western Himalayas to southern China and southwards throughout Malesia to northern Australia.

Uses In Peninsular Malaysia, the leaves of *P. indica* are used for poulticing boils, and the roots for poulticing stubborn itch. A cooled decoction of the leaves is applied to ulcers of the nose. The decoction is drunk during the first days after childbirth as a protective medicine, but also for delayed childbirth and for fever. In the Philippines and India, the root, root bark or stem bark is used for intestinal obstructions. In the Philippines, a poultice of the stem bark is also applied for soothing haemorrhoids. The crushed root bark, with rice water and ginger, is taken as a diuretic and for dropsy. In Indo-China, an infusion of the thinly cut wood is taken for rheumatism. In India, especially the root is considered medicinal and used as a diuretic, purgative, aperient and tonic, and is prescribed in intestinal obstructions, jaundice, headache, urinary diseases and dropsy.

The fruit has a sweet taste when ripe, and is also used as a condiment when kept in vinegar. In some parts of India, the flowers are eaten. In Thailand, an infusion of the fragrant flowers is used as a cosmetic after bathing.

In India, the leaves provide a good green mulch. *P. indica* and several other *Pavetta* are cultivated as ornamentals.

Production and international trade *P. indica* is used on a local scale only.

Properties In general, little information is available on the phytochemistry and pharmacology of *P. indica*. The root bark contains a bitter aromatic glycoside related to salicin. A screening of the stem gave positive reactions for an essential oil (0.6%), alkaloids and tannins (5%). The fresh leaves from plants originating from southern India contain triterpenes and steroids such as β-sitosterol, α-amyrin and 3-epi-ursolic acids, together with common phenolics such as quercetin, caffeic- and chlorogenic acid. An aqueous extract of the leaves, at a daily dose of 0.2 g for 7 days, exhibited a hepatotoxic effect in rays by inhibiting alkaline phosphatase, glutamate-oxaloacetate transaminase and glutamate-pyruvate transaminase.

More information is available on *P. owariensis* Beauv., a medicinally used African species. Pavetannins C-1 to C-6 (tetrameric proanthocyanidins containing one or two double interflavonoid (A-type) linkages), pavetannins B7 and B8 (trimeric proanthocyanidins), as well as the known tetramers cinnamtannin B2 and its positional isomer, pavetannin C1 and the pentamer pavetannin D1, have been isolated from the stem bark. Three major and two minor ferulic acid esters were identified in a hexane extract as well. Several phytochemical analyses and tests on biological activity have been performed; some of them focus on the presence of proanthocyanidins. The schistosomicidal properties of ethanol and acetone extracts of *P. owariensis* were assessed in mice infected with *Schistosoma mansoni*. All extracts containing proanthocyanins were shown to cause a reduction in size of periovular granuloma formation in the liver. This effect was most pronounced with ethanol extracts of both 'white bark' and 'red bark' varieties of the plant. Acetone extracts of the 'red bark' variety, containing the highest concentration of proanthocyanins, caused a marked reduction in the number of eggs in the liver and intestine. *P. owariensis* is used as an anthelmintic in Guinean traditional medicine and 11 proanthocyanidins, isolated from the stem bark, were investigated for molluscicidal activity against *Biomphalaria glabrata*, but at the tested concentrations (3–100 ppm), none of the compounds were lethal to the snails.

No information is available on the presence of proanthocyanidins in *P. indica*. However, since proanthocyanidins will give positive reactions in tests on tannins, and the content of tannins in *P. indica* is substantial (5%), their presence should not be excluded beforehand.

In southern Africa, *P. harborii* S. Moore is one of the species held responsible for congestive cardiomyopathy and death in sheep and goats, called 'Gousiekte'. An aqueous extract from its stem was found to be very active in vitro against mycelial growth of *Alternaria zinnae*, *Macrophomina phaseolina* and *Sclerotium rolfsii*. An aqueous extract from the leaves of *P. oblongifolia* Bremek. from West Africa, was tested against 9 strains of *Neisseria gonorrhoeae*, including penicillin and tetracycline resistant strains, and showed strong antibacterial activity against all the tested strains.

Description A shrub or small tree, 3–5 m tall, with opposite branches; young twigs glabrous, puberulent or pubescent. Leaves opposite, simple, very variable, ovate to oblong, 6–13 cm × 2–5 cm, base acute or cuneate, apex obtuse to acute, glabrous or hairy underneath; petiole 1–2 cm long; stipules interpetiolate, connate at base, distinctly cuspidate. Inflorescence a terminal, compact, erect corymb or corymbose panicle, up to 6 cm long; peduncle short; bracts large, membranaceous, cupuliform, persistent. Flowers bisexual, 4-merous, white, fragrant, protandrous, pedicel short; calyx campanulate, teeth tiny; corolla tube cylindrical, 8–12 mm long, rather thick, lobes obtuse, up to 4 mm long, contorted in bud; stamens inserted at corolla throat, with short filaments, anthers dorsifixed, sagittate and conspicuously twisted; disk annular; ovary inferior, 2-locular, 1 ovule per cell, style filiform, long-exserted, stigma 2-lobed, lobes very short. Fruit a globose drupe, 5–6 mm in diameter, with 1–2 pyrenes, ripening black; pyrene 1-seeded, thin-walled, plano-convex, with a wide, circular excavation. Seedling with epigeal germination; cotyledons leafy, green.

Growth and development Flowering is sea-

Pavetta indica L. – 1, leafy twig; 2, inflorescence; 3, young flower.

sonal in *Pavetta*. The flowers are mainly pollinated by moths and butterflies. The seeds are probably dispersed by fruit-eating birds.

Other botanical information *Pavetta* is widely distributed in the Old World tropics and comprises 200–400 species. It does not occur though in Madagascar, New Zealand and Oceania. Africa has the largest number of species, but Sri Lanka and the Philippines are also very rich. Most *Pavetta* species have a rather local distribution. *Ixora* closely resembles *Pavetta*, but can be distinguished by its short-exserted style with recurved stigmas, reflexed anthers, reddish drying flowers, and shortly united stipules. *P. indica* is a rather controversial species, as some authors claim that it has a wide distribution area, and many varieties are then distinguished, mainly based on the hairiness of different plant parts. Other authors state that the real *P. indica* is confined to India and Sri Lanka, and specimens resembling *P. indica* in other regions bear a multitude of different names. This is the case in Java, where *P. axillaris* Bremek., *P. montana* Reinw. ex Blume, *P. reinwardtii* Bremek., *P. subvelutina* Miq. and *P. syl-*

vatica Blume can also be considered to be *P. indica*. In Australia, similar problems exist.
In several *Pavetta* species, also in *P. indica*, leaves with nitrogen-fixating bacterial nodes are observed, living in symbiosis with the plant; this characteristic is lacking in *Ixora*. The bacteria also pass into the seeds, so that seedlings are already infected.

Ecology *P. indica* is common in primary and secondary forests, where it often forms a single stem, but also occurs in open localities, where branched types are more common, from sea-level up to 1500 m altitude.

Propagation and planting *Pavetta* is propagated by seed, and vegetatively by nodal softwood cuttings or semi-ripe cuttings. Seeds of *P. indica* are sown in a fibrous, loam-based medium, with added sharp sand and charcoal. Fertilizer can be added, but the presence of nitrogen-fixating bacteria enables *P. indica* to thrive in a nitrogen-deficient soil as well.

Harvesting The leaves, stems and roots of *P. indica* are harvested when needed. Commercially available roots in India are crooked in shape, varying from 6–25 mm in diameter.

Handling after harvest Plant parts of *P. indica* are normally used fresh.

Genetic resources and breeding *P. indica* (sensu lato) is widespread and common throughout South-East Asia, and therefore not endangered. There are no known breeding programmes of *P. indica*.

Prospects Phytochemical and phytopharmacological information on *P. indica* is rare. Related African species, however, contain compounds which show interesting activities. More research is therefore needed to investigate the potential of *P. indica*.

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Other selected sources 79, 80, 215, 240, 340, 788, 810, 840, 841, 1000.

G.H. Schmelzer

Pericampylus glaucus (Lamk) Merr.

Interpr. Herb. amboin.: 219 (1917).
MENISPERMACEAE
$2n$ = unknown

Synonyms *Cocculus glaucus* (Lamk) DC. (1817), *Pericampylus incanus* (Colebr.) Hook.f. & Thomson (1855), *Pericampylus membranaceous* Miers (1871).

Vernacular names Broad-leaved moonseed (En). Indonesia: areuy geureung (Sundanese), celuru (Javanese), akar gamat (Moluccas). Malaysia: gasing gasing, kelempenang (Peninsular), taworuk (Kudat, Sabah). Philippines: silong pugo (Tagalog), botang botang (Cebu Bisaya), pamago (Bikol). Thailand: salit hom kha (northern), yan tap tao (peninsular). Vietnam: ch[aa]u d[ar]o, d[aa]y l[ox]i ti[eef]n.

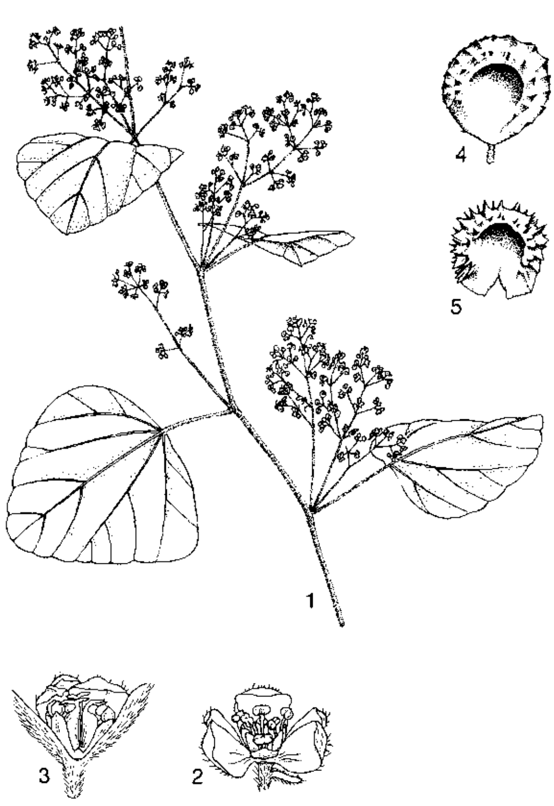
Origin and geographic distribution *P. glaucus* is distributed from the eastern Himalayas, southern China, Taiwan, Indo-China, Thailand and Burma (Myanmar), southward throughout Malesia.

Uses In Malaysia, the leaves of *P. glaucus* are one of the ingredients of an infusion to cure high fever, and in combination with other plants they are made into an infusion used for coughs and asthma. Pounded, the leaves are externally applied to soothe headache. The latter use is also reported for Sumatra. In Sabah, stem juice is used as eye-drops for conjunctivitis. In Indonesia, the mucilage resulting from soaking pounded leaves overnight is applied on the head as a remedy for hair loss. The same mucilageous substance is taken orally to cure a swollen spleen and accompanying fevers. In the Philippines the fluid extract of the roots is injected at the location of a snakebite, neutralizing the poison by precipitating and changing it into an inert substance. In India, the roots are credited with narcotic properties, and are also used as an antidote for snakebites. The tough stems can be used as string for tying and basketry.

Production and international trade *P. glaucus* is only used on a local scale.

Properties The seeds and bark of *P. glaucus* have a bitter taste. Experiments with ground plant material yielded only very low levels of alkaloids (0.01 g/100 g).
Six crystalline substances were isolated from the roots of *P. glaucus* and identified as sterols, triterpenes and fatty acids: epifriedelinol, melissic acid, palmitic acid, stearic acid, butyric acid and daucosterol.

Description A slender, dioecious woody climber up to 5 m long, young stems yellowish tomentose, glabrescent, root tuberous, up to 30 cm in diameter. Leaves alternate, simple, broadly triangular-ovate, 5–10 cm × 5–10 cm, base shallowly cordate or truncate, apex broadly rounded or obtuse, apiculate, margin broadly and shallowly crenate, palmately 5-veined, papyraceous, lower surface tomentose or softly pubescent, upper surface sparsely pubescent; petiole 3–7 cm long, yellowish tomentose; stipules absent. Inflorescence axillary, a cyme, fasciculate, 2–6 together in male plants, solitary in female plants, 2–4 cm long, yellowish tomentose, pedunculate; flowers fragrant, white or yellow, sepals 9, hairy outside, 3 outer ones narrow, minute, 3 middle ones oblanceolate, 3 inner ones obovate, all 1 mm long, petals 6, obcuneate, 0.5 mm long, glabrous; male flowers stamens 6, free, 0.8 mm long; female flowers staminodes 6, filamentose, carpels 3, stigma deeply bifid recurved. Fruit a drupe, transversely obovate, purple to black, glabrous; endocarp rotund in outline, ornate with rows of spines and tubercles. Seed horseshoe-shaped.



Pericampylus glaucus (Lamk) Merr. – 1, flowering twig, male plant; 2, male flower, one sepal removed; 3, female flower, front sepal, petal and one staminode removed; 4, fruit; 5, endocarp.

Growth and development *P. glaucus* can be found flowering and fruiting throughout the year. In Thailand fruiting is from April–July only.

Other botanical information The genus *Pericampylus* comprises 2–3 species; a second species, *P. formosanum* Diels, is confined to southern China, Taiwan and the Ryukyu Islands and a third little-known species *P. macrophyllus* Forman is found in Burma (Myanmar). *Pericampylus* is placed in the tribe *Menispermae*. It is closely related to *Legnephora* but differs in having female flowers with petals, the anthers dehiscing differently. In *Pericampylus* the endocarp is without a dorsal median wing or ridge and lateral crests, instead it is dorsally covered with short pointed processes.

Ecology *P. glaucus* is found in primary and secondary forest, in particular in clearings, and thickets, up to 1700 m altitude, and is locally common. It is a sun-loving plant although some shade may be required in the early stages of growth.

Propagation and planting *P. glaucus* can be easily grown from seed.

Husbandry *P. glaucus* needs adequate support to climb and spread properly so that a maximum amount of leaves can be produced.

Diseases and pests Natural stands of *P. glaucus* exhibit little damage due to diseases and pests.

Harvesting Mature leaves of *P. glaucus* can be harvested at regular intervals by hand or by using a knife or secateurs. Care must be taken not to damage the stems while removing the leaves. Harvesting of roots should be carried out towards the end of the growth period of the plant when production of leaves has declined and the tuberous roots have reached maximum weight and maturity.

Handling after harvest Harvested leaves of *P. glaucus* should be dried quickly to prevent infections or damage. Fresh tuberous roots should be washed before being used.

Genetic resources and breeding In view of the large geographical distribution and its common occurrence in hedges, thickets and disturbed habitats in general, *P. glaucus* does not seem to be threatened by genetic erosion. No germplasm collections or breeding programmes are known to exist.

Prospects Very little is known about the phytochemistry and phytopharmacology of *P. glaucus*. More research is needed to fully evaluate its prospects.

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Other selected sources 74, 128, 316, 407, 810.

H.C. Ong

Persicaria Miller

Gard. Dict. abr. ed. 4 (1754).

POLYGONACEAE

$x = 10, 11$; *P. barbata*: $2n = 20, 22, 40, 60$; *P. chinensis*: $2n = 22, 32$; *P. minor*: $2n = 40$

Major species *Persicaria chinensis* (L.) H. Gross.

Vernacular names Knot grass, smart weed, joint weed (En). Renouée des oiseaux (Fr).

Origin and geographic distribution *Persicaria* comprises about 150 species with an almost cosmopolitan distribution, and is widely distributed in South-East Asia.

Uses A decoction or the juice of the crushed leaves or plant of many *Persicaria* species, including *P. barbata* and *P. chinensis*, are applied to skin problems such as scabies, ringworm, boils, and ulcers, and also to fresh wounds, bites of snakes, dogs or insects for their disinfectant properties. It is also applied as a maturative, a resolvent and a cicatrizant, and as a wash for haemorrhoids, venereal sores and leucorrhoea.

In Java, *P. barbata* is reported to be a fish poison, but this has not been proven. The seeds are taken against cholera, dysentery and colds. The juice of the plant is taken as a haemostatic, antifebrile, diuretic and laxative. In India, the dried rhizome is taken as an astringent and refreshing beverage. In Peninsular Malaysia, the powdered leaves are applied to infected wounds of goats. In Indonesia, the juice of the stem and leaves of *P. chinensis* is employed in the treatment of eye diseases. A decoction of the plant is used against cholera, dysentery and headache. In Vietnam, the aerial parts are externally used to treat pimples, eczema, skin infections and snake bites, and internally against fever, dysentery and throat infections. In Peninsular Malaysia, a poultice of *P. chinensis* or *P. barbata* is applied to the abdomen to treat stomachache. In Peninsular Malaysia, a decoction of the leaves of *P. minor* is taken for indigestion and also after childbirth.

In Vietnam, the roots of *P. maculosa* Gray (synonym *Polygonum persicaria* L.) are used against pulmonary complaints.

In South-East Asia, the young shoots or leaves of most *Persicaria* species are sometimes eaten as a vegetable or mixed into salads. *P. hydropiper* (L.) Spach, *P. odorata* (Lour.) Sojak and *P. pubescens* (Blume) H. Hara have a sharp or pungent taste and are therefore mainly used as a spice, but also medicinally. *P. barbata* and *P. tinctoria* (Aiton) Spach are used to make a dark-blue dye especially in China.

Production and international trade The dried plants of *Persicaria* are found on Chinese markets in Indo-China and Malaysia.

Properties The rhizomes of *P. barbata* contain indole alkaloids, pterocarpanes (2',4-epoxy-isoflavones) and flavonones. The pterocarpanes showed molluscicidal activity, and an extract of the aerial parts exhibited antimicrobial activity.

The leaves of *P. chinensis* contain flavonoids, e.g. kaempferol-3-O-glucuronide and 5,6,7,4'-tetrahydroxy-3'-methoxyflavone. The extract of the aerial parts showed antifungal activity against *Drechslera oryzae*, and antibacterial activity against both Gram positive and Gram negative bacteria. Several steroidal compounds were isolated from roots and stems: 25R-spirost-4-ene-3,12-dione, stigmast-4-ene-3,6-dione, stigmastane-3,6-dione and hecogenin (steroid sapogenin). Several of these compounds have anti-inflammatory and anti-allergic properties.

The aerial parts of *P. minor* contain the flavones 6,7-methylenedioxy-5,3′,4′,5′-tetramethoxyflavone and 6,7,4′,5′-dimethylenedioxy-3,5,3′-trimethoxyflavone. Extracts showed antimicrobial activity against Gram positive bacteria (*Bacillus cereus*, *B. megaterium*) and Gram negative bacteria (*Escherichia coli*, *Pseudomonas aeruginosa*), and antifungal activity against *Aspergillus ochraceus* and *Cryptococcus neoformans*. Other in vitro effects include cytotoxic activity against human cervical carcinoma, and antiviral activity against the herpes simplex type-1 and vesicular stomatitis virus.

Description Annual or perennial herbs, rarely erect, ascending or climbing shrubs, stems jointed. Leaves alternate, simple, linear, lanceolate to broadly ovate or hastate, with well-developed amplexicaul ocrea, upper margin often with bristles. Inflorescence a terminal or axillary spike, raceme or panicle or flowers solitary in bracts. Flowers actinomorphic, bisexual, small, perianth segments 5, venation trifid, pink or white, accrescent and juicy after anthesis or not; pedicel short, jointed; stamens 6–9, filaments filiform, free or connate at base; interstaminal nectaries present; ovary superior, 1-ovulate, styles 2–3, stigmas capitate. Fruit a nutlet, lenticular or trigonous, nearly covered by persistent perianth; embryo curved on one side of albumen. Seedling with epigeal germination.

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

Other botanical information *Persicaria* is a segregate from *Polygonum* s.l. and contains four sections: *Aconogonon*, *Bistorta*, *Persicaria*, and *Tovara*. Section *Persicaria* includes the former sections *Amblygonon*, *Cephalophilon* and *Echinocaulon*, as the characteristics used to differentiate these groups are not clear. The main characteristics distinguishing *Persicaria* from *Polygonum* are the tepals with trifid venation, interstaminal free or fused nectaries, and cylindrical and filiform filaments. *Persicaria* is considered the most advanced in the tribe *Persicarieae*.

The status of *P. minor* is not clear and needs to be studied further. It is supposedly close to *P. decipiens* (R.Br.) K.L. Wilson and *P. subsessilis* (R.Br.) K.L. Wilson, but has a different distribution area.

Ecology *Persicaria* species prefer humid growing conditions with half shade or full sunlight, some species preferring temperate climates, others tropical climates.

Propagation and planting *Persicaria* is propagated by seed, which is dispersed by water, and by stem or root cuttings.

Diseases and pests Slugs and caterpillars are the main problems in *Persicaria*. *P. chinensis* is also a host for the fungus *Colletotrichum capsici*.

Harvesting *Persicaria* plants are collected from the wild when needed.

Handling after harvest *Persicaria* plants, including the roots or rhizomes, can be sun-dried for later use.

Genetic resources and breeding *Persicaria* produces many seeds and grows where water is available. Therefore they are not likely to be threatened by genetic erosion. Neither germplasm collections nor breeding programmes are known to exist.

Prospects Little information is available about the phytochemistry and pharmacology of compounds of *Persicaria*. Further research is needed to fully investigate its potential.

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Selection of species

Persicaria barbata (L.) H. Hara

Fl. E. Himal.: 70 (1966).

Synonyms *Polygonum barbatum* L. (1753).

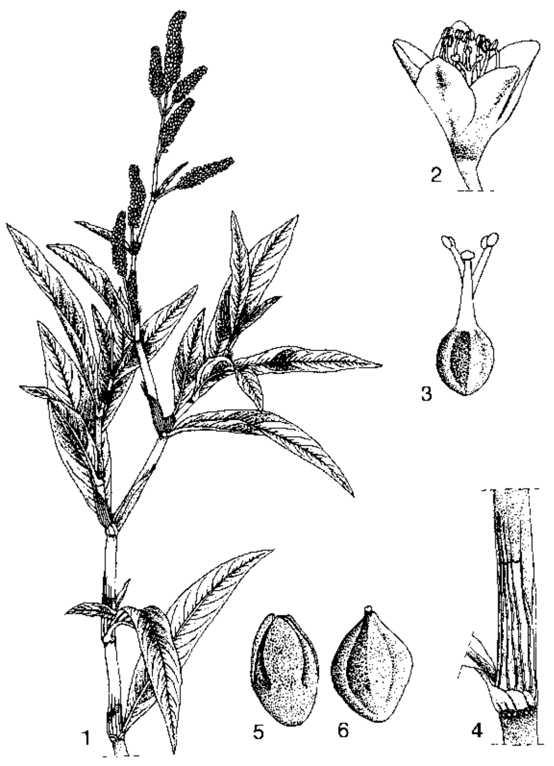
Vernacular names Indonesia: salah nyowo, mengkrengan (Javanese), jukut carang (Sundanese). Malaysia: tebok seludang, johong beraleh, panchis-panchis. Cambodia: kating he. Vietnam: ng[eer] tr[aws]ng, ng[eer] r[aa]u.

Distribution Widely distributed in the tropics and subtropics of Africa, extending to India, South-East Asia, Australia and Micronesia.

Uses In Java, the whole plant is used as a fish poison. In northern India, the dried rhizome is employed as an astringent and cooling medicine. In Vietnam, the seeds are used against dysentery and cholera.

Observations A robust, rhizomatous, perennial herb, 40–80 cm tall, stems creeping to ascending to erect, loosely branched, glabrous or appressed pubescent; leaves oblong to lanceolate, 8–15 cm × 1.5–3 cm, base acute, rarely rounded or cordate, apex acuminate, often with a brown blotch, appressed pubescent on either surface, at least on the veins, or glabrous above, petiole short, ocrea tubular, appressed pubescent, bristles on upper margin 1.3–2 cm long; pseudo-spikes 2–8 at the top of the stems, long cylindrical, dense or lax, at least the longer ones 3 times longer than thick, 2–6 cm long, older ones 7–8 mm thick, at least lower ones peduncled, bracts obconical, ciliate, appressed pubescent or glabrous, 3–5-flowered; flowers 2–3.3 mm long, white, greenish white or pink, not accrescent after anthesis, stamens 6–7, styles 3; nutlet trigonous, 1.7 mm long, black, shining. *P. barbata* is common in soggy sunny localities along rivers and ditches, from sea-level up to 1200 m altitude.

Selected sources 74, 237, 455, 602, 788, 914, 951.



Persicaria barbata (L.) H. Hara – 1, flowering stem; 2, flower; 3, pistil; 4, ocrea; 5, fruit in perianth; 6, fruit.

Persicaria chinensis (L.) H. Gross

Bot. Jahrb. Syst. 49(2): 269 (1913).

Synonyms *Polygonum chinense* L. (1753).

Vernacular names Chinese knotweed (En). Malaysia: pokok semuloh. Laos: sam koi. Vietnam: m[is]a b[er]m, m[is]a mung, th[oof]m l[oof]m.

Distribution Widely distributed in the subtropical regions of India to East and South-East Asia.

Uses In Indonesia, the juice of the plant is employed in the treatment of eye diseases. A poultice is applied to the abdomen for stomach-ache. In Vietnam, a decoction of the plant is used as a depurative. Externally, it is used to treat eczema of the ears.

Observations A glabrous perennial herb, 0.3–6 m long, stem often very long and climbing and drooping, ridged, often woody at base; leaves broadly ovate to oblong, 3–10 cm × 1–5 cm, base rounded, truncate to subemarginate, apex acute to abruptly acuminate, margins often crispate, glabrous or pubescent, petiole 1.5–2 cm long, often with rounded, amplexicaul basal auricles, auricles of highest petioles attached to leaf blade, ocrea 1–2 cm long, membranaceous, glabrous, truncate, veined; corymbs or panicles widely branched, pseudo-spikes usually numerous, 3–7 mm long, 10–20-flowered, bracts 1–3, pedicel subequalling the perianth, glandular; flowers 3–4 mm long, heterodistylous, white or pink, accrescent and fleshy after anthesis, styles 3; nutlet trigonous, subglobose, 2–2.5 mm long, bluish-black, dull. *P. chinensis* is very common in brushwood, forest borders, open forest, riverbanks, and tea- and Cinchona-plantations in the whole of Indo-China, from 250–3300 m altitude. On mountain tops often small and erect.

Selected sources 74, 237, 455, 736, 788, 914.

Persicaria minor (Huds.) Opiz

Seznam: 72 (1852).

Synonyms *Polygonum minus* Huds. (1762).

Distribution Spread widely throughout Europe and temperate and tropical Asia.

Uses In Peninsular Malaysia, a decoction of the leaves is taken for indigestion. In Java, the leaves are sometimes eaten as a vegetable.

Observations An annual to perennial, decumbent or ascending herb, 10–30(–40) cm tall, rooting at the base, stems branched, especially below, spreading, slender, glabrous; leaves ovate-lanceolate to linear-lanceolate, 2–7 cm × 0.3–1 cm, apex acute to subobtuse, appressed hairy on midrib beneath, subsessile, ocrea tubular, truncate, 0.5–1.2 cm long, short ciliate; inflorescence consisting of 1–3 terminal or axillary spikes or pseudospikes, slender, erect, 1.5–5 cm × 0.5 cm, dense or interrupted; bracts 2–2.5 mm long, obtuse, ciliate, perianth minute, pink, rarely white; nutlet ovoid or ellipsoid, 1–2.5 mm long, biconvex, shiny black or brown. *P. minor* occurs in humid or soggy localities and along water sides, in fallowed rice-fields, from 550–2200 m altitude.

Selected sources 455, 838, 1022.

Nguyen Thi Do

Phaeanthus Hook.f. & Thomson

Fl. ind. 1: 146 (1855).

ANNONACEAE

$x = 9$; *P. ebracteolatus*: $2n = 18$

Major species *Phaeanthus ebracteolatus* (C. Presl) Merr., *P. splendens* Miq.

Vernacular names Indonesia: pisang-pisang (used for most *Annonaceae*). Malaysia: mempisang (used for most *Annonaceae*). Vietnam: thu-[oos]c th[uw][owj]ng.

Origin and geographic distribution *Phaeanthus* consists of eight species and occurs in tropical and subtropical regions of South-East Asia. The species are distributed from Vietnam, Peninsular Malaysia, Sumatra, Borneo, Sulawesi, the Lesser Sunda Islands, the Moluccas, New Guinea and the Philippines.

Uses The inner bark or the leaves of *P. ebracteolatus*, *P. splendens* and *P. vietnamensis* are a traditional medicine for sore eyes. *P. splendens* is used in folk medicine to lower blood pressure.

A solution of the quaternary alkaloids, total fluid extracts as well as tinctures of *P. ebracteolatus* similarly have been shown to produce an important pharmacodynamic effect, lowering blood pressure and relaxing smooth muscles. The quaternary alkaloids in aqueous or alcoholic solution depress the smooth muscles, especially of the blood vessels, and as a result blood pressure falls. Sufficiently large doses also depress the intestine, the enterine tracheal muscles and uterus.

The wood of *Phaeanthus* is used for light house construction and the bark is used for tying purposes.

Production and international trade *Phaeanthus* is mainly used on a local scale.

Properties Two bisbenzylisoquinoline alkaloids have been isolated from the bark of *P. ebracteolatus*. The first is a tertiary nonphenolic crystalline, called phaeanthine, which is similar to oxyaeanthine and berbamine. This compound has been credited with anti-tuberculotic effects. The second, a quaternary alkaloid, was named phaeantharine. A solution containing only phaeantharine has practically the same effect as a solution of the bark, i.e. direct depression of the smooth muscles in vascular, intestinal, tracheal and uterine preparations. The most prominent effect of moderate or large doses of the alkaloid solution, hypotension, is partly attributed to a depression of the heart, together with the direct vasodilating action of phaeantharine. With sufficient large doses it also depresses the intestine, tracheal muscles and uterus, and is able to counteract the stimulant effects produced by pilocarpine and histamine in the excised uterus. The fall in blood pressure was of longer duration than that produced by nitroglycerine and acetylcholine, two well-known drugs that lower the blood pressure. With fatal doses, respiration was first increased then decreased and stopped. Blood pressure fell to zero through cessation of the heart beat a few minutes after the failure of respiration. When artificial respiration was applied the heart kept beating and after some time blood pressure increased again. On the basis of these effects, both phaeanthine and phaeantharine are said to be similar to the curare alkaloids.

Furthermore, phaeantharine also has a potent larvicidal effect in mosquitoes, due to ganglionic blocking action, cholinesterase inhibition and a neuromuscular blockade. It has no effect on the pupae and adult stages. Being water-soluble it can be dissolved easily in water where mosquitos breed.

Another tertiary alkaloid in the form of crystals has now also been isolated and given the name kalimatine. All three compounds from *P. ebracteolatus*, phaeanthine, phaeantharine and kalimatine, can also be extracted from the leaves.

Limacine and phaeanthine isolated from *P. splendens* show a certain degree of antibacterial activity against both gram-negative and gram-positive bacteria. Phaeanthine and limacine were active against *Streptococcus faecalis*, *Streptococcus pneumoniae*, and *Escherichia coli*, whereas phaeanthine was also active against *Staphylococcus aureus*.

The alkaloid extract of the leaves of *P. vietnamensis* contains monomeric and dimeric isoquinoline alkaloids, and exhibits anti-microbial activity. The main alkaloid 1S,1'R-(-)-7,7'-O,O'-dimethylgrisabine showed a potent in vitro activity against *Bacillus subtilis*.

Adulterations and substitutes Certain plant families such as the *Menispermaceae* are well-known for the presence of (bis-)benzylisoquinoline alkaloids. It is therefore very possible that the alkaloids present in *Phaeanthus*, or closely related compounds, are also available in members of this family. Examples of these are phaeanthine, which is also present in *Triclisia patens* Oliv. from Africa, and limacine, which can be isolated from several species, including *Cyclea barbata* Miers.

Description Shrubs or trees up to 25 m tall; branches often glabrescent, but sometimes also glabrous. Leaves distichous, simple and entire, obovate to elliptical, papyraceous to coriaceous, base obtuse to cuneate, apex acuminate, pinnately veined with tertiary veins not very clear, often turning black when dried; petiolate; stipules absent. Inflorescence extra-axillary or sometimes terminal, cymose. Flowers solitary or up to 4 together on short, bracteolate peduncle, bisexual, 3-merous with 3 free valvate sepals and two dissimilar whorls of 3 free valvate petals, outer petals sepal-like, inner petals triangular with a broad base and occasionally a glandular-like spot at the base; stamens many, truncate with very short filament and flat connective prolongation that usually covers the thecae; anthers 2, extrorse; carpels many, cylindrical, pubescent, style short or absent, stigma ellipsoidal or club-shaped, ovules 1–2. Fruit a berry-like monocarp, many (up to 30), ellipsoidal to globose, black when dry, stipitate. Seeds 1–2, ellipsoidal, with lamellate ruminations in 4 parts, seed coat papyraceous.

Growth and development *Phaeanthus* can be found flowering and fruiting throughout the year. The flowers may be pollinated by small flies and beetles. These insects are probably attracted by the sweet apple-like smell of the flowers. Birds may disperse the monocarps as they mature from green to dark red (purple).

Other botanical information The classification within the *Annonaceae* is still not resolved. According to a recent classification based on a phenetic analysis of both flower and fruit characters of *Annonaceae* from all over the world, *Phaeanthus* is placed in the same informal group as *Annickia* (African), *Enicosanthum* (Asian), *Ephedranthus* (South American), *Malmea* (South American), *Marsypopetalum* (Asian), *Neo-uvaria* (Asian), *Pseudephedranthus* (South American), *Trivalvaria* (Asian), and *Woodiellantha* (Asian). In another classification, *Phaeanthus* was doubtfully placed in a large group which also includes the Asian genera *Anomianthus*, *Fissistigma*, *Friesodielsia*, *Goniothalamus*, *Melodorum*, *Mitrella*, *Mitrephora*, *Neo-uvaria*, *Oreomitra*, *Papualthia*, *Petalolophus*, *Popowia*, *Pseuduvaria*, *Pyramidanthe*, *Richella*, *Schefferomitra* and *Trivalvaria*. The nomenclature of *P. nutans* remains somewhat unclear as at this moment it can not be proven that *Uvaria ophthalmica* Roxb. belongs to the genus and/or has been used by Hooker and Thomson to describe the genus.

Ecology *Phaeanthus* species are understorey shrubs or trees in primary or secondary lowland forest, and sometimes freshwater swamp. They may occur on steep hills, in particular on ridges, along riversides and in open locations, on various soils, up to 800 m altitude.

Propagation and planting *Phaeanthus* is rarely planted. Initial trials with cuttings of *P. ebracteolatus* proved rather disappointing.

Harvesting Leaves of *Phaeanthus* are plucked whenever the need arises. Strips of bark are simply cut and torn from the trunk.

Yield Fresh leaves of *P. splendens* may yield 0.72% crude alkaloids consisting of 0.09% limacine and 0.03% phaeantine. Total crude alkaloids found in the stem bark amount to 0.78%. In dried plant material of *P. vietnamensis* the content of the main alkaloid, 1S,1'R-(–)-7,7'-O,O'-dimethylgrisabine, is 0.01%.

Handling after harvest After stripping the bark of *P. ebracteolatus* the inner bark is scraped off into very thin pieces, placed in a glass containing a little clean water, and later filtered. The liquid is used as drops. The scrapings or shavings left over, packed in a banana leaf, heated, cooled and then squeezed, can be used again in the same manner.

Genetic resources and breeding Most *Phaeanthus* species treated here are widely distributed and may even occur in disturbed forest. This may indicate that they are not very liable to genetic erosion. *P. vietnamensis* is not widely distributed and since it is confined to primary forest, it is more liable to genetic erosion.

Prospects Although several alkaloids have been detected in *Phaeanthus* several still need to be isolated and identified, and their specific properties assessed. Several alkaloids, however, show interesting pharmacological properties, which might be of interest in future medicine (muscle relaxant, vasodilatating effects), medical research (tuberculosis, anti-microbial) or in agriculture (anti-microbial, larvicidal).

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Selection of species

Phaeanthus ebracteolatus (C. Presl) Merr.

Philipp. Journ. Sci., Bot. 3: 225 (1908).

Synonyms *Phaeanthus cumingii* Miq. (1858), *Phaeanthus macropodus* (Miq.) Diels (1912), *Phaeanthus nigrescens* Elmer (1913).

Vernacular names Papua New Guinea: bien (Kebar). Philippines: kalimatas (Tagalog), takulau (Iloko), lapnisan (Bisaya).

Distribution The Philippines, Brunei, Sabah, East Kalimantan, Sulawesi, the Lesser Sunda Islands, the Moluccas, Kai Islands, Aru Islands, Papua and Papua New Guinea.

Uses A soluble extract from the bark is well-known as a treatment for sore eyes. In traditional medicine the extracts are also used as an anti-spasmodic as well as to cure ulcers and small wounds.

Observations A shrub or tree up to 20 m tall, trunk up to 35 cm in diameter; leaves obovate to elliptical, 7.4–25.3 cm × 2.6–10 cm, the midrib with 9–14 pairs of anastomosing veins; cymes sometimes reduced to one axis; flowers solitary or 3(–4) together, sepals and outer petals 0.8–1.5 mm long, inner petals 1.2–2.9 cm long, stamens 40–80, carpels 30–50, style absent; monocarps 15–30, 11–17 mm × 7-10 mm, glabrous, stipe 1.3–2.6 cm

Phaeanthus ebracteolatus (C. Presl) Merr. – 1, flowering twig; 2, flower; 3, flower with one inner petal removed; 4, infructescence.

long, green to yellow to orange when immature becoming dark red to purple when ripe. The extreme forms within *P. ebracteolatus* differ morphologically quite a lot; this might be an indication of some ongoing speciation. *P. ebracteolatus* is common in primary and secondary lowland forest, on steep hills, especially ridges, on river banks and in open locations, on various soils up to 800 m altitude.

Selected sources 20, 128, 149, 241, 478, 522, 786, 810, 865, 1031.

Phaeanthus splendens Miq.

Ann. Mus. Bot. Lugd.-Bat. 2: 40 (1865).

Synonyms *Phaeanthus crassipetalus* Becc. (1871), *Phaeanthus lucidus* Oliver (1887).

Vernacular names Indonesia: pisang-pisang. Malaysia: mempisang (Peninsular), semukau (Malay, Iban, Sarawak).

Distribution Peninsular Malaysia, Singapore, Sumatra, Bangka and Borneo.

Uses In Sabah, the plant is used by local communities to reduce blood pressure. In Sarawak, the bark is used for making shoulder straps and the wood is used for beams.

Observations A shrub or tree up to 25 m tall, trunk up to 29 cm in diameter; leaves obovate to elliptical, 8.5–23.6 cm × 2.5–9.2 cm, the midrib with 9–13 pairs of anastomosing veins, shiny; cymes reduced to one axis; flowers solitary or 2(–3) together, sepals and outer petals 1–2 mm long, inner petals 0.9–1.7(–2.6) cm long, 1.5–2.3 mm thick, stamens 60–80, connective prolongation not spread over edges and thecae, carpels 30–50, style absent; monocarps (2–)6–15, 19–30 mm × 11–14 mm, glabrous, stipe 1.7–2.8(–3.3) cm, dark red to purple when ripe. *P. splendens* occurs in primary and secondary lowland forest and freshwater swamp, on steep slopes, especially ridges, on various soils up to 550 m altitude. It is common in Borneo, relatively rare in Peninsular Malaysia.

Selected sources 299, 466, 522, 550, 1031.

Phaeanthus vietnamensis Bân

Fl. Vietn. 1: 170 (2000).

Vernacular names Vietnam: thu[oos]c th[uw][owj]ng, thu[oos]c d[aas]u c[af] doong, da x[af] l[aws]c.

Distribution Endemic to Vietnam.

Uses Aqueous extracts of the leaves have been used in Vietnamese folk medicine in the treatment of non-specific conjunctivitis and gastro-intestinal disorders, and for disinfection of wounds.

Observations A shrub; leaves obovate to elliptical, 4.8–20.7 cm × 2.1–7.3 cm, the midrib with 10–14 pairs of anastomosing veins; cymes reduced to one axis; flowers solitary, sepals and outer petals 1–1.8 mm long, inner petals 0.7–1.2 cm long, stamens 80–95, carpels 10–15, style absent; monocarps (2–)10–20, 14–18 mm × 7–9 mm, glabrous, stipe 1.7–2.4 cm long. *P. vietnamensis* is widely distributed in primary forest, on clay or rocky soils up to 600 m altitude.

Selected sources 886.

N.O. Aguilar & J.B. Mols

Phyla nodiflora (L.) Greene

Pittonia 4: 46 (1899).

VERBENACEAE

$2n = (32), 36$

Synonyms *Verbena nodiflora* L. (1753), *Phyla chinensis* Lour. (1790), *Lippia nodiflora* (L.) Michx. (1803).

Vernacular names Lippia, frog fruit, cape weed (En). Philippines: busbusi (Iloko), chachahan (Tagalog), sirik puyo (Bisaya). Cambodia: man am ca dam. Thailand: yaa klet plaa (central). Vietnam: d[aa]y l[uws]c, s[af]i d[aas]t gi[ar].

Origin and geographic distribution *P. nodiflora* is found in tropical and subtropical areas throughout the world.

Uses In the Philippines, an infusion of the leaves and tops of *P. nodiflora* is employed as a carminative and diuretic. In traditional Indian medicine the plant is considered emollient, a febrifuge and diuretic. A poultice of the fresh plant is applied to ripen boils. A paste or poultice is further applied to swollen cervical glands, to erysipelas, burns, and to chronic indolent ulcers. It is said to be useful in the treatment of blenorrhoea, lithiasis, ischuria, constipation and pain in the knees. An infusion is drunk as a post-partum tonic. An infusion of the fresh whole plant or the root is used in the treatment of fever, whereas in Nepal plant juice is applied for the same purpose. In Nepal, fresh juice from roots or aboveground parts and in Iran dried whole plants are used for minor gastro-intestinal complaints. The plant parts are applied as a gastric stimulant and as an astringent also against ulcers. In Iran an infusion is used as an anthelmintic. In Vietnam, the leaves are used in treating bronchitis and other respiratory ailments, and a similar use is reported for some areas in India. In the Philippines, an infusion of the leaves is drunk as a substitute for tea. It is valued as a lawn plant where grass is too difficult to maintain, as it makes an excellent ground cover, withstanding walking and trampling very well. It can be used to control water and wind erosion. Locally it is an important nectar plant for honeybees.

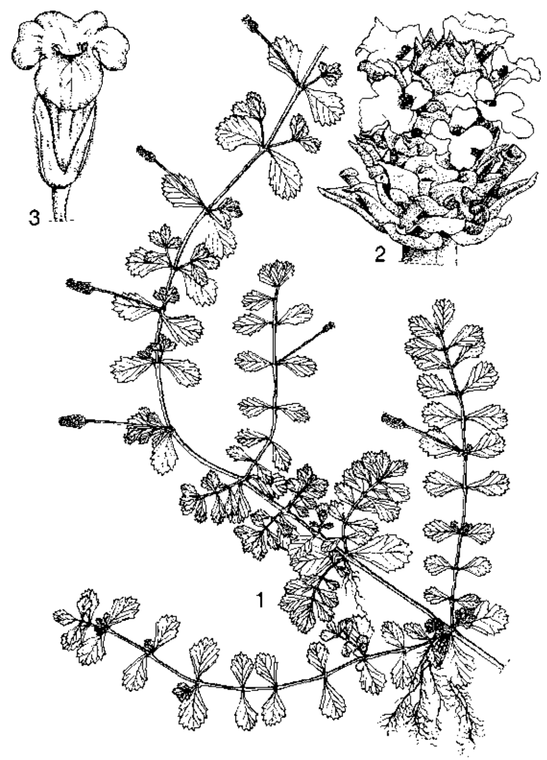
Production and international trade *P. nodiflora* is only used on a local scale.

Properties *P. nodiflora* plants contain an essential oil. Steam volatile compounds include monoterpenes such as carvacrol, thymol, p-cymene, β-ocimene, β-pinene and γ-terpinene, and sesquiterpenes e.g. β-caryophyllene, β-bisabolene and δ-cadinene. Further characteristic compounds are benzenoids, e.g. phenylacetaldehyde, benzaldehyde, benzyl alcohol, 2-phenethyl alcohol and methyl salicylate, and alkanes like octan-3-ol, 2,6-dimethyl-octane.

Phytochemical investigations have revealed the presence of many flavonoids in several parts (aerial parts, leaves, flowers): batatifolin, lippiflorin-A and -B, nodifloridin-A and -B, nodifloretin-A and -B, and derivatives of 6-hydroxyluteolin, hispi-

dulin, jaceosidin and nepetin. Many flavonoids occur as sulphated derivatives in the plant material. Other characteristic phytochemical compounds include the phenylpropanoid verbascoside, and the quinoid cornoside.
A methanolic extract of the dried aerial parts of *P. nodiflora* was active against *Mycoplasma phlei* at a concentration of 1 mg/disk using an in vitro assay. However, in several other assays, no antimicrobial activity could be detected against several strains of yeasts, mycoplasma or some pathogenic bacteria.
Petroleum ether, ethanolic or water extracts of the dried leaves of *P. nodiflora* were tested for anti-inflammatory- or analgesic activity in vivo. In rats, the petroleum ether-extract, at an oral dose of 0.5 g/kg, showed anti-inflammatory activity after induction of pedal oedema with carageenin, and anti-pyretic activity after induction of pyrexia with yeast suspension. Also a decoction of the plant displayed significant anti-pyretic activity using the latter model. In addition, the aqueous extract displayed analgesic activity in mice undergoing the hot-plate- and acetic acid-induced writhing assays.
Other pharmacological effects of hydroethanolic extracts include antispasmodic activity in vitro on the isolated guinea-pig ileum, and in vivo antitumour activity against P-388 cells transplanted in mice. No cytotoxicity could be detected, however, against CA-9KB cells cultured in vitro. A methanolic extract of the dried whole plants also showed no toxic effects against Vero cells, but partially inactivated herpes simplex virus-1 at a concentration of 200 μg/ml. Furthermore, an ethanol extract was active as an anthelmintic; it caused paralysis in human roundworms, *Ascaris lumbricoides*, within 18 hours of application.
Extracts of *P. nodiflora* are considered to be very safe. LD_{50} values reported in the literature include > 10 g/kg orally and > 1 g/kg intraperitoneally for an ethanol extract in mice.

Description A perennial creeping herb, stems prostrate, mostly rooting at the nodes, (10–)30–90 cm tall; branches slender, procumbent or ascending, densely appressed strigillose, to puberulent or glabrescent. Leaves decussate, variable, spathulate to obovate or elliptical, 1–7 cm × 0.6–2.5 cm, base long- or short-cuneate, apex rounded or obtuse, margin basally entire, sharply serrate above the middle, variably strigillose puberulent to glabrous on both surfaces, fleshy; petiole 2–8 mm long or absent; stipules absent. Inflorescence axillary, at first globose-capitate, later cylindrical, often elongating in age, 1–2.5 cm × 0.5–1 cm long when mature, densely many-flowered; peduncle 1–11.5 cm long, bracteolate. Flowers sessile, subtended by a bract, calyx deeply 2-cleft, up to 2 mm long, corolla purple or pink to white, the mouth often yellow and the throat pink-brown, the tube slightly exserted from the calyx, 4-lobed, the lobes subequal, the lower lobe larger and bifid, stamens 4, didynamous, included or slightly exserted; ovary superior, 2-locular, 1 ovule per locule, stigma capitate. Fruit a drupe, dry, globose to oblong, flattened, 1.5–2 mm long, at maturity dividing into 2 planoconvex pyrenes.



Phyla nodiflora (L.) Greene – 1, habit; 2, inflorescence; 3, flower.

Growth and development *P. nodiflora* flowers and fruits throughout the year.

Other botanical information *Phyla* comprises some 10–20 species and is widely distributed in subtropical and tropical America, and only 1 or 2 species are found in the Old World tropics.

Ecology *P. nodiflora* is found on a wide range of soils but prefers well-drained sandy soils and is often encountered bordering waterways and near the sea. It can be a common weed in open, waste places at low and medium altitudes.

Propagation and planting *P. nodiflora* is propagated by seed or division.

Husbandry *P. nodiflora* can be grown in full sun or partial shade. Flowers are most abundant when grown in full sun.

Diseases and pests *P. nodiflora* is susceptible to the fungi *Cercospora lippiae* and *Meliola durantae*.

Harvesting In general *P. nodiflora* is harvested whenever the need arises. Leaves and flowers are in general present throughout the year.

Handling after harvest Plant parts of *P. nodiflora* are usually used fresh but roots and aboveground parts may well be dried for future use.

Genetic resources and breeding *P. nodiflora* is widespread and common throughout South-East Asia, and therefore not endangered.

Prospects Interesting anti-inflammatory and analgesic effects of *P. nodiflora* extracts are reported from the literature. Furthermore, a reasonable amount of phytochemical data is available. More research will be needed, however, especially to investigate possible links between pharmacology and phytochemistry, in order to evaluate its potential for future developments.

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Other selected sources 73, 74, 135, 501, 696, 739, 810, 992, 1007.

Wongsatit Chuakul, Noppamas Soonthornchareonon, Orawan Ruangsomboon.

Phyllodium Desv.

Journ. Bot. appl. 1: 123, t.5, fig. 24 (1813).
LEGUMINOSAE
$x = 11$; *P. elegans*, *P. pulchellum*: $2n = 22$

Major species *Phyllodium pulchellum* (L.) Desv.

Vernacular names Thailand: kaa saam peek, klet plaa.

Origin and geographic distribution *Phyllodium* comprises 7 species and is found in southern Asia and northern Australia; 2 species are present in Malesia.

Uses *P. pulchellum* is used as a post-partum treatment in Peninsular Malaysia and Laos. In Indonesia and the Philippines, the leaves are externally applied on pockmarks and ulcers. A decoction of the roots of *P. elegans* (Lour.) Desv. and *P. pulchellum* as well as *P. longipes* (Craib) Schindler, occurring in Burma (Myanmar), southern China, Thailand and Indo-China, is used in Thailand to relieve liver dysfunctions, as well as in the treatment of some psychotic symptoms, including delirium, fibrillation and weight loss, believed to be caused by black magic. In Laos, the leaves of *P. kurzianum* (O. Kuntze) Ohashi, occurring in southern China, Burma (Myanmar), Laos and Vietnam, are used as a substitute for tea. The leaves of *P. vestitum* Benth., occurring in Burma (Myanmar), Thailand and Indo-China, are used in veterinary medicine in Cambodia to cure wounds.

Properties Phytochemical investigation of *P. pulchellum* revealed the presence of some 15 indolic bases in various parts of the plant, representing three broad structural types: indole-3-alkylamine, β-carboline and tetra-β-carboline. The content of N,N-dimethyltryptamine, a key intermediate in the metabolism of tryptophan in plants, gradually depleted as the congener bases appeared and accumulated in the different parts of the plant. The major accumulation of the N_b-oxides has been observed in the fruits, while the quaternary bases have been localized in the roots.

Description Erect shrubs up to 3 m tall. Leaves alternate, 3-foliolate; petiolate; stipules broadly or shallowly triangular, long-acuminate or cuspidate at apex. Inflorescence racemose, composed of 4–8 flowered fascicles, enclosed by a persistent foliaceous primary bract, petiolate, stipulate, 2-foliolate with a terminal bristle, secondary bracts present at the base of peduncle. Flowers papilionaceous, with two bracteoles present at the base of the calyx; calyx campanulate, 4-lobed, pubescent; corolla standard obovate, clawed or tapering at the base, rounded or emarginate at apex, wings narrowly elliptical, clawed, smaller than the keel petals, keel petals more or less arcuate, fused along the dorsal margins, long-clawed, auriculate at the base; anthers 10, monadelphous but weakly connate; ovary surrounded by a minute disk. Fruit a sessile pod, (1–)2–7-jointed, upper suture shallowly undulate, lower suture more deeply incised, often possessing a long stylar beak, articles broadly oblong to quadrangular. Seed suborbicular to subelliptical, rim-arillate with a ring-like thickening around the hilum.

Growth and development In Java, *P. elegans* flowers and fruits from November–July and *P. pulchellum* from February–June. *P. pulchellum* possesses nodulating ability.

Other botanical information *Phyllodium* is clearly distinguished from allied genera of the tribe *Desmodieae* by its persistent foliaceous primary bracts enclosing a fascicle, the very broadly or shallowly triangular persistent stipules with a long-acuminate or cuspidate apex, the 4–8-flowered fasciculate inflorescences enclosed by the primary bracts, the arcuate keel petals which are larger than the wings, the ovary surrounded by a small disk, the small pods and pollen characteristics. Some confusion exists regarding *P. elegans* from Java, which sometimes has significantly larger primary bracts and more flowers per fascicle.

Ecology *P. elegans* and *P. pulchellum* are found in rather dry open habitats ranging from teak forest, thickets and dry fallow to grassy fields.

Harvesting Leaves or whole plants of *Phyllodium* are simply collected from the wild whenever the need arises.

Genetic resources and breeding The Centro Internacional de Agricultura Tropical (CIAT) in Colombia keeps a total of 21 accessions of *P. pulchellum* from Indonesia, Papua New Guinea, the Philippines, Thailand and Vietnam, 12 accessions of *P. elegans* from Indonesia and 2 accessions of *P. longipes* from Thailand.
Grazing trials indicated that *P. pulchellum* is highly unpalatable.

Prospects Very little information is available on the phytochemical and pharmacological properties of *Phyllodium* species. More research is needed to fully evaluate its possibilities.

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Selection of species

Phyllodium elegans (Lour.) Desv.

Mém. Soc. Linn. Paris 4: 324 (1825).

Synonyms *Hedysarum elegans* Lour. (1790), *Desmodium elegans* (Lour.) Benth. (1861) non DC. (1825), *Desmodium blandum* van Meeuwen (1962).

Vernacular names Cambodia: bang kuöy, praè kraôy. Thailand: klet plaa mo (eastern), kaa saam peek klaang. Vietnam: v[ar]y t[ee] t[ee], v[ar]y [r[oof]ng.

Distribution Southern China, Indo-China, Thailand, Java and Madura.

Uses A decoction of the roots is used in Thailand to relieve liver dysfunctions as well as in the treatment of some psychotic symptoms, including delirium, fibrillation and weight loss, believed to be caused by black magic. In Cambodia, the roots are employed in folk medicine to cure oedema in newborns. In Vietnam, an infusion of the flowers is used to cure respiratory ailments; leafy branches are used for lining chicken nests.

Observations A shrub up to 2 m tall, branches slightly angular, pubescent; leaves 3-foliolate, petiole about 10 mm long, stipules triangular, 3–5 mm × 2–3.5 mm, rachis 5–10 mm long, terminal leaflet ovate, elliptical to obovate, 4–16 cm × 3–7 cm, obtuse or rounded at the base, obtuse or emarginate at apex, lateral leaflets asymmetrical, 2–7 cm × 2–6 cm, base rounded or subcordate; raceme 10–50 cm long, composed of 5–9-flowered fascicles, lateral leaflets of bracts 1–2 cm × 0.8–2 cm, corolla white, standard obovate, 6–7 mm × 3–4.5 mm, pistil 8–10 mm long; pods narrowly oblong, (4–)10–12(–15) mm × 3–4 mm, densely tomentose, not reticulate-veined, (1–)2–3(–4)-articled, articles subquadrangular, 3–4 mm long; seed transversely elliptical, 1.8–2 mm × 2.2–2.5 mm. *P. elegans* is found on a wide range of soils from calcium-rich clay, red soils to sand, in habitats ranging from rather open old forest, secondary growth, dry grassy fields to cattle ground, and rice fallow, up to 600(–1600) m altitude.

Selected sources 47, 74, 201, 547, 749.

Phyllodium pulchellum (L.) Desv.

Journ. Bot. appl. 1: 123, t. 5, fig. 24 (1813).

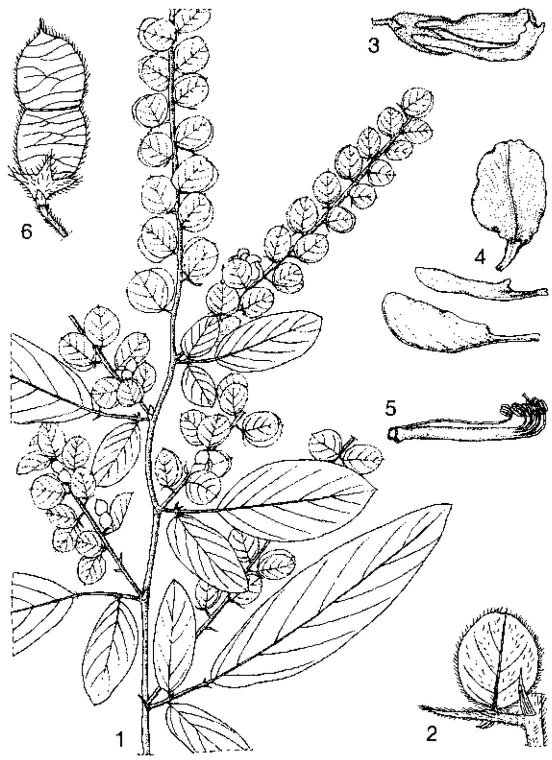
Synonyms *Hedysarum pulchellum* L. (1753), *Desmodium pulchellum* (L.) Benth. (1861)

Vernacular names Indonesia: apa-apa, apa-apa sapi, ketipes (Javanese). Malaysia: serengan kechil (Peninsular). Philippines: gaan-gaan (Sulu), kalaikai (Cebu), payang-payang (Tagalog). Cambodia: âng-prôm, praè kraôy. Laos: kéd linz no:yz (Vientiane). Thailand: klet plaa chon, yaa song plong (central), yaa klet lin (northern, peninsular). Vietnam: chu[oox]i ti[eef]n, d[oof]ng ti[eef]n.

Distribution From India, Sri Lanka, southern China, Taiwan and the Ryukyu Islands throughout South-East Asia, northern Australia and the Solomon Islands.

Uses A decoction of the roots is administered in Peninsular Malaysia as a post partum protective medicine for mothers. In Indonesia and the Philippines, the leaves are externally applied to pockmarks and ulcers. In Laos, the whole plant is used in a post-partum treatment. In Thailand, a decoction of the roots is used to relieve liver dysfunctions, and also in the treatment of some psychotic symptoms, including delirium, fibrillation and weight loss, believed to be caused by black magic. In southern China, the plant is used to treat rheumatic fevers, to cure toothache, to help dissolve internal blood clots and is also considered a remedy for convulsions in infants. In India, a decoction of the bark is used in haemorrhages, as an antidote to poisoning, in diarrhoea and to cure eye diseases. The flowers are used in biliousness.

Observations A shrub up to 2.5 m tall, branches slender, terete, pubescent; leaves 3-foliolate, petiole 6–10 mm long, stipules narrowly triangular, 6–8 mm × 2–3 mm, rachis 10–20 mm long, terminal leaflet ovate, elliptical or obovate, (2.5–)6–9



Phyllodium pulchellum (L.) Desv. – 1, flowering and fruiting twig; 2, detail of floral bracts; 3, flower; 4, details of corolla; 5, staminal column with pistil; 6, pod.

(–17) cm × (1.5–)3–5(–7) cm, obtuse or rounded at the base, emarginate to acuminate at apex, margin shallowly undulate, lateral leaflets similar, (1–)3-5(–8) cm × (1–)2–3(–5) cm, base asymmetrical; raceme 7–55 cm long, composed of 5–6-flowered fascicles, lateral leaflets of bracts orbicular, 8–15 mm × 7–13 mm, corolla white or pale yellow, standard obovate, 5–6 mm × 3–4 mm, pistil 6–7 mm long; pods oblong, 7–8(–12) mm × 3–5 mm, sparsely hairy, reticulate-veined, (1–)2(–3)-articled, articles suborbicular or quadrangular, 3–4 mm long; seed transversely elliptical or suborbicular, 2 mm × 2.2–2.8 mm. *P. pulchellum* is found in teak forest, thickets, dry grassy fields, sometimes along watercourses up to 900(–1600) m altitude.

Selected sources 47, 74, 201, 215, 407, 547, 749, 786, 958, 1038.

Wongsatit Chuakul, Noppamas Soonthornchareonnon, Orawan Ruangsomboon.

Physalis L.

Sp. pl. 1: 182 (1753); Gen. pl. ed. 5: 85 (1754).
SOLANACEAE
$x = 12$; *P. angulata*: $2n = (24), 48$, *P. minima*: $2n = 48$

Major species *Physalis angulata* L., *P. minima* L.

Vernacular names Husk tomato, ground cherry (En). Coqueret (Fr).

Origin and geographic distribution *Physalis* consists of about 100 species, mainly distributed in tropical and temperate America, but some of the species have a worldwide distribution. *P. angulata* and *P. minima* are widely spread as weeds in the Old World, probably as post-Columbian introductions.

Uses In Malesia, *P. angulata* and *P. minima* have the same use. In Peninsular Malaysia and Java, the leaves are used for a poultice to treat headache, and an infusion is taken for intestinal pains and as an antihypertensive. The leaves are smeared with oil, gently heated, and applied to ulcers, or together with limestone powder to wounds and skin diseases. A decoction of the plant together with the leaves of *Plantago major* L. is taken to cure gonorrhoea, and as a diuretic. In Indonesia, the fruits are considered diuretic, alterative, purgative and aperient, and are used for curing epileptic attacks, dysuria, jaundice, bleeding gums, dropsy, urinary diseases, and gout. In Java and Thailand, the root is eaten as a vermifuge and an extract of the root is taken for fevers. In Sulawesi, an infusion of the herb is used to cure hepatitis, influenza, bronchitis, throat infections and orchitis. In the Philippines, a decoction of the roots is used to treat diabetes and hypoglycaemia. In the Solomon Islands, the seeds are reportedly a remedy for sterility. In Thailand, the dried whole plant of *P. minima* in decoction is taken as an antipyretic, diuretic and antidiarrhoeal, while the fresh whole plant is crushed with a little water and slowly swallowed for abscesses in the mouth or topically applied to swellings.
P. angulata is used to treat malaria in Peru, toothache in Puerto Rico, liver ailments and rheumatism in Brazil, and is considered a diuretic and relaxant. In Curaçao and Jamaica, the infusion of the plant used to be taken for gonorrhoea, and in Trinidad for indigestion, nephritis and fever.
The leaves and fruit of *P. angulata* are consumed raw in several countries, but are bitter. Eating too many of the fruits causes dizziness. In larger quantities the plant is poisonous to cattle and sheep, and it makes the meat smell like musk.
Several *Physalis* species are cultivated for their edible fruits, in particular *P. peruviana* L. (Cape gooseberry), *P. philadelphica* Lamk and *P. ixocarpa* Brot. ex Hornem. (Mexican husk tomato or tomatillo). *P. minima* is cultivated in India and South Africa for its edible fruits. *P. alkekengi* L. (Chinese lantern) is cultivated as an ornamental, for its bright orange husks, and is the only *Physalis* from the Old world.

Production and international trade Chinese herbalists in Peninsular Malaysia stock *Physalis* plants green, and the fruits in their husks are widely sold in local markets.

Properties Phytochemically, *P. angulata* and *P. minima* are well distinguished by the presence of several steroidal lactones, in general belonging to the physaline- and withanolide type. *P. angulata* contains the physalins A–I, as well as the withanolides physagulin A–G, withangulatin A and withanolide T, and several vitasteroids (sometimes also mentioned as withasteroids) e.g. vamonolide. *P. minima* contains the physalins physalin D, withaphysalin D and E, and dihydroxyphysalin B, and the withanolide withaminimin.
The pyrrolidine alkaloid phygrine (bis-hygrine) was isolated from the roots and aerial parts of both species, as well as from several other *Physalis*.
The isolated physalins B and F were found to inhibit the growth of several human leukaemia cells in vitro: K562 (erythroleukaemia), APM1840 (acute T lymphoid leukaemia), HL-60 (acute promyelocytic leukaemia), KG-1 (acute myeloid leukaemia), CTV1 (acute monocytic leukaemia) and B cell (acute B lymphoid leukaemia). In general, physalin F was found to be the most active one. Physalin F also showed cytotoxicity in vitro on 5 other human cancer cell lines, HA22T (hepatoma), HeLa (cervix uteri), KB (nasopharynx), Colo-205 (colon) and Calu-1 (lung), and 3 animal cancer cell lines, H1477 (melanoma), Hep-2 (laryngeal) and 8401 (glioma). The anti-hepatoma and anti-HeLa actions were found to be the strongest. In addition, physalin F had an antitumour effect in mice in vivo, against P388 lymphocytic leukaemia, whereas physalin D was inactive, both in vitro and in vivo.
Isolated withangulatin A, was found to be a topoisomerase II inhibitor in vitro, and a cytotoxic, capable of suppressing general protein synthesis and of inducing the synthesis of a small set of proteins, including those generated by heat-shock treatment, in vivo, in 9L rat brain tumour cells.

Vitanolides, isolated from the aerial parts of *P. angulata*, showed anti-inflammatory activity in rat and mice induced inflammation models, although they were less potent than hydrocortisone as reference. Furthermore, the crude leaf extract of *P. minima* contains hyperoside (quercetin-3-O-galactoside), which shows a marked anti-inflammatory activity in the rat paw oedema test.
Other biological effects of *Physalis* extracts include a marked activity against human African sleeping sickness, caused by *Trypanosoma brucei rhodesiense* by petroleum ether-, dichloromethane-, methanol- and water extracts from the aerial parts of *P. angulata*, as well as for cytotoxicity for the human fibroblast cell-line WI-38. The tincture of aerial parts macerated in 50% alcohol also showed a marked in vitro inhibitory effect against *Neisseria gonorrhoeae* strains isolated from symptomatic patients. The ethanol extract of entire plants showed immunomodulating effects via blastogenesis stimulation in cell cultures. However, immunosuppressive activity was observed when administered intraperitoneally to mice.
Finally, the bright orange colour of several *Physalis* fruits is due to the presence of characteristic xanthophylls, e.g. zeaxanthin and cryptoxanthin.

Adulterations and substitutes Some *Solanum* species are used in a similar way as *Physalis* to cure digestive and intestinal problems, including stomach-ache and diarrhoea, and for various skin problems such as sores, boils and cuts. Many *Physalis* species are also employed to treat fever and malaria, headache and rheumatism. Several other *Solanaceae* also contain series of withanolides, e.g. the genera *Withania* Pauquy and *Nicandra* Adans.

Description Annual or perennial herbs, small or large, soft stemmed, angular, often much branched, taproot short. Leaves alternate to sub-opposite, simple, usually ovate, sometimes linear, margins toothed to entire, usually hairy, often with trichomes; petiole present; stipules absent. Flowers axillary, solitary or few together in a fascicle, nodding, actinomorphic, pedicel present; calyx campanulate, 5-toothed; corolla plicate, often open campanulate to rotate, slightly 5-lobed, normally yellowish, often with 5 more or less clear, brownish spots at the throat, varying amounts of hair usually present at the throat; stamens 5, implanted at the base of the corolla tube, anthers 2-celled, opening by a longitudinal slit; style filiform, stigma capitate. Fruit a biloculed pulpy berry, usually sessile, nodding, enclosed in the persistent, inflated bladdery calyx (husk), 5–10 angled or ribbed. Seeds numerous, orbicular to reniform, small. Seedling with epigeal germination.

Growth and development *Physalis* has a zoo- and hydrochorous dispersion. It can be found flowering throughout the year when sufficient water is available. In the United States, *P. angulata* plants grow to 80–100 cm tall before flowering, when free of competition, but where competition pressure is high flowering starts when the plants are 25–30 cm tall. *Physalis* is cross-pollinated. In Malaysia, plants raised from seeds start flowering after 6 weeks, and fruits are ripe 6 weeks later. Dormancy starts 8 weeks after flowering.

Other botanical information *Physalis* is variable and taxonomically confusing, and no comprehensive study of the genus exists. It is closely related to *Margaranthus* and *Nicandra*. Intermediate specimens are found between related species, such as *P. angulata* and *P. minima* in South-East Asia. Both might be varieties of the same species. In America, *P. angulata* is morphologically also very similar to *P. philadelphica*, of which a larger-fruited, cultivated type and a smaller-fruited, wild type exist.

Ecology *Physalis* can be found up to 3000 m altitude at temperatures above 10°C, although light frost does not kill them. At high temperatures the plants do not develop well. They grow best in moist, fertile soils and are tolerant of partial shade. *P. angulata* and *P. minima* occur widely as weeds of annual and perennial crops, in waste areas and pastures.

Propagation and planting In a germination test of *P. angulata* seeds, temperatures of 20, 25 and 30°C gave about 5, 40 and 45% germination respectively, but at constant temperatures of 10 or 40°C no germination occurred. Alternating temperatures for 10 h at 21°C and for 14 h at 30°C gave about 95% germination. Emergence decreased from about 85% for seeds planted 0–1.2 cm deep to 60% at 5 cm deep, and no seedlings emerged when seeds were planted 10 cm deep. Seeds germinate both in the light and the dark, and germination is optimal when pH is 6–8. Tillage promotes germination slightly compared with no tillage, but germination in both cases is low (about 15% and lower). Irrigation diminishes emergence to less than 5%.

Diseases and pests *Physalis* is sensitive to many fungal diseases, caused e.g. by *Albugo*, *Alternaria*, *Bipolaris*, *Cercospora*, *Curvularia*, *Odium*, *Oidiopsis*, *Pseudocercospora*, *Pyricularia grisea* and *Pythium*. *P. angulata* is also a host of

the causal agent of tomato bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*). *Physalis* hosts viruses found in tobacco, potato, okra, *Capsicum* pepper, beans and several other crops, as well as physalis mottle virus, and also several root-knot nematodes (*Meloidogyne* spp.). *P. minima* hosts the parasitic weed *Orobanche indica* Buch.-Ham. ex Roxb.
The inflated calyx of *Physalis* protects the fruit-eating larvae of *Heliothis subflexa* and *H. virescens* (*Lepidoptera*) (which are also pests on cotton, soyabean and tobacco) against parasitism by the braconid *Cardiochiles nigriceps*. *P. angulata* is a host for the caterpillar *Diacrisia obliqua*, and several plant mites.

Harvesting *Physalis* is picked from the wild whenever needed, and used fresh or dried.

Yield Single plants of *P. angulata* may produce 13 100–31 000 seeds. In a field test in Indonesia, the average number of fruits/plant was about 130, and the average number of seeds/fruit was about 130, so about 17 000 seeds per plant were produced.

Handling after harvest The fruits of *Physalis* will keep for 3 months if stored in their husks under dry conditions.

Genetic resources and breeding *Physalis* is widespread, and *P. angulata* and *P. minima* are pantropical weeds, and not liable to genetic erosion. Large germplasm collections of *Physalis* exist in Mexico and Guatemala. *P. angulata* and *P. minima* are kept in gene banks in Germany and the Netherlands.

Prospects Withanolides and physalins isolated from *Physalis* 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.

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Selection of species

Physalis angulata L.

Sp. pl. 1: 183 (1753).

Vernacular names Gooseberry, hogweed, balloon cherry (En). Indonesia: ceplukan (Javanese), cicendet an (Sundanese), daun kopo-kopi (Moluccas). Malaysia: leletup, chipluan, ubat pekong. Papua New Guinea: kaipos (Navuapaka, Central Province), oviovi (Oroi, Central Province), watosivo (Garara, Oro Province). Philippines: putok-putokan, tino tino, toltolaya. Thailand: baa tom tok (northern), thong theng (central), pung ping (peninsular). Vietnam: t[aaf]m b[os]p, lu lu c[as]i.

Distribution Native to tropical America, now distributed pantropically, including Malesia, as a weed.

Uses In Malesia, the aerial parts, including the fruits, are used to cure digestive and intestinal problems, and various skin problems such as sores, boils and cuts. In Papua New Guinea, constipation is relieved by drinking a decoction of the leaves. The sap of the leaves in water is taken as an abortifacient, although their use to treat sterility is also mentioned. The fruit is eaten as a snack, and the leaves as a salad, although the taste is bitter.

Observations An annual herb, 10–100 cm tall, glabrous or with a few short appressed hairs, stems sharply angled, hollow, lower branches sometimes prostrate and rooting at the nodes; leaves ovate to lanceolate, sometimes linear, 4–15 cm × 2.5–10 cm, margins irregularly toothed or entire, short hairy, petiole 2–11 cm long; flowers solitary, flowering calyx 3–5 mm long, fruiting calyx 2–4 cm long, greenish-yellow with purple ribs, corolla 5–10 mm long, up to 1 cm in diameter, pale yellow, with or without dark spots and a triangular spot of dense short hairs at the throat; anthers entirely pale blue; berry 10–16 mm in diameter, yellow. *P. angulata* occurs in sunny to somewhat shaded, not too dry fertile spots in fields, gardens,

Physalis angulata L. – 1, plant habit; 2, flower, ventral view; 3, flower, lateral view; 4, berry, calyx partly removed; 5, seed.

wastelands, fallow fields, along roads, in open forests and forest margins, up to 1500 m altitude.

Selected sources 135, 323, 407, 440, 599, 619, 696, 810, 948, 977, 997.

Physalis minima L.

Sp. pl. 1: 183 (1753).

Synonyms *Physalis indica* Lamk (1786), *Physalis parviflora* R.Br. (1810).

Vernacular names Sunberry (En). Brunei: letup letup (Sengkurong). Indonesia: ciplukan (Javanese), cecendet (Sundanese), lapunonat (southern Moluccas). Malaysia: letup-letup, leletup, chipluan. Philippines: pantug-pantugan (Tagalog), amansit (Iloko), amanti-ti-ugsa (Bontok). Thailand: thong theng (south-western), yaa tom tok (northern), pung ping (peninsular). Vietnam: th[uf] l[uf] nh[or].

Distribution Tropical Africa, Asia and Australia.

Uses In Indonesia, the fruits are considered diuretic, alterative, purgative and aperient. In Java, the root is eaten as a vermifuge and an extract of the root is taken for fevers. In Brunei, chewed roots are applied to the lower abdomen to reduce pain. Pounded leaves are used for headache and itches. In Sabah, a decoction of the roots is drunk to treat hypertension and diabetes. The fruit is edible but poisonous when consumed in large quantities. In Thailand, all parts are used as a diuretic and antipyretic.

Observations An annual herb, 20–50 cm tall, densely covered with patent, long, apically thickened hairs, stems angular above, subterete below, hollow, tinged with purple; leaves ovate to lanceolate, 1.5–9 cm × 1–6 cm, margins irregularly toothed or entire, densely hairy, petiole 0.5–6.5 cm long; flowers solitary, flowering calyx 3–5 mm long, fruiting calyx 1.5–2.5 cm long, greenish-yellow with purple ribs, corolla 5–10 mm long, up to 1 cm in diameter, pale yellow, with 5 distinct dark spots and 2 groups of rather long hairs at the throat; anthers yellow with blue margined cells; berry 8–14 mm in diameter, yellow. *P. minima* is a solitary or gregarious herb in arable land, dry rice-fields, gardens and waste places, up to 400(–1500) m altitude.

Selected sources 135, 201, 215, 407, 810, 896, 997.

Slamet Sutanti Budi Rahayu

Picria fel-terrae Lour.

Fl. cochinch.: 393 (1790).

SCROPHULARIACEAE

$2n$ = unknown

Synonyms *Curanga amara* Vahl (1804), *Curanga fel-terrae* (Lour.) Merr. (1917).

Vernacular names Indonesia: tamah raheut (Sundanese), daun kukurang (Moluccas), papaita (Ternate). Malaysia: hempedu tanah, gelumak susu, rumput kerak nasi. Philippines: sagai-uak (Sulu). Laos: kông saden, (do:k) pu:n. Vietnam: m[aaj]t d[aas]t, thanh ng[aa]m.

Origin and geographic distribution *P. fel-terrae* is distributed in Asia from the eastern Himalayas to India, Burma (Myanmar), southern China, Indo-China, Peninsular Malaysia, Borneo, Java, Sulawesi, Moluccas and the Philippines.

Uses The fresh leaves are very bitter and are generally considered aperient, emmenagogue, stimulant to the intestines, sudorific and diuretic. In Peninsular Malaysia, a decoction of the plant is taken for stomach-ache, nausea, liver complaints and as an appetizer. A poultice of the pounded leaves is applied to wounds. In the Moluccas and the Philippines, the sap or a decoction of the plant is considered a vermifuge for children, and a remedy for colic and malaria. In Indonesia, a poultice of the leaves cures itch and other skin diseases. An infusion of the leaves together with those of *Centella asiatica* (L.) Urb. is used to treat whooping cough and tightness of the chest. An infusion with alcohol is taken by the Chinese in Java for exhaustion, especially after a fall or a fight, in which bruising occurred. In Peninsular Malaysia and Indo-China, the leaves combined with those of *Hedyotis capitellata* Wallich ex G. Don are applied to snakebites. The leaves, macerated in alcohol, are considered a tonic. In the Philippines, an infusion or decoction is considered stomachic and emmenagogue; alternatively the plant may be chewed to the same effect. In Vietnam, the whole plant is also used for treating fever, herpes infections and tumours. In India, the leaves are applied to early stages of dropsy, to intermittent fever, amenorrhoea, colic and lumbar pains. In China the decoction of the leaves is used for the treatment of herpes.

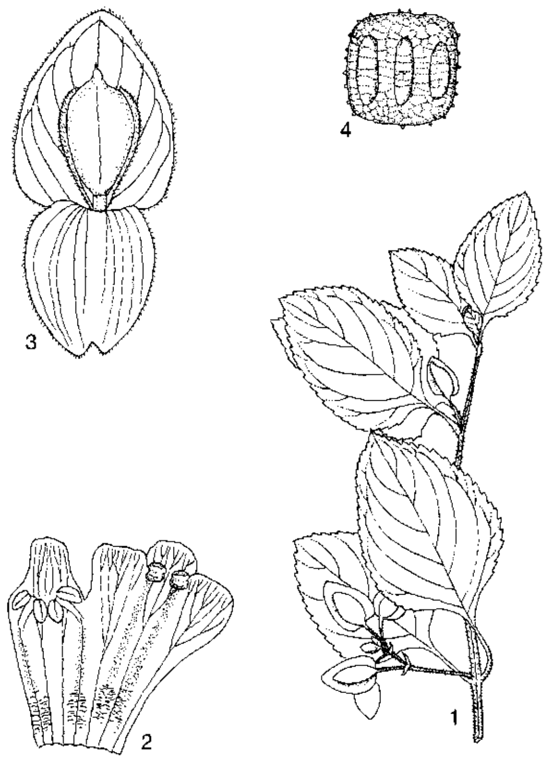
Production and international trade *P. fel-terrae* is often cultivated in gardens and sold fresh on the markets in Indo-China and China.

Properties From a butanol extract of *P. fel-terrae*, the flavonoid glucuronides apigenin-7-O-β-glucuronide, luteolin-7-O-β-glucuronide and apigenin-7-O-β-(2'-O-α-rhamnosyl)-glucuronide were isolated. The plant also contains the glycoside curangin, which seems to possess similar properties as digitalin, and also is a heart-stimulant. It is only slightly poisonous.

In a phytopharmacological screening, the ethyl acetate and butanol fractions of an ethanol extract of the dried plant showed antibacterial activity against *Proteus vulgaris* and *Staphylococcus aureus*. In addition, the methanol fraction showed antiviral activity against herpes simplex 1 and inhibited the classical pathway of the complement system.

The plant also contains a series of triterpene saponins, i.e. the picfeltarraenins IA, IB, II, III, IV, V and VI (= picfeltarraegenin I 3-O-β-D-xylopyranoside). Picfeltarraenins IA, IB, IV and VI acted as inhibitors on both the classical and alternative pathways of the complement system, with picfeltarraenin II exhibiting the highest inhibitory activity. None of the compounds showed antiviral, antibacterial or antifungal activities. Picfeltarraenins IA and IB were tested in an in vitro human tumour cell line panel, but displayed no cytotoxic activity.

Description An annual herb, up to 40 cm tall, stems laxly branched, erect or prostrate, quadrangular, rooting at the nodes, densely minutely pubescent. Leaves simple, opposite, ovate, 2–5 cm × 1.5–3 cm, base cuneate to rounded, apex subacute, margins crenate, minutely pubescent; petiole 2–15 mm long. Inflorescence a terminal or pseudo-axillary raceme, 2–6 cm long, 2–16-flowered, bracts small, lanceolate; pedicel 4–7 mm long, calyx flat, with 4 sepals in 2 series, upper outer one cordate, 7–9 mm × 6–8 mm, lower outer one slightly bilobed, 5–6 mm × 4–5 mm long, accrescent in fruit, 2 lateral inner ones filiform, 2–3 mm long, all minutely pubescent; corolla tubular, bilabiate, tube 8 mm long, glabrous outside, 2 lateral ridges with glandular hairs inside, upper lip 2–3 mm long, lower lip 2.5–3.5 mm long, 3-lobed, tube and upper lip reddish brown, lower lip white; stamens 2, posterior, 1 mm long, staminodes 2, anterior, yellow; ovary superior, deltoid-ovoid, glabrous, style filiform, stigma shortly bilobed. Fruit an obovate capsule, 4 mm × 3 mm, compressed, septically bivalved, seeds several. Seed globose, about 0.6 mm in diameter, with 8 oblong hollows.



Picria fel-terrae Lour. – 1, fruiting stem; 2, opened corolla; 3, fruit with opened calyx; 4, seed.

Growth and development *P. fel-terrae* can be found flowering and fruiting throughout the year.

Other botanical information *Picria* is a monotypic genus, different from other *Scrophulariaceae* because it has a flattened fruit surrounded by 2 large, rounded calyx lobes and 2 filiform calyx lobes.

Ecology *P. fel-terrae* is a rare to rather common herb, occurring on forest slopes, or shady forest edges, from sea-level up to 900 m altitude.

Propagation and planting *P. fel-terrae* is propagated by seed.

Harvesting The leaves or the whole plant of *P. fel-terrae* are harvested when the plant is flowering.

Handling after harvest Plants of *P. fel-terrae* are used fresh or dried for later use.

Genetic resources and breeding *P. fel-terrae* has a rather large area of distribution, and is also planted in gardens, and thus does not seem to be at risk of genetic erosion. There are no known breeding programmes for *P. fel-terrae*.

Prospects *P. fel-terrae* contains compounds which display interesting pharmacological activities, and therefore merits further research in order to fully evaluate their possible potential.

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Other selected sources 135, 452, 456, 739.

G.H. Schmelzer & S.F.A.J. Horsten

Piper umbellatum L.

Sp. pl. 1: 30 (1753).
PIPERACEAE
2n = (24), 26, (28)

Synonyms *Piper subpeltatum* Willd. (1797), *Heckeria umbellata* (L.) Kunth (1840), *Pothomorphe umbellata* (L.) Miq. (1840), *Pothomorphe subpeltata* (Willd.) Miq. (1840).

Vernacular names Indonesia: tombo (Javanese), sak-masakan (Madurese), lomba (Moluccas). Malaysia: lemba, lomba. Philippines: kubamba (Tagalog), balai (Bontok), bayag-bayag (Cebu Bisaya). Thailand: phluu teen chaang, rok chaang (peninsular), haan mu (northern). Vietnam: l[aa]n hoa.

Origin and geographic distribution *P. umbellatum* originates from Mexico and South America, and has been introduced and widely naturalized throughout the Old World tropics, including South-East Asia.

Uses In South-East Asia, the fresh leaves of *P. umbellatum* are applied on abscesses, wounds or contusions. The decoction is taken for stomach problems, and as a diuretic. The leaves are also tied on the stomach for oedema. In Peninsular Malaysia, the fruits are chewed with betel (*Piper betle* L.) for cough. In the Philippines, the juice of the leaves is applied in the eyes for conjunctivitis. The plant is considered a vulnerary and detergent. In Indo-China, the leaves and fruits are used to treat pains in the kidneys, dropsy, chlorosis and colic.

In South America, the leaves of *P. umbellatum* are widely used as an emollient, the juice is taken as an emmenagogue, galactagogue, and diuretic and is employed in poultices on swellings and burns, or dropped into the ear for earache. A decoction of the leaves or roots is taken to relieve liver obstruction, jaundice, malaria, urinary problems, syphilis, leucorrhoea, menstrual problems and stomach-ache, and is also applied on wounds and inflamed tumours. The root is considered stimulant, diuretic and promotes the flow of bile. A decoction is used as a powerful digestive and as a treatment for dyspepsia, constipation and gastralgia. In Brazil, it is much used in baths to subdue oedema and uterine complaints. In French Guyana, the plant is used against tapeworm. In Africa, the leaves are used in massages for migraine and headache, and in decoction as a wash for feverish children. In Ivory Coast, the aerial parts are commonly given to women as an emmenagogue, antiabortive and antihaemorrhagic.

In South America, Java and the Philippines, the young leaves and spikes are eaten raw, steamed or boiled as a condiment with fish or rice. The sweet, ripe fruits are eaten as a delicacy. In Colombia, the scraped, boiled bark of the lower part of the stem and root is an ingredient for arrow poison.

P. peltatum L. is eaten in Java in the same way as *P. umbellatum*, as a side-dish to rice.

Production and international trade *P. umbellatum* is only used locally, and not traded internationally.

Properties The volatile oil of *P. umbellatum* has a high content of β-pinene (27%), α-pinene (18%) and (E)-nerolidol (12%). However, another analysis showed the compounds β-caryophyllene (15%), germacrene-D (28%), bicyclogermacrene (11.5%) and δ-cadinene (13%) made up 67% of the oil.

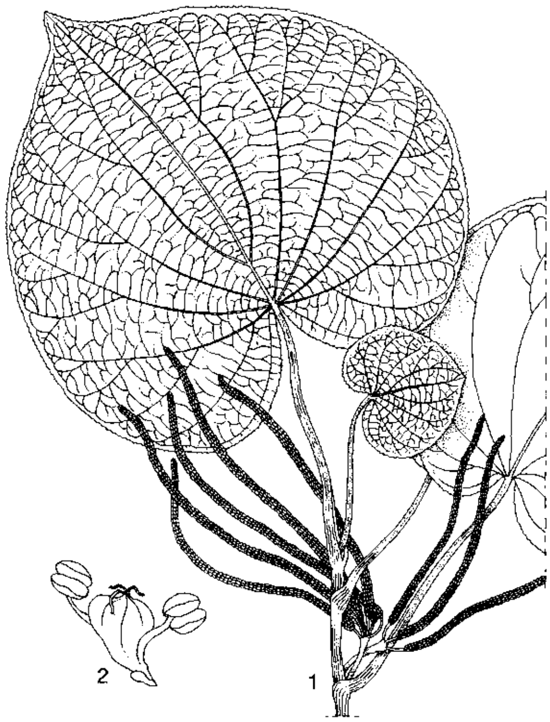
The roots and aerial parts contain 4-nerolidylcatechol. This compound was found to exhibit anti-oxidant potential as a peroxyl radical scavenger, inhibiting Fe(II)-dependant DNA damage, and cytotoxicity against KB tumour cell growth in vitro, possibly through topoisomerase I-inhibition.

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 *P. umbellatum* was administered orally (250 and 1250 mg/kg) and subcutaneously (100 and 500 mg/kg) to *Plasmodium berghei*-infected mice, and showed strong anti-malarial activity, significantly reducing the level of parasites in a dose-dependent manner.

In a pharmacological screen, the aqueous extract of the aerial parts administered intraperitoneally to rats, caused a decrease in watchfulness for 48 hours, together with a fall of the rectal temperature, a decrease of spontaneous motor activity and an increase of analgesic activity.

The aerial parts of *P. peltatum* contain an essential oil, which consists of β-caryophyllene (39%), α-humulene (6%) and germacrene-D (9%) as main components. An aqueous extract was found to be active against crown gall tumour in the potato disk assay (22% inhibition). It also shows anti-oxidant activity similar to that of *P. umbellatum*, but only the methanol extract showed anti-malarial activity.

Description A perennial scrambling shrub or woody herb, 1–2.5(–4) m tall; stems numerous, succulent, ribbed, forming a dense clump, rooting at the nodes, main roots woody. Leaves alternate, almost circular to reniform, 5–36(–40) cm × 4.5–37



Piper umbellatum L. – 1, flowering stem; 2, pistil and stamens.

(–42) cm, base deeply cordate, apex shortly acuminate to rounded, margins entire or crenulate, fairly thin, glandular black punctate, sparsely to densely hairy on the veins above and underneath, veins palmate, 11–15, blade dark green above, greyish underneath; petiole 6.5–30 cm long, dilated and sheathing basally. Inflorescence an axillary or leaf-opposed spike, 5.5–15 cm long, 2–8 together in false umbels, peduncle 3–12 cm long, 1–3 peduncles together, peduncular bracts narrow, 6–8 mm long, white, caducous. Flowers small, bisexual; floral bracts triangular to rounded, 0.5–0.8 mm wide, subpeltate, margins fimbriate, white, cream or yellow; perianth absent; stamens 2; ovary superior, 1-locular, stigmas 3. Fruit a drupe, obpyramidal, 3-angled, 0.6–1 mm × 0.4–0.6 mm, brownish. Seed globose, endosperm little, perisperm copious, embryo small.

Growth and development *P. umbellatum* can be found flowering throughout the year when enough water is available. *Piper* flowers are probably pollinated by insects, but also show self-pollination.

Other botanical information *P. umbellatum* is closely related to *P. peltatum*, but is distinguished by its peltate leaves and inflorescences with many, rather compact spikes. For a long time, these species were classified in the genus *Pothomorphe* Miq.

Many *Piper* species are used as a spice or condiment, or as a stimulant. Most *Piper* species are also valued as medicinal plants, with largely similar uses. The heated leaves are applied on the chest against cough, asthma and other respiratory problems, on the breasts to stop the milk flow and on the abdomen to relieve constipation and other stomach troubles. Leaf preparations or the leaf sap are widely used as a tonic and an antiseptic and are applied on wounds, contusions, ulcers and boils. Tests with black pepper showed that the main component of the fruit, piperine, stimulated tumour formation in mouse and toad (*Bufo regularis*), but that it also has significant anti-inflammatory activity. *P. sarmentosum* Roxb. ex Hunter, a minor spice, has been shown to have considerable antimalarial and hypoglycaemic effects.

Ecology *P. umbellatum* occurs in evergreen forest undergrowth, swamp forest, on river banks, old rubber plantations, always in damp locations, from 150–2100 m altitude.

Propagation and planting *P. umbellatum* is propagated by seed. The seeds show dormancy, which can be interrupted by direct sunlight.

Harvesting The leaves, fruits and roots of *P. umbellatum* are harvested from wild plants whenever needed.

Handling after harvest The plants of *P. umbellatum* are mainly used fresh.

Genetic resources and breeding *P. umbellatum* has a pantropical distribution and does not seem to be liable to genetic erosion. No germplasm collections or breeding programmes are known to exist.

Prospects Little is known about the phytochemistry and pharmacology of *P. umbellatum*. Further research is needed to fully evaluate its potential, e.g in the field of antimalarial activity, since a crude extract showed activity in an in vivo assay.

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Other selected sources 50, 74, 135, 142, 237, 280, 407, 636, 690, 786, 791, 810, 1024.

G.H. Schmelzer

Pipturus Wedd.

Ann. Sci. Nat., Bot. sér. 4, 1: 196 (1854).

URTICACEAE

x = unknown

Major species *Pipturus argenteus* (J.G. Forster) Wedd.

Origin and geographic distribution *Pipturus* comprises about 20–40 species, found on various islands of the Indian Ocean, through Malesia and northern Australia to the Pacific Islands.

Uses Throughout Malesia, various plant parts of *Pipturus* are used for poulticing boils. The fibrous bark of several *Pipturus* species is locally used to produce string and rope.

Production and international trade *Pipturus* is only used on a local scale.

Properties No pharmacological or phytochemical information is available for the Malesian species. However, some general findings for *P. albidus* A. Gray ex H. Mann, used in traditional Polynesian medicine for infectious diseases, may also apply to the Malesian species. Aqueous extracts from the stem of *P. albidus* showed selective anti-viral activity against Herpes Simplex Virus-1 and 2 and Vesicular Stomatitis Virus in vitro. A methanol extract of the leaves showed growth inhibition of *Staphylococcus aureus* and *Streptococcus pyogenes* using the disk diffusion method.

Description Dioecious or monoecious evergreen shrubs or trees; stem in general softwooded; irritant hairs absent. Leaves alternate, simple, membranaceous to coriaceous, serrulate or dentate, 3-veined; petiolate; stipules intrapetiolar, connate, bifid. Inflorescence unisexual or bisexual, axillary, paniculate, flowers borne in globular heads sessile at nodes or alternating on interrupted spikes. Male flowers: tepals 4; stamens 4; pistillode present, densely villous. Female flowers: perianth tubular, minutely 4-toothed, persistent; ovary superior, ovoid, unilocular, stigma simple, exserted, unilaterally stigmatic; staminodes absent. Fruit an achene, enclosed by the perianth, several immersed in enlarged fleshy receptacle, the whole fruit-like. Seedling with epigeal germination.

Growth and development The dispersal of *Pipturus* with fleshy composite fruits is enhanced by frugivorous birds.

Other botanical information *P. argenteus* is an extremely variable species, but the extremes are all connected by intermediates. Some may prefer to retain the *P. incanus* material from Java as a separate species *P. incanus* (Blume) Wedd. (synonyms *Urtica incanus* Blume, *P. velutinus* (Decne.) Wedd.), others as *P. argenteus* var. *incanus* (Blume) Winkl.

Ecology Buried seeds of *P. argenteus* remain viable for a prolonged period even under well-developed rain forest. Locally they dominate the seed bank numerically, germinate most rapidly and dominate the developing plant cover.

Propagation and planting *Pipturus* can easily be propagated from seed.

Husbandry *P. argenteus* is a hardy plant, requiring regular watering only. It fruits optimally in full sun, but will also perform well in semi-shade.

Harvesting Leaves, bark or roots of *Pipturus* are collected from wild plants whenever needed.

Handling after harvest All plant parts of *Pipturus* are usually used fresh.

Genetic resources and breeding All *Pipturus* treated here have a large area of distribution, are common in disturbed habitats, and do not seem liable to genetic erosion.

Prospects Information on the phytochemistry and pharmacology of Malesian *Pipturus* species is not available at present. Therefore, to determine their future applications in South-East Asia more research will be needed to investigate their properties.

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Selection of species

Pipturus argenteus (J.G. Forster) Wedd.

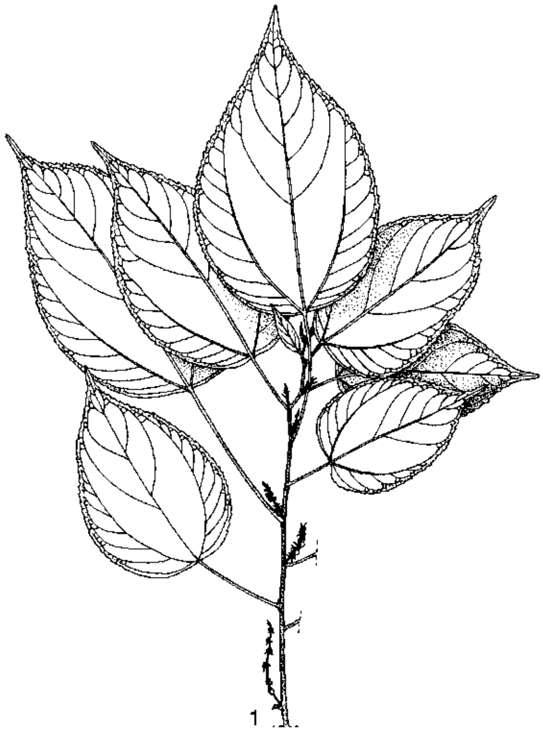
in DC., Prodr. 16(1): 235(19) (1869).

Synonyms *Urtica argentea* J.G. Forster (1786), *Pipturus propinquus* (Decne.) Wedd. (1854), *Pipturus velutinus* (Decne.) Wedd.(1854), *Pipturus incanus* (Blume) Wedd. (1869).

Vernacular names Indonesia: ki beunteur (Sundanese), bedreg (Javanese), lobiri (Moluccas). Papua New Guinea: evakau (Konis, New Ireland), yiwiya (Aseki, Morobe Province), helo (Tipku, Fane, Central Province).

Distribution From the Pacific Islands, northern Australia and New Guinea to the Philippines and Borneo, Java, Sumatra and the islands on the west coast of Peninsular Malaysia, and westward to the Seychelles.

Uses In the Moluccas, the leaves are used for poulticing boils, burns and herpes. Sap from the bark is further taken as a gargle for thrush. On Karkar Island (Papua New Guinea), new roots are cut and the sap is allowed to drip into a container. Some of it is drunk and the rest is used to wash the body of a patient with malaria fever or a severe cough. Crushed leaves are used to treat cough in the Solomon Islands. In New Ireland, the sap of the scraped inner bark is given to women in labour. The juice of heated leaves is applied to sores. In New Britain, leaf sap is drunk and the crushed leaves rubbed on the body to relieve a fever or headache. In the Simbu Province, sap from the scraped bark together with leaves of *Rubus glomeratus* Blume (synonym *R. lederman-*



Pipturus argenteus (J.G. Forster) Wedd. – 1, flowering female twig.

nii Focke) is eaten daily to soothe a bad cough. In Aseki, the rainwater collected from the leaves is used to treat asthma. In the Central Province, the bark is crushed in cold water and drunk twice daily to treat dysentery. The scraped bark is applied to spear wounds, to facilitate removal of the spear head. Root sap is also used on wounds and to soothe toothache. The cooked leaves are eaten as a vegetable. The fibre from the bark is used to make string and rope.

Observations A dioecious shrub or tree up to 10(–20) m tall, trunk 8–20(–40) cm in diameter, bark smooth, grey, lenticellate, inner bark soft, pale yellow to green, twigs sparsely to densely hairy; leaves ovate, 8–15(–35) cm × 5–10(–25) cm, base acute, obtuse, rounded to cordate, apex acuminate, margin serrate, densely strigose, densely woolly beneath, petiole 2–12(–24) cm long, stipules 3–14 mm long; spikes or sparsely branched panicles up to 12(–20) cm long, bracteolate, flowers clustered at intervals, subsessile to sessile, cluster 3–7 mm in diameter; male flowers 4-merous; female flowers perianth urceolate, minutely 4-toothed, densely pubescent, style up to 3 mm long; achene white to brown, partially immersed in the spherical, fleshy, receptacle, up to 7 mm in diameter. *P. argenteus* is common in disturbed habitats, especially in the eastern part of its area of distribution, from sea-level up to 1250 m altitude.

Selected sources 407, 416, 419, 426, 430, 435, 436, 438, 523, 556, 786, 1030.

Pipturus arborescens (Link) C.B. Robinson

Philipp. Journ. Sci., Bot. 6: 13 (1911).

Synonyms *Urtica arborescens* Link (1822), *Pipturus asper* Wedd. (1854).

Vernacular names Philippines: dalunot (Tagalog), agandong (Iloko), himaramai (Bisaya).

Distribution Ryukyu Islands, Taiwan, the Philippines and Borneo.

Uses In the Philippines, scrapings from the bark are used externally as a cataplasm for boils. The composite fruits are edible.

Observations A monoecious or dioecious shrub or small tree up to 10 m tall, twigs with dense short hairs; leaves ovate to orbicular, 6–20 cm × 3–11 cm, base obtuse, rounded to cordate, apex acute to acuminate, margin serrate to crenulate, slightly hairy above, densely woolly beneath, petiole 2–10 cm long, stipules up to 10 mm long, apex bifid; male flowers in dense axillary fascicles, 4-merous, perianth pubescent; female flowers in dense hemispherical heads, 5–6 mm in diameter, perianth pubescent, ribbed, style long-exserted; achene partially immersed in the white, soft, fleshy receptacle, up to 10 mm in diameter. *P. arborescens* is common in thickets and secondary forest at low to medium altitudes, locally up to 2000 m altitude.

Selected sources 455, 523, 786, 810, 1052.

J.L.C.H. van Valkenburg

Pisonia L.

Sp. pl. 2: 1026 (1753); Gen. pl. ed. 5: 451 (1754).

NYCTAGINACEAE

x = unknown; *P. umbellifera*: $2n$ = about 112

Major species *Pisonia aculeata* L., *P. grandis* R.Br.

Origin and geographic distribution *Pisonia* comprises about 35 species, mostly in the Americas (about 20), 1 pantropical (*P. aculeata*), the others in the Old World tropics, from the Indian Ocean Islands to continental Asia, Malesia and Oceania. In Malesia, 8 species occur, of which 5 also in Australia and/or the Oceanic islands.

Uses In the Philippines, a decoction of the fresh leaves of *P. aculeata* is used to wash scabies. In Thailand, the stem is macerated in rice alcohol and taken as a tonic, and the leaves are used for inflammations. In India, the bark and leaves are used as a counterirritant for swellings and rheumatic pains, as are the leaves of *P. umbellifera*. The juice mixed with other ingredients is given to children suffering from pulmonary complaints. In Mexico, *P. aculeata* is officially listed in its Pharmacopoeia. Small whole plants are boiled and the decoction used as a bath for patients with fever. The leaves or bark in decoction are taken internally or externally as a treatment for rheumatic and articular pains.

In Indonesia, the leaves of *P. grandis* cultivar 'Alba' are crushed or heated and applied to swellings or open ulcers, corns, calluses, or applied for oedema of the legs. In India, the fresh leaves of 'Alba' are considered diuretic and, moistened with eau-de-Cologne, they are used to subdue inflammation caused by filariasis in the limbs. The crushed bark, mixed with vinegar, is rubbed onto legs with cramps, and the root is considered purgative. In India, tea from the boiled bark of *P. umbellifera* is sometimes given as a tonic to newborn babies.

In Indonesia, the green bark of *P. longirostris* Teijsm. & Binnend. is sometimes burnt, powdered and mixed with coconut oil to make a balm for fresh wounds. The wood is too soft to be of any use.

In Java, the wild *P. grandis* has long been considered a plant with magical properties, the flowers being used at the coronation of a sultan, his wife eating them in order to obtain a fortunate son. Young leaves of the cultivar 'Alba' are a popular vegetable, cooked with meat but also as a salad. In the Philippines, 'Alba' is cultivated as an ornamental tree for its yellow leaves. In India, *P. aculeata* is also planted as an impenetrable hedge.

In the Philippines, *P. umbellifera* is also cultivated as an ornamental, because of its numerous fragrant flowers, and in Spain, North America and Australia it is therefore sometimes cultivated as a pot plant.

Small birds and animals can be trapped by the sticky fruits of *Pisonia*, and sometimes clusters of fruits are therefore placed under trees.

Production and international trade Most *Pisonia* are not internationally traded. Only *P. grandis* cultivar 'Alba' has been planted in several Asian countries, and leaves are sold in markets as a vegetable. Statistics on trade are not available.

Properties From the leaves of *P. umbellifera* 6 saponins have been isolated; 3 of them are oleanolic acid saponins, and 2 contain an unusual secoglycopyranosyl moiety. In a general screening, an extract of the leaves showed significant bactericidal activity. From Sri Lanka, toxic effects including vomiting, diarrhoea and abdominal pain from eating the leaves have been reported.

In India, the leaves of *P. grandis* cultivar 'Alba' are given to school children as a calcium supplement. The leaves also contain some other nutrients, e.g. iron, phosphate and β-carotene.

Description Erect shrubs or trees, sometimes dioecious, up to 30 m tall, usually unarmed, sympodially branched, glabrescent; wood and bark soft and spongious, brittle, pith hardly distinct from the wood. Leaves (sub)opposite or alternate, simple, dull, midrib flat above; petiole present; stipules absent. Inflorescence normally a small or large, axillary or terminal thyrse, 2–8 times (sub)umbellately branched; pedicel 0.5–10 mm long, bracts caducous. Flowers uni- or bisexual, male and female flowers sometimes of different shape; perianth valvate in bud, somewhat fleshy, campanulate, tubular, urceolate or funnel-shaped, 5(–10)-lobed, basal part tubular, coriaceous, persistent, accrescent after anthesis, apical part often whitish, often circumsessile caducous, often with glands; stamens 2–40, in 1–2 whorls, mostly exserted, sterile in female flowers; ovary superior, subsessile, elongate, apex narrowed, style longer than ovary, stigma with short lobes or fimbriate. Fruit a coriaceous anthocarp, smooth or 5-ribbed, sometimes viscid through lengthwise rows of glands, sometimes with a long beak. Seed oblong, with a deep longitudinal furrow, embryo straight, cotyledons recurved, surrounding the endosperm.

Growth and development Dispersal of *Pisonia* is effected through the sticky fruits which attach themselves to birds.

It is suggested that *P. grandis* can only maintain itself in quantity on islands where bird colonies produce enough guano, as phosphate seems to be a limiting factor for its regeneration. As the root system is shallow, the wood brittle and the leafy crown large, the trees often topple over during storms, but shoots and suckers are frequently formed.

Other botanical information It is said that the male trees of *P. grandis* cultivar 'Alba' are rarely cultivated as their leaves are darker and look less appetizing. *P. grandis*, however, has bisexual flowers, and because 'Alba' rarely flowers, a darker-leaved specimen could be just a variation. Another explanation could be a synonymy problem, because a synonym of *P. grandis* is *P. excelsa* (non Blume) Corner, while *P. excelsa* Blume is a synonym of *P. umbellifera*. In older floras the name *P. excelsa* occurs with 'Alba' as a form of it, having male and female flowers. 'Alba' could thus well be a cultivar of *P. umbellifera*, which could explain the occurrence of male and female trees, if the tree is dioecious.

Ecology Many *Pisonia* species are coastal, and occur often on (coral) islands in the Pacific. Some prefer (swampy) rainforest though and river banks, often on limestone or sandy clay, at low altitudes. *P. grandis* is a characteristic component of the *Barringtonia* formation, a vegetation type important on small coral islands. It does not tolerate shade and can form dominant pioneer groves on bird-inhabited islands.

Propagation and planting *Pisonia* is propagated by seed although cultivar 'Alba', which rarely flowers, is mainly propagated by stem cuttings, which root easily. In vitro propagation seems to be a good alternative. The axillary buds are cultured on Murashige and Skoog (MS) medium supplemented with the cytokinins benzyladenine and kinetin (1 mg/l each), resulting in 8–10 multiple shoots. Roots were induced on half strength MS medium, fortified with the auxins indole butyric acid and naphthalene acetic acid (0.5–1 mg/l) each. Regenerated plantlets were acclimatized on a sandy soil medium before being transferred to field conditions, where 95% of the plants survived.

Husbandry For maintaining a continuous supply of young leaves of *P. grandis*, both the wild type and 'Alba' need to be pruned regularly.

Harvesting The parts of *Pisonia* used, often the leaves, are harvested when needed.

Genetic resources and breeding As many *Pisonia* are restricted to coastal regions, exploitation or disturbance by man of these areas might result in the disappearance of their natural habitat, and of *Pisonia* as well.

P. grandis cultivar 'Alba' is widely cultivated, and does not seem to be at risk of genetic erosion. No breeding programmes of *Pisonia* for medicinal purposes are known to exist. *P. umbellata* cv. 'Variegata' is cultivated in Europe as a greenhouse ornamental.

Prospects Since little information is available on the phytochemistry and pharmacology of *Pisonia*, more research is needed to evaluate its possible medicinal potential.

Literature |**1**| Burkill, I.H., 1966. A dictionary of the economic products of the Malay Peninsula. Revised reprint. Vol. 2. Ministry of Agriculture and Co-operatives, Kuala Lumpur, Malaysia. p. 1755. |**2**| Jagadishchandra, K.S., Rachappaji, S., Gowda, K.R.D. & Tharasaraswathi, K.J., 1999. In vitro propagation of Pisonia alba (L.) Spanoghe (lettuce tree), a threatened species. Phytomorphology 49(1): 43–47. |**3**| Lavaud, C., Beauviere, S., Massiot, G., Le Men Oliver, L. & Bourdy, G., 1996. Saponins from Pisonia umbellifera. Phytochemistry 43(1): 189–194. |**4**| Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische groenten', 1931). Asher & Co., Amsterdam, the Netherlands. pp. 537–541. |**5**| Quisumbing, E., 1978. Medicinal plants of the Philippines. Katha Publishing Co., Quezon City, the Philippines. pp. 277–278. |**6**| Stemmerik, J.F., 1964. Pisonia. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Series 1, Vol. 6. Noordhoff-Kolff, Djakarta, Indonesia. pp. 457–468.

Selection of species

Pisonia aculeata L.

Sp. pl. 2: 1026 (1753).

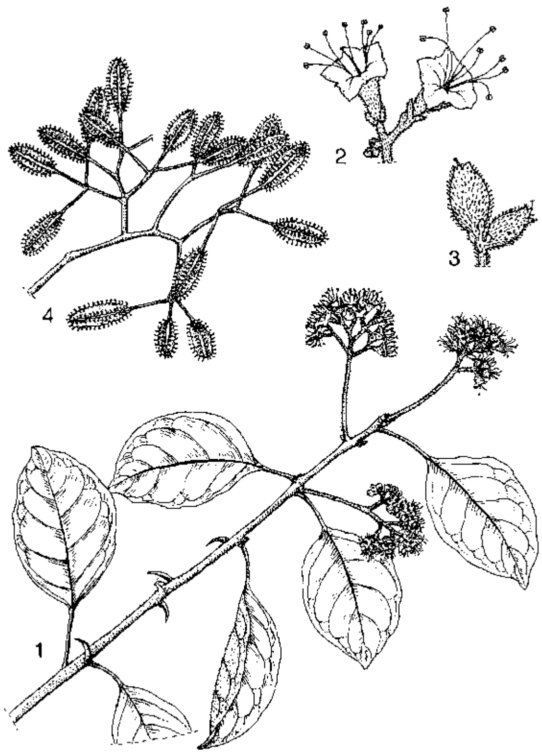
Synonyms *Pisonia villosa* Poir. (1804).

Vernacular names Indonesia: alar (Madurese), cuhun-lamarang (South Bantam), rampari (Sumba). Philippines: digkit, pakat-aso (Tagalog), puriket (Iloko). Thailand: khat khao (peninsular), ma kang phee (northern), huu cha luang (south-eastern). Vietnam: b[if] s[ow]n nh[oj]n, tuy[ees]n qu[ar] d[awf]ng.

Distribution Pantropical, from (sub)tropical America, the West and East coasts of Africa and Indian Ocean islands, to Burma (Myanmar), Indo-China, South Chinese islands, and throughout South-East Asia. In Malesia: Peninsular Malaysia, central Sumatra, Java, Lesser Sunda Islands, northern Borneo, Sulawesi, the Philippines, New Guinea to northern Australia and New Caledonia.

Uses Mainly the leaves of *P. aculeata* are used, fresh or in decoction, to treat skin problems, such as scabies and ulcers. In Mexico, the roots are used to treat cough.

Observations A large, dioecious, climbing and overhanging shrub, up to 20 m tall, armed with solitary, axillary, recurved thorns, 0.5–1 cm long; leaves (sub)opposite, elliptical, 4–10 cm × 1.3–5 cm, base acute, apex obtuse, petiole 0.5–2.5 cm long; thyrse axillary, dense, 1–2.5 cm in diameter, short brown hairy; flowers unisexual, pedicel short, bracteoles 1–3, male flower funnel-shaped, 3 mm long, lobes 10, 5 large, alternating with 5 small ones, opposite 5 rows of black stalked glands



Pisonia aculeata L. – 1, flowering branch; 2, male flowers; 3, female flowers; 4, infructescence.

outside, recurved, stamens 7–8, long exserted, ovary small, stigma trifid, female flower campanulate, urceolate, 2 mm long, lobes as male flower, androecium absent, stigma fimbriate, 1–1.5 mm exserted; anthocarp club-shaped, 15 mm × 2–2.5 mm, 5-ribbed, each with a biserial row of glandular appendages, growing out to soft, viscid prickles, 1.5 mm long. *P. aculeata* occurs along coasts, in hedges, rain forest and open forest, sometimes forming impenetrable masses, from sea-level up to 500 m altitude.

Selected sources 207, 215, 407.

Pisonia grandis R.Br.

Prodr. fl. Nov. Holl. 1: 422 (1810).

Synonyms *Pisonia alba* Span. (1841), *Pisonia sylvestris* Teijsm. & Binnend. (1852), *Ceodes grandis* (R.Br.) D.Q. Lu (1996).

Vernacular names Cabbage tree, lettuce tree, Moluccan cabbage (En, 'Alba'). Indonesia: wijaya kusuma (Javanese, wild type), kol bandang (Javanese, Sundanese, 'Alba'), dagdag see (Balinese, wild type), sayur putih pulu (Moluccas, 'Alba' and wild type). Philippines: maluko, koles-maluko (Tagalog, 'Alba'). Thailand: saeng chan (Bangkok).

Distribution From the islands in the Indian Ocean, the coasts of India and Sri Lanka (introduced and cultivated) to the islands in the southern Chinese sea, throughout South-East Asia (not in Sumatra, rare in Kalimantan and Sulawesi), to some islands at the northern Australian coast, and further throughout Micronesia and Polynesia (except Hawaii).

Uses In Indonesia, the leaves of the cultivar 'Alba' are crushed or heated and applied to swellings or open ulcers, corns, calluses, or applied for oedema of the legs. In Rotuma, the leaves are used for dysentery. Young leaves of 'Alba' are a popular vegetable, rich in calcium.

Observations An irregularly branched tree, 13(–30) m tall, smooth, twigs pale brown, deeply furrowed when dry; leaves opposite, elliptical, oblong or ovate, 10–20(–30) cm × 6–10(–15) cm, base acute to cordate, apex acute or acuminate, veins red or dark coloured, petiole 1–6 cm long; thyrse terminal, 1.7–3.5 cm × 3–4.5 cm, peduncle 1.5 cm long, accrescent to 3 cm, bracteoles 2–4; flowers bisexual, pedicel 1–1.5 mm long, perianth funnel-shaped, 4 mm long, 5-lobed, with 5 rows of black glands, stamens 6–10, exserted for 2 mm, stigma fimbriate, included; anthocarp elongate to club-shaped, 12 mm × 2.5 mm, 5-ribbed, each bearing a row of viscid prickles, 1 mm long, hairy between the ribs. *P. grandis* occurs in open, dry to semi-dry localities along sandy or rocky coasts, or on limestone, from sea-level up to 1200 m altitude, often dominant on atolls and other small islands. The bright green-yellow-leaved cultivar of *P. grandis*, 'Alba', and sometimes the wild type, are cultivated in Bali and Java around houses and in hedges. It is rarely flowers in Bali and neighbouring islands.

Selected sources 207, 215, 407, 696, 804.

Pisonia umbellifera (J.R. Forster & J.G. Forster) Seem.

Bonplandia 10: 154 (1862).

Synonyms *Ceodes umbellifera* J.R. Forster & J.G. Forster (1776), *Pisonia excelsa* Blume (1826), *Pisonia brunoniana* Endl. (1833).

Vernacular names Indonesia: angkola (Sumatra), gendala (Javanese), hares (Moluccas). Papua New Guinea: paribui (Kebar), fafoni-mo (Onjob, Oro Province), namba namba (Aseki, Morobe Province). Philippines: anilin, balagasaha (Tagalog), anuring (Panay Bisaya). Vietnam: b[if] s[ow]n t[as]n.

Distribution From South Africa and the islands in the Indian Ocean, to the islands in the southern Chinese sea, throughout South-East Asia, especially in the eastern part, to northern Australia, and further throughout Melanesia, and Palau, Yap and Truk.

Uses In highland areas of Papua New Guinea, salt from the ashes of the leaves and bark is added to many herbal medicines. In India, the leaves are used, like those of *P. aculeata*, for rheumatic pains. They are also taken in decoction against poisoning by certain marine fishes. The leaves are also used as a green manure.

Observations A tree, up to 28 m tall; leaves opposite or in pseudo-whorls towards the end of twigs, elliptical, oblong to ovate, 9–25 cm × 4–12 cm, base and apex acute to rounded, petiole 0.5–4 cm long; thyrse terminal, many-flowered, 3–9 cm in diameter, puberulous or glabrous, peduncle 3.5–4 cm long; flowers uni- or bisexual, pedicel 1.5–6 mm long, bracteoles 1–3, perianth campanulate, 2.5–7 mm long, lobes 5, truncate, stamens 6–9(–14), up to 4 mm exserted in male flowers, 1 mm in female flowers and 1.5 mm in bisexual flowers, stigma fimbriate; anthocarp elongate, 2–4 cm × 0.3 cm, 5-ribbed, viscid. *P. umbellifera* occurs in coastal areas, but also in everwet or monsoon forest, along river banks, creeks, on sandy clay, sandy and rocky soils, at low altitudes.

Selected sources 100, 207.

G.H. Schmelzer & N. Bunyapraphatsara

Pistia stratiotes L.

Sp. pl. 2: 963 (1753).
ARACEAE
$2n = 28$

Vernacular names Water lettuce, tropical duckweed, Nile cabbage (En). Lettue d'eau (Fr). Indonesia: ki apu (Sundanese), kayu apu (Javanese), kiambang (West-Kalimantan). Malaysia: kiambang. Philippines: kiapo, apon (Tagalog), loloan (Iloko). Thailand: chok (central), kaa kok, phak kok (northern). Vietnam: b[ef]o c[as]i, b[ef]o tai t[uw][owj]ng, d[aj]i ph[uf] b[if]nh.

Origin and geographic distribution *P. stratiotes* has a pantropical distribution, and occurs throughout South-East Asia.

Uses In China, Vietnam, Thailand, India, West Africa and Brazil, the leaves of *P. stratiotes* are used externally for skin diseases, such as boils, piles and syphilitic sores, and internally as a laxative, emollient and diuretic. They are also mixed with rice and coconut milk for dysentery, and mixed with rose water and sugar for cough and asthma. In Peninsular Malaysia, the leaves are applied in the treatment of gonorrhoea, probably because they act as a diuretic. They are also applied to haemorrhoids. In India, the ashes are used to treat ringworm, and a decoction of the plant for dysuria and as an expectorant. In Nigeria, the leaves are taken as a stomachic, but an overdose may cause acute diarrhoea. In Cuba, a decoction of the whole plant is drunk to relieve dyspepsia, and in Venezuela, a decoction is used in baths to reduce oedema.

In Java, *P. stratiotes* is tolerated because shrimps are known to take cover underneath. It is also good fodder for gourami, carp and goldfish. In India and China, it is cooked as a fodder for pigs and ducks, and can be used fresh to feed rabbits. In India and the Sudan, it has been used as a famine food, but humans do not generally find it very palatable. The Chinese eat the young leaves cooked, but their taste is first nondescript and then sharp because of the calcium oxalate.

The plant is also used as a manure, especially for its high potash content. The plant can be used with soap for taking stains out of clothing, probably because of its potash content.

Experiments have shown that *P. stratiotes* is a good waste water-cleaning agent, as it takes up nitrogen and phosphorous compounds, as well as heavy metals, and harbours active microbial organisms.

In the tropics, *P. stratiotes* is sometimes cultivated as an ornamental in fountains and aquatic gardens. In Europe and North America, *P. stratiotes* is sold as an indoor aquatic ornamental, but has been known to be introduced in fresh water illegally, where it dies back during winter, so it cannot become a noxious weed.

Production and international trade *P. stratiotes* is not known to be traded as a medicinal plant.

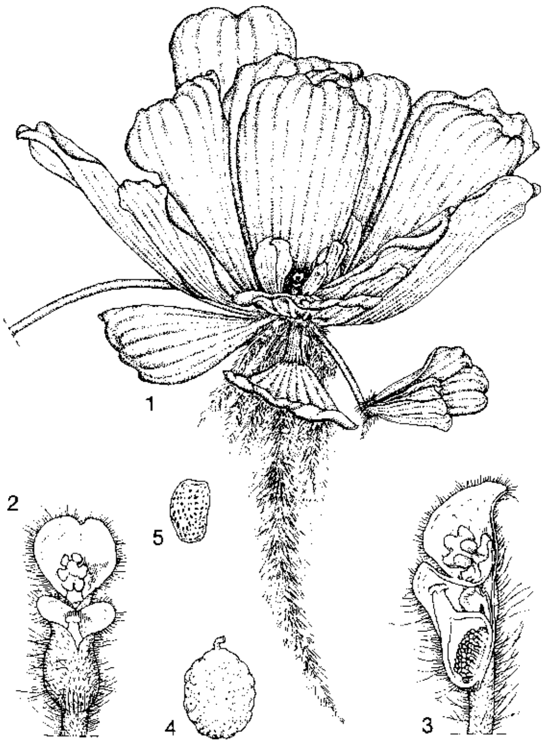
Properties The ash of *P. stratiotes* contains 75% potassium chloride and 23% potassium sulphate. It also contains small amounts of salts of sodium, magnesium, calcium, iron and aluminium. The fresh plant is a source of vitamins A, B and C, and also contains polysaccharides (galactose, glucose, mannose and arabinose residues), uronic acids, steroids, as well as the polyamines spermidine, spermine and some closely related compounds. Several potential allelochemicals have been extracted from the leaves, including linoleic acid, γ-linolenic acid, (12R,9Z,13E,15Z)-12-hydroxy-9,13,15-octadecatrienoic acid, (9S,10E,12Z,15Z)-9-hydroxy-10,12,15-octadecatrienoic acid and 24S-ethyl-4,22-chloestadiene-3,6-dione. They were found to inhibit the growth of several algae and cyanobacterial species in solid media. Also the phenylpropanoid α-asarone was isolated, which was found to be toxic to sensitive algal strains in liquid medium.

Several flavonoids were isolated as well, e.g. chrysanthin, lucetin, luceolin-7-glucoside, orientin, vicetin and vitexin. Other isolated compounds included the norterpene glucosides stratioside I and II.

A methanol extract of the whole plant showed calcium channel blocking activity in isolated segments of rabbit jejunum in vitro; this was confirmed by pretreatment with verapamil (a standard calcium channel blocker). Additionally, the extract inhibited dose-related bronchodilating activity in isolated guinea-pig trachea and dose-related neuromuscular blocking actions of reference compounds. It also caused a decrease in systolic and diastolic blood pressure in anaesthetised rats of 18% and 10% respectively, at a dose of 10 μg.

In the brine shrimp lethality bioassay, some undefined *P. stratiotes* extracts exhibited moderate toxicity in low concentrations.

Description A small, monoecious, perennial, quick-growing, free-floating aquatic herb; stolons 10–60 cm long, stem almost absent; roots adventitious, 20–80 cm long, forming a dense tuft, root hairs plumosely spreading. Leaves rosulate, subimbricate, variable in shape and size, spathulate or tongue-shaped, 2–10 cm × 2–9 cm, patent or erect when crowded, pale to yellowish-green, whitish velvety hairy, blade succulent, veins flabellate; petiole absent. Inflorescence a spadix surrounded by a spathe, several in upper part of rosette, peduncle 12–15 mm long; male and female flower small, located separately on the spadix; spathe narrowly ovate, 7–9(–20) mm × 3 mm, acuminate, outside pubescent, white, inside glabrous, lower margins connate with each other and with ovary wall, free margins folded between stigma and stamens to form a constriction, just below spathe partition a thin pouch-shaped flap, green; spadix mostly adnate to spathe, at apex free, with 1 naked male flower, 4–6(–8) stamens united in a synandrium, at base subtended by a thin, cup-shaped ring, pores in anthers 4, in 2 superposed pairs; at base of spathe 1 naked female flower, ovary 1-celled, ovules many, in 4–6 rows on convex parietal placenta, style free from spadix, thick, stigma subglobose, bearded. Fruit a dry, ellipsoid berry, irregularly rupturing, with few to numerous seeds. Seed ovoid, 2 mm long, wrinkled, tapering towards the base, apex truncate and depressed in the centre, brown. Seedling germinating under water, emerging with a 2-lobed, cotyledon-like structure, filled with aerenchyma and floating; no primary root is developed, but 2–3 adventitious roots emerge soon from the base of the cotyledon; between the 2 lobes the first leaf appears, broadly ovate, densely hairy.



Pistia stratiotes L. – 1, plant habit; 2, inflorescence; 3, longitudinal section of lateral view of inflorescence; 4, fruit; 5, seed.

Growth and development The leaves of *P. stratiotes* are able to float because the short depressed hairs on both surfaces trap air and repel water. Some leaves also have a conspicuous, ovoid swelling on the underside filled with spongy parenchyma, which enables the plant to float. The roots stabilize the rosettes, and when a portion of the roots is destroyed, part of the foliage may become partly or fully submerged.

Flowering and fruiting patterns of *P. stratiotes* vary by the region. Flowering seems to be markedly enhanced when vegetative reproduction is inhibited by crowding. In India, flowering starts in the hot season and continues up to the rainy season, while the fruits appear after the rainy season.

In Indonesia, flowering can occur throughout the year. There are about 8 days between the appearance of the first flower buds and when the flowers open. At anthesis, first the pistil emerges, and after a few hours the stamens. *P. stratiotes* is pollinated by insects. Seeds reach maturity about 30 days after fertilization.

Other botanical information *Pistia* belongs to the subfamily *Pistoideae* and is a monotypic genus.

Ecology *P. stratiotes* floats in stagnant or slowly flowing fresh water, ponds and tidal areas, from sea-level up to 1200 m altitude. It is cold sensitive and thus cannot exist far beyond the tropics of Cancer and Capricorn. It can become a part of dense aggregations of free-floating vegetation, called sudds, which are common in wide, slow-flowing rivers and in extensive swampy areas. Sudds are formed by thick, floating mats of *P. stratiotes*, and/or *Eichhornia crassipes* (Mart.) Solms, which are then colonized by hydrophytes, mainly grasses and sedges, which often invade from the shore. When the raft is large enough, it may be torn away from the shore by wind or flood, to become a floating island. It performs best at pH 4, and cannot grow at pH 3; its range of pH tolerance is much narrower than that of *Eichhornia crassipes*, which has its optimum growth at pH 7. *P. stratiotes* is a noxious weed like *E. crassipes*, obstructing navigation in rivers and grills of hydro-electric plants. It interferes with fisheries by hindering the nets and lowering the oxygen content of the water and the pH.

Propagation and planting *P. stratiotes* is propagated by seed, or, more rapidly, by stolons. Seed production varies from 0–1 per flower in laboratory experiments in the United States, to several seeds per flower in Africa. The seeds float in the water for a few days, after which they sink and germinate. The seedling appears at the surface in 5 days.

Diseases and pests *P. stratiotes* is most troublesome as a weed in Africa, but is also a serious problem in Southern Asia and the Caribbean islands. It is a serious competitor in irrigated rice fields, where it can root in shallow water.

The leaves of *P. stratiotes* serve as a niche for several mosquito species, which in turn serve as principal vectors of malaria, encephalomyelitis and filariasis.

Intensive research on biological control of *P. stratiotes* is being carried out. In several locations, it is periodically devastated by insects, of which the larvae of *Proxenus hennia* occur exclusively on *P. stratiotes*. *Nymphula responsalis* and the noctuid *Spodoptera pectinicornis* from South-East Asia also feed on other noxious water plants. In Indonesia, tropical Africa and tropical Australia, long-term control of *P. stratiotes* is done effectively by *Neohydronomus affinis* (Coleoptera), while areas with shallow water infested by *P. stratiotes*, which are regularly subjected to alternate wet and dry regimes, are best controlled chemically. Fungal pathogens have received much less attention as potential biological control agents, although some are promising, such as *Cercospora pistiae*, which causes leaf spot.

Harvesting Plants of *P. stratiotes* are pulled out of the water when needed.

Handling after harvest The leaves of *P. stratiotes* are used fresh or are dried in the sun or shade before use.

Genetic resources and breeding As *P. stratiotes* is a fast growing, pantropical weed, propagating by seed and stolons, it is certainly not genetically endangered.

Prospects The fatty acids extracted from the leaves of *P. stratiotes* show interesing potential as allelochemicals, and therefore could be of use as a local source in the control of algae. More research is needed, however, to fully evaluate other possibly interesting activities, e.g. in developing new calcium channel blocking agents.

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Other selected sources 48, 74, 87, 134, 135, 215, 246, 301, 384, 696, 912, 1123.

G.H. Schmelzer & N. Bunyapraphatsara

Platycladus orientalis (L.) Franco

Portugaliae Acta Biol., Sér. B, Sist. Vol. 'Julio Henriques': 33 (1949).

CUPRESSACEAE

$2n = 22$

Synonyms *Thuja orientalis* L. (1753), *Platycladus stricta* Spach (1841), *Biota orientalis* (L.) Endl. (1847).

Vernacular names Chinese arbor-vitae, biota (En). Thailand: chantayee (northern), son phaeng (Bangkok), son haang sing (central). Vietnam: tr[aws]c b[as], tr[aws]c b[as]ch di[eej]p.

Origin and geographic distribution The natural distribution of *P. 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 the Russian Far-East. Its distribution has long extended to Japan, Taiwan and Central Asia. It is locally naturalized in Indo-China. It has been cultivated in Europe since the first half of the 18th Century.

Uses In traditional Chinese medicine the leaves of *P. orientalis* 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, duodenic and gastric ulcers, gonorrhoea and colds. The seeds are prescribed as sedative, tranquillizer, antitussive and haemostatic. In Indo-China the ground leaves are used as an emmenagogue, haemostatic 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 Thailand, the leaves are used as antipyretic, diuretic, anti-inflammatory and anticough.

Production and international trade Dried herbal materials of *P. 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.

Properties The leaves and fruits of *P. orientalis* contain an essential oil which can be easily obtained by steam distillation. The leaf essential oil contains high amounts of α-pinene, β-caryophyllene, cedrol, β-myrcene, R-(+)-limonene and aloaromadendrene. The essential oil from the fruits contains high amounts of α-pinene, δ-3-carene, β-terpinene, rho-cymene, cedrol, camphene, D-limonene and myrtenol. In Egyptian material the highest yield was obtained from fresh fruits (0.32 % v/w).

Furthermore, a labdane-type diterpene, pinusolide was isolated from the hexane and chloroform extracts of the leaves of *P. orientalis*. Pinusolide is a potent platelet activating factor (PAF) receptor-binding antagonist, which inhibited PAF-induced aggregation of rabbit platelets (IC_{50} value of 5 μM), but had no inhibitory effect on ADP-, thrombin-, or collagen-induced platelet aggregation. Pinusolide also protected mice from PAF-induced lethality (ED_{50} values of 1.1 mg/kg, intravenous, and 69 mg/kg, per oral). Topical administration of pinusolide, at 2 mg/ear, was effective in inhibiting croton oil-induced mouse ear oedema. Ears of treated mice fully recovered, in contrast to the necrotized ears of their untreated controls.

The effects of pinusolide on PAF-induced [3H]serotonin release from rabbit platelets, hypotension and vascular permeability were furthermore confirmed. Pinusolide (IC_{50}, about 5 x 10^{-6} M) inhibited specifically [3H]serotonin release from rabbit platelets when stimulated with PAF (5 x 10^{-8} M), but showed no effect when induced by ADP, collagen and thrombin. It also inhibited PAF-induced hypotension in a dose-dependent manner in rats with no effect on the hypotension induced by acetylcholine, histamine and serotonin. The inhibitory effect of pinusolide on the PAF-induced vascular permeability is less specific than the induced hypotension. The results suggest that pinusolide may prove of therapeutic value in the treatment of hypotension and a molecular design of pinusolide analogues may provide the possibility of new PAF specific antagonists.

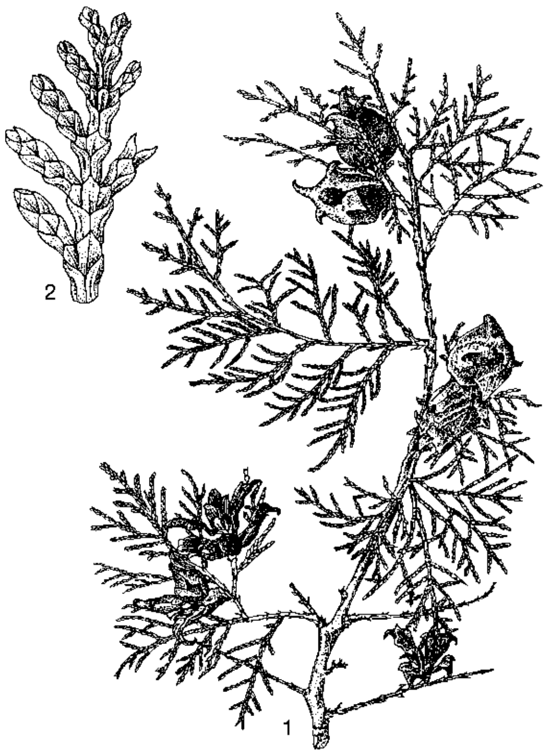
The related compound pinusolidic acid, obtained from the $CHCl_3$ extract of *P. orientalis*, also inhibited PAF-induced aggregation of rabbit platelets (IC_{50} value of 2.3 x 10^{-5} M).

In an experiment with mice, an ethanol extract of the seeds of *P. orientalis* was investigated for its effect on learning impairment, produced by bilateral lesion of basal forebrain, and judged by performance in the step-through and step-down type passive avoidance tests. Chronic oral administration of the ethanol extract at a daily dose of 250 or 500 mg/kg, from the day of surgery until the end of the behavioural test, dose-dependently improved memory acquisition impairment in the step-down test, and memory retention disturbance in both behavioural tasks. Other effects of extracts include the haemostatic properties of the leaves, which are confirmed in a series of experiments in rabbits and dogs, aqueous and ethanolic extracts which showed marked in vitro and in vivo antitumour activity, and a decoction of the leaves which is reported as having an activity similar to that of vitamin K.

In a preliminary antibacterial screening the aqueous extract of *P. orientalis* inhibited the growth of gram-positive bacteria at minimum inhibitory concentration of less than 3.9 mg/ml. Aqueous extracts of *P. orientalis* significantly inhibited aflatoxin production of *Aspergillus parasiticus* on agricultural commodities, including rice, wheat, maize and groundnut.

Immunosuppressant activity was observed in mice fed with a diet containing 10% seed oil.

Description A large shrub or small to medium-sized tree, rarely exceeding 20 m tall, in cultivation often forming multiple stems; habit dense, usually broadly conical with ascending branches from bare stems; bark thin, reddish-brown, exfoliating in thin longitudinal strips; branches with the foliage held in vertically aligned sprays that always point upwards. Leaves decussate, scale-like, size correlated with growth of the shoots; leaves on leading shoots continue to elongate until after some years they wither and break up, leaves of finer lateral sprays about 2 mm long, tightly adpressed; foliage pale green, odourless when crushed. Inflorescence a unisexual cone. Male cones terminal, 2–3 mm long. Female cones oblong, 20–25 mm long, 10–18 mm wide when closed, usually with 6–8 fleshy scales, with a deeply recurved horn below the tip of each scale. Scales glaucous when growing, maturing and ripening to bright brown before opening; lower 4 scales fertile with 2(–3) seeds. Seed ovate, wingless, 5–7 mm long, 3–4 mm in diameter.



Platycladus orientalis (L.) Franco – 1, fruiting twig; 2, detail of shoot.

Growth and development In Vietnam, *P. orientalis* flowers in March–April, and fruits in June–August. In trials in Kazakhstan on the eastern shore of the Caspian Sea *P. orientalis* started fruiting at 3 years.

Other botanical information *P. orientalis* belongs to a monotypic genus closely related to *Thuja*. It can be easily distinguished by the vertical arrangement of its sprays of foliage, which lack odour when crushed, the strongly hooked bract tips of the cone scales and its wingless seeds. Numerous cultivars are registered in horticultural trade, ranging from dwarf forms to small trees; some with juvenile needle-like leaves, others green golden, slightly variegated or with filamentous branches.

Ecology In its assumed native habitat, *P. orientalis* usually grows on steep rocky hillsides and cliffs. This explains the success of plantings on poor, excessively drained soils even with a high pH, as well as the success of smaller cultivars in rock and succulent gardens.

Propagation and planting *P. orientalis* can be raised easily from cuttings and seed, and the young plants adapt to most soil types and sites. Its cultivars are best raised from cuttings, but side-veneer grafting is the best option for those that prove most difficult.

Husbandry *P. orientalis* prefers full sun but is tolerant of partial shade. Growth performance of seedlings is enhanced by NPK application. NPK treatment at 10:20:10 markedly increases stem diameter. The 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 in NPK treatment. Total soluble sugars generally increase as N level increases, but total soluble phenols decrease.

Harvesting Leafy parts of *P. orientalis* can be collected whenever the need arises. Mature fruits are generally collected in autumn.

Handling after harvest Leafy parts of *P. orientalis* can be dried and stored for future use. The seeds are obtained by opening the dried fruits and used fresh or after extraction of the essential oil.

Genetic resources and breeding *P. orientalis* has a large area of distribution, either naturally or as a result of cultivation, and does not seem to be at risk of genetic erosion.

Prospects The potential for cultivation of *P. orientalis* in South-East Asian countries especially at higher elevations needs further investigation. Pinusolide shows interesting activity in the field of hypertension and platelet activating factor (PAF-)antagonism. Although more research will be needed, the compound or its (semi-)synthetic analogues may have some potential in future medicinal research.

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Other selected sources 135, 215, 263, 296, 312, 562, 577, 739, 786, 928.

S. Aggarwal

Pluchea indica (L.) Less.

Linnaea 6: 150 (1831).
COMPOSITAE
$2n = 20$

Synonyms *Pluchea foliosa* DC. (1836).

Vernacular names Indian (marsh) fleabane, Indian pluchea (En). Indonesia: beluntas (Indonesian), luntas (Javanese), baruntas (Sundanese). Malaysia: beluntas, beluntas paya. Papua New Guinea: a'apu ('Ere 'Ere, Central province). Philippines: kalapini (Tagalog), banig-banig (Sulu). Cambodia: pros anlok. Laos: nat luat. Thailand: khlu (central), nuat ngua, naat wua (north-eastern). Vietnam: c[us]c t[aaf]n, l[as] l[uws]c.

Origin and geographic distribution *P. indica* is found from India to southern China, through Indo-China, Thailand, Malaysia, Indonesia and the Philippines, to Australia (including Christmas Island) and the Pacific Islands (including Hawaii).

Uses In Malesia, Indo-China and India a decoction of the leaves, or the crushed fresh leaves or roots of *P. indica* are used especially as a febrifuge and diaphoretic. In Indonesia and Malaysia, the leaves are also used as a stomachic, a galactagogue, and cough medicine. Juice from the crushed leaves, mixed with the juice of other plants, is a remedy for dysentery. An infusion of the leaves, usually in combination with other ingredients, is given against leucorrhoea. In Papua New Guinea, a decoction of the leaves and stem is drunk to ease asthma and other pulmonary problems. *P. indica* is also used externally, in special baths as an aromatic and stimulant, and also in nerve-strengthening fomentations. In Indonesia it is mixed with other ingredients into a poultice which is an effective embrocation against weakness after diarrhoea, and against ulcers and sores. The roots, mixed with other ingredients, are applied as a poultice for rheumatic pains. In Thailand all parts of the plant are used as a diuretic and antidiabetic. Externally it is used to relieve skin diseases, and fresh leaves are applied to cure haemorrhoids. In Vietnam, a decoction of the roots or leaves is recommended for treating fever, headache, rheumatism, sprains, dysentery and dyspepsia, and in baths to treat scabies. A decoction of the fresh leaves is also used in an inhalant to cure colds. The powdered leaves, mixed with beeswax and castor oil, are applied in bandaging closed fractures. In Vietnam and Cambodia, an infusion of the leaves as a tea, or the leaves and young shoots crushed in alcohol, are used for treating lumbago.
In Indonesia, the crushed leaves, raw or steamed, are eaten to correct foul breath and offensive perspiration odour. Leaves, young tops and inflorescences, either raw or cooked, are consumed in Java as a side-dish to rice, or as a salad, and sometimes as components of a soup. In Thailand, the leaves are eaten as a flavouring. In Indonesia and Vietnam, *P. indica* is also regularly used as a hedge plant and as an intercrop in teak forests.

Production and international trade *P. indica* is produced and traded locally on a small scale only.

Properties The leaves and aerial parts of *P. indica* contain an essential oil, with camphor, α-pinene, benzyl alcohol, benzyl acetate, eugenol, linalool and δ-cadinol as main components. In the above-ground parts the presence of terpenoids has been indicated, e.g. 3-(2',3'-diacetoxy-2'-methylbutyril) cuauhtemone, linaloyl glucoside, linaloyl apiosyl glucoside, 9-hydroxylinaloyl glucoside, plucheoside A and B, 6-hydroxydammar-6-en-3-acetate and dammadienol. Flavonoids including quercetin and quercetin-3-riboside are also found. The roots contain pterocaptriol, plucheoside C, D1, D2 and D3 and E, plucheol A and B, hop-17(21)-en-3β-yl acetate and boehmeryl acetate.

A root extract of *P. indica* was tested on locomotor activity responses, pentobarbital-induced sleep responses, social isolation-induced aggressive behaviour responses, motor coordination (rotarod test) responses, pentetrazole-induced convulsions and nociceptive (tail-pinch test) responses in mice. The root extract significantly decreased locomotor activity, suppressed isolation-induced aggressive behaviour and prolonged pentobarbital sleeping time in a dose-dependent manner in isolated mice, but not in house-grouped mice. The extract had no effect on pentetrazole-induced convulsions, motor coordination in the rotarod test, or nociceptive responses in the tail pinch test in house-grouped mice. These results suggest that the root extract of *P. indica* attenuates pathophysiological changes caused by social isolation stress in mice.

The methanol fraction of *P. indica* root extract was tested in various models of inflammations and ulcers in vivo. It showed significant anti-inflammatory activity on arachidonic acid-, platelet activation factor- and compound 48/80-induced paw oedemas. Ulcer studies revealed significant protective action of the fraction on indomethacin-, alcohol- and indomethacin-alcohol-induced ulcerations. There was also a significant decrease in gastric volume and acidity in pylorus ligated rats. Significant anti-inflammatory activity of *P. indica* root extract is also found for carrageenin-, histamine-, serotonin-, hyaluronidase- and sodium urate-induced pedal inflammation. The root extract exhibited carrageenin- and cotton pellet-induced granuloma formation as well as turpentine-induced joint oedema and adjuvant-induced polyarthritis assays in vivo.

Furthermore, the methanol fraction of the root extract exhibits significant hepatoprotective activity against experimentally induced liver damage by CCl_4 in rats and mice. This fraction lowered elevated serum enzyme and bilirubin levels, reduced the prolonged pentobarbitone-induced sleeping time and bromosulphalein retention, and decreased the plasma prothrombin time and serum total protein, albumin and albumin/globulin ratio, following CCl_4-induced liver damage.

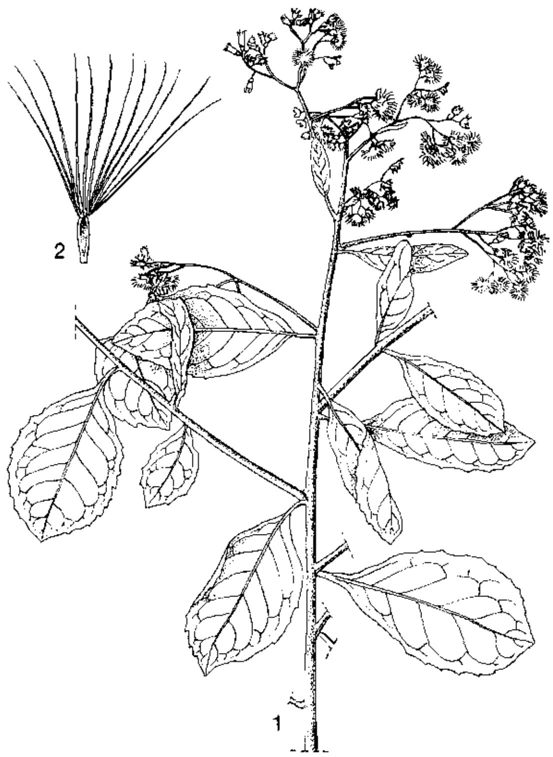
A methanol extract of the roots was also screened for activity against the venom of the snake *Vipera russellii*, and was found to significantly reduce venom-induced lethality and haemorrhagic activity in rats and mice. Venom-induced coagulant and anticoagulant activity was also antagonized.

The plant extract of *P. indica* displays a dose-related diuretic effect on water-loaded rats under ethanol anaesthesia, with no detectable pathological changes after high doses. An infusion of the extract is known to have similar effects on humans.

The essential oil from the leaves, diluted in polyethylene glycol, demonstrated antimicrobial activity under laboratorium conditions on the growth of the bacteria *Staphylococcus aureus* and *Escherichia coli*, the pathogenic fungi *Microsporium gypseum* and *Candida albicans*, as well as of the non-pathogenic *Pithium ultimum* and *Xanthomonas campestris*.

Description An evergreen, slender, erect, much-branched shrub, 1–3 m tall; branches cylindrical, ribbed and woody, dark brown, towards the tip green, glabrous but young shoots pubescent. Leaves alternate, simple, ovate to obovate, 2.5–8 cm × 1–5 cm, base attenuate, apex acute or mucronate, margins serrate, obscurely glandular on both surfaces, aromatic when crushed; petiole short or subsessile; stipules absent. Inflorescence consisting of many heads in a hemispherical terminal or axillary corymb or panicle, more or less dense, 2.5–12.5 cm wide; peduncles short, involucral bracts 6–7-seriate, outer ones ovate, hairy, inner ones lanceolate, shiny, ciliate at the apex, falling off together with the ripe achenes, heads narrowly cylindrical, 7 mm across. Flowers all tubular, the marginal flowers female, corolla 3.5–5 mm long, 5–6-fid, the central flowers 2–6, bisexual but functionally staminate, corolla filiform, 4–6 mm long, lilac or pale violet, anthers 5; ovary inferior; style-arms long, exserted. Fruit a cylindrical achene, 1 mm long, glabrous with about 5 ribs, brown, achene of central flowers rudimentary; pappus white, 3–4 mm long, spreading. Seedling with epigeal germination.

Other botanical information *Pluchea* is a heterogeneous assemblage of about 40 species from warm regions and belongs to the tribe *Inuleae*. Much more research is needed before a satisfactory taxonomy can be established.



Pluchea indica (L.) Less. – 1, flowering branch; 2, achene.

Other medicinally known species are *P. pteropoda* Hemsl. in Indo-China, and *P. lanceolata* Oliv. & Hiern in India. They are used as a febrifuge, and a tea of the leaves of *P. lanceolata* is known to cure inflammations and bronchitis; a decoction of the above-ground parts of the plant prevents the swelling of joints in arthritis.

Ecology *P. indica* occurs especially along the sea shore and tidal streams and swamps, on clayish or hard and stony soils, occasionally near salt-springs in the interior, in sunny or slightly shaded localities. It is cultivated as a hedge in the lower regions, sometimes up to 1000 m altitude, on fertile soils.

Propagation and planting *P. indica* is mostly propagated by stem cuttings, but also by seed.

Husbandry In Java, the quickset hedges of *P. indica* are regularly pruned to regulate height and general appearance. *P. indica* planted as a vegetable is cut back to allow a constant supply of new growth and young leaves.

Harvesting Leaves and roots of *P. indica* are collected all year round. The leaves should preferably be picked before flowering starts.

Genetic resources and breeding *P. indica* is relatively widespread in coastal regions, and the risk of genetic erosion seems rather limited. No germplasm collections or breeding programmes are known to exist for *P. indica*.

Prospects The significant activity of the methanol fraction of the root extract in many inflammation and anti-ulcer models merits further research. The leaves also have potential as a diuretic; at present they are found in local markets and sold for that purpose.

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Iman Raharjo & S.F.A.J. Horsten

Pogostemon auricularius (L.) Hassk.

Tijdschr. natuurl. gesch. physiol. 10: 127 (1843).
LABIATAE
$2n = 34$

Synonyms *Dysophylla auricularia* (L.) Blume (1826).

Vernacular names Indonesia: ke kucing (Aceh), ketumpang (Javanese), kambing kambing (Kalimantan). Malaysia: kekucing. Philippines: buntot pusa (Tagalog). Thailand: saapraeng saapkaa (peninsular). Vietnam: t[us] h[uf]ng h[if]nh tai, c[or] c[of].

Origin and geographic distribution *P. auricularius* is distributed from India throughout South-East Asia and southern China but is not recorded from the Lesser Sunda Islands and from Australia.

Uses In Peninsular Malaysia and Indo-China, *P. auricularius* is commonly used in the treatment of simple stomach problems in children. The pounded leaves, sometimes mixed with lime, are applied as a poultice on the abdomen. In Indonesia, a poultice made from the leaves is also applied as a cure for diarrhoea, colic, worms, sores, kidney problems, and a sore throat. The leaves are chewed in Java against colic and flatulence. In Indo-China, a decoction is drunk to cure malaria, whereas a lotion is applied as a rubefacient against rheumatism. In Thailand, roots, stems or leaves are used as a diuretic or antipyretic. *P. auricularius* has also been mentioned as a potential anti-carcinogen.

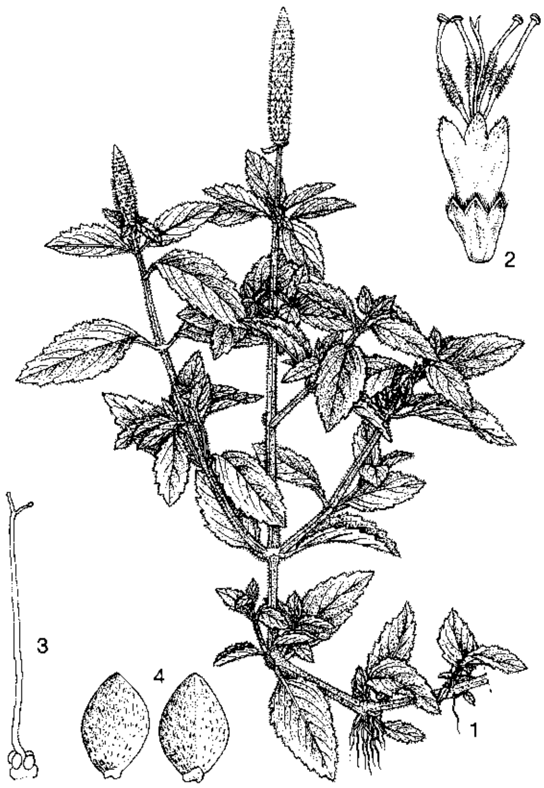
The ground leaves of *P. glaber* Benth. are externally applied to relieve pain and itching of mosquito bites. In Malesia, an infusion of leaves of several *Pogostemon* species, e.g. *P. auricularius*, *P. cablin*, *P. heyneanus* Benth. and *P. verticillatus* (Roxb.) Bhatti & Ingr., is taken to allay painful menstruation. The leaves are also added to bath water to alleviate rheumatism. *P. heyneanus* is also known to be used as a carminative and diuretic, and as an insecticide for stored cereals. From the leaves of *P. cablin* (Blanco) Benth. an important essential oil, patchouli oil, is produced. The leaves are also put between clothes as an insect repellent, and the volatile oil is also used as an insect and leech repellent.

Production and international trade In Malesia, dried plants of *P. auricularius* are sold in Chinese pharmacies.

Properties From the aerial parts of *P. auricularius*, 4 cleistanthane type diterpenoids (C_{20}) were isolated, of which one was identified as auricularic acid. On preliminary screening, these compounds exhibit spasmolytic activity.

The volatile oil of *P. cablin* contains a number of sesquiterpenes, of which (–)-patchouli alcohol (patchoulol), and the closely related derivatives patchoulenol and patchoulenone are most abundant. Patchouli alcohol, pogostol and pogostone (dwelwanine) show antimicrobial activity against periodontopathic bacteria and/or fungi, while patchouli alcohol also showed significant inhibitory activity on K^+ induced contractures of a guinea-pig taenia coli preparation. Patchouli alcohol, pogostol, stigmast-4-en-3-one, retusin and pachypodol show anti-emetic activity on copper sulphate induced-emesis in young chickens. The aerial parts also contain the flavonoid licochalcone A, which is used in the treatment of promyelocytic leukaemia cells (HL-60)with licochalcone A induced cell differentiation. Some *Pogostemon* species show toxicity to *Anopheles stephensi* and *Culex quinquefasciatus* mosquito larvae.

Description An erect or procumbent, strong smelling annual herb, 30–80 cm tall, stem simple or laxly branched, weak, bluntly 4-angular, pubescent with spreading hairs, pinkish. Leaves decussate, elliptical to ovate, 4–6 cm × 2–3 cm, base cuneate, apex acute, margin irregularly serrate, except near the base, membranaceous, pubescent and glandular on both surfaces; petiole 2–10 mm long, hairy; stipules absent. Inflorescence composed of crowded verticillasters, forming a dense terminal spike, 4–8 cm long; bracts narrowly elliptical, long ciliate; calyx subcampanulate, gland-dotted outside, 1.2–1.5 mm long, 5-toothed, teeth subequal, triangular, ciliate; calyx in fruit urn-shaped, 2.5–3.5 mm long, teeth often incurved over the nutlets; corolla 2–3.5 mm long, tube slender, exserted, lobes 4, equal, obtuse, pubescent,



Pogostemon auricularius (L.) Hassk. – 1, flowering stem; 2, flower; 3, pistil; 4, frontal and dorsal view of nutlet.

lavender, pale pink or white; stamens 4, subequal, filaments 3.5–4 mm long, slender, upper half villous, lilac; style 5 mm long, bifid; disk 0.3 mm long. Fruit consisting of 4 dry 1-seeded schizocarpous nutlets enclosed in the persistent calyx, nutlets ellipsoid, 0.6 mm × 0.4 mm, finely reticulate, brown. Seedling with epigeal germination; hypocotyl 1–2 mm long, glandular; cotyledons triangular, 2 mm long, apex obtuse; epicotyl hairy, greenish to purplish; first leaves 2, ovate, 3.5 mm long, margin crenate, nerves prominent, hairy, glandular underneath.

Growth and development *P. auricularius* flowers and fruits throughout the year. In marshy locations the stems are prostrate and root at the nodes. Plants spread over 1–2 m, with the erect flowering branches arising from the main stem. *Pogostemon* is pollinated by insects.

Other botanical information *Pogostemon*, including the genus *Dysophylla*, comprises almost 80 species, which are distributed from India to China and Japan, and throughout South and South-East Asia. India is the centre of diversity. The species that belonged to *Dysophylla* are still recognized at the sub-generic level, and *P. auricularius*, the former type of *Dysophylla*, now belongs to subgenus *Dysophyllus*, section *Dysophyllus*.

Ecology *P. auricularius* grows on sunny, constantly or periodically humid localities, borders of ditches, dams and upland rice fields, grassy wasteland and thickets. It is locally often common, from the lowland to 2000 m altitude.

Propagation and planting *P. auricularius* is propagated by seed, which is hydro- and epizoochorous.

Diseases and pests Specific information on *P. auricularius* is not available, but *Pogostemon* species are often affected by fungi including *Alternaria* and *Cercospora* spp., which attack the leaves, while other fungi attack the roots of the perennial species. In India, several viruses are known to cause mottling of the leaves of *Pogostemon* as well. Nematodes such as *Heterodera marioni* in Indonesia and *Helicotylenchus*, *Tylenchorhynchus* and *Meloidogyne incognita* in India, are very common pests.

Harvesting *P. auricularius* is harvested from the wild whenever the need arises.

Handling after harvest The leaves or whole plants of *P. auricularius* are dried in the shade, or used fresh.

Genetic resources and breeding *P. auricularius* is widespread in anthropogenic habitats and does not seem to be at risk of genetic erosion. No breeding programmes or germplasm collections are known to exist.

Prospects The isolated compounds from *P. auricularius* need more research to assess their usefulness. Until more is known, its use will remain of local importance only.

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Other selected sources 135, 510, 764, 774, 802, 1102.

Eulis Retnowati

Polygala L.

Sp. pl. 2: 701 (1753); Gen. pl. ed. 5: 315 (1754).

POLYGALACEAE

x = 14, 17; *P. chinensis*: $2n$ = 28; *P. paniculata*: $2n$ = 52–56; *P. sibirica*: $2n$ = (30, 32), 34, (68)

Major species *Polygala polifolia* Presl., *P. sibirica* L.

Vernacular names Milkwort (En).

Origin and geographic distribution *Polygala* comprises about 500 species and occurs in tropical, subtropical, temperate and montane regions throughout the world, except New Zealand. The majority of the species grow in tropical Central and South America, and secondary centres of diversity are found in North America and South Africa.

Uses *Polygala* roots are pungent, sweet, warming and tranquillizing. Several *Polygala* species, such as *P. sibirica* in China, *P. crotalarioides* Buch.-Ham. ex DC. in the Himalayas, *P. polifolia* in southern India and Java, and *P. senega* L. (snake root) from northern America are known for the expectorant action of the roots, which are used for coughs, asthma, pulmonary catarrh and bronchitis. The roots of *P. glaucoides* L., occurring from Sri Lanka to South-East Asia, and *P. senega*, are also known to be active against snake bites. The roots of *P. sibirica* are a constituent of traditional Chinese and Japanese medicine mixtures for treating mental and neurological disorders. In Peninsular Malaysia, they are imported for use as a tonic. The leaves and roots of locally occurring *P. polifolia* and *P. paniculata* L. are used in the same way. In China, the roots of *P. sibirica* are applied to furuncles and painful swellings in the breast. They are also used to promote a clear mind, to dispel phlegm, as a remedy for heart trouble, head and chest pains, for reddish urine, jaundice, hysteria, and infantile convulsions. In Vietnam, a decoction of the roots is also employed for impaired memory and sexual impotency. In India, the roots of *P. polifolia* and *P. chinensis* are used for fever, dizziness and as an antiseptic. A sweetened infusion of *P. paniculata* is a remedy for gonorrhoea and lumbago. The pulverized leaves may be applied to wounds, but should be handled carefully since the sap causes inflammation if it gets in the eyes. In New Guinea, the women eat the flowers against infertility. In Indo-China, the leaves and stem of *P. chinensis* are used to treat congestion, the pith of the roots is prescribed to treat fever, inflammations of the throat, spermatorrhoea, and haematuria. In Java, an infusion of the leaves is taken for cough and asthma, and is a constituent in a remedy for diarrhoea. An infusion of the whole herb is recommended for chronic bronchitis. In India, the tender leaves of *P. polifolia* are used as a vegetable in times of scarcity. They are said to have a pleasant flavour. In Java, the roots of *P. paniculata* are kept between clothes, because of their fragrance. *P. butyracea* Heck. is cultivated in West Africa for its fibre and as an oil-seed crop. It has been tried as an oil-seed crop in Peninsular Malaysia and Java, but the seeds ripened too unevenly to be useful.

Production and international trade *Polygala* is only traded on a local scale in South-East Asia. The roots of *P. sibirica* are imported by the Chinese into Peninsular Malaysia and Vietnam. *P. sibirica* is cultivated for the roots in China and Japan, as is *P. senega* in Europe, but no information on production is available.

Properties Many *Polygala* species contain saponins in their roots, but only limited tests have been performed to investigate the biological activity of these purified compounds.

The roots of *P. senega* ('Senegae Radix') contain 6–12% triterpenoid saponins: senegin II, III and IV. These are based on the aglycone presenegin to which 2 separate sugar groups are attached. Various other saponins, mainly artefacts depending on the conditions of hydrolysis, have been identified, together with several oligosaccharide multi-esters (10%). Besides saponins, the samples also contain a volatile oil with small amounts of methyl salicylate.

Isolated senegin II showed a hypoglycaemic effect in normal and streptozotocin-induced diabetic mice. Also, a syrup made from the roots is a well known and established expectorant, perhaps via a reflex mechanism in which irritation of the gastric mucosa by the saponins leads to expectoration.

The roots of *P. sibirica* contain triterpenoidal saponins which are referred to as onji-saponins (A–G); they have a very similar composition as those from *P. senega*, based on the aglycone presenegin. The plant also contains xanthones (e.g. polygalaxanthone III), acylated sugars (tenuifolisides A–P) and a tenuifolic saponin.

Onji-saponin F has sedative properties. The effect of tenuifolic saponin on arterial pressure was investigated in rats. Systolic blood pressure of conscious and renovascular active hypertensive rats was measured by the tail cuff method, and treatment reduced the main arterial pressure by 21–50%, depending on the dose. However, it had no effect on carotid-occlusion-induced or ephedrine-induced hypertensive responses.

The compound 3,5-dimethoxy-4-hydroxycinnamic acid (= sinapinic acid) from the roots induced choline acetyltransferase activity in the cerebral cortex of basal forebrain-lesioned rats, and also induced nerve growing factor secretion in astroglial cells.

An aqueous extract of the roots of *P. sibirica* was investigated for its inhibitory effects on secretion of tumour necrosis factor-α (TNF-α) by primary cultures of mouse astrocytes. The extract inhibited interleukin-1 secretion, which elevates TNF-α secretion, and also had an anti-inflammatory effect on the central nervous system. Other pharmacological effects of whole extracts include a reduction of catecholamine contents and tyrosine hydroxylase activity of PC12 cells (derived from rat adrenal pheochromocytoma, and demonstrating many properties of adrenal medullary chromaffin cells) by the butanol fraction of the methanol extract of the dried roots, and significant anthelmintic properties against *Clonorchis sinensis* by the aqueous extract of the aerial parts.

The roots of *P. chinensis* (synonym *P. glomerata*) contain polygala-saponins, and oligosaccharide polyesters: glomeratoses A–G. The roots also contain several flavonoids e.g. rutin, afzein.

The leaves and bracts of *P. paniculata* contain the anthocyanidins delphinin-3-bioside and cyanidin-3,5-dimonoside. An extract of the plant contains the coumarins aurapten, phebalosin, murrangatin, 7-methoxy-8-(1,4-dihydroxy-3-methyl-2-butenyl)coumarin and the diester 3'-acetyl-4'-benzoylkhellactone. Of the latter compounds, phebalosin has molluscicidal and fungistatic activity.

Description Annual or perennial herbs, shrubs or small trees, sometimes spiny. Leaves in general spirally arranged, entire. Inflorescence a terminal, axillary or supra-axillary raceme, subtended by a small, caducous or persistent bract, bracteoles 2, caducous or persistent. Flowers bisexual, zygomorphic; sepals 5, normally free, caducous or persistent, unequal, 2 inner ones largest, often petaloid (wings); petals 3, 2 upper ones basally adnate to the staminal tube, lower one boat-shaped (keel), clawed, entire or with a dorsal crest, crest consisting of 2 lobes, the latter entire or divided into a various number of appendages; stamens 8, monadelphous, anthers sessile or on a free filamentous stalk, basally attached, opening with only 1 terminal pore common to both cells; disk annular, or consisting of 1–2 short appendages, often persistent in fruit; ovary laterally compressed, 2-celled, each locule with 1 subapical ovule; style variable. Fruit a capsule, compressed contrary to the sept, mostly margined, sometimes winged, dehiscing by a marginal split, reniform to oblanceolate. Seed in Malesia usually dark and hairy, at micropilar side with a lobed or unlobed aril, at the opposite side usually with an elongate, black, glossy appendage (strophiolus). Seedling with epigeal germination; cotyledons ovate, rounded; first pair of leaves ovate to elliptical, reddish green.

Growth and development *Polygala* species can be found flowering throughout the year in everwet climates. In seasonal climates they flower early in the summer season, and complete their life cycle in 4–5 months. Self-pollination probably occurs in all species, although the flowers of the majority are attractive to insects, and adaptations to pollinating insects occur.

Other botanical information In Malesia, *Polygala* is divided into 4 little-related sections, of which the largest one is section *Polygala*, probably an artificial assemblage. Considerable taxonomic confusion exists in some *Polygala* species. Following the latest revision, the name *P. chinensis* has been misapplied in nearly all cases for *P. polifolia*, but also for the closely resembling *P. triflora* L. and *P. glaucoides*. *P. glomerata* Lour. has become a synonym of *P. chinensis*, because the first name was illegally introduced to prevent the confusion in *P. chinensis*. In several *Polygala* species monstrous flowers sometimes occur, with supernumerary flower parts especially in the calyx; these flowers are normally sterile. The name milkwort was given to *Polygala* because it was previously thought that the plants increased the yield of cow milk.

Ecology The herbaceous *Polygala* species are sun-loving, and grow in open woodland, often grasslands in areas with a seasonal climate, in contrast to the shrubby species, which are restricted to the undergrowth of the rain forest.

Propagation and planting The seeds of *P. chinensis* show dormancy. When the seed coat is removed or deeply scarified, germination reaches 100% or 70% respectively, suggesting the presence of a germination inhibitor in the seedcoat. Washing the seeds in running water for 10 days results in 60% germination. Maximum germination occurs between 25–28°C. Diffuse daylight gives better results than either continuous light or dark periods, and red light stimulates germination of scarified seeds more than other wavelengths. The optimum pH for germination was 6.5, and gibberellic acid is effective in breaking the dormancy of both scarified and untreated seeds, at rates of 100% and 70% respectively.

Diseases and pests In Indonesia *P. paniculata* is infested by the cinchona mite (*Tetranychus cinnabarinus*) and the orange mite (*Brevipalpus obovatus*).

Harvesting *Polygala* plants are dug up completely in order to obtain the roots. When only the aerial parts are needed, plants are cut off aboveground.

Handling after harvest The roots and aerial parts of *Polygala* are used fresh or dried for storage.

Genetic resources and breeding The *Polygala* species described here are widespread in anthropogenic habitats and are not at risk of genetic erosion. Neither germplasm collections nor breeding programmes are known to exist.

Prospects Saponins from *Polygala* are well-known expectorants, with a reasonably well-established history of use. A local source of these species might therefore be of interest for rural communities. For instance, *P. sibirica* is not cultivated at present in South-East Asia, but due to its medicinal prospects, cultivation could be possible in mountainous areas.

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Selection of species

Polygala chinensis L.

Sp. pl. 2: 704 (1753).

Synonyms *Polygala glomerata* Lour. (1790), *Polygala telephoides* Willd. (1802).

Vernacular names Indonesia: jukut malela (Sundanese), andong peturun, godong sereg (Javanese). Malaysia: lidah ayam. Thailand: kham tia (north-eastern). Vietnam: kim b[aas]t ho[as]n, d[aj]i kim ng[uw]u.

Distribution From India to southern China and South-East Asia; in Malesia, it occurs in Peninsular Malaysia, Sumatra, Java, Lesser Sunda Islands, Borneo, the Philippines and New Guinea.

Uses In Java, an infusion of the leaves is ingested for cough and asthma, and is a constituent in a remedy for diarrhoea. An infusion of the whole herb is recommended for chronic bronchitis.

Observations A perennial, erect or ascending, branched, hairy herb or undershrub, up to 75 cm tall; leaves very variable, broadly elliptical to lanceolate, 5–65 mm × 2–20 mm, apex acute or mucronate; raceme supra-axillary, up to 1.5 cm long, few-flowered and cluster-like, bracts early caducous, minute; flowers 4.5 mm long, sepals lanceolate, acuminate, mucro long, ciliate, wings asymmetrical, 5-veined, green, upper petals spathulate, white, as long as the keel, basal half inside hairy, keel more or less auriculate, appendages filiform, in 2 bundles, filaments halfway free, ovary orbicular, emarginate, ciliate, style strongly curved in the upper half, subapically strongly reflexed, stigmatic lobe inside; capsule shorter and wider than wings, slightly asymmetrically orbicular, 4 mm × 4 mm, notched, wing narrow; seed ovoid, at micropylar side with an unequally 3-lobed aril, black, hairy. *P. chinensis* occurs in waste places, grasslands and along roadsides, normally in everwet climates, from sea-level up to 1300 m altitude.

Selected sources 74, 135, 215, 345, 498, 739, 780, 788.

Polygala paniculata L.

Syst. Nat. ed. 10: 1154 (1759).

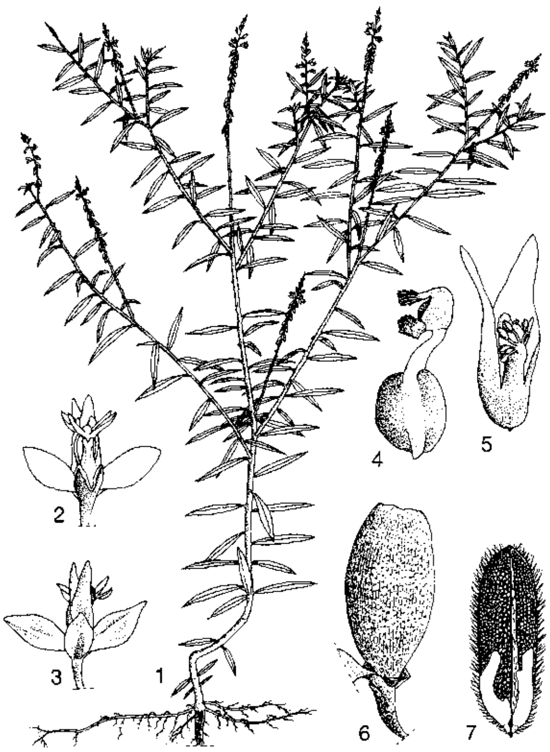
Vernacular names Indonesia: jukut rindik, sasapuan, katumpang lemah (Sundanese). Vietnam: d[aaf]u n[os]ng.

Distribution Native to tropical America, from Mexico to Brazil; in the 17th Century introduced into central tropical Africa, Indo-Australia and the Pacific Islands, including South-East Asia, and now abundantly naturalized.

Uses A sweetened infusion of the aerial parts is a remedy for gonorrhoea and lumbago, and the pulverized leaves may be applied to wounds.

Observations An annual, erect, much-branched, glandulous herb, up to 50 cm tall; leaves lanceolate to linear-lanceolate, 5–20 mm × 1–4 mm, apex acute, lower leaves in pseudo-whorls; raceme axillary or terminal, 5–12 cm long, bracts and bracteoles early caducous; flowers 1.5–2 mm long, sepals lanceolate, obtuse, wings weakly 3-veined, upper petals lanceolate, whitish, often purple-tinged, keel not auriculate, with 2 bundles of about 6 appendages, filaments connate except for the uppermost part, ovary orbicular, style straight, subapically curved and widened in an asymmetrical, wide cup, upper side with a hair tuft, inner side with a stigmatic lobe; capsule a little longer than the wings, elliptical, 2 mm long, notched, not winged; seed oblong, micropilar side with a deeply 2-fid aril, black, hairy. *P. paniculata* occurs in waste places, plantations and fields, on different soils, avoiding dry areas, often abundant, from sea-level up to 2250 m altitude.

Selected sources 74, 215, 385, 951.



Polygala paniculata L. - 1, plant habit; 2, flower, dorsal side; 3, flower, ventral side; 4, pistil with asymmetrical stigma; 5, opened corolla showing filaments; 6, capsule; 7, seed.

Polygala polifolia Presl

Rel. Haenk. 2: 101 (1835).

Synonyms *Polygala brachystachya* DC. (1824).

Distribution Distributed from Pakistan, Sri Lanka, India to China, Taiwan, and throughout South-East Asia to northern Australia and Micronesia. In Malesia occurring in Peninsular Malaysia, Sumatra, Lesser Sunda Islands, Sulawesi, Moluccas, the Philippines and New Guinea; perhaps on Java.

Uses The root is known for its expectorant action, and is widely used for coughs, asthma, pulmonary catarrh and bronchitis.

Observations An annual, erect to prostrate, branched, hairy herb, up to 50(–70) cm tall; leaves elliptical to lanceolate, 2–20 mm × 1–7 mm, apex acute to mucronate; raceme supra-axillary, up to 1 cm long, few-flowered and cluster-like, bracts persistent, minute, acute, ciliate; flowers 2.5–3(–3.5) mm long, sepals lanceolate, acuminate, ciliate, wings asymmetrical, 5-veined, green to partly red, upper petals spathulate, pale to deep blue, turning violet, emarginate, shorter than the keel, keel auriculate, appendages in 2 bundles, filiform, staminal tube split halfway, with 2 single filaments and 2 bundles of 3 fully connate filaments with sessile anthers, ovary broadly elliptical, ciliate, style curved in upper half, apically widened, stunted, at one side with a sterile tip, at the inner side with a stigmatic lobe; capsule shorter and wider than the wings, orbicular, 1.5 mm long, notched, very narrowly winged, ciliolate; seed oblong, at micropylar side with an unequally 3-lobed aril, black, hairy. *P. polifolia* occurs along roadsides, in grasslands and waste places, from sea-level up to 750(–1800) m altitude. Taxonomically, it has long been confused with *P. chinensis*.

Selected sources 74, 215.

Polygala sibirica L.

Sp. pl. 2: 702 (1753).

Synonyms *Polygala tenuifolia* Willd. (1802).

Vernacular names Vietnam: vi[eex]n ch[is], k[is]ch nh[ux].

Distribution Distributed from Central Europe to Central China and North-East India.

Uses *P. sibirica* has the same uses as *P. polifolia*, as an expectorant and an antiseptic, but is also widely known in Chinese medicine as an ingredient in mixtures taken for mental problems.

Observations A perennial, erect, pubescent herb, 10–25 cm tall, branching from the base; lower leaves ovate, small, upper leaves elliptical to linear-lanceolate, 3–27 mm × 1–10 mm, apex acuminate; raceme terminal and lateral, 1–10 cm long, bracts caducous; flowers 5–6 mm long, sepals lanceolate, ciliate, wings ovate-lanceolate, 4–6 mm × 1.5–3 mm, acuminate, 3-veined, upper petals equalling or shorter than the keel, keel 4–5 mm long, with 2 clusters of filiform appendages; capsule obcordate, about 5.5 mm in diameter, wing 0.5–0.75 mm long, ciliate; seed rounded, at micropylar side with an unequally 3-lobed aril, black, hairy. *P. sibirica* occurs in open waste places, grasslands, and in mountainous areas with a seasonal climate, at 1200–2000 m altitude.

Selected sources 130, 135, 739, 788.

Rina R.P. Irwanto

Polygonum aviculare L.

Sp. pl. 1: 362 (1753).

POLYGONACEAE

$2n = 20$ (22), 40, 60

Vernacular names Knot grass, prostrate knot weed, wire weed (En). Renouée des oiseaux (Fr). Vietnam: bi[eef]n s[us]c, rau d[aws]ng.

Origin and geographic distribution Native to Europe and northern Asia, now widely distributed in temperate, subtropical and tropical regions, including Vietnam and Malesia.

Uses *P. aviculare* possesses astringent, tonic, antipyretic, antiseptic, diuretic, haemostatic and vermifuge properties. It contains tannins, and is therefore used for cicatrization of wounds. In Vietnam, it is prescribed in the treatment of oliguria, dysuria, urinary stones and jaundice. In China, the aerial parts are also used as a vermifuge and for skin diseases including eczema and stubborn itch. In India, the juice or a decoction is taken as a tonic, and used in the treatment of diabetes, rheumatism, fever and external and internal ulcers. A decoction of the whole plant is given in dysentery, diarrhoea, bronchitis and bleeding piles, and to check profuse menstruation. The seeds are aromatic and are considered a powerful emetic and cathartic.

P. aviculare is used as fodder for cattle, sheep and goats. In Australia, however, cases of dermatitis and gastric disturbances have been observed among sheep and horses feeding on it. Also, milk of animals fed *P. aviculare* acquires a bitter taste. The herb yields a blue dye, similar to indigo.

Production and international trade *P. aviculare* is mainly locally used. In Vietnam and Malesia, the dried plant is found in Chinese pharmacies.

Properties The aerial parts contain about 4% total tannins, of both gallotannin and catechin type. Also, several organic acids are recorded, like gallic-, chlorogenic-, cinnamic- and coumaric acid, as well as several flavonoids: avicularine (= quercetin-3-arabinofuranoside, 0.2%), astragalin, kaempferitrine (kaempferol-3,7-dirhamnoside), hyperoside, quercitrine and luteoline. In addition, the herb contains about 0.2% soluble and 1% insoluble silicic acids.

Pharmacological effects of *P. aviculare* extracts include lowering of blood pressure in cats, rabbits and dogs, an anticoagulant activity on sheep-blood by aqueous and alcohol extracts, and anti-inflammatory and hepato-protective activity. In mice, the aqueous extract showed immunomodulatory effects by stimulation of the production of anti-sheep red blood cells (IgG) antibodies.

The alcohol extract is moderately active in vitro against fungi causing leaf-spot disease in potato: *Alternaria alternata*, *A. solani*, *Cladosporium herbarum*, *Colletotrichum coccodes*, *Phytophthora infestans* and *Verticillium lycopersici*. The alcohol extract of the aerial parts exhibited insect repellent and insecticidal activities.

Finally, *P. aviculare* has been found to be phytotoxic in the United States and Australia, where it shows allelopathic activity in crop, pasture and weed species.

Description An annual, very variable, procumbent or ascending herb, 10–80 cm tall; stems much branched, grooved, glabrous. Leaves alternate, simple, oblanceolate to elliptical, 0.7–1.5 cm × 0.2–0.5 cm, base cuneate, apex acuminate to acute, both surfaces glabrous, papillose, subsessile, ocrea 2–5 mm long, glabrous, conspicuously veined, upper margin lacerate. Inflorescence an axillary, 3–6-flowered fascicle, often hidden in ocrea, bracts lacerate, glabrous. Flowers with short, jointed pedicel, actinomorphic, bisexual, small, perianth segments 5, elliptical, 2–3 mm long, apex acute, 1 main vein per tepal, sometimes branched, white to pink; stamens 8, filaments flattened, base swollen, dilated, anthers ovate, small; interstaminal

Polygonum aviculare L. – 1, flowering stem; 2, dissected flower; 3, inflorescence; 4, fruit.

nectaries absent; ovary superior, 1-ovulate, styles 3-partite. Fruit a trigonous nutlet, 2–3 mm long, puncticulate, dark brown, dull. Seedling with epigeal germination.

Growth and development *P. aviculare* can be found flowering and fruiting throughout the year when enough water is available. The flavonoid content is highest at the start of flowering. Self-pollination in the open flower is the main pollination type. If this fails, pollination occurs as the perianth is closing. The flowers stay open for 1–5 days. Self-pollination in flower buds mainly takes place after a week of hot, sunny weather. Outbreeding seems to be extremely rare, and emasculation in flower buds precluds fruit formation.

Other botanical information *Polygonum* s.l. has been a major challenge for taxonomists since Linnaeus established the genus as a large and loosely knit unit. After a major revision, 2 tribes within subfamily *Polygonoideae* were established. Tribe *Persicarieae* comprises the large genus *Persicaria* Mill., in which 4 sections are recognized, and 3 more small genera. Tribe *Polygoneae* comprises *Polygonum*, with about 20 species, and 6 small genera, one of which is *Fallopia*. In *Polygonum*, two sections are distinguished, *Polygonum* and *Tephis*, although their boundaries are not clear due to the high level of variability within the genus.

P. aviculare is a successful weedy species complex, due to the genetic polymorphism it shows, as well as the ploidy levels, and high phenotypic plasticity.

Ecology *P. aviculare* occurs in tropical regions in meadows and river banks, but in the temperate zone it is a weedy species. It is found from sea-level up to 3600 m altitude.

Propagation and planting *P. aviculare* is a noxious weed in temperate regions because it germinates rapidly in spring and seeds may remain viable for up to 60 years. Emergence of seedlings declines with increasing depth of burial. The germination rate decreases at temperatures higher than 15°C and under saline conditions. The salinity induced dormancy is alleviated by gibberellic acid.

Harvesting In China, from May to July, whole plants are cut off above ground, tied in small bundles and dried in the sun.

Genetic resources and breeding *P. aviculare* is a widespread weed with large genetic variation, and thus does not seem to be liable to genetic erosion. No substantial germplasm collections exist for *P. aviculare*.

Prospects Only general and preliminary information on the phytochemistry and pharmacology of *P. aviculare* is known, therefore more research is needed to explore its potential as a medicinal plant.

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Other selected sources 63, 215, 273, 455, 786, 788, 967.

Rina R.P. Irwanto

Pouzolzia Gaudich.

in Freyc., Voy. Uranie: 503 (1830).

URTICACEAE

$x = 12, 13$; *P. hirta*: $2n = 26$, *P. sanguinea*: $2n = 26$, *P. zeylanica*: $2n = 24, 48$

Major species *Pouzolzia hirta* (Blume) Hassk., *P. pentandra* (Roxb.) Benn., *P. zeylanica* (L.) Benn.

Origin and geographic distribution *Pouzolzia* comprises about 35–40 species widely distributed throughout the tropics; in South-East Asia about 7–10 species are found.

Uses The leaves or crushed stems of several *Pouzolzia* species are used in poulticing sores and ulcers in various parts of South-East Asia. In Java, an infusion of the roots of *P. sanguinea* (Blume) Merr. (synonym *P. viminea* Wedd.), a species known for its strong bark fibres, is prescribed for patients vomiting blood.

Production and international trade *Pouzolzia* is only used on a local scale.

Properties No phytochemical information is available for the Malesian *Pouzolzia* species. Only one report exists on antifungal activity against *Exserohilum turcicum* (synonym *Helminthosporium turcicum*) northern leaf blight.

Description Monoecious, rarely dioecious herbs or shrubs, without irritant hairs. Leaves alternate, sometimes opposite, simple, chartaceous, upper leaves sometimes grading into bracts, usually entire, often 3-veined; petiolate or subsessile; stipules free. Inflorescence axillary, sessile clusters or short-peduncled cymes or spike-like by reduction of upper leaves. Male flowers: pedicellate, bracteolate, tepals 3–5, valvate, acuminate, stamens 3–5, pistillode present. Female flowers: sessile or subsessile, perianth tubular, 2–4-dentate, ovary superior, free, included, stigma filiform, unilaterally stigmatic. Fruit an achene, enclosed in an accrescent, ribbed or winged perianth.

Growth and development Most *Pouzolzia* species flower and fruit without any particular seasonality.

Other botanical information *Pouzolzia* comprises a group of highly variable species and is in urgent need of a monographic treatment. Two sections are discerned: *Pouzolzia* with entire or serrate-dentate leaves, 3-veined at base, the lateral veins branched, male tepals convex or gibbous at the back (e.g. *P. zeylanica*), and *Memorialis* with entire leaves, 3-veined usually to the leaf apex, upper leaves grading into bracts, male tepals inflexed at middle, the flowers appearing truncated, often with filiform processes (e.g. *P. hirta*, *P. pentandra*).

Ecology *Pouzolzia* can be found in relatively open or semi-shaded, not too dry habitats, grasslands, along ditches and in forest margins.

Propagation and planting *Pouzolzia* can easily be propagated from seed. Those species rooting at the nodes can be easily propagated by stem cuttings. *P. zeylanica* cuttings develop adventitious roots and new shoots after 1 week.

Harvesting Leaves, bark or roots of *Pouzolzia* are collected from the wild whenever needed.

Handling after harvest All plant parts of *Pouzolzia* are usually used fresh.

Genetic resources and breeding Since all *Pouzolzia* treated here have a large area of distribution, and are common in disturbed habitats, they do not seem to be at risk of genetic erosion.

Prospects Very little information is available about the phytochemistry and pharmacology of *Pouzolzia*. More research is therefore needed to evaluate its possible potential.

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Selection of species

Pouzolzia hirta (Blume) Hassk.

Cat. Hort. Bogor.: 80 (1844).

Synonyms *Pouzolzia quinquenervis* Benn. (1838), *Gonostegia hirta* (Blume) Miq. (1869), *Memorialis hirta* (Blume) Wedd. (1869).

Vernacular names Papua New Guinea: chol (Tibku, Central Province), gogo (Fane, Central Province). Vietnam: thu[oos]c d[of]i l[oo]ng.

Distribution From India to China and Japan, throughout South-East Asia to Australia.

Uses In Papua New Guinea, leaves are rubbed on the throat giving a numbing sensation, and are eaten when a person has a severe cough or sore throat. Crushed leaves are applied to ulcers. In China, an infusion of the whole plant is drunk by children suffering from atrophy and indigestion. A poultice of the roots is applied to bruises. Bark fibre is used for string.

Observations An annual or perennial, monoecious herb up to 75 cm tall, stems erect, scrambling or drooping, woody at base; leaves opposite, ovate-oblong, 1–10 cm × 0.5–4 cm, base rounded to truncate, apex acute, entire, 3-veined up to the leaf apex, slightly hirsute above, nearly glabrous beneath, sessile or subsessile, stipules ovate; flowers in male or bisexual clusters; male flowers pedicellate, tepals 5; female flowers subsessile to sessile, perianth tubular, prominently ribbed, stigma caducous; achene ovoid or ellipsoid, black, shining, enclosed by the ribbed perianth. *P. hirta* is found in grasslands, steep gullies, brushwood and disturbed habitats, from sea-level up to 2200 m altitude, in Java above 1400 m altitude.

Selected sources 74, 331, 419, 455, 770.

Pouzolzia pentandra (Roxb.) Benn.

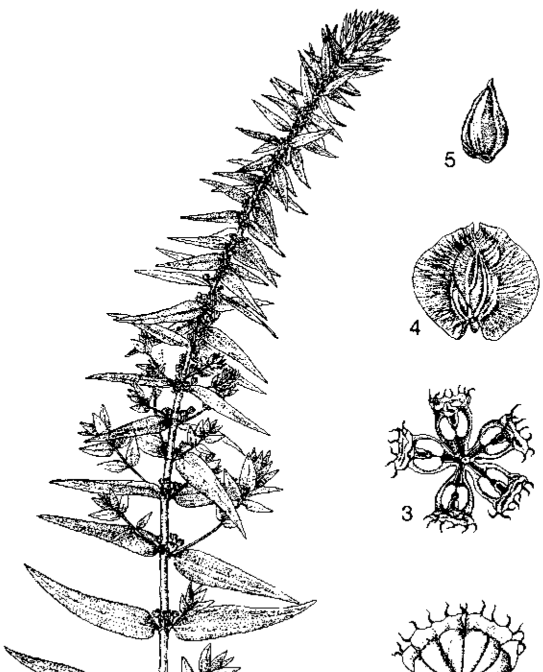
Pl. jav. rar.: 64 (1838).

Synonyms *Gonostegia pentandra* (Roxb.) Miq. (1869), *Memorialis pentandra* (Roxb.) Wedd. (1869).

Vernacular names Thailand: khop cha naang, yaa non taai (northern). Vietnam: thu[oos]c d[of]i ng[ux] h[uf]ng.

Distribution From India to the Philippines and throughout South-East Asia.

Uses In Thailand, a decoction of the whole plant is taken as an emmenagogue and diuretic. It may well be applied as an insecticide. The ground fresh leaves are used topically on abscesses and as an anti-inflammatory. In Taiwan, a decoction is taken as a blood purifier.



Pouzolzia pentandra (Roxb.) Benn. – 1, flowering and fruiting twig; 2, male flower seen from below; 3, male flower seen from within; 4, ripe fruit enclosed in its 2-winged perianth; 5, achene (fruit perianth removed).

Observations A perennial, monoecious herb up to 60 cm tall, stems creeping, with erect branches; lowermost leaves opposite, upper leaves alternate, strikingly smaller, ovate lanceolate, 2–10 cm × 0.5–1.5 cm, base rounded to subcordate, apex acute, entire, 3-veined up to the leaf apex, shortly ciliate or glabrous, sessile or subsessile, stipules ovate; flowers in bisexual clusters, spicately arranged in the upper leaf axils, whitish tinged pink; male flowers shortly pedicellate, tepals (4–)5; female flowers subsessile to sessile, perianth tubular with 2 broad wings and 1 narrow wing, stigma caducous; achene ovoid or ellipsoid, black, shining, enclosed by a broadly winged perianth. *P. pentandra* is found in humid forest and along watersides from sea-level up to 600 m altitude.

Selected sources 74, 331, 455.

Pouzolzia zeylanica (L.) Benn.

Pl. jav. rar.: 67 (1838).

Synonyms *Pouzolzia indica* (L.) Gaudich. (1830).

Vernacular names Indonesia: deresan (Javanese), jukut krincing , urang-aring (Sundanese). Malaysia: ubai-ubai, daun balam, kudu paya. Philippines: tuia, apoyapoyan (Tagalog), kayutkoran (Bagobo). Vietnam: b[oj] m[aws]m, thu[oos]c d[of]i.

Distribution From India, throughout South-East Asia to Australia. Introduced in Central America.

Uses In Malaysia, a poultice of the leaves is placed on the abdomen of children as a vermifuge, or in general for stomach-ache. It is also externally applied as a poultice for sores. In Indonesia, the leaves are used as a poultice for ulcers. In Java, the juice from fresh leaves or a decoction of the dried leaves is drunk as a galactagogue. In Vietnam, the whole plant is used in folk medicine for cough, sore throat, and as a diuretic and galactagogue. In the Philippines, the leaves are used as a cicatrizant for gangrenous ulcers. In India, the entire plant is used internally for gonorrhoea and syphilis and externally for cuts and wounds. In China, the plant or its roots are pounded into a soft mass and applied to sores, abscesses, and swellings as a vulnerary and emollient. The leaves are occasionally eaten as a vegetable.

Observations A monoecious perennial herb up to 1 m tall, stem ascending, basal part creeping and rooting with erect branches; leaves lowermost opposite, upper leaves alternate, broadly ovate to elliptical, 1–5(–10) cm × 0.2–3 cm, base acute, obtuse or rounded, apex acute, margin entire, 3-veined at base, hairy or glabrous, petiole short, stipules broadly ovate, ciliate; flowers in a sessile bisexual cluster; male flowers shortly pedicellate tepals 4; female flowers subsessile to sessile, perianth tubular with 4–5 ribs or wings, stigma caducous; achene ovoid or ellipsoid, about 2 mm long, black, shining, enclosed by a thickened perianth. *P. zeylanica* is found in usually damp open forest, brushwood, arable land, grasslands, and disturbed habitats, from sea-level up to 1600 m altitude.

Selected sources 74, 331, 407, 455, 728, 739.

Mulyati Rahayu

Psychotria L.

Syst. Nat. ed. 10, 2: 929, 1122, 1364 (1759).
RUBIACEAE
$x = 11, 22$; *P. curviflora*: $2n = 22, 44$, *P. emetica*: $2n = 22$, *P. ipecacuanha*: $2n = 22$, *P. rubra*: $2n = 22$, *P. serpens*: $2n = 22$

Major species *Psychotria curviflora* Wallich, *P. ipecacuanha* (Brot.) Stokes, *P. sarmentosa* Blume.

Origin and geographic distribution *Psychotria* comprises between 800–1400 species, distributed in Africa, South-East Asia and tropical America. About 115 species occur in Papua New Guinea and the Pacific islands.

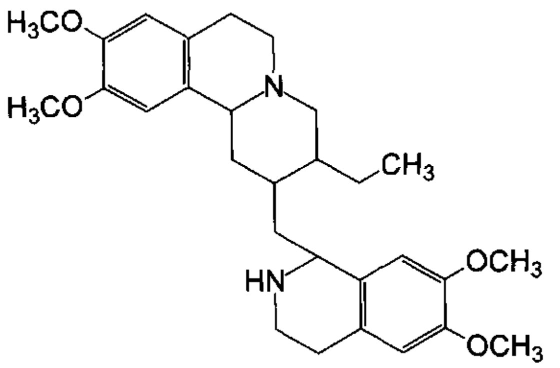
Uses The most important medicinal *Psychotria* is *P. ipecacuanha*, of which the rhizome, 'Radix ipecacuanhae', has a long history of being used to treat amoebic dysentery as well as being a valuable expectorant and antispasmodic drug. In northern America, ipecac syrup has long played a principal role as an emetic in the management of acute childhood poisonings and overdoses. However, due to its side effects, many toxicologists nowadays discourage its use under any circumstances, and promote either the use of gastric lavage or better, activated charcoal, which inhibits absorption of poisonous substances. Milk does not interfere with ipecac-induced emesis. Patients with eating disorders frequently use ipecac, which can be freely bought, as an emetic, and its frequent use has been associated with serious cardiac toxicity. Several other *Psychotria* from South and Central America have emetic properties identical to those of *P. ipecacuanha*.

Most *Psychotria* from South-East Asia are of little medicinal use. Their leaves are mainly applied for poulticing skin complaints and swellings, or taken as a decoction after childbirth, for protection. In Peninsular Malaysia, any part of *P. cantleyi* Ridley, *P. rhinocerotis* Reinw. ex Blume or *P. malayana* Jack (synonym *P. stipulacea* Wallich) may be used as a medicine after parturition. The leaves and roots of *P. mindorensis* Elmer and *P. extensa* Miq. (synonym *P. leptothyrsa* Miq.) from the Philippines, and also *P. malayana*, are used for infected eyes, skin eruptions and ulcers, crushed as a poultice. For fever, the roots of *P. malayana* are boiled and the water used for bathing. In Peninsular Malaysia, a decoction of the roots of *P. griffithii* Hook.f. is drunk for pain in the bones.

P. adenophylla Wallich is used in Indo-China for stomach-ache, intestinal problems and breast pain. The epiphytic creeper *P. serpens* L. from Japan, Taiwan, southern China and Indo-China, is taken to improve the blood circulation, and to cure rheumatism, backache, arthritis and wounds, in southern China. In the Solomon Islands, the leaves of *P. olivacea* Val. are eaten with betel nut (*Areca catechu* L.) to relieve stomach-ache. The sap of the stem is used in the treatment of gonorrhoea, and the macerated, boiled leaves are applied to sore legs. The crushed leaves or a decoction of the leaves of *P. rubra* (Lour.) Poir., from Japan, Taiwan, southern China and Indo-China, is used as a remedy for contusions and swellings. A decoction of the leaves and stem is taken to calm moody children. It is considered resolvent and stimulant, useful for treating toothache and earache. An infusion of the root is prescribed for malaria. In Vietnam, a decoction of the roots is also used for oedema, boils, wounds, haematuria, backache and snakebite, the whole plant for joints inflamed by rheumatism, pain in the arms and legs. It is not to be used by pregnant women.

Production and international trade The main world supply of *P. ipecacuanha* comes nowadays from South America, Peninsular Malaysia and Burma (Myanmar), and to a lesser degree from Central America and India. It is also experimentally cultivated in southern Nigeria. Recent production statistics are lacking. The best commercial drug ('Ipecac') comes from Brazil (Matto Grosso), and is collected from wild plants. Indian and Johore ipecac are from continental Asia and are also of good quality.

Properties The roots and rhizomes of *P. ipe-*



emetine

cacuanha contain a series of terpenoid tetrahydroisoquinoline type alkaloids, derived from the amino acid tyrosine, the most important being emetine, cephaeline and psychotrine. In smaller quantities, also 0-methyl-psychotrine, emetamine, the desmethyl-, proto- and neo- derivatives of the main alkaloids, and traces of ipecamine and hydroipecamine are isolated. In addition to the alkaloids, the roots contain several iridoids (monoterpenes) e.g. 6-O-methylipecoside, ipecosidic acid, demethylalangiside, neoipecoside, 7-O-methylneoipecoside, 3,4-dehydroneoipecoside, lipecoside, alangiside, sweroside and 7-dehydrologanin.

Ipecacuanha alkaloids display several biological activities. For instance, emetine, when taken internally, is a strong irritant, causing first strong salivation followed by nausea and vomiting. When injected subcutaneously, it does not show any irritation of the tissue, but is a strong antiamoebic. It acts only on the parasites present in the tissue, not on encysted amoebae or amoebae present in the lumen of the bowels. Cephaeline is an even more powerful emetic. Both compounds are active in the stomach and duodenum. Psychotrine was found to be almost inert. In general, toxic doses of the alkaloids cause gastro-enteritis, cardiac failure, dilation of the blood vessels, severe bronchitis and pulmonary inflammation.

According to several of the main Pharmacopoeias (European, USP), the standardized commercial drug should contain 1.9–2.1% alkaloids. In addition, the USP requires the ratio emetine (non-phenolic) to cephaeline (phenolic) to be 1–2.5:1. On the molecular level, emetine is a protein synthesis inhibitor, which is used as an amoebicide, but it has severe adverse effects. A range of alkaloids of the emetine-, tubulosine- and ochrolifuanine types having structural affinities to emetine were tested in vitro against *Entamoeba histolytica* (NIH 200) and for cytotoxic effects against guinea-pig ear keratinocytes (GPK). Emetine was most potent in both GPK and *E. histolytica* assays, while 2,3-dehydroemetine was equally cytotoxic but 2–3 times less potent than emetine against *E. histolytica*. Compounds without the 9,10-dimethoxy substituents had greatly reduced amoebicidal and cytotoxic effects, suggesting that this substituent is important in the mechanism of drug action. Furthermore, in an in vitro test, *Trypanosoma cruzi*, causing Chagas' disease, a major health problem in Central and South America, was markedly inhibited by emetine.

An extract of *P. curviflora* was evaluated for antileishmanial activity against *Leishmania donovani* infection in golden hamsters (*Mesocricetus aureus*) at 1 g extract/kg body weight orally for 5 days. The extract was found to possess considerable leishmanicidal action, defined as more than 52% reduction in numbers of amastigotes in treated animals, 7 days after cessation of treatment.

An unboiled water extract of stems and leaves of *P. sarmentosa* was investigated for analgesic and/or anti-inflammatory activity. Different doses of the extract (7.5, 15 and 22.5 ml/kg) were administered orally to rats, and the analgesic potential was determined using hot plate and tail flick tests. In another set of rats, the highest dose of the extract was orally administered, and paw oedema induced with 1% carrageenan. All the doses of the extract were well tolerated and the highest dose had potent analgesic activity and antihyperalgesic activity, comparable to that of an indomethacin reference. However, the extract had no anti-inflammatory activity.

The pyrrolidino-indole alkaloid quadrigemine B, isolated from *P. rostrata*, was shown to be cytotoxic with HEp-2 cells and normal human lymphocytes. The cytotoxicity was time- and dose-dependent. Bactericidal activity was also shown for this compound toward *Escherichia coli* and *Staphylococcus aureus*. In addition, also the pyrroloindoline alkaloids (+)-chimonananthine, (–)-calycanthine, calycosidine and hodgkinsine were isolated from its bark and twigs.

The crude extract of *P. extensa* showed moderate toxicity when administered intraperitoneally and slight toxicity when applied orally to Swiss mice in a 7 day LD_{50} toxicity test. A slight analgesia and decrease in motor activity were observed.

A new naphthoquinone, isolated from the alcoholic extract of *P. rubra*, exhibited significant cytotoxicity in the KB cell assay (ED_{50} = 3 µg/ml). Naphthoquinone derivatives 6, 8, 13, and 14 were prepared and exhibited superior cytotoxic activity to that of psychorubrin. However, when a hydrophilic hydroxy group was present in such compounds, reduced in vitro activity was observed. A butanol extract inhibited platelet aggregation, induced by arachidonic acid, U46619, collagen and thrombin.

A phytochemical study of two *Psychotria* species from New Caledonia led to the isolation of several pyrrolidinoindoline alkaloids: meso-chimonanthine, N-b-desmethyl-meso-chimonanthine and hodgkinsine were isolated from *P. lyciiflora* Schltr. Hodgkinsine, quadrigemine C, isopsychotridine B, psychotridine, quadrigemine I, oleoidine, and caledonine, were isolated from *P. oleoides* Schltr. Several of these compounds isolated showed analgesic and anti-viral activity.

Adulterations and substitutes The main adulterant of *P. ipecacuanha* rhizome is its stem, which contains much less alkaloids. Another common adulterant is almond meal. Many plant resources are used as a substitute for *P. ipecacuanha* for emetic purposes, especially *Asclepias curassavica* L. ('bastard Ipecacuanha'), *Calotropis gigantea* (L.) Aiton f. and *Psychotria emetica* L. but there are many more, some containing emetine, some others not. Synthetic anti-amoebic medicines have taken the place of *P. ipecacuanha*, as they do not have the strong side effects.

Description Shrubs or small trees, climbers, rarely epiphytes or herbs, normally evergreen. Leaves opposite, simple, normally entire; petiole absent or present and short; stipules interpetiolar, large or small, usually entire. Inflorescence a terminal cyme, or spiciform, paniculiform to corymbiform; peduncle normally present. Flowers bisexual, usually heterostylous, actinomorphic, normally 5-merous, often white, pedicel present; sepals all partly joined, usually persistent, corolla tube usually straight, rarely curved, lobes 5, caducous; stamens normally 5, filaments free, joined at various levels to the perianth, enclosed or exserted, anthers 2-loculed, basifixed, dehiscing by long slits; ovary inferior, 2-celled, 1 ovule per cell, style 1, enclosed or exserted, stigma variously 2-lobed. Fruit a berry or drupe; 2 stones (pyrenes) per fruit. Seed small, variable in shape, often flattened, albumen copious or little, wall thick or thin. Seedling with epigeal germination.

Growth and development *Psychotria* can be found flowering and fruiting throughout the year throughout its distribution area. In Brazil, observations of *P. ipecacuanha* show that flowering and fruiting occurs in more than one period, but flowering is concentrated in the rainy season of the region, December–April, while fruiting occurs between May–June.

In Indo-China, *P. curviflora* flowers from April–July, and fruits from August–October. Many *Psychotria* species have conspicuous domatia on the underside of the leaves, providing shelter for beneficial mites (acarodomatia) or, rarely, for bacteria (bacteriodomatia).

Other botanical information A worldwide revision of *Psychotria* and related genera is urgently needed to clarify the relationships in this complex, paraphyletic group. *Cephaelis* is nowadays considered as belonging to *Psychotria*. According to some authors, *P. curviflora* belongs to the closely related *Chassalia*, of which several orthographic variants exist, *Chasalia* and *Chasallia*. *Chassalia* is considered different from *Psychotria* in that the corolla lobes are curved, the stipules usually bifid and usually subpersistent, the sepals persistent and the fruit is fleshy or not. These characters though, occur in different combinations in the huge genus *Psychotria* as well.

Psychotria, one of the primitive genera of the *Rubiaceae*, is able to accumulate large amounts of aluminium in its tissues.

Ecology *Psychotria* prefers warm and humid conditions and partial shade and is commonly found in forests at low or medium altitudes. In Peninsular Malaysia, cultivation of *P. ipecacuanha* is nowadays successful in forest areas on sandy loams, rich in humus and minerals, and in rubber plantations on well-drained, coastal peat or clay soil. It thrives best in climates with an annual rainfall which is well distributed throughout the year, and temperatures between 20–38°C, with narrow fluctuations.

Propagation and planting *Psychotria* is propagated by seed and by soft wood cuttings. *P. curviflora* can also be propagated by marcotting. *P. ipecacuanha* has long been difficult to cultivate in South-East Asia and India, as the seeds do not germinate well and plantlets die often as they cannot stand heavy rains, cool or dry seasons, direct sunshine or sudden changes of weather. In a test in India, seeds sown in nursery beds and watered regularly failed to germinate even after 6 months, but soaking seeds for 24 h in water or in 200 ppm potassium dihydrogen phosphate gave 11% and 95% germination respectively, after 2 weeks. As the plants do not set seed in Peninsular Malaysia, multiplication is normally done there by stem cuttings or more often, by small rhizome parts. These pieces are kept under glass in wet sand, after which fine roots develop at the eyes. Rooted pieces of rhizome are kept in nurseries till the plants are 5–8 cm tall, after about 6 months, and subsequently transplanted. *P. ipecacuanha* seedlings can be hardened by transplanting them once or twice, which has a beneficial effect on biomass production and alkaloid content, which rose by 18–40% compared to the direct-sown control, in India. Possibly, some of the failures in the early times were due to the provenance of the seeds, some of them being hardier than others. Planting distance of *P. ipecacuanha* is 75 cm × 75 cm, on well-drained, raised beds, made of well-mixed sand and humus (3:2), and in partial shade to prevent direct sunshine and heavy rain.

In vitro production of active compounds In vitro culture of *P. ipecacuanha* has been tried for a long time and several protocols have been developed. Callus was obtained from leaf explants from *P. ipecacuanha* on Murashige & Skoog (MS) basal medium supplemented with 0.5 mg/l kinetin, 4 mg/l 2,4-D and 3% sucrose. Plantlet regeneration through somatic embryogenesis was achieved on MS medium containing 2.5 mg/l kinetin, 1 mg/l 2,4-D and 3% sucrose. Maturation and germination of somatic embryos was achieved on MS basal salts supplemented with vitamins and 2% sucrose without growth regulators. In another experiment, callus cultures were established from hypocotyl explants on various media containing various combinations of growth regulators. The best callus growth in terms of both fresh and dry weight was obtained on B5 medium supplemented with 3% sucrose, 8 mg/l indole butyric acid, 4 mg/l indole acetic acid and 4 mg/l naphthalene acetic acid. The highest alkaloid yields were obtained with a medium containing the macronutrient elements of Shenk & Hildebrandt, supplemented with the above combination of growth regulators. Cephaeline at 0.9% and emetine at 0.4% were obtained. Somatic embryo derived plantlets were hardened in the greenhouse and eventually planted in the open field. Several other protocols also show successful in vitro production of alkaloids. Roots cultured for 7 weeks in 50 ml MS liquid medium supplemented with 5,6-dichloro-indole acetic acid at 0.01 mg/l yielded 0.6 mg emetine and 2.4 mg cephaeline. Shoots cultured in Woody Plant liquid medium supplemented with 0.01–0.1 mg butyric acid/l contained 0.04–0.07% dry weight emetine and 0.4–0.5% dry weight cephaeline. One-year-old regenerated plants cultivated in a greenhouse had similar alkaloid contents as the parents, the roots contained 0.82% dry weight emetine and 2.16% dry weight cephaeline.

The exogenous feeding of 2 precursors, shikimic acid and L-phenylalanine (50 mg/l), increased the overall bioproduction of cephaeline in leaf-callus cultures of *P. ipecacuanha*, but both precursors failed to influence emetine production in callus, cell and immobilized cultures.

Diseases and pests Natural *Psychotria* stands exhibit little damage due to insects and other pests. In cultivated *P. ipecacuanha* sole cropping may face some problems, e.g. from fungi causing leaf blight.

Harvesting *Psychotria* is harvested from the wild when needed. In Peninsular Malaysia, *P. ipecacuanha* reaches a height of 25 cm about 3.5 years after transplanting and can be uprooted. In India, the rhizomes are harvested 2.5 years after transplanting, when the alkaloid content exceeds 2%. The plants may be dug up at any time of the year.

Yield A single plant of *P. ipecacuanha* may produce 6–10 rhizomes, weighing 75–85 g. The average dry weight of rhizomes per plant 1–5 years after transplanting increases from 3.5–16.5 g, whereas the total alkaloid content will increase from 1.5–2.5%, the percentage of non-phenolic alkaloids will decrease from about 80–53%, and the percentage of emetine will be about 1.2%. Cephaeline content of the roots of *P. ipecacuanha* from Panama of unknown age ranged from 0.7–1.2% and was highest in August and lowest in March. Emetine content was 0.5–1.3% and was highest in June and lowest in March.

Handling after harvest In Peninsular Malaysia, the rhizomes of *P. ipecacuanha* are washed and dried in the sun, while during the night they are placed indoors. In India, the rhizomes are washed and dried in the shade. The roots and stem of *P. curvifolia* have thick bark and hard wood. They should be cut into small pieces and dried soon after harvest. Dried material can be kept in closed containers for a long time without being attacked by fungi or insects.

Genetic resources and breeding There seems to be some danger of genetic erosion, because natural *Psychotria* populations occur mainly in forest areas, which are currently being destroyed. As some of the treated species have a large area of distribution, either naturally or as a result of cultivation, the risk of genetic erosion will probably be restricted.

In order to conserve *P. ipecacuanha* in Brazil, expeditions to collect genetic material for incorporation in the germplasm banks at the Centre for

Agroforestry Research of the Eastern Amazon (CPATU), in Belem and in Campos dos Goytacazes have been carried out since 1990. Germplasm collections of locally adapted populations of *P. ipecacuanha* exist in India. There are no known breeding programmes of South-East Asian *Psychotria*.

Prospects At present, increased interest in 'ipecacuanha' is unlikely, as the demand for this product is decreasing. Due to its side effects as an emetic, many toxicologists nowadays discourage its use. The use of emetine as an anti-amoebic is also diminishing, as safer synthetic products nowadays exist. Thus, the prospects for *Psychotria* are not promising.

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Selection of species

Psychotria curviflora Wallich

Roxb., Fl. ind. 2: 167 (1824).

Synonyms *Psychotria ophioxyloides* Wallich (1824), *Chassalia curviflora* Thw. (1859), *Chasallia chartacea* Craib (1931).

Vernacular names Indonesia: ki kores wungu (Sundanese), tenam (Bangka). Malaysia: biring sigalak, lado-lado, pindul ribatan (Peninsular). Cambodia: trong pra na. Thailand: khem khaao (northern), khem mai (central), khem phra (Bangkok). Vietnam: d[ow]n t[uw][ows]ng qu[aa]n, x[uw][ow]ng s[ow]n, m[awj]t tr[aws]ng.

Distribution From India and Sri Lanka to Indo-China, southern China, Thailand, Peninsular Malaysia, Indonesia (Sumatra, Java) and the Philippines.

Uses In Peninsular Malaysia, a decoction of the roots is taken for malaria, cough and after childbirth. Crushed, they are applied as a poultice for headache, convulsions and herpes. A lotion made with the roots or the leaves is applied to cuts, wounds and ulcers, and also after childbirth. In Vietnam, an infusion of the leaves is used for fever. In Cambodia, the crushed leaves are applied to horses with wounds caused by friction from the saddle. The fruits are sometimes eaten.

Observations An erect shrub, 0.3–2(–4) m tall; leaves oblong-elliptical to lanceolate, 8–25 cm × 2.5–7 cm, base cuneate, apex abruptly acuminate and obtuse, glabrous, petiole 1–2.5(–6) cm long, stipules broadly triangular, slightly fused at the base, deeply 2-fid to shortly 2-lobed, becoming corky; inflorescence corymbiform, crowded, 2.5–6 cm long, peduncle short; flowers subsessile, white, pink or violet, base yellow, calyx 1.5 mm long, glabrous, corolla tube variable, 4–9 mm long, variably curved, sparsely pubescent inside, lobes 2–6 mm long, stamens inserted in upper part of corolla; drupe globose, 6–8 mm long, hardly ribbed; seed semiglobose. *P. curviflora* occurs commonly in humid lowland, hills and lower montane forests, from sea-level up to 2000 m altitude. Some of the synonyms represent merely a large polyploid race (*P. ophioxyloides*) or other subpopulations of this variable species.

Selected sources 74, 126, 135, 215, 407, 788, 838, 1066.

Psychotria ipecacuanha (Brot.) Stokes

Bras. Bot. Mat. med. 1: 365 (1812).

Synonyms *Cephaelis ipecacuanha* (Brot.) A. Rich. (1818).

Vernacular names Ipecac, ipecacuanha (En).

Distribution Native to South America (Bolivia, Brazil, Colombia) and Central America (Costa Rica, Nicaragua). Widely cultivated in the semi-humid and humid tropics.

Uses The dried rhizomes have long been an important medicine as an emetic, expectorant and for amoebic dysentery, and also in the treatment of bilharzia, guinea worms and sores. In small doses the drug is a stimulant, increasing appetite and facilitating digestion. In larger doses it is an expectorant and diaphoretic and in even larger doses it is nauseating and emetic. It is used in the form of syrup, powder, tinctures and lozenges.

Observations A small, straggling shrub, up to 30 cm tall, young branches densely short-hairy, glabrous when mature, main rhizome thick, compact, horizontal rhizomes 3–8, slender, whitish when young, thick and brownish when older, with transverse furrows; leaves elliptical or obovate, 5–9 cm × 2.5–5.5 cm, base acute, apex shortly acuminate, petiole 0.5–1 cm long, stipules deeply divided into 8–10 lobes, 5–7 mm long; involucrum shortly hairy, 1–3 cm long, inflorescence corymbiform; flowers white, calyx small, short pubescent, corolla 5–6 mm long, sparsely hairy outside, tube inflated above the middle, long hairs at base inside, lobes acute; berry ellipsoid, about 7 mm long, 6-ribbed. In South-East Asia, *P. ipecacuanha* occurs only in cultivation in per-humid climate, at low altitudes.

Selected sources 126, 130, 134, 135, 151, 170, 399, 407, 489, 643, 844, 1036, 1037, 1113.

Psychotria luconiensis (Cham. & Schltdl.) Fern.-Vill.

Nov. app.: 112 (1880) 'luzoniensis'.

Synonyms *Coffea luconiensis* Cham. & Schltdl. (1829), *Psychotria malayana* Fern.-Vill. (1884).

Vernacular names Philippines: tagpong-gubat (Tagalog), kadpaayan (Iloko), lugani (Bontok).

Distribution The Philippines (Luzon, Mindoro, Masbate, Leyte, Panay).

Uses The fresh leaves are applied to the head for headache. A decoction of the young leaves or the scraped fresh roots are used for cleansing ulcers and infected wounds. A decoction of the root is taken for dysentery, and a decoction of the bark is taken for intestinal pains.

Observations A glabrous, erect shrub, 1.5–5 m tall; leaves oblong to elliptical-oblong, 8–20 cm × 2.5–5 cm, acute at both ends, shining, petiole short; cyme compact, 2–3 cm long, many-flowered; flowers white, calyx small, corolla 4–4.5 mm long, throat hairy; berry obovoid, 5–6 mm long, somewhat fleshy, yellow or reddish. *P. luconiensis* is commonly found in thickets and secondary forest, at low and medium altitudes.

Selected sources 126, 786.

Psychotria montana Blume

Bijdr. fl. Ned. Ind.: 961 (1826).

Synonyms *Psychotria expansa* Blume (1826), *Chasalia montana* (Blume) Miq. (1857), *Psychotria viridissima* Kurz (1872).

Vernacular names Malaysia: selada, kayu semelit (Peninsular). Vietnam: l[aas]u, n[us]i, m[aj]y c[as]n c[aa]n.

Distribution From Burma (Myanmar) and Vietnam to Peninsular Malaysia, and Sumatra and Java (Indonesia).

Uses In Peninsular Malaysia, the root is used for poulticing ulcers and swellings. It is made into a lotion which is used hot for bathing a feverish person and for treating enlarged spleen. In Indo-China, the boiled leaves are employed on swellings, rheumatism and an aching stomach, and to wash wounds. The decoction is taken for bacillary dysentery. It is sometimes planted in gardens in Java.

Observations An erect, glabrous shrub, 0.5–2.5 m tall; leaves oblong-lanceolate, 11–15(–25) cm × 3–10 cm, base acute, apex acuminate, acute, petiole 1.5–3.5 cm long, stipules triangular, apex slightly 2–fid, base of stipules clasping the petiole as a conspicuous ring; inflorescence paniculate, 2–6(–12) cm long, compact, normally glabrous, peduncle 0.5–4 cm long; flowers greenish to whitish, pedicel 2–5 mm long, calyx truncate, subentire to 4–6-dentate, corolla tube 3 mm long, ring of hairs inside or glabrous, lobes 4–5, 3–4 mm long, stamens inserted in the middle of the tube; berry subglobose to ellipsoid, 8–13 mm long, slightly ribbed when dry, red turning blackish. *P. montana* occurs in forest, village groves, also on limestone, from 800–2000 m altitude.

Selected sources 74, 135, 215, 788, 1066.

Psychotria rostrata Blume

Bijdr. fl. Ned. Ind.: 961 (1826).

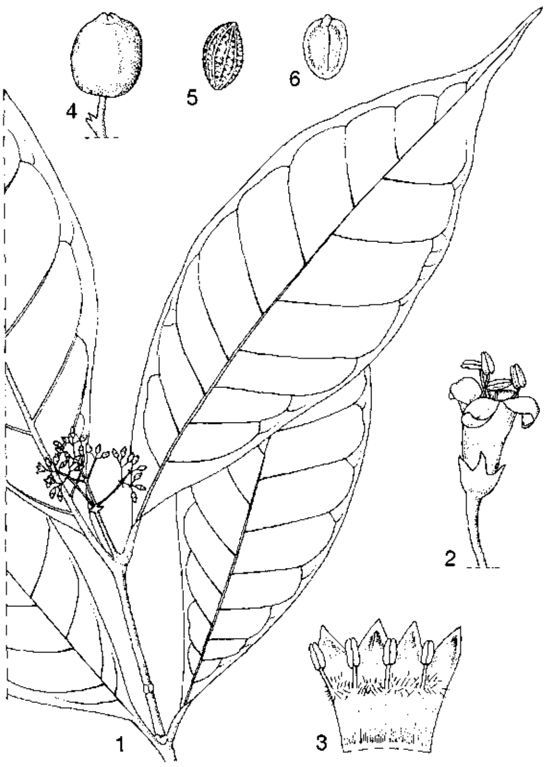
Synonyms *Chasalia rostrata* Miq. (1857).

Vernacular names Malaysia: nyarum, sedoman, segerang (Peninsular).

Distribution Peninsular Malaysia, Sumatra, Borneo.

Uses In Peninsular Malaysia, the leaves in decoction are taken for constipation. The wood is little used, mainly for fencing or firewood. As wood tar, it is used for blackening teeth.

Observations A slender, erect shrub, 1–3 m tall, leaf-bearing nodes alternating with leafless nodes, 1–1.5 cm long; leaves elliptical to narrowly lanceolate, 10–22 cm × 1.5–9 cm, base acute, apex long tapering, acute, glabrous, conspicuously veined, petiole 0.5–1.7 cm long, stipules of leaf-bearing nodes minute, soon caducous, of leafless nodes tubiform, larger, long-persistent; panicle 1.5–6 cm long, slender, glabrous, peduncle 0.5–3 cm long; flowers homostylous, white, pedicel short, calyx campanulate, 1–2 mm long, corolla tube 2 mm long, lobes 4, minute, 1 mm long, inside below throat with hairy ring, stamens inserted at ring,



Psychotria rostrata Blume – 1, flowering branch; 2, flower; 3, opened corolla; 4, fruit; 5, stone; 6, seed.

slightly exserted, style enclosed; berry ellipsoid, globose or obovoid, base broad or narrowed, 7–12 mm long, weakly 4–5-ribbed, orange, pale when dry. *P. rostrata* is a variable species and is common in lowland forest, from 50–1000 m altitude.

Selected sources 74, 135, 578, 641, 786, 1066.

Psychotria sarmentosa Blume

Bijdr. fl. Ned. Ind.: 964 (1826).

Vernacular names Malaysia: akar daldaru, pena kara jantan, rambai padang (Peninsular). Thailand: duuk kai yaan, yaa ruat (peninsular). Vietnam: l[aas]u leo.

Distribution From India and Sri Lanka to Peninsular Malaysia (very common), Java and Borneo.

Uses The leaves are used to poultice sores, and are also an ingredient of an infusion to hasten parturition.

Observations A climber, up to 15 m long, branches normally glabrous; leaves variable, elliptical to narrowly lanceolate or subovate, 4–11 cm × 1–1.5 cm, base acute, long attenuate or cuneate, apex shortly narrowed, acuminate, obtuse, normally glabrous, petiole short, stipules 3 mm long, soon caducous; panicle dense, many-flowered, branches paniculiform, normally short hairy, 4–13 cm long, peduncle 1.5–5 cm long, bracts pubescent; flower greenish, calyx 2 mm long, corolla 2 mm long, densely finely hairy, stamens exserted or not; berry obovate, 3–5 mm long, base obtuse-rounded. *P. sarmentosa* is a very variable species, occurring in forest, from sea-level up to 2300 m altitude.

Selected sources 135, 215, 786.

Psychotria viridiflora Reinw. ex Blume

Bijdr. fl. Ned. Ind.: 963 (1826).

Synonyms *Psychotria sylvatica* Blume (1826), *Psychotria jackii* Hook.f. (1880).

Vernacular names Indonesia: halan, ki kores (Sundanese), tenam betul (Belitung). Malaysia: jarum-jarum, julong-julong bukit, sepanggang (Peninsular).

Distribution India, Nepal, Burma (Myanmar), Thailand, Peninsular Malaysia, Sumatra, Java and Borneo.

Uses In Peninsular Malaysia and Java, the leaves are used for skin complaints such as scabies and the bites of poisonous insects and snakes. In Java, the bark and the juice of the stem are also used for these purposes. In West Kalimantan, the aerial parts are used for itch and skin infections.

In Sarawak, the old, yellowish leaves are boiled, and cloth is dyed reddish(-brown) in the thickened liquid. Powdered lime can be added as a mordant.

Observations A large shrub or small tree; leaves variable, lanceolate to elliptical, 3.5–10(–18) cm × 2–5(–6.5) cm, entire or broadly crenate, apex gradually narrowing, shortly acuminate, rather thickly leathery, glabrous, underneath with acarodomatia, stipules variable, triangular, ovate or lobulate, acute or obtuse, margin finely fimbriate, 5–10 mm long; inflorescence paniculiform-corymbiform, glabrous to short hairy, 4–6 (–10) cm long, flowers subsessile, heterostylous, greenish-pink or white, calyx about 1.5 mm long, hairy, corolla tube 2 mm long, lobes 2 mm long, throat inside densely hairy; berry very variable, ellipsoid or subglobose, 3–6 mm long, succulent, 10–12-ribbed when dry, yellowish to red. *P. viridiflora* occurs in (secondary) forest and hedges, from sea-level up to 1200(–2400) m altitude.

Selected sources 74, 135, 407, 1066.

H.C. Ong & S. Brotonogoro

Pycnarrhena manillensis S. Vidal

Revis. pl. vasc. filip.: 45 (1886).
MENISPERMACEAE
$2n$ = unknown

Synonym *Pycnarrhena elliptica* Diels (1910).

Vernacular names Philippines: ambal, managal (Tagalog), heluot (Cebu Bisaya).

Origin and geographic distribution *P. manillensis* is endemic in the Philippines (Luzon, Panay, Samar, Leyte, Negros, Mindanao, Basilan, Sulu Archipelago).

Uses The powdered root of *P. manillensis* is taken internally as a tonic. It is very efficacious as a cicatrizant and is also claimed to be an excellent vulnerary and a remedy for snakebites. An infusion is considered helpful for women in parturition. The powdered roots are used to cure cholera and other intestinal diseases, and they are said to be useful in fever and as an emmenagogue and abortifacient.

Production and international trade *P. manillensis* is only used on a local scale.

Properties From plant material of *P. manillensis* the following berbamine/bisbenzylisoquinoline alkaloids have been isolated: pycnarrhine, ambaline and ambalinine, phaeanthine, phaeanthine-2'α-N-oxide, isotetrandrine, pycnamine, pycnarrhenine, pycmanilline, pycnarrhenamine and berbamine.

From the leaves and bark of a New Guinean specimen of *P. ozantha* Diels two bisbenzyltetrahydroisoquinoline alkaloids were isolated: (+)-2-norobamegine (2-N-norobamegine) and (+)-bisnoraromoline(N,N-bisnoraromoline). Research on stem material from Vanuatu yielded another six bisbenzylisoquinoline alkaloids: (+)-2-northalrugosine, (+)-bisnorobamegine, (+)-bisnorthalrugosine, (+)-pycnazanthine, (+)-2-norberbamine and (+)-daphnoline, in addition to the findings of the New Guinean material. However, the daphnoline-related alkaloid bisnoraromoline was not present in the Vanuatu material.

Information on 2-N-norobamegine isolated from *P. novoguineensis* Miq. is somewhat contradictory. From the stems of *P. novoguineensis* from Halmahera, the following bisbenzylisoquinoline alkaloids with a berbamane skeleton were isolated: phaeanthine, pycnamine, limacine, isofangchinoline, berbamine and 2 unidentified alkaloids. Also, the quaternary alkaloid magnoflorine was isolated.

From the roots of *P. longifolia* (Decne. ex Miq.) Becc. six bisbenzylisoquinoline alkaloids were identified, four of which had the oxyacanthane skeleton (obaberine, homoaromaline, aromoline, daphnoline), and two had a berbamane skeleton (limacine, krukovine); also the quaternary alkaloids magnoflorine and pycnarrhine were isolated. The roots and stems had a similar alkaloid composition and contained 4% and 1.2% alkaloids per dry weight, respectively. Alkaloid concentrations were very low in the leaves. Later investigations yielded another 2 quarternary bisbenzylisoquinoline alkaloids, 1',2',3',4'tetrahyro-limacusine and the corresponding berbaman alkaloid.

Several of the alkaloids isolated show biological activities. For instance, berbamine displays an antimicrobial and curare-like activity. The compound further increased a pathologically decreased number of leukocytes, and stimulated biliary secretion in an experimental model. Phaeanthine is cytotoxic, and also is said to have a curare-like activity. Pharmacological activities mentioned for isotetrandine include a calcium channel blocking activity, an inhibition of histamine release (in vitro), inhibition of nitric oxide production (in vitro) and selective inhibition of T-cell dependent immune responses (in vivo, mouse model). Furthermore, the compound is analgesic and has antimicrobial activity.

Finally, homoaromaline showed inhibition of the histamine production by RBL-2H3 cells in vitro, and was capable of inhibiting the growth of cultured *Plasmodium falciparum* strains and tumour cell lines.

Extracts of the bark of *P. ozantha* show significant activity against Walker intramuscular carcinoma 256 in rats and against cells derived from human carcinoma of the nasopharynx carried out in KB-cell culture. The inhibitory activity was located in the alkaloid fraction, that primarily consisted of the bisbenzylisoquinoline alkaloids (+)-2N-norobamegine (0.05%) and (+)-N,N-bisnoraromoline (0.3%).

Adulterations and substitutes Bisbenzylisoquinoline and related alkaloids are a common biochemical feature within the *Menispermaceae*. Several alkaloids found in *P. manillensis* can also be isolated from other genera, e.g. isotetrandrine from *Cyclea*, and homoaromaline from *Arcangelisia*.

Description A scandent, dioecious shrub up to several m tall. Leaves alternate, simple, elliptical or oblong-elliptical, (9–)11–18 cm × (2.5–)4–8 cm, base obtuse to rounded, apex acuminate, lateral veins about 6 pairs, strongly impressed above, conspicuously joined near the margin, usually bul-

Pycnarrhena manillensis S. Vidal – 1, flowering branch (male); 2, fruiting branch; 3, male flower.

late; petiole 1–3 cm long, puberulous to subglabrous; stipules absent. Male inflorescence axillary, cymose, well-branched, many-flowered, 2.5–4 cm long, puberulous. Male flowers with outer sepals 2–5, minute, puberulous, inner sepals 4–7, rotund to broadly elliptical, 1.5–2 mm long, glabrous or slightly puberulous outside; petals 2–4, obovate, 0.75–1 mm long; stamens 10–15, connate, 0.75–1 mm long. Infructescence axillary and very short, 0.5–1 cm long, or ramiflorous and up to 2 cm long; peduncles usually bearing 1–3 fruits. Fruit a drupe, globose or subreniform, 1–1.5 cm long, minutely puberulous; endocarp crustaceous. Seed broadly ellipsoidal, cotyledons large and thick, very slightly curved, endosperm absent.

Growth and development *P. manillensis* flowers from May–November and fruiting is during the period July–March.

Other botanical information The genus *Pycnarrhena* belongs to the tribe *Tiliacoreae* and comprises 9 species found from southern China, throughout Sout-East Asia to Australia (Queensland). The delimitation of some species is posing problems, due to a lack of good herbarium specimens available and the considerable variation in foliage within a given species. Although alkaloids have been found in several *Pycnarrhena* spp., traditional medicinal use has only been recorded for *P. manillensis*. Bisbenzylisoquinoline alkaloids isolated in *P. ozantha*, from New Guinea, New Britain, New Ireland and the Vanuatu, show antitumour activity. Related bisbenzylisoquinoline alkaloids have been isolated in *P. novoguineensis* (synonym *P. australiana* F. v. M.), from Australia and New Guinea, and *P. longifolia*, from Sumatra, Java and the Lesser Sunda Islands. The leaves of *P. poilainei* (Gagnep.) Forman, from Thailand and Indo-China, are used as an ingredient of soups in Vietnam. *P. tumefacta* Miers, found from the Solomon Islands, New Guinea, the Moluccas to Borneo and the Philippines, is locally used as a vegetable in Borneo and has a protein content of 6–7%.

Ecology *P. manillensis* is found in thickets and forest from sea-level up to 1600 m altitude.

Harvesting Roots of *P. manillensis* are harvested by uprooting the entire plant or by partially exposing its root system.

Handling after harvest Roots of *P. manillensis* are washed and dried for future use.

Genetic resources and breeding In view of its common occurrence in thickets and disturbed habitats, *P. manillensis* does not seem to be threatened by genetic erosion. No germplasm collections or breeding programmes of *P. manillensis* are known to exist.

Prospects The vast array of pharmacological activities displayed by the bisbenzylisoquinoline and related alkaloids merits further investigation in *P. manillensis* and related species. In particular the neuromuscular, antimalarial and cytotoxic activities deserve more research in order to evaluate their potential.

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Other selected sources 128, 316, 786, 810, 879, 944, 1023, 1044, 1045.

N.O. Aguilar

Quassia L.

Sp. pl. ed. 2, 1: 553 (1762); Gen. pl. ed. 6: 212 (1764).

SIMAROUBACEAE

x = unknown; *Q. amara*: $2n = 36$

Major species *Quassia amara* L., *Q. indica* (Gaertner) Noot.

Vernacular names Bitter wood (En). Malaysia: kayu pahit.

Origin and geographic distribution *Quassia* comprises about 40 species; it has a pantropical distribution, with its major centre of diversity in South and Central America. Two species are found in Burma (Myanmar) and Indo-China; *Q. indica* extends from India eastward to the Solomon Islands. *Q. borneensis* Noot. is confined to Borneo and Sumatra, and 2 species are native to Australia. *Q. amara* is cultivated in many parts of Malesia and is locally naturalized.

Uses *Q. amara* is cultivated throughout the tropics for its medicinal properties and as an ornamental. Whereas the medicinal use of *Q. amara* is limited to its wood, all parts of *Q. indica* are used medicinally. *Quassia* in decoction or as an infusion is considered a general tonic, a febrifuge and a cure for intestinal disorders in various parts of the world. An extract of the plant or seed is used as an insecticide. Extracts of *Q. amara* bark are sometimes employed as a general bitter in digestive tonics, liqueurs and beer. Furthermore, *Quassia* or preparations containing its bitter principle quassin are used to denature alcohol. In Sarawak, the wood of *Q. indica* is used for making handles of knives. The purified oil from the seeds can be used for illumination as a lubricant and for the manufacture of soap.

Properties In general, all plant parts are exceedingly bitter. The quassinoids comprise the most important group of compounds isolated; in the case of *Simaroubaceae* these are sometimes also known as simaroubolides. The principal basic skeleton of these decanotriterpenes (C_{20}) is that of picrasan-16-one. In addition, the quassinoids differ in the positions of double bonds, hydroxy-, epoxy-, oxo- and/or ester-groups (often with acetic- or C_5-acids, e.g. hydroxybutyric, isovalerenic). Examples are quassin (= nigakilacton D), isoquassin (picrasmin), neoquassin and quassinol. Other components isolated belong to 2 categories of indole alkaloids: the β-carbolides (e.g. 1-vinyl-4,8-dimethoxy-β-carbolin) and the canthin-6-ones (e.g. 2-methoxycanthin-6-one).

Peristaltic activity was significantly increased in mice at an oral dosage of 1000 μg/kg aqueous extract of *Q. amara*. Acute toxicity of orally administered aqueous extracts of *Q. amara* has not been observed in standard tests with mice and rats. However, intraperitoneal administration did result in acute toxicity. *Quassia* tincture has been very effectively applied to control head lice, without side effects, thereby confirming this traditional application.

The crude methanol extract of the stem wood of *Q. amara* caused a significant reduction in the weight of the testis, epididymis and seminal vesicle of rats, together with an increase of that of the anterior pituitary gland. Epididymal sperm counts, serum levels of testosterone, luteinizing hormone (LH) and follicle stimulating hormone (FSH) were significantly reduced when the rats were treated with the extract. Furthermore, the basal and LH-stimulated testosterone secretion of Leydig cells isolated from rats pretreated with the extract were inhibited. These changes seemed to be restored eight weeks after the withdrawal of extract treatment. Two compounds, quassin and 2-methoxycanthin-6-one were isolated after fractionation of the crude methanol extract. Quassin produced biological actions similar to those of the extract, whereas the effects of 2-methoxycanthin-6-one did not seem to differ from those of the controls. Thus, quassin appears to be the antifertility principle of *Q. amara*.

Several quassinoids isolated from *Q. indica* exhibited a variety of pharmacological effects. Samaderines B, E, X and Z were shown to exhibit significant growth-inhibitory activity against the cultured malarial parasite *Plasmodium falciparum* (a chloroquine-resistant K1 strain). Furthermore, samaderines B, C, E, X, Y, Z and indaquassin C and X were shown to exhibit in vitro cytotoxicity against KB-cells (IC_{50} 0.04–1.00 μg/ml). Samaderines B, C and X as well as indaquassin X also exhibited inhibitory activity in the in vitro endothelial cell-neutrophil leukocyte adhesion assay, whereas samaderines B and X were found to exhibit significant anti-inflammatory activity too. Aqueous extracts of *Q. amara* have been successfully applied against cereal aphids and various pests in peach and apple, in both laboratory and field tests. Furthermore, quassin in aqueous extracts of *Q. amara* effectively killed larvae of *Culex quinquefasciatus*, a known malaria vector, at a concentration of 6 ppm.

Adulterations and substitutes Several pharmacopoeias allow both the wood of *Picrasma excelsa* Planchon (from Jamaica) or the wood of *Q. amara* (from Suriname) to be used as the simplex quassiae lignum. To differentiate between the 2 species, the wood of only *Q. amara* might be known as 'quassiae lignum surinamense' or 'quassiae lignum verum'.

Description Shrubs or trees up to 25 m tall. Leaves spirally arranged, paripinnate or imparipinnate, or simple; petiolate; stipules absent; leaflets usually with pitted glands on the upper surface along the margin and especially at the apex. Inflorescence a simple or branched raceme, panicle or pseudo-umbel. Flowers 4–6-merous, unisexual, bisexual, or polygamous; petals imbricate or contorted in bud, longer than the calyx; stamens double the number of petals, hairy, adaxial scale with a shorter or longer free apex; disk present; carpels free or coherent, 4–6, style 1, but parts of carpels discernible. Fruit consisting of 1–6 drupaceous or woody parts, often compressed. Seedling with epigeal germination; cotyledons emergent, fleshy, hypocotyl elongated; leaves simple, the first two opposite, subsequent ones spirally arranged.

Growth and development In a seedling trial in Malaysia, *Q. indica* seed germinated in 57–181 days. *Q. indica* flowers and fruits throughout the year.

Other botanical information *Quassia* is taken here in the broader concept to include *Simaba* and *Simarouba*. This broad concept has recently been disputed on grounds of molecular research.

Ecology The Malesian *Quassia* are confined to lowland forest.

Propagation and planting *Quassia* can be grown from seed, cuttings and by means of air-layering. Partial shade is required for the early stages of growth.

In vitro production of active compounds Quassin can be produced from both callus and suspension cultures of *Q. amara* stem and leaf explants. Quassin production in callus culture is promoted by adding naphthalene acetic acid or 2,4-D. Quassin yield in suspension culture in B5 medium can be as high as 0.25 mg/l per day.

Husbandry Depending on site and light conditions, partial shading may be required over a longer period. Cut surfaces after harvesting of branches need proper tending to prevent infections, pest damage and to ensure proper healing.

Diseases and pests Natural stands of *Quassia* exhibit little damage from diseases or pests.

Harvesting Cutting of branches should be done so as to sustain health and vigour of plants to ensure future harvests.

Handling after harvest Branches should be cut in smaller pieces to facilitate drying and prevent infections that would decrease the quality. Properly dried wood can be kept for a considerable time. The crude drug is usually marketed in the form of chips.

Genetic resources and breeding Neither *Q. amara*, that is commonly cultivated, nor *Q. indica*, with its large area of distribution, seem to be seriously threatened by genetic erosion.

Prospects The application of *Q. amara* preparations in medicine is well known. Furthermore, in general quassinoids and canthin-6-ones display a variety of interesting pharmacological effects, which make them of potential use in the development of new templates for new drugs. Because of the growing resistance of malaria parasites to the well-known, and even newer, antimalarials currently in use, there is a continuous need to develop new compounds to control this almost global infectious disease. The quassinoids and the canthin-6-one alkaloids might also have good potential for the development of a cytostatic drug to treat various cancers.

Literature |1| Garcia-Gonzalez, M., Gonzalez-Camacho, S.M. & Pazos-Sanou, L., 1997. Pharmacologic activity of Quassia amara (Simarubaceae) aqueous wood extract on albino rats and mice. Revista de Biologia Tropical 44/45: 47–50. (in Spanish) |2| Jensen, O., Nielsen, A.O. & Bjerregaard, P., 1978. Pediculosis capitis treated with quassia tincture. Acta Dermato Venereologica 58(6): 557–559. |3| Kitagawa, I., Mahmud, T., Yokota, K.I., Nakagawa, S., Mayumi, T., Kobayashi, M. & Shibuya, H., 1996. Indonesian medicinal plants. XVII. Characterization of quassinoids from the stems of Quassia indica. Chemical and Pharmaceutical Bulletin (Tokyo) 44(11): 2009–2014. |4| Njar, V.C.O., Alao, T.O., Okogun, J.L., Raji, Y., Bolarinwa, A.F. & Nduka, E.U., 1995. Antifertility activity of Quassia amara: quassin inhibits the steroidogenesis in rat Leydig cells in vitro. Planta Medica 61(2): 180–182. |5| Nooteboom, H.P., 1962. Generic delimitation in Simaroubaceae tribus Simaroubeae and a conspectus of the genus Quassia L. Blumea 11(2): 509–528. |6| Raji, Y. & Bolarinwa, A.F., 1997. Antifertility activity of Quassia amara in male rats: in vivo study. Life Sciences 61(11): 1067–1074.

Selection of species

Quassia amara L.

Sp. pl. ed. 2, 1: 553 (1762).

Vernacular names Quassia wood, Surinam quassia wood (En). Indonesia: genteng peujit, ki congcorang (Sundanese). Philippines: corales, kuasia (Tagalog). Thailand: prathat yai, prathat cheen, ping. Vietnam: l[as] lau, th[awf]n l[awf]n.

Distribution Native in northern Brazil, cultivated in Malesia and locally naturalized.

Uses Throughout South-East Asia the wood extract is valued as a bitter tonic, febrifuge and stomachic. It promotes gastric, intestinal, hepatic and renal secretions. In Central and South America a decoction of the wood is employed in dyspepsia, dysentery, diarrhoea, flatulence and gonorrhoea. A decoction is sometimes employed as enema to get rid of threadworms. In Costa Rica a decoction is used in the control of diabetes mellitus.

Observations A shrub or small tree, 2–3(–6) m tall; leaves imparipinnate with (1–3)–5 leaflets, petiole winged, 5–16 cm long, rachis winged and conspicuously articulated, leaflets obovate-oblong, almost sessile; inflorescence an often branched raceme, 10–25 cm long; flowers bisexual, calyx patent, 7–8 mm long, bright red, petals 5, oblong, about 3–4 cm × 0.5 cm, remaining mostly tight together, bright red outside, white inside, stamens and style protruding; fruit an aggregate of up to 5 drupes, elliptical-obovate, 8–15 mm long, purplish black, attached to a fleshy red receptacle.

Selected sources 74, 121, 135, 241, 291, 304, 380, 407, 415, 647, 696, 746, 788, 839, 861, 868, 885, 894.

Quassia indica (Gaertner) Noot.

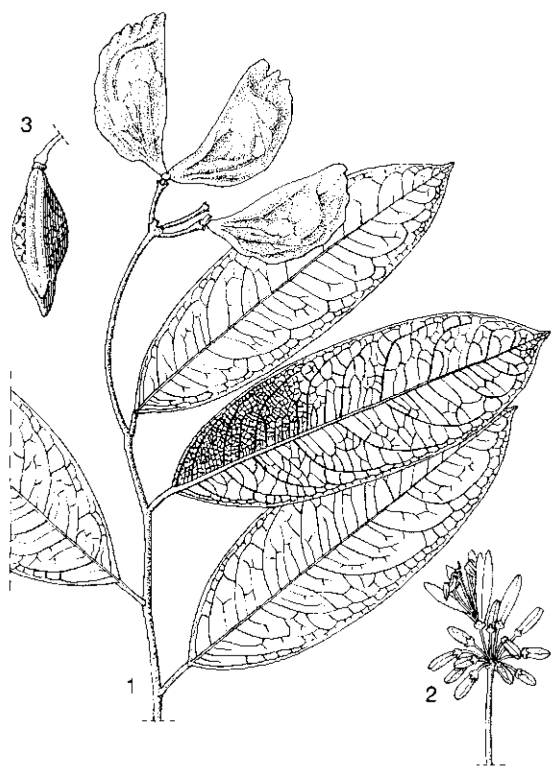
Fl. males. ser. I, 6: 199 (1962).

Synonyms *Samadera indica* Gaertner (1791), *Manungala pendula* Blanco (1837).

Vernacular names Indonesia: gateph pait (Bangka), sahangi (Minahasa) lani (Ambon). Malaysia: kayu pahit (Peninsular), kelapahit (Murut, Sabah), manuggal (Iban, Sarawak). Papua New Guinea: tosi (Delena, Central Province). Philippines: manunggal (Tagalog, Bikol, Bisaya). Vietnam: s[aa]m d[eef], th[awf]n l[awf]n [aas]n.

Distribution *Q. indica* occurs naturally from Madagascar eastward to Sri Lanka, Burma (Myanmar) and Indo-China, throughout Malesia (except for Sumatra, Java, Lesser Sunda Islands), eastward to the Solomon Islands. Cultivated in Java and elsewhere in Malesia.

Uses A decoction of the plant is used to relieve intestinal problems. The seeds in particular are of medicinal importance and are commonly applied as an emetic and purgative. In the Philippines, the juice of the pounded bark is considered a cure for skin diseases. After maceration or in decoction the bark and wood are applied as a febrifuge, tonic, stomachic and emmenagogue. The oil from the seeds is a liniment for bruises and rheumatism. Crushed leaves are applied in erysipelas. In the Central Province, Papua New Guinea, a decoction of the leaves is taken to relieve cough. In the



Quassia indica (Gaertner) Noot. – 1, fruiting twig; 2, inflorescence; 3, fruit side view of inner margin.

Solomon Islands, macerated leaves mixed with coconut oil are used to kill head lice. An infusion of the leaves is used as an insecticide.

Observations A shrub or tree up to 20 m tall; leaves simple, elliptical-oblong to lanceolate, 12–30 cm × 4–12 cm, veins prominent, with pitted glands on both surfaces, petiole 1–2.5 cm long; inflorescence a terminal or axillary pseudo-umbel, 1–30 cm long; flowers bisexual, calyx 4-lobed, petals free, accrescent, up to 3 cm × 1 cm, creamy green to violet; fruit an aggregate of the 4 carpels, laterally compressed, with a straight inner and semicircular outer margin, 4–9 cm × 2.5–5 cm; seed with thin testa, endosperm absent, cotyledons planoconvex, up to 3.5 cm × 2.5 cm. *Q. indica* is usually rather rare but locally common in tidal swamp forest or periodically inundated forest. In lowland mixed dipterocarp forest it is usually found below 150 m altitude.

Selected sources 74, 135, 348, 368, 407, 421, 730, 746, 786, 810, 949, 1066.

H.C. Ong

Rheum palmatum L.

Syst. nat. ed. 10: 1010 (1759).

POLYGONACEAE

$2n = 22$

Vernacular names Chinese rhubarb, medicinal rhubarb, Turkish rhubarb (En). Rhubarbe de Chine (Fr). Indonesia: kalembak (Sundanese), kelembak (Javanese), talembak (Madurese). Malaysia: kelembak. Vietnam: d[aj]i ho[af]ng ch[aa]n v[ij]t.

Origin and geographic distribution *R. palmatum* originates from the highlands of most of northern and western China and Tibet, and is nowadays widely cultivated in China and Russia, and to a lesser extent in Europe and the United States, for medicinal and ornamental purposes. In Java, attempts were made to cultivate *R. officinale* rather than *R. palmatum* in the 19th Century, but it developed roots of very inferior medicinal value. It is still found here and there in the highland area.

Uses The short, thick rhizomes, and sometimes the smaller roots of *R. palmatum* but also of the closely related *R. officinale* Baillon are used widely in China for laxative, tonic, astringent, anti-inflammatory, anti-hypertensive and antitumour purposes, mostly in decoction or as an infusion. In weak doses, they are astringent and a tonic, and when more concentrated, they are laxative and purgative. The rhizomes are employed in a pure form or as part of a mixture against constipation, dysentery, swollen gums, sore throat, sores, furuncles, burns, jaundice, strangury and after childbirth. The dried rhizomes are widely found in Chinese herbalist shops in South-East Asia.

In the European Pharmacopoeia, medicinal rhubarb was already known as a laxative in the Middle Ages, when it was introduced from Russia. It was also well known to the Arabs. The rhizome is taken orally for occasional constipation, but not recommended for children. It should not be taken in cases of intestinal obstruction, stenosis, atony, inflammatory colon diseases, appendicitis and haemorrhoids. Long-term use should be avoided, as it may result in aggravation of constipation, in albuminuria, liver damage and haematuria. There is insufficient information on damaging or undesirable effects during pregnancy, and the excretion of metabolites in breast milk. A laxative effect in breast-fed babies is not known. A harmless side-effect is the yellow or red-brown discolouration of the urine by metabolites. In case of an overdose, the major symptoms are gripes and severe diarrhoea, and fluids and electrolytes should be replaced. Potassium shortage may be responsible for symptoms such as decrease in muscle activity and cardiac arrhythmia. In Europe and the United States, rhizome extracts are often constituents of slimming cures, spring time tonics and blood purifying teas. The leaf blades of *Rumex* are toxic, because of the high levels of oxalic acid, which can interact with blood calcium. Precipitation of calcium oxalate in the renal tubules can lead to renal failure. There is some prejudice against the use of *Rheum* because it is said to cause rheumatism. This however, is due to its astringent action, stirring up possible poisons in the blood before eliminating them.

In Java, the rhizomes of *R. palmatum* (or *R. officinale*) are used in a cosmetic applied for freckles. In Central Java, rhizome shavings are used in a mixture with tobacco and Sumatran benzoin (from *Styrax benzoin* Dryand.) in cigarettes, known as 'rokok kelembak manyan'.

The fleshy petioles of *R.* ×*cultorum* Thorsrud & Reisaeter or garden rhubarb (parental species: *R. rhabarbarum* L., *R. rhaponthicum* L. and/or *R. palmatum*), widely cultivated in cooler regions in the tropics, are mainly used as a vegetable; the rhizomes are of inferior medicinal value. The petioles of *R. officinale* are sometimes used as a vegetable.

R. palmatum is also cultivated as an ornamental, especially those forms with striking red inflorescences.

Production and international trade The rhizomes of *R. palmatum* (and *R. officinale*) are regularly imported into South-East Asia from China. China and Russia are the main producers of *R. palmatum* roots, Japan and Korea are minor producers.

Properties According to the definition of the European Pharmacopoeia, 'Rhei Radix' consists of the whole or cut rhizomes of *R. palmatum* or *R. officinale*, of hybrids of these two species or a mixture. The smell is pleasant, and the taste is sweetish, astringent and bitter at the same time. It contains about 2.2% of 1,8-hydroxyanthracene derivatives, consisting mainly (60–80%) of monoglucosides of rhein, chrysophanol, aloe-emodin, physcion and emodin. Dianthrone glycosides are also present together with free aglycones and a small amount of anthrone glycosides, depending on the time of harvesting and the conditions of drying. The anthracene derivatives may occur in various oxidation stages; anthraquinones can be reduced to anthrones, which may be oxidized to dianthrones. Dianthrones, on the other hand, can be reduced back to anthrones, which may oxidize to anthraquinones relatively easily. The rhizomes also contain about 1% gallotannines.

The 1,8-hydroxyanthracene derivates possess a laxative effect, which may be based on 2 distinct mechanisms, (1) an influence on the motility of the large intestine, resulting in accelerated colonic transit, thus reducing fluid absorption and (2) an influence on secretion processes, resulting in enhanced fluid secretion. Defecation takes place after a delay of 8–12 hours due to the time taken for transport to the colon and metabolic conversion of hydroxyanthracene glycosides by the bacteria of the large intestines to the active forms, the anthrones. Laxative drugs containing anthraquinone derivatives should be used with caution, however, as daily and prolonged use can lead to a dependence syndrome and 'cathartic colon'.

In vitro studies have demonstrated antimutagenic and anti-oxidant properties of anthranoid constituents. Antimicrobial properties were found as well, against *Bacteroides fragilis* and *Trichomonas vaginalis* in mice. The extract has also been reported to decrease blood urea in rats with chronic renal failure. A water extract of the fruits showed strong suppression activity on hepatitis B virus surface antigen, and was also active against herpes simplex virus 1 and influenza viruses.

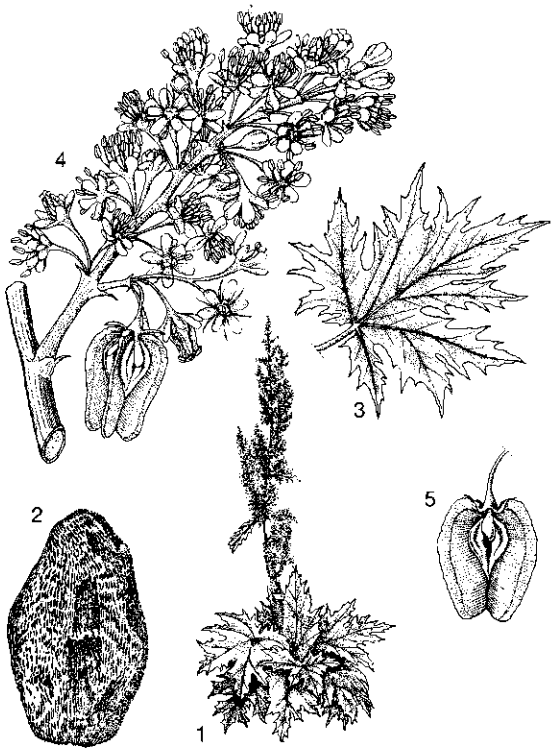
There are no studies on single dose toxicity, repeated dose toxicity, reproductive toxicity or carcinogenicity of the preparations of 'Rhei radix'. Some isolated anthraquinones (aloe-emodin, emodin, physcion and chrysophanol) gave positive results in in vitro genotoxicity studies, but all in vivo genotoxicity studies were negative. The anthranoids in their anthrone form inhibit cell growth and thymidine incorporation in human cultured cells, and inhibit both DNA replication and repair synthesis, through an imperfectly understood mechanism. Because of these effects on the cell cycle, anthrones are used locally in the treatment of psoriasis and other skin infections.

Hot water extracts of *R. palmatum* rhizomes showed molluscicidal activity against the snails *Oncomelania hupensis*, *Biomphalaria glabrata* and *Bulinus globosus*, which are vectors of *Schistosoma japonicum*, *S. mansoni* and *S. haematobium* respectively. Activity was highly correlated with the anthraquinones rhein and the anthrone chrysophanol as a 0.03% solution killed 50% of the snails after 2 days. The extract of the rhizomes has a controlling effect of 50–67% on tomato mosaic virus, if sprayed 24 hours before or immediately after inoculation.

Adulterations and substitutes Anthraquinone glycosides with similar uses as those found in *Rheum* are found in ripe pods of *Senna* and *Cassia*, and in *Aloe* leaves. Psyllium (*Plantago* spp.), a natural bulk laxative that does not cause dependency or 'cathartic colon', is better suited for prolonged use. It is for this reason one of the substitutes of anthraquinone-containing laxative drugs.

The action of *R. palmatum* differs from other laxatives in that the tannin present may exert an astringent action after purgation.

Description A large, erect, perennial herb, up to 2.5 m tall; rhizome and roots thick, branched, almost fleshy, bright yellow. Leaves partly in a radical rosette, partly spirally arranged on an erect stem; leaves of rosette borne on a thick, subcylindrical petiole, up to 30 cm long, blade orbicular, 50–90 cm × 50–70 cm, base cordate, deeply palmately lobed, 3–5-veined, lobes ovate-oblong or lanceolate, apex acute, entire, dentate or pinnatifid, upper surface normally rough; ocrea large, membranaceous. Inflorescence a loose, hairy panicle with racemiform branches, foliated to the tip. Flowers bisexual, fascicled; tepals in 2 whorls of 3, mostly red, sometimes pink or whitish, little or not accrescent after anthesis; stamens 9; ovary trigynous, styles 3, recurved, stigmas thick. Fruit a trigonous nutlet, 10 mm × 8 mm, brown, much



Rheum palmatum L. – *1, flowering plant habit; 2, rhizome; 3, leaf; 4, flowering and fruiting branch; 5, fruit.*

longer than perianth, 3-winged, scarious.

Growth and development The rhizome of *R. palmatum* measures 10–15 cm in diameter after several years. In Russia, *R. palmatum* flowers in July; in Europe, from May to June. *Rheum* L. is wind pollinated.

Other botanical information Several subspecies are distinguished in *R. palmatum*: subsp. *palmatum* is cultivated as an ornamental in Europe and leaves of *R. palmatum* subsp. *tanguticum* (Maxim.) Stapf are more elongated and less deeply lobed than those of subsp. *palmatum*, and more often cultivated as a medicinal in Europe.

R. officinale is closely related to *R. palmatum*, and their rhizomes are used indiscriminately. *R. officinale* is more robust than *R. palmatum*, the leaves are 30–100 cm across, 3–7-veined, and generally less deeply lobed; the flowering stem is up to 3 m tall, much branched, tepals greenish, nutlets reddish. It is widely cultivated in China where it is now running wild, and is sometimes cultivated in West and Central Europe. *R. officinale* occurs naturally in the highlands of western China and eastern Tibet, and towards the South touching the distribution area of *R. palmatum*.

Ecology *R. palmatum* grows in scrub and grassland of highlands, at 2500–4400 m altitude.

Propagation and planting *R. palmatum* is mainly propagated by rhizome cuttings. *R. palmatum* can also be quickly multiplied through meristem tips, grown on a Murashige and Skoog (MS) medium, containing naphthalene acetic acid and benzylaminopurine (BAP), where shoots are formed. Subsequent transfer of the shoots to a BAP free medium resulted in root development within 3 weeks, and the shoots could then be transplanted to peat pots.

In vitro production of active compounds Biosynthesis of anthraquinones in cell cultures of *R. palmatum* was established on MS medium supplemented with 2,4-D and kinetin. However, it was difficult to obtain high yields of specific compounds, and even where yields approach or exceed those found in whole plants, in many of these cultures only oxyanthraquinones and dianthrones are produced and the pharmacologically more potent dianthrone glycosides (sennosides) are peculiarly absent. A MS medium, at pH 5.5–5.8 and in darkness, stimulated hairy root growth and biosynthesis of free anthraquinones. The addition of auxin, however, inhibited the biosynthesis of these compounds. The highest yield of sennosides A and B (0.0083% and 0.004%, respectively) was obtained from callus from cut portions of a hybrid between *R. palmatum* and *R. coreanum* Nakai, on a MS medium containing 20 g maltose/l, 1 ppm indole acetic acid and 1 ppm 4-PU-30.

Husbandry In tests in Germany, medicinal rhubarb plants produced less active compounds when nutrients were added. The 1,8-hydroxyanthracene derivate concentration was highest in untreated plants.

Diseases and pests *Rheum* is attacked by a brown spot disease, caused by *Ascocyta rhei*. *Rheum* leaves are sometimes damaged by leaf-eating insects and mites and in Russia the damage can be considerable.

Harvesting Rhizomes of cultivated and wild plants are dug up. In China, the rhizomes of *R. palmatum* are harvested in September or October, sometimes around May, 6–10 years after planting.

Yield In China, rhizome yield of *R. palmatum* can be as high as 8–12 kg of rhizomes per plant.

Handling after harvest The rhizomes of *R. palmatum* are peeled, and either sliced in small pieces and dried in the sun or oven, or dried as a whole, and cut into pieces after drying. The dried pieces are very hard, with a smooth surface, pale yellow, with a whitish netting pattern. Before use, the pieces are powdered.

Genetic resources and breeding A small genebank collection of *R. palmatum* and *R. officinale* is kept in Gatersleben, Germany. Wild *Rheum* plants are possibly threatened by genetic erosion because plants are widely harvested in the mountainous areas of China and Tibet. Breeding programmes for medicinal purposes exist mainly in China and Russia, but other countries, such as New Zealand, are showing some interest as well. Breeding for ornamental purposes is mainly done in Europe and the United States.

Prospects 'Rhei radix' is a well-known medicine still in use, and present in many Pharmacopoeias worldwide. The potential for cultivation of *R. palmatum* in some high land regions in South-East Asian countries needs further investigation.

Literature |1| Chang, Z.Z., Guo, D.A., Shen, X., Wang, S.S. & Zeng, J.H., 1998. Anthraquinone production and analysis in hairy shoot cultures of Rheum palmatum L. Acta Pharmaceutica Sinica 33(11): 869–872. (in Chinese) |2| Fairbaim, J.W. & Moss, M.J.R., 1970. The relative purgative activities of 1,8-dihydroxyanthracene derivatives. Journal of Pharmacy and Pharmacology 22: 584–593. |3| Heidemann, A., Völkner, W. & Mengs, U., 1996. Genotoxicity of aloe-emodin in vitro and in vivo. Mutation Research 367(3): 123–133. |4| Komarov, V.L. (Editor), 1970. Flora of the USSR. Volume 5. Rheum. Translated from Russian. Peter Kress, Jerusalem, Israel. pp. 379–392. |5| Liu, S.Y., Sporer, F., Wink, M., Jourdane, J., Henning, R., Li, Y.L. & Ruppel, A., 1997. Anthraquinones in Rheum palmatum and Rumex dentatus (Polygonaceae), and phorbol esters in Jatropha curcas (Euphorbiaceae) with molluscicidal activity against the schistosome vector snails Oncomelania, Biomphalaria and Bulinus. Tropical Medicine & International Health 2(2): 179–188. |6| Yokozawa, T., Suzuki, N., Oura, H., Nonaka, G.-I. & Nishioka, I., 1986. Effect of extracts obtained from rhubarb in rats with chronic renal failure. Chemical and Pharmacological Bulletin 34(11): 4718–4723.

Other selected sources 129, 130, 132, 135, 222, 260, 308, 338, 357, 459, 490, 533, 533, 548, 575, 596, 603, 640, 647, 784, 786, 914, 1062, 1097.

G.H. Schmelzer & S.F.A.J. Horsten

Rhus L.

Sp. pl. 1: 265 (1753); Gen. pl. ed. 5: 129 (1754).

ANACARDIACEAE

$x = 13$; *R. chinensis*: $2n = 30$, *R. succedanea*: $2n = 30$, *R. verniciflua*: $2n = 30, 45$ (autotriploid)

Major species *Rhus chinensis* Miller, *R. succedanea* L.

Vernacular names Sumac, sumach (En).

Origin and geographic distribution *Rhus* comprises about 200 species, widely distributed in both hemispheres extending into the subtropics and tropics, abundant in seasonal and dry areas, but surprisingly seldom occurring in Australia; in Malesia some 10 species are found.

Uses In South-East Asia the galls of *R. chinensis* are used as an astringent, styptic and a poultice for sores. They are prescribed for haemorrhages, diarrhoea and dysentery, and as an expectorant. Sometimes the fruits are used in diarrhoea. In Papua New Guinea, scrapings of bark or stem of *R. taitensis* Guillemin (synonym *R. simarubaefolia* A. Gray) mixed with water is drunk against boils and ulcers. Additionally the bark residue may be placed on boils. *R. verniciflua* Stokes (synonym *R. vernicifera* DC.) is a major source of laquer obtained by cutting the bark, and the fruit yields a wax similar to the wax of *R. succedanea*. Urushiol present in the exudate causes acute dermatitis. In Vietnam it is locally grown intercropped with cinnamon and tea. It may still be cultivated in Malesia for non-commercial purposes. The dried sap is used in traditional Chinese medicine to treat cough in tubercular lung trouble, amenorrhoea and intestinal worms. The leaves are likewise reported to be an anthelmintic and the seeds a haemostatic. Various North American and European *Rhus* species are used in traditional medicine and are well-known sources of tannin.

R. succedanea is cultivated for the pulpy mesocarp of the fruit yielding a well-known wax, and the stem exudes a highly irritant latex used for laquer. The wax is used as a medium for ointments. *R. chinensis* is the source of Chinese or Japanese galls known in Europe since the 15th Century, used in tanning and as a blue dye for silk.

Production and international trade Despite the reported trade of *R. chinensis* galls from China no information on international trade is available. *R. succedanea* figures on export lists in India.

Properties Urushiol is the allergen found in intercellular secretory canals in the stem, leaves and petioles of *Rhus*. The chemical properties of urushiol have been well studied. The major constituents are pentadec(en)yl catechols, with small amounts of 3-n-heptadec(en)yl catechols. On exposure to the air, the sap turns black due to an oxidation process but still retains its allergenic activity. Urushiol is also found on the surface of the leaves and is thus readily accessible. In contact with the eyes, it may cause swelling of the eyelid and conjunctivitis. If the cornea is involved, pain, photophobia, and blepharospasm may be experienced. Brushing past the foliage with unprotected skin may result in a delayed reaction exhibiting a highly typical linear pattern of vesicular dermatitis. Hypersensitivity may be developed when one comes close to the plants. Urushiol, if allowed to contaminate articles of clothing, animals, tools, etc. may subsequently be transferred to human skin. Even burning the plant material may be hazardous if unburnt particles of the plant, or vaporised urushiol is carried away in the smoke.

The leaves, fruit, and bark of *R. succedanea* can cause dermatitis, but the sap causes more severe symptoms. Dermatitis develops in workers handling fabrics waterproofed with the wax. This plant is the commonest cause of 'poison ivy dermatitis' in Australia. Laccol, isolated from this species, was identified as a 3-heptadec(en)yl catechol.

R. verniciflua and its lacquer can give rise to dermatitis at all stages from the initial collection of the latex to the final application of the lacquer, and even, it appears, a thousand years later. The clinical features are almost infinitely variable, according to the mode and sites of contact, and the degree of sensitivity. Repeated contact may lead to hypersensitization. The lacquer contains 3-pentadec(en)yl catechols. Urushiol constitutes 35–70% of Chinese lacquer, and a somewhat greater proportion of Japanese lacquer. Sensitivity to *R. verniciflua* is specific with no cross-sensitivity to *R. succedanea* or *R. radicans* L.(poison ivy).

The first symptom is intense pruritus; papules soon appear, often in a linear pattern in the case of poison ivy contact, and these evolve into vesicles or bullae. Any and all parts of the body may be affected in severe cases, the allergenic material being easily carried by the fingers to sites remote from the points of initial contact. The allergenic material is not, however, present in the vesicle fluid. Areas of thicker skin are less susceptible. Except in regions well protected by hair, oedema may be considerable, and particularly so on the eyelids and male genitalia. The evolution of the eruption occurs in crops, affecting first the sites where most allergen has been absorbed, and then successively the less heavily contaminated sites or sites of thicker skin. The dermatitis commonly reaches its full extent after 48 hours. Healing occurs within 2–3 weeks unless there is re-exposure to the offending allergen. Scarring does not occur unless secondary infection has been introduced.

Experiments in guinea-pigs showed that urushiol can induce delayed type hypersensitivity. The activity depends on the nature of the ring substituents. Catechol and 3-n-alkyl catechols were equally effective in inducing sensitivity, but the degree of sensitivity as well as cross-reactivity depended upon the length of the alkyl chain. Dermal toxicity was unrelated to sensitising capacity. Further studies emphasised the importance of the alkyl chain in determining antigenic specificity and non-reciprocal cross-reactivity.

Urushiol isolated from the sap of *R. verniciflua* exhibited cytotoxicity against L1210 (mouse leukaemia cells), PC-9 (human lung adenocarcinoma cells), A427 (human lung adenocarcinoma cells) and KATO III (human stomach adenocarcinoma cells). Urushiol was most active against A427 cells, but was more potent than tetraplatin against KATO III cells. Hinokiflavone isolated from *R. succedanea* showed cytotoxic activity. Comparison of cytotoxic activity of hinokiflavone and related biflavonoid indicated that ether linkage between two units of apigenin is structurally required.

R. chinensis has been shown to exhibit anti-herpes simplex virus (HSV) activity and potentiate the anti-HSV activity of acyclovir in vitro and in vivo. This hot water extract (obtained from a commercial source in Japan) was examined for its suppressive efficacy on recurrent genital infection in guinea-pigs which were primarily infected intravaginally with HSV type 2 (HSV-2). Prophylactic oral administration of *R. chinensis*, at the dose corresponding to human use, significantly reduced the incidence, severity and/or frequency of spontaneous and severe skin lesions as compared with latently infected guinea-pigs administered with water. This prophylactic efficacy was confirmed by the crossover administration, for more than 2 months, of *R. chinensis* and water to the infected guinea-pigs. Toxicity, such as weight loss, from *R. chinensis* administration was not observed. When recurrent HSV-2 disease was induced by ultraviolet irradiation 3 months after primary infection, the prophylaxis with *R. chinensis* was also significantly effective in reducing the severity of ultraviolet-induced skin lesions. Thus, prophylaxis of recurrent genital HSV-2 infection with *R. chinensis* may preserve the efficacy of acyclovir by reducing both the use of acyclovir and the appearance of acyclovir-resistant viruses. *R. chinensis* extracts show therapeutic anti-herpes simplex virus type 1 (HSV-1) activity. In combination with acyclovir, the standard medication, the effect in mice was stronger, compared with both acyclovir and the herbal extract alone.

R. chinensis, exhibits oral therapeutic anti-herpes simplex virus (HSV) activity in mice. Two major anti-HSV compounds, moronic acid and betulonic acid, were isolated from the herbal extract using ethyl acetate at pH 10. Moronic acid was quantitatively the major anti-HSV compound in the ethyl acetate-soluble fraction. The effective concentrations of moronic acid and betulonic acid for 50% plaque reduction of wild-type HSV type 1 (HSV-1) were 3.9 and 2.6 μg/ml, respectively. The therapeutic index of moronic acid (10.3–16.3) was larger than that of betulonic acid (6.2). Susceptibility of acyclovir-phosphonoacetic acid-resistant HSV-1, thymidine kinase-deficient HSV-1, and wild-type HSV type 2 to moronic acid was similar to that of the wild-type HSV-1. When this compound was administered orally to mice infected cutaneously with HSV-1 three times daily, it significantly retarded the development of skin lesions and/or prolonged the mean survival times of infected mice without toxicity compared with the control. Moronic acid furthermore suppressed virus yields in the brain more efficiently than those in the skin. This was consistent with the prolongation of mean survival times. A hot water extract of *R. chinensis* inhibited replication of human and murine cytomaegalovirus in vitro.

A methanol extract of *R. chinensis* shows strong in vitro inhibitory activity against *Clostridium perfringens* under anaerobic conditions.

Methyl gallate (MG) and gallic acid (GA) isolated from galls of *R. chinensis* show growth inhibitory activity against intestinal bacteria in the impregnated paper disk method. At 10 mg/disk, MG and GA inhibited the growth of *Bacteroides fragilis*, *Clostridium perfringens*, *C. paraputrificum*, *Escherichia coli*, *Eubacterium limosum* and *Staphylococcus aureus*. MG was inactive against *Bifidobacterium adolescentis* and *B. longum*. The growth of *Bifidobacterium animalis*, *B. bifidum*, *B. breve*, *B. infantis*, *B. thermophilum*, *Lactobacillus acidophilus*, *L. plantarum* and *Streptococcus faecalis* was slightly affected by MG. GA did not adversely affect the growth of bifidobacteria or lactobacilli. At 5 mg/disk, MG significantly inhibited the growth of *C. perfringens* and *C. paraputrificum* but did not affect the growth of the bifidobacteria or lactobacilli. At 1 mg/disk, MG inhibited the growth of *C. perfringens* alone.

Bioassay-directed fractionation of the n-hexane extract of the stem of *R. chinensis* has led to the isolation of 6-pentadecylsalicylic acid. It showed antithrombin activity at 50 μg/ml in the amidolytic method. It also prolonged the clotting time in a dose-dependent manner in the clotting assay of thrombin-fibrinogen interaction. The extract inhibited cyclooxygenase and lipoxygenase which are the important enzymes involved in the platelet aggregation process. Therefore it may be useful in treating thrombosis and arteriosclerosis. The ether-soluble fraction of *R. chinensis* was active at only 10 mg/l in arachidonic acid metabolism in rabbit platelets.

A crude methanol extract of *R. chinensis* was screened for its effect in immunoglobulin A nephropathy, by testing its effect on human mesangial cell proliferation. The extract inhibited human cell proliferation activated by interleukin-1β (IL-1β) and IL-6 at 31 μg/ml, and decreased IL-1β and tumour necrosis factor-αproduction. Moreover, IL-1β mRNA expression was also inhibited by the extract.

Extract of *R. chinensis* galls (SG) and its major constituent gallic acid (GA) were administered intraperitoneally (i.p.) or orally (p.o.) to rats with CCl_4-induced hepatitis. Both substances significantly prevented the progression of acute liver injury with both p.o. and i.p. administration. It was suggested that the mechanism for this prevention might be due mainly to the protective effect of these substances on cell membranes rather than O_2 radical-scavenging activities.

The leaves of *R. succedanea* contain 8–10% tannins as a possible good source for commercial tanning.

Robustaflavone, a naturally occurring biflavanoid isolated from the seed kernel extract of *R. succedanea*, was found to be a potent in vitro inhibitor of hepatitis B, with an effective concentration (EC_{50}) of 0.25 μM and an in vitro selectivity index (IC_{50}/EC_{90}) of 153. Further studies suggested that inhibition of HBV DNA polymerase is the mechanism of action. The methanol extract of *R. chinensis* showed growth inhibition effect in *Brassica rapa* L. at a concentration of 500 ppm.

Biflavonoids obtained from the seed kernel of *R. succedanea*, such as amentoflavone, agathisflavone, robustaflavone, hinokiflavone, rhusflavanone and succedaneaflavone and their acetates rhusflavanone hexaacetate and succedaneaflavone hexaacetate were evaluated for their antiviral activities. The inhibitory activities against a number of viruses including respiratory viruses (influenza A, influenza B, respiratory syncytial, parainfluenza type 3, adenovirus type 5 and measles) and herpes viruses (HSV-1, HSV-2, HCMV and VZV) were investigated in various human and animal cell lines. The results indicated that robustaflavone exhibited strong inhibitory effects against influenza A and influenza B viruses with EC_{50} values of 2.0 μg/ml and 0.2 μg/ml, respectively, and selectivity index values (SI) of 16 and 454, respectively. Amentoflavone and agathisflavone also demonstrated significant activity against influenza A and B viruses. Amentoflavone and robustaflavone exhibited moderate anti-HSV-1 and anti-HSV-2 activities with EC_{50} values of 18 μg/ml (HSV-1) and 48 μg/ml (HSV-2), and SI values of > 5.6 (HSV-1) and > 2.1 (HSV-2) for amentoflavone; EC_{50} values of 8.6 μg/ml(HSV-1) and 8.5 μg/ml(HSV-2), and SI values of > 11.6 (HSV-1) and > 11.8 (HSV-2) for robustaflavone. Rhusflavanone demonstrated inhibitory activities against influenza B, measles and HSV-2 viruses with SI values of 9.3, 8 and > 6.4, respectively. Succedaneaflavanone exhibited inhibitory activities against influenza B virus and VZV with SI values of 15 and < 3.0, respectively.

Robustoflavone and hinokiflavone isolated from the seeds of *R. succedanea* demonstrated activity against HIV-1 reverse transcriptase in primary human lymphocytes at an IC_{50} value of 65 μM, amentoflavone and agathisflavone were moderately active at an IC_{50} value of 119 μM and 100 μM, respectively.

Description Erect or scandent shrubs, trees or lianas, sometimes hemi-epiphytic, mostly deciduous. Leaves spirally arranged, imparipinnate, trifoliolate, unifoliolate, rarely simple; leaflets usually (sub)opposite, entire, rarely crenate-dentate, with or without domatia or a spot-like group of papillae or glands; petiolate; stipules absent. Inflorescence paniculate, rarely racemose and few-flowered, (pseudo-)terminal or axillary. Flowers unisexual or bisexual, 5-merous; calyx 5-lobed; petals 5; stamens 5; ovary superior, 1-celled, disk present. Fruit a drupe, 1-celled. Seed with testa adnate or free; embryo straight, cotyledons free, flat.

Growth and development The galls on the leaf of *R. chinensis* are globular or cone-shaped, but as they develop, they become branched or produce horn-like protuberances in each of which is a cavity occupied by the insects. The galls are at first greenish yellow, but later turn dark green with patches of red, they are covered with a dense velvety fur. On reaching maturity on the tree, the galls split open and the insects escape. *R. chinensis* flowers from July–October, and fruits mature in September–November. *R. succedanea* flowers in April and fruits mature in August. *R. taitiensis* flowers and fruits almost throughout the year.

Other botanical information Here *Rhus* is considered in a broad sense. Some authors prefer to separate e.g. *Toxicodendron*, which is to be distinguished by fruits which are not glandular pubescent, by significantly smaller pollen grains and by the presence of a toxic latex.

Ecology In South-East Asia, *Rhus* is usually found in primary or montane forest, sometimes in savanna, in mossy and inundated forest, or in secondary vegetation from sea-level up to 2400 m altitude.

Propagation and planting Most species of *Rhus* are propagated by seed. *R. verniciflua* is easily propagated by root cuttings. Soaking the seeds in hot water for 30 seconds significantly increases germination of *R. chinensis*.

In vitro production of active compounds Adventitious root cultures of *R. chinensis* produce large amounts of galloylglucoses (gallotannins) and an anthocyanidin, riccionidin A, found also in liverworts. Production of both galloylglucoses and riccionidin A in the adventitious root culture system is suppressed by light. The root culture showed the highest productivity for those secondary metabolites in a modified Linsmaier-Skoog (LS) liquid medium containing 30 mM NH_4^+ and 30 mM NO_3^- as N sources in the presence of 10^{-6} M indole acetic acid.

Husbandry Casing the gall-forming aphids (*Schlechtendalia chinensis*) in bags on the tree at the appropriate time increases the number of leaves with galls in *R. chinensis*. Artificial infestation in spring with aphids that have overwintered in an insectary likewise increases gall yield. In Japan, *R. vernicifera* is cultivated as coppice, varnish is obtained by making incisions in 3-year-old stems, and when depleted the stems are removed. Important in more temperate China and Japan, it has been tried in plantations in South-East Asia, but failed there.

Diseases and pests *R. succedanea* may suffer locally from *Fusarium* spp. causing wilt.

Harvesting Galls of *R. chinensis* are harvested before they split open and the aphids escape. Fruits are harvested when mature. In Japan, fruits of *R. succedanea* for commercial extraction of wax are harvested before they are fully ripe and stored in straw to mature. In China, however, they are harvested when fully mature.

Yield Dried galls of *R. chinensis* contain 50–80% tannin, principally in the form of gallotannic acid.

Handling after harvest The galls of *R. chinensis* are immersed in boiling water to kill the insects, and subsequently dried in the sun. Fruits of *R. chinensis* are eaten fresh, and as such used medicinally. In China, the wax of *R. succedanea* is extracted by steaming the crushed fruit and running off the melted fat. In Japan, the fruits are crushed, the seeds removed, and the pulp is steamed and pressed for wax.

Genetic resources and breeding All *Rhus* species described here have a large area of distribution, either naturally or as a result of cultivation, and do not seem to be at risk of genetic erosion. There are no known breeding programmes of *Rhus* for medicinal purposes.

Prospects The potential for cultivation of *R. chinensis* in other South-East Asian countries appears limited, as traditionally used galls are not produced in the absence of the aphid species. The biological activities of isolated compounds, especially the flavones and moronic acid in the field of virus inhibition are very interesting, and therefore merit further research in order to evaluate their potential in development of future anti-virals.

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Selection of species

Rhus chinensis Miller

Gard. Dict. ed. 8: sub n. 7 (1768).

Synonyms *Rhus semialata* Murray (1784), *Rhus javanica* auct. non L.

Vernacular names Chinese gall, nutgall (En), Chinese sumac (Am). Indonesia: batu babru, kayu pora, martipos (Sumatra). Thailand: sung, ma liam hin, som phot (northern). Vietnam: mu[oos]i, ng[ux] b[ooj]i, di[ee]m phu m[ooj]c.

Distribution Widely distributed in temperate and subtropical Asia, India, Burma (Myanmar), Thailand to Indo-China, Taiwan, Ryukyu Islands and Japan; in Malesia indigenous in Sumatra and cultivated in Java.

Uses In Peninsular Malaysia and Indonesia, the leaf galls imported from China are used in traditional Chinese medicine as an astringent and styptic, and also in poultices to cure sores. In Java, they are an ingredient of several 'jamus' apparently for their astringent properties. In Vietnam, the leaf galls are used as an astringent and prescribed in diarrhoea and sometimes paralysis. The fruits are edible and used as a condiment. In India, the fruits are used in the treatment of colic, intestinal worms and dysentery and an infusion is drunk for diarrhoea. In China, the dried galls are applied to treat burns.

Observations A small tree or shrub, 4–12 m tall, stem 6–18 cm in diameter; leaves imparipinnate with 4–6 pairs of leaflets, rachis 10–30 cm long, winged or not, petiole 8–11 cm long, leaflets ovate-oblong, ovate or lanceolate, 5–15 cm × 2.5–8 cm, base unequal, cuneate, apex acute or acuminate, crenate-dentate, lower surface tomentose and distinctly papillose, without domatia; inflorescence usually terminal, paniculate, up to 15–20 cm (female) or 30–40 cm long (male), branches up to 25 cm long; flowers unisexual, white or pale yellow-green, calyx lobes triangular, petals broadly elliptical or oblong, about 2 mm × 1–1.5 mm, stamens 2 mm long, staminodes 1–1.5 mm long, ovary globose, densely puberulous; drupe subglobose, about 5 mm diameter, densely puberulous, exocarp separating from mesocarp in ripe fruits.

R. chinensis is found in primary and secondary forest and thickets from 900–1200 m altitude.

Selected sources 135, 215, 312, 407, 573, 574, 647, 739, 786, 909, 988, 1115, 1128.

Rhus succedanea L.

Mant. pl. 2: 221 (1771).

Synonyms *Toxicodendron succedanea* (L.) Moldenke (1946).

Vernacular names Wax tree, Japanese wax tree (En). Thailand: kaen mo (north-eastern), makok kiam (south-western), makkak khao (south-eastern). Vietnam: s[ow]n d[aaf]u, s[ow]n l[aws]s.

Distribution Found from India, Burma (Myanmar), Thailand, to Indo-China, China, Taiwan, the Ryukyu Islands and Japan; in Malesia found in Peninsular Malaysia and northern Sumatra, formerly rarely cultivated in Java.

Uses The wax of *R. succedanea* is used medicinally to seal wounds and as a medium for ointments. In India, horn-like galls on the branches are credited with astringent, tonic, expectorant and stimulant properties. They are used for diarrhoea and dysentery in children. *R. succedanea* is cultivated in Japan, China and Vietnam for the fruits from which a wax (sumach wax, Japan tallow, vegetable wax) is extracted for use in varnishes, polishes, ointments, and plasters. The fruits are applied in the treatment of epilepsy, hiccups, hysteria and vomiting. It is a popular plant for cultivation as a bonsai.

Rhus succedanea L. – 1, fruiting twig; 2, flower; 3, dissected flower.

Observations A small tree or shrub up to 5(–15) m tall, stem up to 50 cm in diameter; leaves imparipinnate with (2–)3–4(–6) pairs of leaflets, rachis (1.5–)8–27 cm long, petiole 4–6 cm long, leaflets lanceolate to linear, 3–8 cm × 1.3–2.5 cm, base obliquely cuneate, apex acuminate, entire, lower surface sparsely pubescent, usually with a group of reddish brown papillae or glands in the axils of the veins; inflorescence axillary, paniculate, up to 24 cm long, branches up to 10 cm long; flowers usually bisexual, creamy white, calyx lobes triangular, petals ovate or slightly oblong, 1–1.5 mm × 0.7 mm, stamens 1.5–2.5 mm long, ovary subglobose, glabrous; drupe subglobose, 5–8 mm in diameter, dull yellowish when ripe, exocarp separating from mesocarp in ripe fruits. *R. succedanea* is found on open slopes or along streams in montane forest at 900–2200 m altitude.

Selected sources 215, 312, 407, 616, 617, 618, 647, 712, 786.

S. Aggarwal

Rourea Aublet

Hist. pl. Guiane: 467 (1775).

CONNARACEAE

x = unknown; *R. minor*: $2n = 28$

Major species *Rourea mimosoides* (Vahl) Planch., *R. minor* (Gaertner) Alston.

Origin and geographic distribution *Rourea* comprises about 40–70 species and is found in both the New World and Old World tropics.

Uses In South-East Asia, various parts of *R. mimosoides* and *R. minor* are used for gastro-intestinal and urogenital disorders. They are generally considered tonic and in decoction are a well-known post partum medicine. In Indonesia, the soaked leaves of *R. fulgens* Planch. (synonym *Santaloides fulgens* O. Kuntze) and *R. rugosa* Planch. (synonym *Santaloides rugosum* (Planch.) O. Kuntze) are externally applied to the abdomen to soothe stomach-ache. In Peninsular Malaysia, a decoction of the roots of *R. rugosa* is given for constipation. A poultice of the leaves of *R. emarginata* (Jack) Jongkind (synonyms *Roureopsis emargina-*

ta (Jack) Merr., *Roureopsis pubinervis* Planch.) is used in fevers, ague, and on any part of the body for aches. The boiled roots of *R. acutipetala* Miq. (synonyms *Roureopsis acutipetala* (Kurz) Leenh., *Taeniochlaena acutipetala* Kurz) are used as an application for lumbago.
In India, roots and twigs of *R. minor* are employed as a bitter tonic and prescribed for rheumatism, scurvy, diabetes and pulmonary complaints. The roots are also used as a mild aperient and in external applications for ulcers and skin complaints.
In Africa, the seeds of several species are used as dog-poison. The roots of *R. obliquifoliolata* Gilg from Central Africa are taken finely ground as a cold infusion against diarrhoea and dysentery. The plant is also used for toothache and elephantiasis.
The flexible tough stems of several *Rourea* species are used for binding purposes.

Production and international trade *Rourea* is only used on a local scale.

Properties Aqueous extracts of leaves and stems of *R. mimosoides* from Sumatra showed some antimicrobial activity against gram-positive (*Staphylococcus aureus*) and gram-negative (*Escherichia coli*) bacteria in vitro. Methanol and aqueous extracts of roots of *R. obliquifoliolata* show strong antibacterial activity against a range of enteropathogens (e.g MICs 31.25 μg/ml for *Vibrio cholerae* and *Shigella dysenteriae*) in vitro. The aqueous extract also acted weakly against *Entamoeba hystolytica* with an MIC value of 500 μg/ml after 72 and 144 hours' incubation. A general phytochemical screening found that biological activity may well be attributed to the presence of tannins; this would support its traditional use as an antidiarrhoeal.
A decoction of the roots of *R. minor* in a small dose acts as an emetic. Larger doses are poisonous. The decoction mixed in the food of pigs and dogs kills them. A water extract has no decisive effects on dogs or guinea-pigs. The fruit is poisonous to dogs but has no effect on guinea-pigs. No information is available about the principle responsible for this activity. However, from the roots of *R. orientalis* Baill., an African species traditionally used as a dog-poison, a neurotoxic compound was isolated, which was identified as methionine sulphoximine. From the roots of Indian *R. minor*, n-hentriacontane, leucopelargonidine and rapanone were isolated.

Description Lianas, shrubs or small trees; twigs often ending in a tendrilloid tip. Leaves alternate, imparipinnate, occasionally unifoliolate, leaflets opposite or subopposite, entire; stipules absent. Inflorescence axillary, paniculate or racemose, often together pseudo-terminal. Flowers bisexual, 4–5-merous, heterodistyllous, sweet-scented, sepals free or almost completely connate, imbricate in bud, usually accrescent, petals lanceolate, up to 2–3 times as long as sepals, stamens 10, in 2 whorls, carpels 5, free. Fruit an ovate to ellipsoid follicle, 1–2(–5) per flower, apex rounded to acute or beaked, orange to red, dehiscing by a ventral suture or more or less circumscissile at base, 1(–2) seeds per follicle. Seed subovoid to ellipsoid, testa partly or totally fleshy, this part yellow to red, or the seed enveloped by a fleshy arilloid, endosperm absent. Seedling with epigeal or hypogeal germination, first two leaves opposite.

Growth and development *R. mimosoides* and *R. minor* flower and fruit throughout the year. The sweet-scented flowers are most likely pollinated by insects. Dispersal is probably effected by birds, in view of the conspicuous fruit with the contrasting pericarp and seed, (partly) covered by a fleshy yellow to orange arilloid.

Other botanical information In a recent revision, *Rourea* has been divided into 5 sections. In South-East Asia 3 sections are present, i.e. section *Rourea*, section *Roureopsis* (e.g. *R. acutipetala*, *R. emarginata*), and section *Santaloides* (e.g. *R. fulgens*, *R. mimosoides*, *R. minor*, *R. rugosa*). Within the population of the species complex *R. minor*, certain local populations can be distinguished. However, when considering larger distributional areas, the distinguishing characters merge. A non-geographical variation in number and dimensions of leaflets and size of fruits can be observed. *Rourea* may well be confused with *Sarcotheca* (*Oxalidaceae*); synonyms linking the 2 genera abound. However, *Rourea* has a dry indehiscent fruit containing a seed covered in an arilloid, whereas *Sarcotheca* has a fleshy fruit and seed without an arilloid.

Ecology *Rourea* is found in both primary and secondary forest, with a preference for forest edges and margins. Most species are confined to lowland habitats.

Propagation and planting *Rourea* is propagated by seed.

Harvesting Leaves, bark and roots of *Rourea* are collected whenever the need arises.

Handling after harvest Leaves of *Rourea* are used either fresh or dried; roots, bark and stem parts are either used directly or stored for some time.

Genetic resources and breeding The *Rourea* species treated here are widespread and common throughout South-East Asia. They are commonly encountered in disturbed habitats and do not seem to be at risk of genetic erosion. There are no known breeding programmes of *Rourea*.

Prospects The use of tannin-containing extracts in the treatment of diarrhoea is quite well documented; the mechanism of action is believed to be the absorption of bacterial toxins. When extracts of e.g. *R. obliquifoliolata* also show antibacterial activity against enteropathogenic organisms, this could be an extra advantage. However, more research is needed to investigate the activity in vivo and the toxicological aspects in order to fully evaluate its potential use in (local) medicine.

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Selection of species

Rourea mimosoides (Vahl) Planch.

Linnaea 23: 420 (1850).

Synonyms *Santalodes concolor* (Blume) O. Kuntze (1891), *Santalodes mimosoides* (Vahl) O. Kuntze (1891), *Santalodes simile* (Blume) O. Kuntze (1891).

Vernacular names Indonesia: semberlit merah darah (Sumatra). Malaysia: akar sembelit (Peninsular). Vietnam: d[aa]y kh[ees] l[as] nh[or].

Distribution From the Andaman and Nicobar Islands, Burma (Myanmar), Thailand, Cambodia, Vietnam to Malaysia, Sumatra, West Java and Borneo.

Uses In Peninsular Malaysia, a decoction of the roots is taken for colic. A decoction is also taken as a post-partum medicine, and as a remedy for colds in children. In Sumatra, a decoction of the leaves is taken as a remedy for bloody diarrhoea or as a diuretic. In Cambodia a maceratopn in alcohol is reputed to be a stimulant and aphrodisiac.

Observations A large liana up to 50 m long, stem up to 10 cm in diameter, rarely a shrub with drooping branches, twigs minutely fulvous-tomentose; leaves 2–15-jugate, leaflets ovate or elliptical to oblong, 0.5–3.5 cm × 0.5–1.5 cm, base slightly cordate or truncate, apex emarginate or obtuse; inflorescences axillary, often together pseudo-terminal, each consisting of 1–3 narrow panicles, up to 12 cm long, many-flowered, calyx 1.5–2(–3) mm long, variously hairy, corolla 3.5–5(–6.5) mm long; follicle narrowly ellipsoid, curved, 1–1.5 cm × 0.5 cm, dehiscing with a ventral lengthwise slit. *R. mimosoides* is a rather variable species especially in the vegetative parts. It occurs in habitats ranging from beach forest, river banks, roadsides, bamboo forest and shrubberies to secondary and primary forest, from sea-level up to 750(–1500) m altitude.

Selected sources 135, 312, 372, 373, 786.

Rourea minor (Gaertner) Alston

in Trimen, Handb. Fl. Ceylon 6(2): 67 (1931).

Synonyms *Rourea santaloides* (Vahl) Wight & Arnott (1834), *Santalodes floridum* (Jack) O. Kuntze (1891), *Santalodes pulchellum* (Planch.) O. Kuntze (1891), *Rourea erecta* Merr. (1909), *Santaloides erectum* Schellenb. (1910).

Vernacular names Malaysia : akar nyamuk, akar sembelit (Peninsular). Philippines: kamagsa, gikos-gikos (Tagalog). Vietnam: d[ooj]c ch[os], tr[os]c c[aar]u.

Distribution From tropical Africa, Madagascar, to Sri Lanka, continental South-East Asia, throughout Malesia (except the Lesser Sunda Islands east of Bali) to northern Australia, New Caledonia, the New Hebrides, Fiji and Samoa.

Uses In Peninsular Malaysia, the plant is used as a slight aperient. A decoction of the wood is taken as a post-partum medicine and in fever. The root is rubbed on sore places in the mouth of children with thrush. In the Philippines a decoction of the roots is used as a uterine tonic and a depura-

Rourea minor (Gaertner) Alston – 1, flowering twig; 2, infructescence; 3, variation in leaflets.

tive. The boiled pounded root or the seed is mixed in dog food to poison them. The fresh or dried leaves in decoction are used to cure gastralgia and are an absorbent. In Indo-China, the bark of the stem and the leaves are considered tonic and diuretic, and a decoction is prescribed as a post-partum tonic. The fresh arilloid of the ripe fruits can be eaten.

Observations A large liana up to 26 m long, stem up to 15 cm in diameter, rarely a small tree or shrub, twigs glabrous; leaves unifoliolate to 9-jugate, leaflets suborbicular or ovate to lanceolate, terminal one sometimes obovate, 1–25 cm × 0.5–10 cm, base acute to cordate, oblique to equilateral, apex short and broad to caudate, acuminate, acumen blunt; inflorescence in the upper leaf-axils or pseudo-terminal, consisting of 1–5 axes, central axis up to 20 cm long, loosely paniculate to subracemose, many-flowered, calyx 2–3 mm long, minutely tomentose to glabrous, corolla 4–7.5 mm long; follicle oblique-ellipsoid to oblique-ovoid, straight to curved, 1–3 cm × 0.3–1 cm, dehiscing with a ventral lengthwise slit or circumscissile at base. *R. minor* occurs in habitats ranging from secondary forest and bamboo-forest to primary rainforest, and swamps to coastal rocks, with a preference for more open locations, from sea-level up to 1800 m altitude.

Selected sources 135, 312, 407, 739, 786, 825, 838.

J.L.C.H. van Valkenburg

Rubus L.

Sp. pl. 1: 492 (1753); Gen. pl. ed. 5: 864 (1754).

ROSACEAE

$x = 7$; *R. moluccanus*: $2n = 28$

Major species *Rubus moluccanus* L., *R. rosifolius* J.E. Smith.

Vernacular names Blackberry, raspberry (En). Mûre, framboise (Fr).

Origin and geographic distribution *Rubus* comprises some hundreds of species, apart from the microspecies in the apogamous *R. fruticosus* L./*R. caesius* L. complex, and has an almost cosmopolitan distribution. In Malesia about 50 native species are found, New Guinea and the Philippines being richest in species, followed by Java and Sumatra. Within Malesia, New Guinea is the only centre of endemism with 12 endemic species; the other islands have very few endemic species or none at all.

Uses The traditional medicinal use of South-East Asian *Rubus* is very similar to the traditional use of *Rubus* in Europe. Leaves and roots are used for their astringent and tonic properties in mild diarrhoea. In Malaysia, a decoction of the roots of *R. moluccanus* is drunk for dysentery and urinary disorders. The leaves are externally applied in fever. The leaves are included in a traditional steam bath for the first week after childbirth. In Indonesia, the roots are chewed with other ingredients for intestinal disorders. Fresh leaves chewed with roasted coconut are said to cure thrush. Chewed with betel nut (*Areca catechu* L.) they are considered antitussive and a remedy to avoid a miscarriage. The fruits of *R. moluccanus* and *R. rosifolius* are occasionally mentioned as a remedy for nightly micturition. In Papua New Guinea, the leaves of both species are chewed and spat onto sores, to promote healing. In the Philippines, a decoction of the roots of *R. rosifolius* is given as an expectorant, and a syrup of the fruit as a demulcent. *R. alceifolius* Poir. is used indiscriminately as *R. moluccanus* in traditional Thai and Malay medicine. In Sabah, the pounded inner stem of *R. alceifolius* or *R. moluccanus* (misidentified as *R. glomeratus* Blume) is applied as a paste to mouth ulcers. In Vietnam, the fruit of *R. alceifolius* is used in folk medicine as a stomachic. In Papua New Guinea, the fruits of *R. glomeratus* (synonym *R. ledermannii* Focke) cooked and eaten with fish, are considered a tonic. In Simbu Province (Papua New Guinea), the leaves with bark sap of *Pipturus argenteus* (J.G. Forster) Wedd. added are heated and eaten daily to relieve a bad cough. In Morobe Province, the extracted stem sap of *R. neo-ebudicus* Guillaumin (synonym *R. brassii* Merr. & Perry) is drunk as a tonic by elderly people. In Java (Indonesia), the ground leaves of *R. fraxinifolius* Poir. mixed with water are occasionally used in dysentery. In Papua (Indonesia), it is used to treat wounds and for internal sickness. In Papua New Guinea, the juice of heated leaves of possibly the former species (identified as *R. muelleri* F.M. Bailey, nom. illeg.) is used on cuts and scratches. Roots and leaves of *R. parvifolius* L. are used in folk medicine in East Asia and eastern Australia. The plant is credited with astringent, anti-inflammatory, diuretic, antipyretic, antilithic, antithrombotic and resolvent properties. In Sumatra (Indonesia), the shoots of *R. alceifolius* are eaten as a vegetable. The fruits of several species are locally collected as luxury food. Outside their natural range *Rubus* are often considered noxious weeds.

Production and international trade *Rubus* is only used on a local scale.

Properties *Rubus* plants contain tannins, which, due to their astringent properties are responsible for their traditional use in cases of diarrhoea and throat troubles. As an example, dried leaves of *Rubus fruticosus* L. (blackberry) contain about 8% tannin of the hydrolysable type (gallotannins).

Aqueous extracts of *R. parvifolius*, from China, proved useful in shortening bleeding time and coagulation time in mice, shortening euglobulinlysis time in rabbits, and inhibited platelet thrombosis in rabbits in vivo. *R. parvifolius* extracts increased coronary flow in isolated rat heart, preventing rats from pituitrin-induced changes of electrocardiogram (ECG). Furthermore, *R. parvifolius* extracts increased the tolerance of mice to hypoxia. The toxicity of *R. parvifolius* is reported to be insignificant.

Description Shrubs, usually climbing, straggling or creeping, rarely erect; twigs and other parts nearly always with prickles. Leaves alternate, compound or simple; petiole present; stipules free. Inflorescence terminal, mostly paniculate, at the end of axillary leafy branches of determinate growth. Flowers 5-merous, mostly bisexual; sepals free, persistent; petals free, usually white; stamens many, ovaries many on a mostly elevated torus. Fruits cohering and falling as a collective fruit, either together with the dried torus (blackberry-like) or without and hollow (raspberry-like). Seed with a thin testa.

Growth and development Pollination is by insects and dispersal is obviously endozoochorous.

Other botanical information *R. alceifolius*, *R. glomeratus* and *R. moluccanus* are closely resembling species that are often confused. Plants are often designated as the more common, and very variable, *R. moluccanus*. Uses mentioned for any of these species may well be mutually exchangeable. *R. alceifolius* differs in the shape of the closed flower buds and in the stipules which have very thin, filiform lobes. *R. glomeratus* differs in the leaf indumentum, which is never entirely closed and the leaf surface remains visible.

Ecology The majority of Malesian *Rubus* belongs to the mountain flora and occurs only above 1000–1500 m altitude. A dozen *Rubus* species are found at lower elevations, and only 3 species occur down to sea-level (*R. fraxinifolius*, *R. moluccanus* and *R. rosifolius*). Most species are light-loving and are restricted to more or less open places, either natural or anthropogenic.

Propagation and planting Vegetative propagation of *Rubus* is by root suckers (stolons).

Diseases and pests *R. rosifolius* is susceptible to strawberry mild yellow edge potexvirus (SMYEPV), which causes yellow leaf margins in e.g. strawberry.

Harvesting Leaves and roots of *Rubus* are collected whenever the need arises. Fruits are collected when ripe.

Handling after harvest Roots and leaves of *Rubus* are either used fresh or dried for future use.

Genetic resources and breeding All *Rubus* species treated here have a large area of distribution, either naturally or as a result of cultivation, and do not seem to be at risk of genetic erosion. Their preference for disturbed habitats tends to make them less vulnerable. However, molecular studies have revealed that in its natural range intra-island gene flow in *R. moluccanus* is high, but significant differentiation may occur over even short distances on individual islands. Preservation of only a limited number of populations would therefore be inadequate. Likewise the genetic basis of *Rubus* is very limited, given that it behaves as a weed outside its natural range.

Prospects Little is known about the phytochemistry and phyto-pharmacology of *Rubus*. The presence of (gallo-)tannins is well documented, as well as the application in cases of diarrhoea and throat-troubles of these compounds. More research is needed to fully evaluate other possibilities.

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Selection of species

Rubus moluccanus L.

Sp. pl. 2: 1197 (1753).

Synonyms *Rubus glomeratus* auct. non Blume

Vernacular names Indonesia: hareueus (Sundanese), berete (Javanese), karembang ne langkow (Minahasa). Malaysia: akar kupur. Papua New Guinea: auiteteya (Nupuru, Eastern Highlands), laolo (Vunanope, New Britain), fapa (Sililio, Morobe Province). Philippines: sapinit (Igorot, Bagobo), bunut (Bontok), dagamit (Bisaya). Vietnam: dum molucca.

Distribution *R. moluccanus* is found throughout South-East Asia to northern Australia and New Caledonia.

Uses In Malaysia, a decoction of the roots is used for dysentery and other internal complaints. In Indonesia, sap from the leaves or stems is applied to eye diseases. In the Eastern Highlands (Papua New Guinea), the leaves are chewed with traditional salt and spat on sores to promote healing. In Morobe Province, stem sap is drunk by patients suffering from diarrhoea or dysentery, until recovered. In New Britain (Papua New Guinea), the sap from young shoots is drunk in a single dose to induce labour. In New Ireland, the leaves are taken internally as a remedy for diarrhoea, and as an abortifacient. In Thailand, the roots and leaves are used for cough and as a blood tonic.

Observations A climbing or scrambling, rarely creeping shrub with stems up to 6(–10) m long, stems tardily glabrescent, prickles small; leaves simple, ovate to broadly ovate in outline, variously lobed, 6–20 cm × 4–15 cm, base cordate to subtruncate, apex acute to acuminate, margin serrate, upper surface hairy, lower surface with a densely woven felt of long, thin, curly hairs all over, petiole 2–6 cm long, stipules pinnatilobed to pinnatipartite with 4–12 pairs of lobes, early caducous; terminal leafy compound raceme up to 20(–50) cm long, with up to 12 laterals, those up to 5(–9) cm long and with up to 10(–30) flowers; flowers bisexual, flower buds ovoid, pointed, hypanthium cupular, densely woolly, 4–7 mm across, sepals triangular to ovate, 4–9 mm × 2–6 mm, petals suborbicular to elliptical, 3–7 mm × 3–6 mm, long remaining, white, rarely pink, red or yellow, stamens 30–185, pistils 30–135, ovaries glabrous; collective fruit globular, about 1 cm in diameter when dry, red, falling off as a whole together with the dried torus. *R. moluccanus* is found on various soils in forest edges, secondary forest and thickets, from sea-level up to 2000(–3000) m altitude.

Selected sources 135, 407, 418, 433, 810.

Rubus rosifolius J.E. Smith

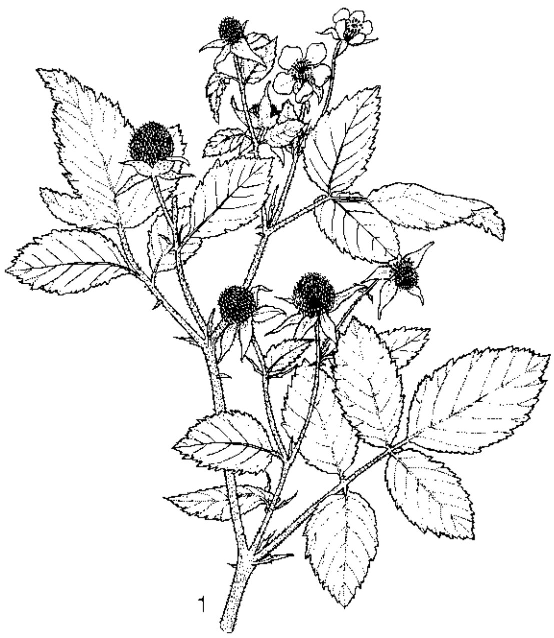
Pl. Icon. Hact. Ined. 3 : t. 60 (1791).

Synonyms *Rubus rosifolius* J.E. Smith var. *coronarius* Sims (1816), *Rubus taiwanensis* Matsum. (1902).

Vernacular names Indonesia: beberetean (Sundanese), ujen-ujen (Javanese), gharunggung (Madurese). Papua New Guinea: momitl (Mt Hagen, Western Highlands), wei (Nupuru, Eastern Highlands). Philippines: sagmit, sapinit (Tagalog), init (Iloko). Vietnam: ng[aas]y l[as] h[oof]ng, dum l[as] h[uw][owf]ng.

Distribution *R. rosifolius* occurs naturally in India, Indo-China, Taiwan, the Philippines, Borneo, Indonesia (except Sumatra), Papua New Guinea and Australia. It is cultivated as an ornamental or for its fruit and naturalized throughout the tropics and warm temperate regions.

Uses In the Philippines, a decoction of the roots is given as an expectorant, and a syrup of the fruit



Rubus rosifolius J.E. Smith – 1, branch with flowers and fruits.

as a demulcent. In the western Highlands (Papua New Guinea), the leaves are externally applied to itches. In Indonesia, the leaves enter into various traditional prescriptions apparently for their astringent properties. In Java, the leaves are eaten raw or cooked as a side dish.

Observations An erect or scrambling, rarely climbing shrub up to 1(–3) m tall, stems soft-hairy, glabrescent, with usually rather few curved to straight prickles; leaves imparipinnate up to 18 cm long, petiole 1–5.5 cm long, stipules linear, entire, persistent, leaflets in (1–)2–3(–4) opposite pairs, ovate to ovate-oblong, 2–6 cm × 1–2.5 cm, terminal leaflet up to 8 cm × 4 cm, base acute to cordate, apex acute to long tapering, margin biserrate; inflorescence with up to 4 dichasia in the axils of the upper leaves about 10 cm long, with up to 10 flowers; flowers bisexual, hypanthium saucer-shaped, 4–6.5 mm across, with scattered hairs and many glands outside, sepals ovate to narrowly triangular, 7–15(–22) mm × 2–5 mm, petals broadly ovate to ovate, 8–17 mm × 6–12 mm, white, falling early, stamens 60–140, pistils up to 600, ovaries with some apical hairs and usually many shortly stalked pale glands; collective fruit ovoid to globose or ellipsoid, up to 2.5 cm across, red, becoming loose from the torus as a whole. *R. rosifolius* is found on various soils in open places such as clearings, forest edges, secondary forest and thickets, from sea-level up to 2000(–3000) m altitude. Garden forms exist with more than 5 petals in the flower, which resemble a small rose. They are usually called var. *coronarius* Sims. These plants may produce fruits and sometimes escape from cultivation.

Selected sources 407, 418, 810.

J.L.C.H. van Valkenburg

Rumex L.

Sp. pl. 1: 333 (1753); Gen. pl. ed. 5: 156 (1754).

POLYGONACEAE

$x = 10, 20$; *R. acetosa*: $2n = 14, 15$; *R. crispus*: $2n = 60$; *R. maritimus*, *R. patientia*: $2n = 40$

Major species *Rumex acetosa* L., *R. crispus* L.

Vernacular names Sorrel, dock (En). Oseille, surelle (Fr). Indonesia: daun suring, surengan.

Origin and geographic distribution *Rumex* consists of about 200 species originating from the northern temperate regions, now distributed worldwide, sometimes cultivated. In South-East Asia, wild plants are mostly escapes from cultivation.

Uses The rhizomes and roots of many *Rumex* species, especially *R. acetosa* and *R. crispus*, but also *R. dentatus* L., *R. maritimus* and *R. wallichii*, are generally used for medicinal purposes in South-East Asia and India, internally as a laxative, and externally applied on swellings and against ringworm (*Tinea* sp.). The leaves are used for this latter purpose as well.

In Indonesia and Indo-China, the rhizomes of *R. crispus* are used as a mild purgative and astringent, and a decoction of the roots is prescribed for intermittent fevers and chronic bronchitis. In China, the rhizomes are also used as tonic and febrifuge. In Vietnam, the dried rhizomes and leaves, in decoction, are used for treatment of tuberculosis, hepatitis, arthritis, diabetes, scabies, haemorrhoids, anaemia and leucorrhoea. In the Philippines, China and Japan, sun-dried rhizomes are used for treatment of chronic bronchitis, ringworm, and haemorrhoids. In Brazil and Cuba, a decoction of the rhizome was formerly taken as an astringent tonic, depurative and laxative. In Cuba this was used especially for people with skin eruptions. The mashed rhizome is applied externally to lymphatic or glandular swellings. In Europe and the United States, the rhizome has been much used in the treatment of syphilis, tuberculosis and rheumatism. They are now mainly taken,

like the rhizomes of *R. acetosa*, as a tonic, haematic, and for acute and chronic inflammation of the nasal passages and respiratory tract. Fatal acute oxalate poisoning after eating large amounts of *R. crispus* leaves was observed in humans and sheep. Mucus membrane irritation, accompanied by vomiting, is possible following intake of the fresh rhizome, due to its anthrone content.
In Vietnam, the dried roots of *R. wallichii* are used for treatment of constipation, yellow skin, ringworm, acne, scabies and swellings. The bruised leaves are applied on ringworm and sprains. In India and Vietnam, the seeds of *R. maritimus* are used as an aphrodisiac and the leaves for the treatment of burns, swellings and ringworm.
In Haiti, a decoction of the root of *R. patientia* is applied to skin diseases, and taken internally as a tonic, astringent and depurative.
In Malesia, the leaves and petioles of several *Rumex* species are sometimes eaten raw as a salad or cooked as a rather sour vegetable.
The roots of *R. crispus* are sometimes used for tanning.

Production and international trade Whole plants and roots of *Rumex* are only used on a local scale, and sold in markets and medicine stores.

Properties *R. crispus* is known to contain several anthraquinone derivatives, e.g. oxymethylanthraquinone (0.2%) and emodin (0.1%) in the roots, and rumicin, physcion, chrysophanol, emodin, aloe-emodin, rhein and their glucosides, in the above-ground parts. Anthraquinone-containing drugs are well-known laxatives. In the colon, bacteria hydrolyse the glycosides and reduce the liberated anthraquinones to anthrones, which act directly on the large intestine to stimulate peristalsis.
The plant also contains 7–11% oxalic acid; fatal acute oxalate poisoning in sheep occurred within 40 hours after having eaten the plants. Clinical signs of poisoning were excess salivation, tremors, ataxia and recumbency. Other signs were hypocalcaemia, azotaemia, perirenal oedema, tubular degeneration.
R. acetosa also contains anthraquinones both in the roots and leaves: physcion, emodin, aloe-emodin, rhein and their glucosides. In addition, an extract showed strong antitumour activity in female ICR mice implanted with Sarcoma 180 solid tumour. The extract depressed aniline hydroxylase, aminopyrinedemethylase activities, prolonged the duration of pentobarbital-induced narcosis, and significantly enhanced the phagocytic activity and complement activity. Also, a water extract of the aerial parts exhibited antifungal activity.
R. nepalensis contains chrysophanic acid. An aqueous and ethanol extract of the leaves showed antihistaminic, anticholinergic and/or antibradykinin activity on rabbit skin in vivo.
The aqueous extract of the leaves of *R. patientia* was found to possess anti-inflammatory activity in rats in carrageenan, histamine, dextrane, or serotonine formaldehyde-induced oedema tests, as well as in cotton-pellet granuloma and Kabak tests. Acute toxicity studies revealed that the extract was non-toxic up to a dose of 3 mg/kg given orally.
R. wallichii contains anthraquinone glucosides. The aqueous extract of the root significantly increased the tonus of isolated intestines of frog and rabbit.

Adulterations and substitutes Anthraquinone(-glycosides) are also obtained from several other species, often in higher concentrations. These include *Rheum palmatum* L. roots, ripe pods of *Senna* and *Cassia* spp., *Aloe* leaves, and frangula (*Rhamnus frangula* L.) and cascara bark (*Rhamnus purshianus* DC.).

Description Annual or perennial, variable herbs, usually with stout rhizomes or roots. Leaves spirally arranged, the lower ones mostly in a rosette, sheathing at base, ocrea amplexicaul, blade linear, lanceolate, ovate, hastate or sagittate; petiole present. Inflorescence a raceme or panicle, often elongate, composed of pseudo-clusters. Flowers small, unisexual or bisexual, perianth segments 6, in 2 whorls of 3, the inner usually enlarged and mostly enclosing the fruit; stamens 6, in 2 whorls of 3, inserted at the base, anthers basifixed; ovary 3-carpellate, styles 3, outwardly deflexed or adnate to the marginal ribs, stigma penicillate or fimbriate. Fruit a sharply trigonous nutlet, included in the enlarged inner perianth, brown, shiny. Seedling with epigeal germination; cotyledons small, ellipsoid, apex pointed; first leaf ovate, base cuneate, apex acuminate.

Growth and development *Rumex* flowers at the beginning of the rainy season, and fruits ripen 5–6 months later. *Rumex* is wind pollinated. Seed is dispersed by wind and will pass through digestive tracts of most birds and cattle, but are destroyed when fed to chickens.

Other botanical information In *Rumex*, several subgenera are recognized, mainly based on gender of the flowers, the size of the inner perianth in fruit and the form of the leaves. There is no general botanical revision of the genus and therefore the status of lesser-known species remains unclear.

Ecology *Rumex* occurs in the northern temperate regions and preferably in the tropical highlands. It is commonly found in humid localities along roadsides, ditches, irrigation canals, and rice fields, and can become a troublesome weed. It prefers sunny or lightly shaded, not too dry localities, and occurs from sea-level up to 500 m altitude. Some species though grow mainly in moist, cool climates, up to 2000–3000 m altitude.

Propagation and planting *Rumex* is mainly propagated by seed, and after establishment, by division. Differences in size and in germination requirements are found in *Rumex* seeds borne on different parts of the plant, but are also caused by the stage of maturity of a plant and the year of production. Most seeds germinate readily under moist conditions. *R. crispus* may produce 60 000 seeds per plant per year.

Husbandry *Rumex* can be cultivated in the tropics at higher altitudes in fertile soils. For optimal leaf production, the inflorescences should be removed. When cultivated under shade, the leaves become less sour. *R. acetosa* can be cultivated on the same site for 4 years. *Rumex* grown as a vegetable should be watered every day; for medicinal use, watering once a week is adequate.

Diseases and pests The leaves of *Rumex* are often attacked by caterpillars. The larvae and adults of the Chrysomelid *Gastrophysa atrocyanea* were found to attack in particular weedy *R. acetosa* and *R. crispus* var. *japonicus*, causing a progressive decline of these populations in China.

Harvesting In Vietnam, whole plants or the roots of *Rumex* are harvested all year round. The roots are collected preferably before flowering. Mature seeds are harvested at the end of the year.

Handling after harvest *Rumex* plants are cleaned and the leaves are cut or just bunched for transport to the market. The roots are chopped and dried.

Genetic resources and breeding As *Rumex* produces large amounts of seed, which germinate easily, it is unlikely that it will become rare. A large germplasm collection of *Rumex* is kept in Gatersleben (Germany).

Prospects Anthraquinone-containing plants are well-known laxatives, widely used in medicine. The best known preparations, and those of first choice, are senna, frangula or cascara. Therefore, *Rumex* will probably remain only of local importance, since its anthraquinone content is lower. The potential for cultivating *Rumex* in the highlands of other South-East Asian countries needs further investigation.

Literature |**1**| Aggarwal, P.K., Kumar, L., Garg, S.K. & Mathur, V.S., 1986. Effect of Rumex nepalensis extracts on histamine, acetylcholine, carbachol, bradykinin, and PGs evoked skin reactions in rabbits. Annals of Allergy 56(2): 177–182. |**2**| Fleming, T. (Editor), 1998. PDR for herbal medicines. Medical Economics Company, Montvale, New Jersey, United States. pp. 1105–1107. |**3**| Le Tran Duc, 1997. Vietnamese medicinal plants: culture, harvesting, preparation, initial treatment. Agricultural Press, Hanoi, Vietnam. p. 645. |**4**| Panciera, R.J., Martin, T., Burrows, G.E., Taylor, D.S. & Rice, L.E., 1990. Acute oxalate poisoning attributable to ingestion of curly dock (Rumex crispus) in sheep. Journal of the American Veterinary Medical Association 196(12): 1981–1984. |**5**| Perry, L.M., 1980. Medicinal plants of East and Southeast Asia. Attributed properties and uses. MIT Press, Cambridge, Massachusetts, United States & London, United Kingdom. p. 322. |**6**| Suleyman, H., Demirezer, L.O., Kuruuzum, A., Banoglu, Z.N., Gocer, F., Ozbakir, G. & Gepdiremen, A., 1999. Antiinflammatory effect of the aqueous extract from Rumex patientia L. roots. Journal of Ethnopharmacology 65(2): 141–148.

Selection of species

Rumex acetosa L.

Sp. pl. 1: 337 (1753).

Synonyms *Rumex acetosella* sensu Pham Hoang Ho (1970).

Vernacular names Sorrel (En). Cambodia: slök mchuu. Vietnam: rau chua, rau b[os] x[oo]i, toan th[ar]o.

Distribution Native to Eurasia, now widely distributed in the temperate regions of the northern hemisphere, and cultivated in Indo-China.

Uses In Europe, *R. acetosa* is used as a diuretic, and is said to improve resistance to infections. In Vietnam, the leaves are used in local medicine for the treatment of constipation, furuncles and ringworm. The leaves are also eaten raw or cooked as a vegetable and have a sour taste. Cultivated in Vietnam as a medicinal herb and as a vegetable.

Observations A dioecious, perennial herb, 30–80 cm tall, stem sometimes branched, tinged red, roots thick and long; basal leaves sagittate, lobes directed backward, 3–11 cm × 0.5–3.5 cm, cauline leaves few; inflorescence a narrow, loose panicle; male flowers with all perianth segments alike, 2–3 mm long, female flowers with outer perianth segments 1 mm long, reflexed, inner segments pinkish-red, orbicular-cordate, 3–5 mm long, tubercled at base; nutlet ellipsoid. *R. acetosa* occurs in humid meadows, along roadsides and canals.

Selected sources 455, 473, 647, 914.

Rumex crispus L.

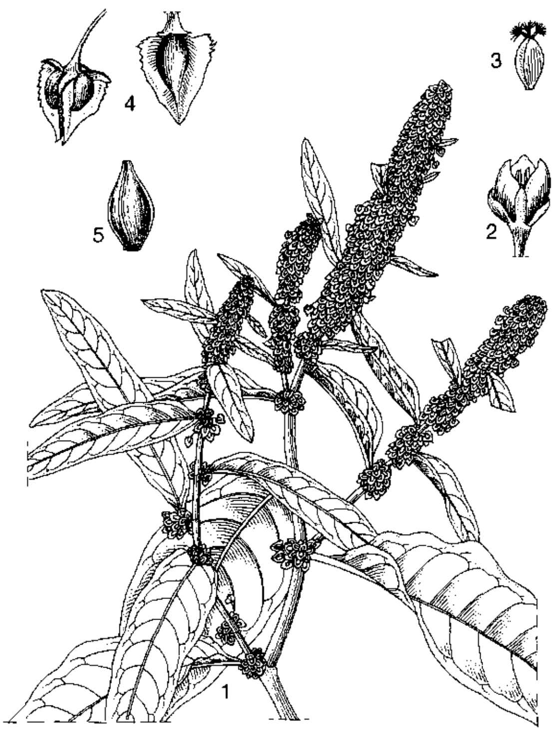
Sp. pl. 1: 335 (1753).

Vernacular names Curly dock, curled dock, yellow dock (En). Vietnam: d[uw][ow]ng [dd][eef] nh[aw]n.

Distribution Originating from Europe, now widespread throughout the world, from temperate to (sub)tropical regions, including Vietnam and Java.

Uses In Vietnam, a decoction of the plant is taken for fever. In Taiwan, a vapour bath of the leaves is used to relieve the eyes.

Observations A perennial herb, 30–150 cm tall, sparingly branched, stem reddish, taproot carrot-like, 20–30(–150) cm long; basal leaves narrowly lanceolate to oblanceolate, 10–30 cm × 2–8 cm, 4–5 times longer than wide, base shallowly cordate, rounded, truncate or cuneate, apex acute to obtuse, margins undulate or crisped, petiole shorter than blade, 10–12 cm long; inflorescence a dense raceme, branches erect or ascending, lower flower whorls somewhat remote; flower bisexual, inner perianth segments enlarged in fruit, 3–3.5(–6) mm long, entire to subentire, at least one segment tuberculate; nutlet 2.5–3 mm long. *R. crispus* is a weed of cropped land, along humid roadsides and waste places, in Java at 1250–2100 m altitude. Sometimes var. *japonicus* (Houtt.) Makino (formerly *R. japonicus* Houtt.) is recognized, which has a cordate leaf base, and distinctly denticulate valves of the perianth.



Rumex crispus L. – 1, flowering and fruiting branch; 2, flower; 3, pistil; 4, nutlets with perianth; 5, nutlet.

Selected sources 74, 440, 455, 647, 696, 788, 810, 838, 1092.

Rumex maritimus L.

Sp. pl. 1: 335 (1753).

Vernacular names Sea dock (En). Vietnam: d[uw][ow]ng [dd][eef] ta[uf], ch[us]t ch[is]t.

Distribution North and South America, Europe, India, China, Indo-China.

Uses In Vietnam, the dried roots are prepared as a laxative pill, and the fresh roots in decoction are used for the same purpose. In Europe, the seeds are sometimes used as an aphrodisiac.

Observations An annual to biennial herb, 30–70 cm tall, stem much branched, deeply grooved; basal leaves narrowly lanceolate to elliptical, 5–20 cm × 1–3.5 cm, base cuneate to obtuse, apex acute; inflorescence a panicle, flowers arranged in dense whorls; flowers bisexual, inner perianth segments enlarged in fruit, 2–3 mm long, marginal teeth usually 1–2 on each side, callous tubercles on all valves, subequal, ovoid, 1–1.5 mm long; nutlet oblong, yellowish-brown. *R. maritimus* occurs in humid localities, along ditches, roads, fields and irrigation canals.

Selected sources 455, 647, 736.

Rumex nepalensis Sprengel

Syst. 2: 159 (1825).

Vernacular names Vietnam: ch[us]t ch[is]t n[ee]pan.

Distribution India and Sri Lanka, South-West China, northern Vietnam, Java, westward to Asia Minor, the Balkan Peninsula and southern Europe; also in South Africa.

Uses In India, the leaves are applied to swellings.

Observations A perennial herb, 60–170 cm tall, rhizome stout; lower leaves oblong-ovate, 20–30 cm × 12–20 cm, 1.5–3 times longer than broad, base cordate, margins undulate-denticulate, crispy or flat, puberulous beneath, long petiolate, cauline and upper leaves broadly ovate-lanceolate, base cordate to rounded or subtruncate, short petiolate; inflorescence an open panicle, branches spreading, almost leafless, whorls of flowers somewhat remote; flowers bisexual, inner perianth segments more or less oblong-ovate, 3–4 mm long in fruit, including teeth, apex circinately incurled, at least 1 segment with pronounced fusiform tubercle; nutlet 3–5 mm × 2–2.5 mm. *R. nepalensis* occurs along roadsides, scrubland and forest clearings, on Java at 2100–2800 m altitude.

Selected sources 74, 838.

Rumex patientia L.

Sp. pl. 1: 333 (1753).

Distribution Native to central Europe and East Asia, but naturalized in the highlands of many tropical countries.

Uses In Java, occasionally cultivated as a vegetable, but it could be used medicinally as well.

Observations A perennial herb, 1–2 m tall; basal leaves ovate-lanceolate, base rounded to narrowed, margin slightly undulate or not; inflorescence a panicle; flowers bisexual, inner perianth segments enlarged in fruit, orbicular, 6–10 mm long, base subcordate, often denticulate, only one valve with a well developed tubercle; nutlet 3–4 mm long. In Java, *R. patientia* is occasionally found as an escape from cultivation, up to 2550 m altitude.

Selected sources 74, 647, 696, 914.

Rumex wallichii Meisn.

in DC., Prodr. 14(1): 48 (1856).

Vernacular names Vietnam: ch[us]t ch[[is]t, l[uw][owx]i b[of].

Distribution Occurring in India, China and Vietnam.

Uses In Vietnam, the leaves are put into baths against scabies, while the bruised leaves are used in the treatment of ringworm. The root in decoction is taken as a laxative.

Observations A robust, annual herb, 40–120 cm tall, stem angular, little branched; basal leaves lanceolate, 15–20 cm × 2–5 cm, base cuneate, apex acute, margin undulate-crenate; inflorescence a terminal or subterminal raceme or panicle; flowers bisexual, inner perianth segments ovoid, 1–1.5 mm long, enlarged in fruit, margins entire, tubercles on all valves, subequal; nutlet oblong. In Vietnam, *R. wallichii* grows in wet locations, along roads and irrigation canals. *R. wallichii* is very close to *R. maritimus*, but differs in the margins of the valves which are entire, not toothed.

Selected sources 736, 739, 788.

Nguyen Thi Do

Ruta L.

Sp. pl. 1: 383 (1753); Gen. pl. ed. 5: 180 (1754).

RUTACEAE

x = unknown; *R. angustifolia*: $2n = 40$

Major species *Ruta angustifolia* Pers., *R. chalepensis* L.

Vernacular names Rue (En). Indonesia: godong minggu (Javanese), inggu (Sundanese), anruda busu (Makassar). Malaysia: aruda, sadal. Vietnam: c[uwr]u l[ys] h[uw][ow]ng, [aa]n h[uw][ow]ng.

Origin and geographic distribution *Ruta* comprises about 8 species and is found from Macaronesia eastward through the Mediterranean to South-West Asia. *Ruta* has also been introduced in other parts of Asia, the West Indies, South and Central America.

Uses *Ruta* acts as a rubefacient and the oil may even blister the skin. This may well explain its traditional use in South-East Asia, in combination with turmeric, for itch. It is assumed that it kills the mites and stimulates the skin. Internally it has an anti-aphrodisiac effect and slows the pulse, possibly explaining its traditional use in mixtures that are applied to the wrist and temples to treat convulsions in hysteria and as a treatment for fevers. In Malaysia, leaf sap is used as eardrops for earache. In Java, the leaves are an ingredient of a mixture for coughs.

Ruta has traditionally been used as a condiment, excessive use is, however, dangerous. Its toxic effects are clearly dose-dependent. It is potentially toxic and carcinogenic when consumed orally, and can produce dermatitis when touched. Used internally, the leaves and oil can cause haemorrhages, miscarriage and abortion, and have been used as such since ancient times. It may further cause vomiting, gastroenteritis, swelling of the tongue, coldness of the extremities, and even death. Rue oil is used as an anthelmintic, antispasmodic, anti-epileptic, rubefacient and emmenagogue especially in veterinary medicine.

The oil is used as a flavouring agent and in perfumes and soap scents. Oils rich in methyl nonyl ketone are used for the preparation of methyl-n-nonyl acetylaldehyde, widely applied as a synthetic perfume.

Production and international trade In South-

East Asia, *Ruta* is only used on a local scale. Commercial production of rue oil is centred in the Mediterranean.

Properties *Ruta* is characterized by the presence of alkaloids (acridonal-, chinolone-, furochinolone- type alkaloids, and quaternary furochinolines), (furano-)coumarins and essential oils. The compounds isolated from *R. angustifolia*, *R. chalepensis* and *R. graveolens* L. are essentially the same; quantitative differences are observed, however, between the species, but are of the same magnitude as those observed from different sources of the same species. Qualitative and quantitative differences are also found for the different parts of the plants.

In general, characteristic components of *Ruta* essential oils include 2-nonanone and 2-undecanone, of which the concentrations vary between species, parts and sources.

Major compounds isolated from the roots of *R. chalepensis* are the furochinolin alkaloids, kokusaginin, skimmianin and graveolin, the acridonal alkaloids 1-hydroxy-N-methylacridon and chaloridon, and the furanocoumarin, chalepensin. From the dried plant, major compounds isolated include the furochinolin alkaloids, kokusaginin, skimmianin, graveolin, γ-fagarin, and dictamnin, the acridonal alkaloid, arborinin, and the (furano-)coumarins, bergapten and chalepensin.

Bergapten (or 5-methoxypsoralen) and chalepensin belong to the family of the linear furanocoumarins, which are known to have phototoxic activity. Dermatosis may arise after plant material containing these compounds comes into direct contact with the skin, if this is immediately followed by exposure to UV-A light, e.g. from the sun. The mechanism of photosensitization by linear furanocoumarins is based on interference with DNA base pairs. Energy provided by UV-A irradiation leads to the formation of additional products between the furanocoumarin and cytosine and thymine bases. This bridge-building inhibits the replication and transcription of DNA and, consequently, the synthesis of RNA and proteins and the occurrence of cell division.

Furthermore, ethanol extracts of air-dried flowering material of *R. chalepensis* have been studied in various models. Oral administration at a dose of 500 mg/kg significantly reduced carrageenan induced oedema in rats. Similar results were reported using the cotton-pellet granuloma test model. Additionally, intraperitoneal administration at 100 mg/kg significantly reduced subcutaneously induced (yeast suspension) fever in mice. By using the same route, doses of 50, 100 and 500 mg/kg also significantly reduced motility in mice. No analgesic activity was observed in the hot-plate test with mice, however. Of the isolated compounds, chalepsin at an i.p. dose of 10 mg/kg significantly prolonged hexobarbital-induced sleeping time in mice.

Finally, a hexane extract of *R. chalepensis* shows strong molluscicidal activity against the schistosomiasis-transmitting snail *Bulinus truncatus* with an LC_{90} value of 2.23 mg/l. Ethanolic extracts furthermore showed in-vitro activity against the bacteria *Staphylococcus aureus* and *Pseudomonas vulgaris* (disk diffusion assay).

For *R. graveolens* some 40 alkaloids (examples include graveolin, γ-fagarin, skimmianin, arborinin, furacridon), more than 40 coumarins and furanocoumarins (linear types: e.g. bergapten, chalepensin, psoralen, xanthotoxin) and some 30 compounds in the essential oil (predominantly 2-nonanone and 2-undecanone) have been identified in various plant parts.

R. graveolens essential oil has a reported spasmolytic activity on the isolated rabbit ileum. Furthermore, the in-vitro anthelmintic activity of the oil is proportional to the nonylmethylketone concentration. The LD_{50} for *Tubifex rivulorum* was 0.1–0.15 g/100 ml, for *Hirudo officinalis* 0.075–0.125 g/100 ml and for *Ascaris suilla* 0.06–0.12 g/100 ml. An LD_{100} for *Anuillula aceti* was achieved after 10 minutes at 0.2 g/100ml and after 45 minutes at 0.02 g/100 ml.

In addition, the methanol extract of the plant has a spasmolytic effect on the isolated rabbit ileum. The active principles have been identified as the coumarin derivates bergapten, psoralen and xanthotoxin, several furochinoline type alkaloids, and the acridon alkaloid arborinin. Furthermore, the spasmolytic activity of isolated rutamarin (a coumarin) and arborinin in various animal models was found comparable with that of papaverin. Other effects of arborinin also include inhibition of the histamine induced bronchospasms in guinea-pigs after application of a dose of 10 mg/kg intravenously, and anti-exudative activity in rats (3 mg/kg, s.c.) by using the dextran-oedema model.

Information on the antifertility effect of rue presents a mixed picture.

Whereas oral consumption of the essential oil induces abortion in guinea-pigs and humans, this probably has to be attributed to a general toxic effect. The essential oil has no effect on the isolated uterus in (non-)pregnant cats or the isolated oviduct in (non-)pregnant women. An ethanol extract of the plant, however, shows a significant anti-implantation effect, an increased absorption rate and an overall reduced pregnancy ratio in albino rats. Petroleum ether and methanol extracts are reported to have similar results, whereas benzene and chloroform extracts merely have a toxicological effect. None of the extracts had any effect on the golden hamster. The antifertility effect is attributed to the furanocoumarin, chalepensin, which has a very narrow therapeutical range. In view of the known variations in concentration in different source materials, this may very well explain the somewhat contradictory research findings for the various test systems.

Adulterations and substitutes Alkaloids of the types present in *Ruta* species have also been found in several other genera belonging to the *Rutaceae*. Examples include kokusaginine and skimmianine, which are also reported for *Glycosmis*, *Orixa* and *Zanthoxylum* species.

Description Perennial herbs, more or less woody at the base. Leaves spirally arranged, 2–3-pinnatisect, obovate to oblong-obovate in outline, ultimate segments linear to obovate; petiolate or not; stipules absent. Inflorescence cymose, terminal or in the upper leaf axils, often combined into a corymb, bracteate. Flowers 4(–5)-merous, the lower ones bisexual, the upper ones male; petals cucculate, dentate or ciliate or more rarely entire, yellow; anthers twice as many as the petals; ovary superior, semi-globose, 4–5-lobed, 3–5-celled. Fruit a capsule, dehiscent at the apex only. Seed angulate. Seedling with epigeal germination.

Growth and development Flowering phenology patterns of protandrous *R. angustifolia* populations in Spain showed 87.5% overlap between male and female phases. Male flowers offered a higher nectar reward than female flowers, and higher visitation rate occurred during the population male phase. Flowers were visited by different unspecialized insects. Bagging experiments showed a clear trend to allogamy, but a limited production of fruits and seeds was observed when pollinators were not available. In Java, *R. angustifolia* does not flower at elevations below 1000 m altitude. At higher elevations it flowers from March–October.

Other botanical information The botanical identity of *Ruta* growing in South-East Asia is unclear. The taxonomy of *Ruta* is already complex in Europe, the Mediterranean and the Near East. The name *R. angustifolia* as referring to small-leaved plants has been merged with *R. chalepensis* as well as *R. graveolens*, sometimes as a full synonym, sometimes retained at subspecies level. The chemical composition of the three species is almost identical and as *Ruta* is only known in South-East Asia in cultivation, the name *R. angustifolia* has been retained in this treatment.

Ecology *Ruta* will thrive under fairly dry conditions in partial shade but will survive successfully in full sun. It is easily grown on any soil but prefers a well-drained calcareous clayey soil.

Propagation and planting *R. angustifolia* and *R. chalepensis* are primarily propagated by seed. They can also be reproduced by layering, division of roots, and from cuttings. The latter means of propagation is advantageous at lower elevations in the tropics where it is reported to flower rarely.

In vitro production of active compounds Research has concentrated on *R. graveolens*, and tissue cultures and cell suspension cultures have been established using explants of stems, roots or leaves harvested from whole plants or plantlets. Various media and phytohormones have been used. Cultures are characterized by easy organogenesis, an autothrophic aptitude to phytohormones and also towards light and especially strong biogenetic potentialities. A wide range of the pharmacological active compounds isolated from the plants are also produced by the tissue cultures and cell suspension cultures.

Husbandry In South-East Asia *Ruta* is only known in cultivation and as a potplant. It may be pruned back to encourage fresh growth.

Harvesting In South-East Asia leaves and flowering shoots of *Ruta* are collected whenever the need arises.

Handling after harvest The aboveground non-woody parts of *Ruta* are preferably dried in the shade, and should be regularly turned as they do not dry easily.

Genetic resources and breeding Within South-East Asia, there might be some danger of genetic erosion. *Ruta* has been introduced in the region and therefore the genetic basis might be limited. Furthermore, plants flower only occasionally and are mostly reproduced vegetatively.

Prospects Application of the linear, phototoxic furanocoumarins in medicine as found in *Ruta* is well documented, for instance in the treatment of psoriasis. They therefore merit further research on their potential as a local- or industrial source. Other constituents (e.g. arborinin) might also have future potential.

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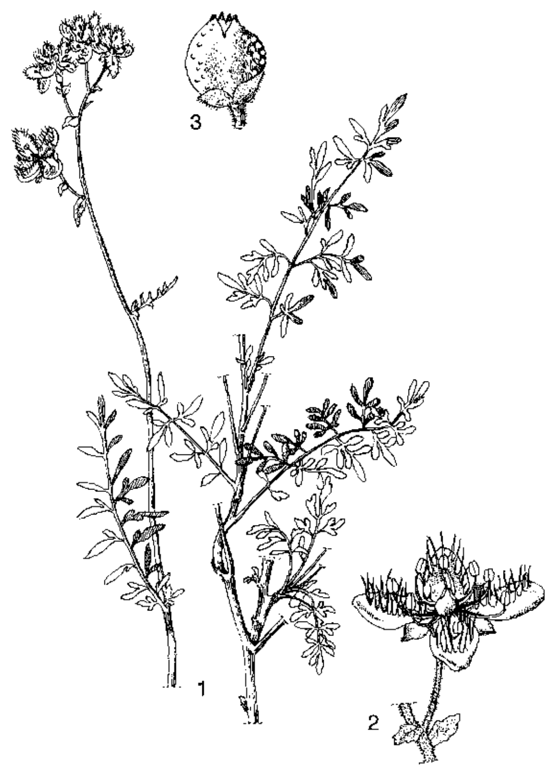


Ruta angustifolia Pers. – 1, habit; 2, flower; 3, fruit.

Selection of species

Ruta angustifolia Pers.

Syn. pl. 1: 464 (1805).

Synonyms *Ruta chalepensis* auct., *Ruta graveolens* auct., *Ruta graveolens* L. var. *angustifolia* (Pers.) Hook.f. (1875), *Ruta chalepensis* L. var. *angustifolia* (L.) Backer (1911).

Vernacular names Indonesia: godong minggu (Javanese), daun inggu (Sundanese). Malaysia: aruda, sadal. Vietnam: c[uwr]u l[ys] h[uw][ow]ng.

Distribution *R. angustifolia* is native to the Mediterranean region. Used for medicinal and culinary purposes since ancient times it has been introduced in the Near East and India; in South-East Asia it is cultivated as a potplant in Malaysia, and occasionally in Vietnam and in Java for medicinal purposes.

Uses See under genus.

Observations A perennial herb, woody at the base, 0.3–1.5 m tall; leaves spirally arranged, 2–3-pinnatisect, obovate to oblong-obovate in outline, 4–15 cm × 2–9 cm, ultimate segments obovate-lanceolate to narrowly oblong about 8–14 mm × 1.5–3.5 mm, conspicuously glaucous, crenate, translucent glandular punctate, strong smelling, lower leaves shortly petiolate; cyme, terminal or in the upper leaf axils, often combined into a corymb, bracts lanceolate, not or scarcely wider than the subtended branch, usually glandular puberulent; flowers 4(–5)-merous, sepals deltate-ovate, 2–3 mm × 1–2 mm, subacute, glandular puberulent, petals oblong, 7–10 mm long, fringed with cilia as long as the width of the petal; capsule glabrous, segments accuminate. In South East Asia only known in cultivation.

Selected sources 74, 135, 215, 309, 407, 696, 786, 788, 945.

Ruta chalepensis L.

Mantissa: 69 (1767).

Synonyms *Ruta bracteosa* DC. (1824).

Vernacular names Indonesia: godong minggu (Javanese), daun inggu (Sundanese). Malaysia: aruda, sadal. Vietnam: c[uwr]u l[ys] h[uw][ow]ng.

Distribution *R. chalepensis* is native to the Mediterranean region and the Canary islands. Used for medicinal and culinary purposes since ancient times it has been introduced in the Near East and India; in South-East Asia it is cultivated as a potplant in Malaysia, and occasionally in Vietnam and in Java for medicinal purposes.

Uses See under genus.

Observations A perennial herb, woody at the base, 0.3–1.5 m tall; leaves spirally arranged, 2–3-pinnatisect, obovate to oblong-obovate in outline, 4–15 cm × 2–9 cm, ultimate segments obovate-lanceolate about 5–30 mm × 1.5–6 mm, conspicuously glaucous, crenate, translucent glandular punctate, strong smelling, lower leaves more or less petiolate; cyme, terminal or in the upper leaf axils, often combined into a corymb, bracts cordate-ovate, wider than the subtended branch, glabrous, rarely with a few minute glans above; flowers 4(–5)-merous, sepals deltate-ovate, 3–4 mm × 2–3 mm, glabrous, petals oblong, 4–8 mm long, fringed with cilia not as long as the width of the petal; capsule glabrous, segments acuminate. In South-East Asia only known in cultivation.

Selected sources 74, 135, 215, 309, 407, 696, 786, 788, 945.

Rina R.P. Irwanto

Saussurea costus (Falc.) S.J. Lipschitz

Bot. Journ. USSR 49(1): 131 (1964).

COMPOSITAE

$2n = 26$ (36)

Synonyms *Saussurea lappa* C.B. Clarke (1876).

Vernacular names Costus (root) (En). Malaysia: costus, kut, puchok. Vietnam: m[ooj]c h[uw][ow]ng, qu[ar]ng m[ooj]c h[uw][ow]ng, v[aa]n m[ooj]c h[uw][ow]ng.

Origin and geographic distribution *S. costus* originates from northern India and Nepal but occurs now in the whole of the mountainous Asian region, since it was exported to the East in the 13th Century. It is cultivated in northern India, Vietnam and China, but it is not known to be cultivated in Malesia.

Uses *S. costus* is cultivated for its extremely bitter and aromatic roots, which contain essential oils. In addition, they are valued for their powerful medicinal properties. In the whole Asian region, the roots have been used for a long time as a universal antidote, as a tonic, and for coughs, asthma, dyspepsia, constipation, flatulence, inflammations, fever, skin diseases, and as a fumigant. They are also regarded as an aphrodisiac. In Peninsular Malaysia, the root is given after childbirth to the mother, to restore health. In Indonesia, it is used in the treatment and prevention of affections of the respiratory organs. In China and Korea, it is applied to relieve pains in the chest and stomach. It is also used as a uterine sedative, and for indigestion, nausea, diarrhoea, and dysentery. In Thailand, the roots are used are used as a carminative and to prevent fainting. The Chinese use the root more for fumigation than as a medicine. The roots are sometimes smoked as a substitute for opium, as it produces a marked depression of the cerebral nervous system. It is also put among clothes to protect them from insects. In India the dried stems are used as a fodder.

Production and international trade In India, essential oil production of *S. costus* roots reaches 6–12 t per year, and large quantities of Costus root are exported to China and other Asian countries, where they are used as an incense. In the 1960s the annual production of Costus root was 250–550 t, the main importing countries being Hong Kong, France and Singapore. Indonesia, Thailand, Vietnam, Japan and Sri Lanka also import smaller quantities of the roots.

Properties Similar to other *Compositae* species, the root of *S. costus* contains inulin (18%), a polysaccharide made up from fructose residues. It also contains an essential oil ('costus oil'), from which the terpenes costus lactone, dehydrocostus lactone, costol, α- and β-costene, camphene, phellandrene and aplotaxene were isolated. The sesquiterpene lactone costunolide is also reported to be contained in the roots.

Several of these compounds display biological activities. Costus oil itself often causes contact dermatitis, which is attributed to the presence of costulide and dehydrocostus lactone. Costulide exhibits strong antimicrobial activity against *Streptococcus* and *Staphylococcus*. Furthermore, dehydrocostus lactone inhibits the production of nitric oxide in lipopolysaccharide-activated RAW 246.7 cells (murine macrophage-like cells) by suppressing inducible nitric oxide synthase enzyme expression and also by decreasing the tumour necrosis factor-αlevel in lipopolysaccharide (LPS)-activated systems in vitro and in vivo. This compound may thus be a possible candidate for the development of new drugs to treat endotoxemia accompanied by the overproduction of nitric oxide and tumour necrosis factor-α. Costunolide and dehydrocostus lactone act as inhibitors of killing activity of cytotoxic T-lymphocytes, through preventing the increase in tyrosine phosphorylation in response to the cross linking of T-cell receptors. Both compounds also show a strong suppressive effect in a dose-dependent manner on the expression of the hepatitis B surface antigen (HBsAg) in human hepatoma Hep3B cells, but have little effect on the viability of the cells. Both compounds were also tested for effects on the central nervous system of mice by intraperitoneal, intragastric and intracerebroventricular administration, and were found to decrease methampetamine- and apomorphine-induced spontaneous motility.

Another sesquiterpene lactone, reynosin, isolated from the roots, was found to inhibit cytokine-induced neutrophil chemoattractant-1 induction in LPS-stimulated rat kidney epitheloid NRK-52E cells, in a dose-dependent manner.

The root also contains the alkaloid saussurine, which has antispasmodic properties, useful in controlling paroxysms of bronchial asthma and in the treatment of persistent hiccup. Five amino acid-sesquiterpene adducts, saussureamines A, B, C, D and E, were furthermore isolated from the dried root of *S. costus*. Saussureamines A, B and C showed an anti-ulcer effect on HCl/ethanol-induced lesions in rats, and saussureamine A also inhibited an inhibitory activity on stress-induced ulcer formation in mice.

The crude extract of *S. costus* displayed significant lethality to brine shrimp larvae. The compounds responsible are shikokiols, C17-polyene alcohols, which also exhibited moderate cytotoxicity against the human tumour cell lines A549, SK-OV-3, SK-MEL-2, XF498, and HCT15.

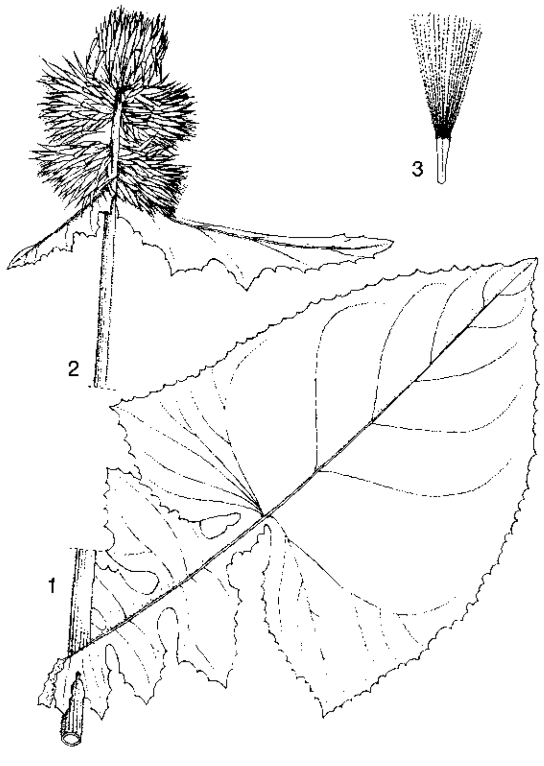
The ethanol root extract of *S. costus*, used traditionally to treat diabetes, was also administered to rats, who showed a significant hypoglycaemic response, together with increased concentrations of liver glycogen, after 8 hours. Alcoholic root extracts also show a potent antifungal effect with a broad spectrum.

Boiled water extract of *S. costus* was screened for clonorchicidal activity in rabbits infected with the worm *Clonorchis sinensis*. The extract caused significant regressive and progressive changes such as degeneration, atrophy, necrosis and dilatation of viscera of the worms. Plant extract of *S. costus* applied topically to nymphs of the mustard aphid (*Lipaphis erysimi*), caused significant immediate mortality. A root extract was also effective against the red cotton bug (*Dysdercus koenigii*), and the pulse beetle (*Callosobruchus chinensis* or *C. maculata*).

The crude oil from the root of *S. costus* significantly reduced the damage by larvae of *Spodoptera litura* to leaves of *Ricinus communis* L. Mortality was more than 50% for treatment at 5%. There were no effects on pupae and adult insects.

Finally, the sesquiterpene lactone 4β-methoxydehydrocostus lactone, isolated from the roots of *S. costus*, displayed significant biological activity as a plant growth regulator, stimulating root formation on hypocotyl cuttings of *Vigna radiata* (L.) R. Wilczek.

Description An erect, robust, unbranched, perennial herb, 1.5–2(–2.3) m tall; roots up to 60 cm long, carrot-like, with a penetrating odour. Leaves simple, basal ones spirally arranged in a rosette, cauline leaves alternate, basal leaves triangular, very large, 30–60 cm × 10–15 cm, base cordate, apex pointed to rounded, margins irregularly toothed, membranous, scaberulous above and almost glabrous beneath, cauline leaves smaller, with an auricled, semi-amplexicaul base; petiole of rosette leaves lobately winged, cauline leaves shortly petiolate or sessile. Inflorescence consisting of heads, in terminal or axillary clusters of 2–5, involucral bracts numerous, ovate-lanceolate, acuminate, rigid, squarrosely recurved, glabrous, purple, peduncles 1–6 cm long, heads 2.5–3.5 cm across, very dense and hard. Flowers all tubular, about 1 cm long, corolla blue-purple; stamens 5, filaments glabrous, anther-tails fimbriate; style bifid. Fruit a compressed subcylindrical achene, 8 mm long, tip narrowed, margins



Saussurea costus (Falc.) S.J. Lipschitz – 1, basal leaf; 2, inflorescence; 3, achene.

thickened, 1 rib on each face; pappus with feathery brown hairs in several rows. Seedling with epigeal germination.

Growth and development The number of flowering heads is larger when cultivated in unshaded fields than under shade.

Other botanical information *Saussurea* is a large genus with about 300 species in temperate Asia, 9 in Europe, 1 in North America and 1 in Australia. *Saussurea* belongs to the tribe *Cardueae*, but its position there is uncertain, as its chemical composition is different from the other genera in the tribe. Most species are densely white-woolly-haired alpine plants, some of which are ornamentals.

Ecology *S. costus* requires a cool climate, and grows in the mountains at the upper limits of tree growth, between 1500–3300 m altitude. It is a casual in irrigated areas, and a deep, rich, porous soil is preferred. In India, *S. costus* is planted on sunny localities, with an average temperature of 14–23°C, and an annual rainfall of 800–1100 mm. In Vietnam, *S. costus* is cultivated at 1500 m altitude, with an average temperature of 15°C, and an annual rainfall of 2000–2500 mm.

Propagation and planting *S. costus* has been planted in Northern India since the 1920s. It can be cultivated under semi-natural conditions in the forest areas, under a canopy, and as a regular crop with occasional irrigation. *S. costus* can be propagated either by root cuttings or by seed. In regions in India where it grows naturally, the collar zone of the root and pieces smaller than 2.5 cm are replanted, providing a natural regeneration. For cultivation, propagation by achenes is more economical. The infructescences are harvested in September, a little before ripening, and then stacked in the sun for a week before threshing. The achenes, 35–40 per gram, retain their viability for a year or more. At 15°C, 8% of the achenes germinate after 17 days, and at 25°C, 36% germinate after 7 days. In India, seeds of *S. costus* are sown at the beginning of the rainy season, in April/June. They can be sown in a nursery, and one-year old seedlings transplanted at a spacing of 0.9 m × 0.9 m, by which time the root is 15–35 cm long. Direct sowing is successful in areas where the risk of seedling mortality from drought is minimal. In that case the seeds are sown in pits at a spacing of 0.3 m × 0.3 m, and the plants later thinned to 0.6 m × 0.9 m.

Rapid micropropagation of *S. costus* was achieved by culturing shoot tips (0.5–1 cm long) of 2-week old seedlings on Murashige and Skoog media supplemented with thidiazuron, obtaining callus-free multiple shoots. Shoot tips containing proliferative buds were divided into equal halves and subcultured for further multiplication and elongation. Multiplication of induced shoot buds was more effective when cultured in liquid medium than on agar-solidified medium. Shoots (8–10 cm long) were rooted in Murashige and Skoog medium containing naphthalene acetic acid (NAA). Micropropagated plantlets were successfully transferred to soil after hardening. Shoot cultures stored at 5°C in the dark for 12 months, without an intervening subculture survived with 100% viability. Shoots cold-stored for 6 months or more showed higher rates of multiplication under culture room conditions than the untreated roots.

Diseases and pests *S. costus* is subject to fungal diseases caused by *Puccinia saussureae*, *Septoria sordidula*, *Bremia saussurea*, *Leveillula taurica* and *Albugo candida*; the crop can also suffer from the insect *Vanessa cardui*, which can complete 2 generations in 1 year.

Harvesting Roots of *S. costus* cultivated as a sole crop can be harvested 3 years after sowing. Plants grown under forest conditions attain maximum root weight when about 5 years old and then start flowering. After the first flowering the plants continue to grow, but the quality of the root deteriorates. In India, the roots are harvested in October.

Yield A yield of 2–2.5 t/ha of dry roots can be obtained from forest plantations, while 3.5–4 t/ha can be harvested from sole crops.

Handling after harvest In India the roots are cut into pieces of 10 cm long and dried in the sun, where they become greyish to dull brown. Afterwards they can be powdered.

The oil can be obtained by a number of methods, with yields ranging from 0.8–5.8%. The common method is by steam distillation of sliced and macerated roots in water, yielding 1.2% of oil. The improved method of extraction, using petroleum ether, yields 6% of oil, of which the lactonic constituents (about 50%) can be easily crystallized and separated. The oil is a pale yellow to brownish, very viscous liquid, with a persistent and particular odour, and is used in the perfume industry. In Japan, several drying methods have been evaluated, but the best one was outdoor drying for about 1 month in the dry season, during which the inulin in the roots is enzymatically hydrolysed to produce fructose and a small amount of glucose. Lengthwise splitting of roots or hot-air drying shortened the drying period, but reduced the quality of the product, 'Saussureae Radix'.

Genetic resources and breeding *S. costus* has become almost extinct in India because of uncontrolled exploitation, and conservation measures include in-situ preservation and ex-situ propagation.

Prospects *S. costus* is a potential crop for the cooler regions in South-East Asia. Several compounds, especially the sesquiterpene lactones isolated from the roots, display a multitude of interesting biological activity. Research in the fields of e.g. immunology, virology, asthma and chemotherapeutics, is needed, however, to evaluate their potential as lead compounds in drug discovery.

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G.H. Schmelzer

Scaevola taccada (Gaertner) Roxb.

Fl. ind. 2:146 (1824)

GOODENIACEAE

$2n = 16$

Synonyms *Lobelia taccada* Gaertner (1788), *Scaevola sericea* Vahl (1791), *Scaevola frutescens* Krause (1912).

Vernacular names Sea lettuce tree (En). Indonesia: dudulan (Javanese), babakoan (Sundanese), subong-subong (Bengkulu). Malaysia: ambong-ambong, buas-buas laut, akar pahit. Papua New Guinea: gavagava (Milne Bay), pahop (Manus Island). Philippines: boto, mosboron (Tagalog, Bisaya), bosboron (Tagalog, Bikol, Bisaya). Thailand: bong bong, rak thale (peninsular), ho raa (southeastern). Vietnam: h[ees]p, s[ow]n d[uw][ow]ng.

Origin and geographic distribution *S. taccada* is found from Madagascar eastward to South-East Asia, throughout Malesia, tropical Australia, the Pacific Islands and Hawaii. It is cultivated and sparingly naturalized in the south-eastern United States.

Uses Throughout South-East Asia and Australia, diluted sap from the leaves or sap from the ripe berries of *S. taccada* is used in folk medicine to clear opacity of the eye and in the treatment of eye infections. In Malaysia, the bitter leaves may be eaten as a cure for indigestion, and the leaves may be used as a poultice for headache. In Indonesia, the root is applied as an antidote after eating poisonous fish or crab. In the Philippines, the roots in decoction are used in beri-beri and in certain syphilitic affections, also in dysentery. In Thailand, roots and leaves are used for skin affections.In Finschafen (Papua New Guinea), the young leaves are chewed and boiled into a tea or else the juice from the heated leaves is mixed with water to treat cough. The sap may be directly applied to sores. Likewise, young leaves are chewed to soothe a cough on New Hanover Island, and to treat tuberculosis on Karkar Island. After removal of the epidermal layer the leaf is chewed to treat malaria. Similarly, on several islands north of New Guinea, the leaves are used to treat cough or colds. In New Ireland and Milne Bay, an extract from the leaves is used as a form of long-term contraception by women. Other applications include the treatment of earache in Manus Island, and asthma and tuberculosis in Karkar Island. In northern Australia the juice squeezed from young stems and ripe fruits is applied directly to bites and stings. In Samoa, the leaves are traditionally used for skin ailments, swellings, elephantiasis, scrotal swellings, oedema, chill and indigestion; the roots are considered a good therapy for cancer; the bark is applied for abscesses, menstrual complaints and bone fractures; the stem is used for abdominal complaints. In the Western Highlands in Papua New Guinea juice from the stems of *S. oppositifolia* R.Br. is applied to ear inflammations. In other parts of New Guinea, stem sap is further used to cleanse a sore eye and on wounds, and when hot on topical ulcers.

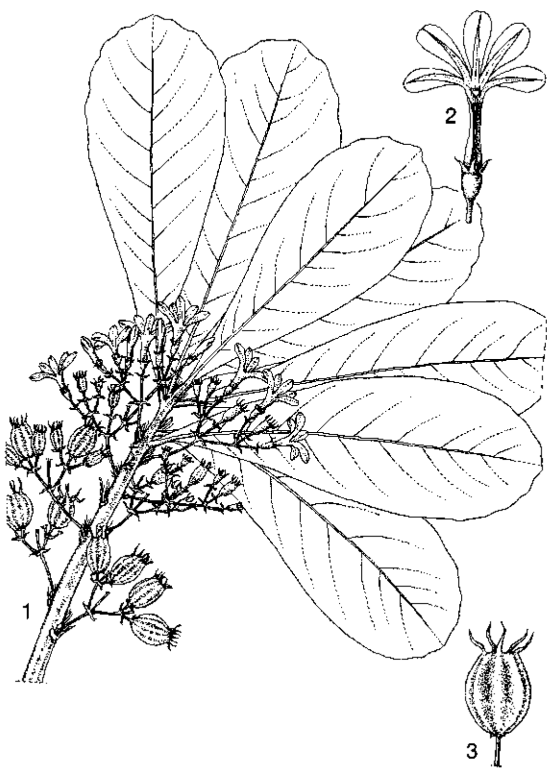
Throughout Malesia, the wood from the base of the mature stems of *S. taccada* is used as nails in traditional boat building. In the Philippines, its leaves are occasionally smoked like tobacco. Apart from its ornamental value *S. taccada* is used for soil stabilization and wind and salt spray protection in coastal zones.

Production and international trade *S. taccada* is only used on a local scale.

Properties A general phytochemical screening of the leaves, bark and flowers of *S. taccada* gave no positive tests for alkaloids. Leaves were positive for saponins, as well as coumarins. In the literature, there is occasional mention of the presence of an alkaloid scaevolin.

Furthermore, in an in vitro assay, an acetonitrile extract of the leaves showed selective antiviral activity against herpes simplex virus 1 and 2 and vesicular stomatitis virus.

Description An erect spreading shrub or small tree up to 4(–7) m tall; branchlets terete. Leaves alternate, the majority crowded at the end of the branches, spathulate to obovate, 12–26 cm × 5–10 cm, base attenuate, apex blunt to rounded, margin entire, sinuate to dentate, herbaceous to thin-fleshy, glabrous to shortly tomentose, sessile; stipules absent. Inflorescence axillary, cymose, laxly branched, about 4 cm long, few-flowered, bracts persistent, peduncle 0.5–2 cm long. Flowers 5-merous, zygomorphic, 2–2.5 cm long, scentless, white to pale yellow, pedicel 0.3–1.2 cm long, glabrous to densely appressed hairy; calyx adnate to the ovary, lobes linear to narrowly elliptical, 0.2–0.5 cm long, persistent; corolla glabrous to pubescent outside, densely pubescent inside, tube 0.5–1 cm long, lobes membranous, fimbriate towards the base, about 0.5 cm long; ovary inferior, 2-celled, style faintly pubescent at base. Fruit a fleshy drupe, 1–1.5 cm in diameter, faintly 2-lobed and ribbed, pellucid-white when ripe, stone 0.8 cm × 0.6 cm, 2-seeded. Seedling with epigeal germination; cotyledons emergent, fleshy; hypocotyl elongated.



Scaevola taccada (Gaertner) Roxb. – 1, flowering and fruiting branch; 2, flower; 3, fruit.

Growth and development Flowers of *S. taccada* are protandrous, thereby enhancing cross pollination. They are frequently visited by bees and wasps. The fruits are dispersed by frugivorous birds and sea-currents. The fruits are buoyant because of a corky outer layer and no significant loss in viability is observed after 250 days in sea water. *S. taccada* flowers and fruits throughout the year.

Other botanical information *Scaevola* has a pantropical distribution and comprises about 100 species, most of them endemic to Australia. The genus is divided in 3 sections. The vast majority of species belong to section *Xerocarpa* that is almost exclusive to Australia. Section *Enantiophyllum* is confined to eastern Malesia and northern Australia, represented by *S. oppositifolia*. Confusion is rampant concerning the nomenclature of the strand *Scaevola* species, both belonging to section *Scaevola*. The widespread variable species are at present classified as 2 species, *S. plumieri* (L.) Vahl with an Indo-Atlantic distribution and *S. taccada* with an Indo-Pacific distribution. They are primarily distinguished by the incision of the calyx and the colour of the fruit.

Ecology *S. taccada* is a typical constituent of the *Barringtonia* formation. It is usually confined to the seashore, restricted to sandy beaches or rock and coral outcrops, occasionally found inland on Pacific atolls in sunny disturbed habitats and rock faces. It is capable of substantial growth and physiological responses, which are required in coastal habitats characterized by large temporal and spatial variations in substrate salinity and salt spray levels. Seaward expansion is limited by a combination of salt spray and substrate salinity.

Propagation and planting *S. taccada* can be propagated by seed or cuttings. The stone should be removed from the pulp before planting. After rubbing and washing, stones can be dried for storage. Stones are preferably soaked in cool water for 24 hours and covered lightly by soil in a well-drained potting mix. Germination may take up to 3(–9) months. Germination is enhanced by soaking in sea water, speeding up the process by 1–2 weeks. Cuttings can be up to 50 cm long, with the lower leaves removed, and the upper ones cut in half. Planting should be in a light well-drained potting mix or a sandy soil, with watering once a day. Rooting should be achieved in 2–3 months. Air layering is another option for propagation.

Diseases and pests In Florida, ornamental *S. taccada* plants are affected by ringspot disease caused by a strain of the cucumber mosaic virus.

Harvesting Fruits of *S. taccada* are collected when ripe, all plants parts are simply collected whenever the need arises.

Genetic resources and breeding *S. taccada* is widespread and common in coastal habitats throughout South-East Asia, and therefore not endangered.

Prospects Very little is known about the phytochemistry and phytopharmacology of *S. taccada*. More research will be needed to fully evaluate its possible medicinal potential.

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Other selected sources 135, 143, 148, 258, 350, 407, 418, 730, 786, 810, 1075, 1077.

Trimurti Hesti Wardini

Scoparia dulcis L.

Sp. pl. 1: 116 (1753).
SCROPHULARIACEAE
$2n = (20), 40$

Synonyms *Scoparia ternata* Forssk. (1775), *Gratiola micrantha* Nutt. (1822), *Scoparia grandiflora* Nash (1896).

Vernacular names Sweet broomweed, Macao tea (En). Herbe à balai, balai doux (Fr). Indonesia: ginje menir, ginje jepun (Javanese), jakatuwa (Sundanese). Malaysia: teh makao, cha padang, pokok delis. Philippines: mala-anis, sampalokan (Tagalog), isisa (Iloko). Thailand: mafai duean ha (Bangkok), kratai chaam yai (south-eastern), yaa hua maeng hun (northern). Vietnam: cam th[ar]o nam, d[ax] cam th[ar]o, cam th[ar]o d[aas]t.

Origin and geographic distribution *S. dulcis* is native of tropical America, but has long since become a pantropical weed. It is widely distributed in South-East Asia, India and China.

Uses *S. dulcis* roots, leaves and tops are traditionally used in India, Indo-China and South-East Asia as an analgesic, diuretic and antipyretic, to treat gastric disorders such as diarrhoea and dysentery, and also for cough, bronchitis, hypertension, haemorrhoids and insect bites. In Malaysia and India, the leaves are chewed to treat cough; they first taste bitter and later sweet (like licorice). In Vietnam, the whole plant is also used for treating snakebites and as an antidote for cassava intoxication. The fresh or dried plants are used to treat pimples, impetigo, ulcers and eczema. In India, a decoction of the plant is drunk for gonorrhoea and to induce labour, and the leaves were formerly used in the treatment of diabetes. A cold decoction of the plant is taken for gravel and kidney complaints. An infusion of the seeds obtained by soaking them in water overnight is a cooling drink. The Chinese also use the whole plant against herpes. In India and Burma (Myanmar), an infusion of the herb is used as a mouthwash for infected gums.

In West Africa and South America, *S. dulcis* is also extensively used as a medicinal, basically in the same way as in India. In Sierra Leone, an infusion of the plant is taken for remittent fever and gonorrhoea. For feverish headache, the leaves or the whole plant are macerated in warm water and drunk copiously when cooled. In Liberia, a decoction is taken cold for gravel and kidney complaints. A decoction is applied as a fomentation to bruises and contusions. In Trinidad, a decoction of the plant is taken as a remedy for diabetes, urinary burning, diarrhoea and eczema. An infusion is used to bathe children suffering from rash, sores or marasmus, while the juice of the leaves is given for jaundice and as an anodyne eyewash. In Mexico, the astringent, mucilaginous decoction is commonly applied to bruises and contusions. The fresh or dried plants are said to kill fleas, lice and intestinal worms.

In Indonesia, the leaves were formerly used as a substitute for opium. The leaves are smoked in Gabon, in place of tobacco. In South America, *S. dulcis* is sometimes planted as a sand-binder. In India and Brazil, the plant is used as cattle fodder.

Production and international trade *S. dulcis* is traded on local markets in Asia and Africa, as a medicinal. No data on trade statistics are available.

Properties Aerial parts of *S. dulcis* contain about 4% of a viscous oil, which besides fatty acids like stearic, myristic and linolenic acid contains a series of diterpenes e.g. dulciol, scoparol, scopadulcic acid A and B, scopadulciol, scoparinol, dulcinol and dulcilone. They also yield nitrogen-containing components such as 2-hydroxy-2H-1,4-benzoxazin-3-one and 6-methoxy-benzoxazolinone (from the roots). The aerial parts also contain flavonoids including acacetin, apigenin and circimarin.

Analysis of the diterpene composition of *S. dulcis* from different sources (Taiwan, China, Thailand, Paraguay), revealed the presence of 2 chemotypes based on the major components: the SDX type, which produces scopadulciol and scopadiol, and the SDB type, which produces scopadulcic acid B and scoparic acid A. The hereditary nature of these phenotypes was confirmed by analysis of the progeny of the chemotypes. Furthermore, callus and multiple shoots derived from an SDX-type produced scopadulciol. Similar amounts of scopadulciol were produced by multiple shoots and callus cultures (5-fold higher than that produced by SDB-type multiple shoots).

Several of the isolated diterpenes have pharmacological activity, e.g. scopadulin, an aphidicolane-type diterpene from the aerial parts, which showed mild antiviral activity. Its cytotoxicity (ID_{50}) against HeLa cells was 285 μg/ml and its inhibitory activity (ED_{50}) against herpes simplex virus type 1 (HSV-1) was 38 μg/ml. The antiviral activity of scopadulciol (SDC), a tetracyclic diterpenoid related to aphidicolin, was also studied in vitro against herpes simplex virus type 1 (HSV-1). SDC was found to inhibit the virus replication, as shown by reduction of virus production. The action was not due to the inhibition of viral DNA polymerase activity or virus penetration, but might involve a virucidal effect.

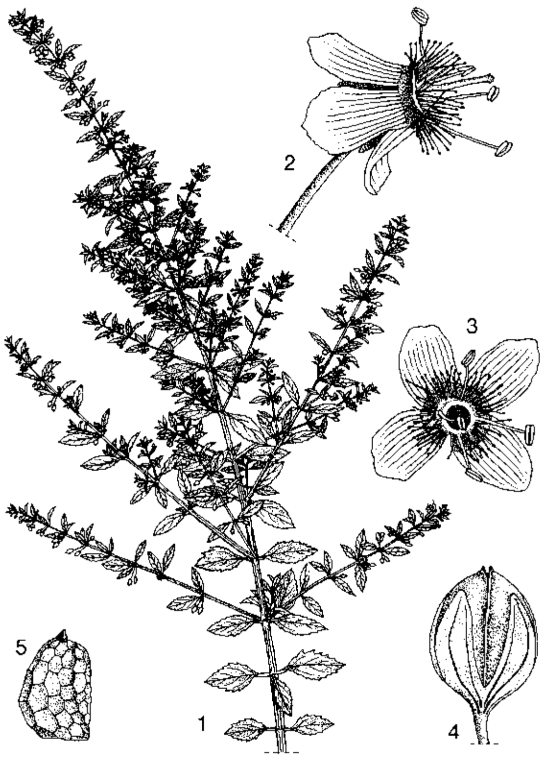
Scopadulcic acid B (SDB), a tetracyclic diterpenoid, inhibited the effects of tumour promoter 12-O-tetradecanoylphorbol-13-acetate (TPA) in vitro and in vivo. SDB inhibited TPA-enhanced phospholipid synthesis in cultured cells, and also suppressed the promoting effect of TPA on skin tumour formation in mice initiated with 7,12-dimethylbenz(a)anthracene. The potency of SDB proved to be stronger than that of other natural antitumour-promoting terpenoids, such as glycyrrhetinic acid. In addition, SDB has also been shown to inhibit replication of herpes simplex virus type 1 (HSV-1) and the enzyme H^+,K^+-ATPase from the gastric mucosa.

In addition, the fresh stems and leaves of *S. dulcis* contain a compound called amellin, thought by some to have an important therapeutic action in diabetes; however, others doubt this. Oral administration of amellin relieves symptoms of glycosuria, reduces hyperglycaemia and increases RBC count. It has also been found helpful in anaemia, albuminuria, ketonuria, retinitis and other complications associated with diabetes mellitus. Unlike insulin, amellin does not cause blood sugar levels to drop below normal and reduction of both blood and urine sugar occurs gradually.

The aqueous and ethanol extracts from the aerial parts were found to be active in the carrageenin induced rat paw oedema model, at 0.5 and 1 g/kg, p.o. (at 40% and 70%, respectively), and also inhibited the exudate and leukocyte migration induced in the rat pleurisy model (by 60% and 70%, respectively). Both extracts reduced acetic acid induced writhing in mice (20–60%), but were ineffective in the tail flick test. The sympathomimetic activity of an ethanol extract was also evaluated in rodent preparations in vivo and in vitro. Administration of this extract to anaesthetized rats produced a dose-related hypertension blocked by the α-adrenoceptor antagonist prazosin. Partition of the extract in chloroform-water yielded an aque-

ous phase 20 times more potent than the extract; this produced hypertension in either reserpine-treated or pithed rats. Prazosin reduced the maximum contractile effect of the aqueous fraction, and shifted the concentration-response curves for noradrenaline to the right. The aqueous fraction increased the inotropism of electrically driven left atria of rats, the effect being blocked by propranolol. In preparations of guinea-pig tracheal rings the aqueous fraction relaxed the muscle contraction induced by histamine in proportion to the concentration. The effect was antagonized competitively by propranolol. The results indicated that both catecholamines may account for the hypertensive and inotropic effects obtained after parenteral administration of the extracts. This sympathomimetic activity is, however, unrelated to the previously reported analgesic and anti-inflammatory properties of the plant extract, but may explain its effectiveness as a topical application in the healing of mucosal and skin wounds.
Finally, in a clinical trial 25 healthy people and 30 with gingivitis were given mouthwashes containing 1% aqueous extract or 0.02% chlorhexidine gluconate for 6 weeks. There was a slight increase in gingival inflammation in people with gingivitis using the extract, but the antiplaque activity was similar to that of 0.02% chlorhexidine.

Description An annual to perennial, erect, much branched herb, 20–75 cm tall, glabrous, 4–6-striate. Leaves opposite or 3–4-whorled, oblanceolate to oblong-obovate, 0.5–3.5 cm × 0.2–1.5 cm, base attenuate, apex acute, margin coarsely acute-serrate, glabrous above, gland-dotted beneath; petiole 0.5–1 cm long; stipules absent. Flowers axillary, bisexual, actinomorphic, 1–4-fascicled, regular, pedicel 3–7 mm long; calyx deeply 4-lobed, 2 mm long, accrescent in fruit to 2.5 mm, lobes oblong-ovate, subacute; corolla rotate, white or very pale-purple, sometimes with darker centre, deeply 4-lobed, lobes oblong, 3 mm long, apex obtuse, throat on inside with dense, long white hairs; stamens 4, subequal, erect, filaments filiform, 2 mm long; ovary superior, 2-celled, glabrous, style filiform, 1.5 mm long, stigma capitate. Fruit a subglobose capsule, 2.5–3 mm long, 4-valved, thin-walled, yellowish-brown, seeds numerous. Seed oblong-globose to ovoid, 0.5–0.6 mm × 0.3–0.4 mm, angular, covered with thin, reticulate testa, brown. Seedling with epigeal germination; cotyledons rhomboid, up to 2.2 mm long, glabrous, petiolate, epicotyl 1.5–4 mm long, 4-angular; first leaves 2, ovate, up to 6 mm long, glandular dotted, margin with rounded teeth, midvein present, petiolate.



Scoparia dulcis L. – 1, flowering and fruiting branch; 2, lateral view of flower; 3, top view of flower; 4, fruit; 5, seed.

Growth and development *S. dulcis* is found flowering and fruiting throughout the year.

Other botanical information *Scoparia* consists of about 20 species, originating from tropical America. Some *Scoparia* have become pantropical weeds.

Ecology *S. dulcis* is a common weed on waste ground, along roads, in dry deciduous forest and dry rice fields, from sea-level up to 700 m altitude. It prefers regions ranging from everwet conditions to a prolonged dry season, and grows on all kinds of soils.

Propagation and planting *S. dulcis* is propagated by seed, and can produce 800–1000 seeds per plant. Light was found to be the primary environmental factor affecting seed germination; full germination required 32 h continuous light, 3 days of 8 h light/day or 4 days of 4 h light/day. Temperature had no effect on the final germination rate, but it affected the speed of germination. At 15°C, the start of germination was delayed by about 3 days for imbibed seeds and 5–6 days for dry seeds, when compared with germination at 23–31°C.

In vitro production of active compounds Production of scopadulcic acid B and scopadulciol by leaf organ culture was examined by addition of cytokinins to culture media. Of the tested cytokinins, N-phenyl-N'-(4-pyridyl)urea was the most efficient when added to the mass spectroscopic liquid culture medium at 0.1 μM. 6-Methoxybenzoxazolinone (MBOA) was found to be present in all plant parts, with the highest concentration being observed in younger leaves. The content of MBOA in leaves increased with the growth of the plant before the fruiting stage. MBOA was also found to be produced by the callus tissues, multiple shoots and hairy roots.

Diseases and pests In Togo, *S. dulcis* was found to be a probable host for the coconut-yellows-disease, caused by a mycoplasma-like organism.

Harvesting In Vietnam, *S. dulcis* is harvested during the rainy season.

Handling after harvest In Vietnam, whole plants of *S. dulcis* are thoroughly washed before drying in the sun or in an oven.

Genetic resources and breeding *S. dulcis* is widespread and common throughout South-East Asia, and there is no danger of genetic erosion. As several chemotypes exist in *S. dulcis* throughout the world, it is important to get a clear view of these different types, for possible breeding purposes.

Transgenic herbicide-resistant plants were obtained through *Agrobacterium*-mediated transformation by means of scratching young plants. Hairy roots resistant to the herbicide bialaphos were selected and plantlets were regenerated. Transgenic plants accumulated scopadulcic acid B, a specific secondary metabolite of *S. dulcis*, in amounts of 15–60% of that in normal plants. The transgenic plants and progenies showed resistance to the herbicides bialaphos and phosphinothricin.

Prospects In general, diterpenes possess a wide range of pharmacological activities. This is also true for *S. dulcis*: e.g. antiviral, antitumour and enzyme inhibition. However, diterpenes are also known for their often strong (cyto-)toxicity. Therefore, more research of the isolated compounds and extracts is necessary to fully evaluate a future potential.

Literature |1| Hayashi, T., Kasahara, K. & Sankawa, U., 1997. Efficient production of biologically active diterpenoids by leaf organ culture of Scoparia dulcis. Phytochemistry 46(3): 517–520. |2| Hayashi, T., Kawasaki, M., Miwa, Y., Taga, T. & Morita, N., 1990. Antiviral agents of plant origin. III. Scopadulin, a novel tetracyclic diterpene from Scoparia dulcis. Chemical and Pharmaceutical Bulletin 38(4): 945–947. |3| Hayashi, T., Okamura, K., Kawasaki, M. & Morita, N., 1991. Two chemotypes of Scoparia dulcis in Paraguay. Phytochemistry 30(11): 3617–3620. |4| Morton, J.F., 1981. Atlas of medicinal plants of Middle America. Bahamas to Yucatan. Charles C. Thomas, Springfield, Illinois, United States. pp. 815–816. |5| Nishino, H., Hayashi, T., Arisawa, M., Satomi, Y. & Iwashima, A., 1993. Antitumor-promotor activity of scopadulcic acid B isolated from the medicinal plant Scoparia dulcis L. Oncology (Basel) 50(2): 100–103. |6| Quisumbing, E., 1978. Medicinal plants of the Philippines. Katha Publishing Co., Quezon City, the Philippines. pp. 872–873.

Other selected sources 134, 135, 215, 311, 324, 396, 398, 710, 739, 786, 951, 955, 974, 1095.

N.O. Aguilar & G.H. Schmelzer

Sida L.

Sp. pl. 2: 683 (1753); Gen. pl. ed. 5: 306 (1754).

MALVACEAE

$x = 7, 14$; *S. acuta*: $2n = (18), 28$; *S. cordifolia*: $2n = 28$; *S. rhombifolia*: $2n = 14, (18), 28, (36)$

Major species *Sida acuta* Burm.f., *S. cordifolia* L., *S. rhombifolia* L.

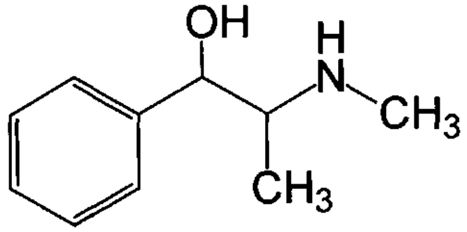
Origin and geographic distribution *Sida* is a large tropical and subtropical genus comprising 150–200 species. About two thirds of these species occur only in the New World, but some are restricted to South-East Asia, Australia, the Pacific Islands or Africa. Several species, like *S. acuta, S. cordifolia* and *S. rhombifolia*, have been widely distributed throughout the tropics for over a century.

Uses In general, the decoction, infusion or pressed juice of the mucilaginous leaves and bitter roots of *Sida* are used for cooling, emollient, diuretic and febrifuge purposes, to treat gonorrhoea and rheumatism and externally as a poultice for boils, ulcers, swellings, cuts, coughs and chickenpox. The crushed leaves or roots are put on the head for headache, and on the gums for toothache. The leaves are used for cooling of fever in small children, the root for high fever, constipation, colic and chronic bowel complaints. In decoction, the plant may be used as an emmenagogue. In Papua New Guinea, the Philippines and Fiji, a decoction of the leaves, the juice of the leaves mixed with honey, or the root juice in water is given for diarrhoea or dysentery. In Borneo, Vietnam and Central Africa, the leaves or roots are used as an abortifacient.

In Indo-China, the roasted leaves of *S. rhombifolia* make a refreshing drink, while in South America, leaves and shoots are used as a vegetable. Most *Sida* species are appreciated as a fodder, and are widely used as fibre crops. *S. acuta* is cultivated in Mexico and *S. rhombifolia* in India, Australia, Africa and America as a fibre crop. In India, the charcoal of *S. rhombifolia* may be used for blackening teeth.

Production and international trade *Sida* species are used and traded at a local level only, for medicinal purposes. In Peninsular Malaysia, the Chinese herbalists stock *S. acuta* and *S. rhombifolia* plants.

Properties Many *Sida* species contain ephedrine, a pseudo-alkaloid, biosynthetically derived from the amino acid phenylalanine. Ephedrine acts as a sympathomimetic on the body, which means that its effects are similar to those of the sympathetic (adrenergic) neurotransmitters like noradrenalin and adrenalin (also known as norepinephrine and epinefrine). The mechanism of action of ephedrine is of the indirect type: the substance does not activate adrenergic receptors directly, but it facilitates the release of neurotransmitters from sympathetic nerves. Pharmacological effects of ephedrine include e.g. stimulation of the heart rate and cardiac output, together with a variable increase of the peripheral resistance; as a result it usually increases blood pressure. In the lungs, it promotes bronchodilatation, acceleration and intensification of respiration. It may increase the resistance to the outflow of urine in the bladder. Furthermore, ephedrine crosses the blood-brain barrier, it has a stimulating psychic effect: stimulation of the attention and concentration, decrease of the sensation of fatigue and the need to sleep, and thus qualitatively it resembles an amphetamine. Because of the numerous contraindications, drug interactions and required precautions, the compound is no longer used very often.



ephedrine

In the United States, ephedrine-containing products are sometimes marketed as slimming aids. Over a period of 2 years, 500 reports were received of adverse events in persons who consumed dietary supplementary products containing ephedrine and related alkaloids (pseudo-ephedrine, nor-ephedrine and N-methyl ephedrine).

The alkaloids ephedrine (0.07 %) and cryptolepine were isolated from the roots of *S. acuta*. The latter compound is also present in the aerial parts. The seeds, like those of *S. rhombifolia*, contain up to 0.26% alkaloids, as well as sterculic (11%) and malvalic acid (1.7%). The water soluble portion of the alcoholic extract of *S. acuta* exerts spasmodic action on the smooth muscle preparations of ileum, trachea, uterus and heart of experimental animals. Thus, the activity of the extract is similar to that of acetylcholine. The untreated seeds in dung heaps show antibacterial activities on *Bacillus subtilis*, *Escherichia coli*, *Pseudomonas cichorii*, and *Salmonella typhimurium*. Furthermore, a leaf extract exhibits strong feeding deterrence and toxicity against the larvae of the insect pest *Earias vittella*.

The roots of *S. cordifolia* are very mucilaginous, and contain the chinazoline alkaloid vasicine (= peganine). The seeds contain up to 0.3% alkaloids, mainly ephedrine, and a fatty oil (3%) containing the cocacinegenic acid coronaric acid. Pharmacological effects of extracts of the plant include: antiprotozoal activity against *Entamoeba histolytica* strain STA by an ethanolic extract, and depression of blood pressure in cats and dogs. Furthermore, an extract of the aerial parts and the roots show analgesic, anti-inflammatory and hypoglycaemic activities. The methanolic and aqueous extracts of whole plants finally showed significant antihepatoxic activity against CCl_4^-, paracetamol- and rifampicin-induced hepatotoxicity.

Leaves and roots of *S. rhombifolia* contain ephedrine. The ethanolic extract of the plant depresses the activities of the smooth muscles of the ileum of guinea-pig preparations. The methanolic plant extract shows antimicrobial activity against *Aspergillus ochraceus*, *Candida albicans*, *C. intermedia*, *Cunninghamella elegans*, *Pseudomonas aeruginosa* and *Staphylococcus aureus*. Finally, in a screening assay, the leaf extract exhibited anticancer activity and anti-HIV activity against 60 human cell lines tested.

Adulterations and substitutes The roots and leaves of *Abutilon*, *Triumfetta* and *Urena* in decoction are used as an emollient in the same way as those of *Sida*.

Description Prostrate, creeping or erect herbs or shrubs, annual to shortly perennial, often stellate pubescent. Leaves alternate, entire or lobed; petiole present; stipules present. Flowers axillary or on axillary side-shoots, sometimes combined into a leafy panicle or spike, pedicel present, epicalyx absent; calyx 5-lobed, corolla with 5 petals, joint at the base, mostly yellow; stamens numerous, joined in a tube, monadelphous, ovary 4–12-celled, carpels verticillate, 1-ovuled; styles as many as the carpels, connate at base, stigmas capitate. Fruit a capsule, mericarps indehiscent or apically dehiscent, aristate or not, mature ones separating from the persistent central column. Seedling with epigeal germination.

Growth and development *S. acuta*, *S. cordifolia* and *S. rhombifolia* are considered noxious weeds in many crops and pastures, because of the tough stems and the ability to grow fast from seed. Overgrazing will cause a rapid increase of the weeds, as the stems are unpalatable to cattle. *S. rhombifolia* has well developed roots and grows well even under dry conditions.

Other botanical information It has been suggested that on the basis of the morphological and geographical diversity, *Sida* could be of polyphyletic origin. It is morphologically fairly close to *Abutilon* and *Wissadula*, and all lack the epicalyx.

Ecology The Malesian *Sida* species are mainly sun-loving herbs or undershrubs, usually occurring in open locations, especially in lowland areas. Many of them are restricted to seasonally dry parts. The treated *Sida* flower throughout the year when water is available, and the flowers open in the morning and wither in the afternoon.

Propagation and planting *Sida* produces large amounts of seed. Seeds from *S. acuta* have a germination rate of 54%, a month after harvesting. The majority of the seeds of *S. rhombifolia* are dormant 12–24 months after maturity. The optimum temperature range for germination is 25–35°C.

Diseases and pests A common insect found on *Sida* is whitefly (*Bemisia tabaci*), which transmits a range of viruses, including Sida golden mosaic virus, cassava mosaic virus, okra leaf curl, tobacco leaf curl and tomato yellow leaf curl. *S. acuta* is a host for *Aphis gossypii*, which transmits cotton leaf roll disease. Mycoplasm-type organisms cause yellow symptoms on *S. cordifolia* and *S. rhombifolia* in Burkina Faso. *S. cordifolia* is a common host for several nematodes, including *Meloidogyne incognita*.

Harvesting Generally, whole plants of *Sida* are harvested, including the roots.

Handling after harvest *Sida* species are mostly used fresh, but can also be dried for storage.

Genetic resources and breeding The *Sida* species dealt with, except *S. javensis*, are widely distributed, also as weeds, and locally rather common in open and disturbed areas. They are not likely to succumb to the threats of genetic erosion. Small germplasm collections of *S. rhombifolia* are kept in Russia and in the United Kingdom.

Prospects *Sida* might be of interest as a local industrial source of the alkaloid ephedrine. However, as ephedrine can also be produced synthetically, and as its use in medicine is rapidly becoming obsolete, it is doubtful whether it will be a major source.

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Selection of species

Sida acuta Burm.f.

Fl. ind.: 147 (1768).

Synonyms *Sida carpinifolia* (non L.f.) Mast. (1875).

Vernacular names Broom weed, spinyhead sida (En). Indonesia: sidaguri (Javanese), galungang (Sundanese), taghuri (Madurese). Malaysia: bunga telur belangkas, lidah ular, sedeguri (Peninsular). Papua New Guinea: kuriakuria (Vanapa Bridge, Central Province). Philippines: ualisualisan, takkimbaka (Tagalog), pamalis (Tagalog, Bisaya). Cambodia: kantrang ba sa. Thailand: naa-khuimee, yaa khat mon (northern), yung kwaat (central). Vietnam: b[as]i ch[oor]i, ch[oor]i d[uwj]c, b[as]i nk[oj]n.

Distribution Widely distributed in the tropics and common in South Asia.

Uses In Indo-China and the Philippines, a decoction of the leaves and roots of *S. acuta* is used against haemorrhoids, impotency and for expelling intestinal worms. The roots are a tonic, used as a stomachic, a diaphoretic, and in some parts of the Philippines for vomiting of blood. In India, the leaves are boiled in oil and applied to testicular swellings and elephantiasis. In the Philippines, the seeds are used to cure enlarged glands and inflammatory swellings.

Observations An erect, branched, nearly glabrous herb or small shrub, 30–100 cm tall with a strong taproot, stems and branches flattened at the tips; leaves oblong-lanceolate to linear, 2–9 cm × 0.5–4 cm, base acute to rounded, apex acute, margins serrate-dentate, lower surface glabrous or with short stellate hairs, petiole 3–6 mm long, at least one stipule of each pair lanceolate-linear, 1–2 mm broad, often curved, ciliate, the other narrower; flowers solitary, or densely crowded on side-shoots, 1.3 cm in diameter, pedicel 3–8 mm, petals emarginate, 6–8 mm long, pale yellow; mericarps 5–8, 3.5 mm long, awns 2, 1–1.5 mm long, glabrous. *S. acuta* grows on roadsides, dams, fields, lawns, waste places and teak-forests, common at sea-level but also up to 1500 m altitude. Two subspecies are distinguished: subsp. *acuta*, with linear to lanceolate leaves, base acute, margins coarsely serrate, indumentum with a few hairs and flowers in clusters of 2–3, and subsp. *carpinifolia* (L.f.) Borss. Waalk., with ovate to oblong, finely serrate leaves with rounded base, indumentum with many simple hairs and flowers in clusters of up to 8.

Selected sources 74, 135, 143, 215, 407, 418, 739, 785, 786, 788, 810.

Sida cordifolia L.

Sp. pl. 2: 684 (1753).

Vernacular names Flannel weed (En). Malaysia: poko kelulut puteh (Peninsular). Papua New Guinea: guguni pepe (Hula, Central Province), autubua autubua (Gaire, Central Province), sanapu (Darubia, Normanby Island, Milne Bay). Philippines: gulipas (Subanun). Thailand: taan saai (south-western), yaa khatbai pom (northern). Vietnam: b[as]i thi, k[es] d[oof]ng ti[eef]n, b[as]i tr[aws]ng.

Distribution Widely distributed in the tropics as a weed.

Uses In Malaysia, the leaves of *S. cordifolia* are applied to conjunctivitis. The juice of the whole plant pounded with a little water is given for spermatorrhoea. An infusion of the roots is given for diseases such as hemiplegia or facial paralysis, for asthma as well as in disorders of the blood and bile. The root bark powder is given with milk and sugar to persons suffering from leucorrhoea. The seeds are considered aphrodisiac and are also used for gonorrhoea, cystitis, and colic. In Papua New Guinea and the Philippines, the juice of the leaves mixed with honey is given for dysentery.

Observations An erect herb, often woody and branched at the base, 0.5–2 m tall, stem and petioles covered with patent, long soft hairs; leaves ovate-elliptical, 0.5–6 cm × 0.5–4.5 cm, base cordate to rounded, apex obtuse to acute, margins dentate-serrate, densely and softly hairy on both surfaces, light green, stipules equal; flowers solitary or in clusters of 2–5, pedicel 2–25 mm long, petals truncate, 7–10 mm long, pale yellow; mericarps 9–11, 3–3.5 mm long, awns 2, 2.5–5 mm long, setulose with reflexed bristles. *S. cordifolia* grows on drier sandy locations, especially near sea-level, often locally abundant.

Selected sources 74, 135, 215, 418, 739, 785, 786, 788, 810, 832.

Sida javensis Cav.

Diss. 1: 10, t. 1, f. 5 (1785).

Vernacular names Philippines: igat-igat, marmaraipus (Iloko), hapunang-niknik (Tagalog). Vietnam: b[as]i java.

Distribution India and South-East Asia; in Malesia, it is common in Java, Peninsular Malaysia, the Moluccas and the Philippines.

Uses A decoction of the entire plant is used specifically against gonorrhoea.

Observations A prostrate herb, branched at base, with stems rooting at the nodes, more or less hairy; leaves orbicular-ovate, 0.5–6 cm long, entire or trilobed, base cordate, apex pointed, margins crenate-serrate, palmiveined, petiole 0.5–6 cm long, stipules equal; flowers normally solitary, pedicel 10–25 mm long, petals obovate, emarginate, 7 mm long, yellow; mericarps 5, tetrahedral with rounded angles, 3–5 mm long, awns 2, 1–2 mm long, slender, short hairy. *S. javensis* grows along roadsides, in teak forests, secondary growths, forest edges, from sea-level up to 1500 m altitude, mainly restricted to areas with a dry season. Two subspecies are distinguished: subsp. *javensis*, with usually trilobed, pointed leaves, pedicel 20–25 mm long, accrescent to 35 mm, calyx 6–7 mm in diameter, stems sparsely stellate-hairy, and subsp. *expilosa* Borss. Waalk., with entire, obtuse leaves, pedicel 7–15 mm long, accrescent to 20 mm, calyx 4 mm in diameter, and densely hairy stems and petioles. The 2 subspecies have a similar ecology and distribution.

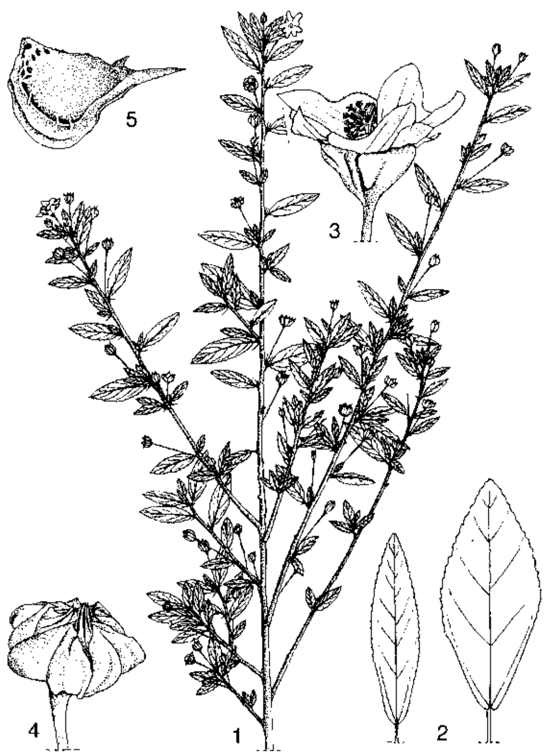
Selected sources 135, 810.

Sida rhombifolia L.

Sp. pl. 2: 684 (1753).

Synonyms *Sida retusa* L. (1763).

Vernacular names Queensland hemp, Cuba jute, arrowleaf sida (En). Indonesia: sadagori (Sundanese), sidaguri (Sumatra, Java), taghuri (Madurese). Malaysia: sendaguri, seleguri padang, bunga padang (Peninsular). Papua New Guinea: sipuni (Kurereda, Northern Province), sihuhu (Hegata, Oro Province), irimo irimo (Papa, Central Province). Philippines: ualis-haba (Tagalog), basbasot (Iloko), baseng-baseng (Bisaya). Laos: nha kat mone. Thailand: khatmon (central), yaa khat (northern), yaa pat mae maai (Bangkok). Vietnam: k[es] hoa v[af]ng, k[es] d[oof]ng ti[eef]n, b[aj]ch d[ows]i.



Sida rhombifolia L. – 1, flowering and fruiting branch; 2, types of leaves; 3, flower; 4, capsule, 5; seed.

Distribution Widely distributed in the tropics as a weed.

Uses In the Philippines and Indonesia, a paste of the leaves mixed with coconut oil of *S. rhombifolia* is applied to scurf and itch. The flowers are applied to wasp stings or eaten with wild ginger to ease labour pains. In Malaysia, the plant has been used to treat pulmonary tuberculosis. In Fiji and Papua New Guinea, the leaves are used to treat strained muscles, labour pains and migraine. Roots are chewed against dysentery. It is considered a plant with magical properties in Malaysia.

Observations An erect or semi-procumbent, much-branched herb or shrub, 30–150 cm tall, with tough, hairy stems; leaves rhomboid to oblong, broadest about the middle, apex narrowed to emarginate, surfaces green, or grey underneath, petiole 2–4 cm long, stipules equal; flowers solitary or in clusters of 2–5, pedicel 30–40 mm long, petals oblique, 7–12 mm long, yellow; mericarps 8–12, flattened trigonous, 2.5 mm long, awns 0–2, 1–3 mm long, glabrous or stellately pubescent. *S. rhombifolia* is common along roadsides, lawns, waste places, coconut plantations, scattered in grassy plains, from sea-level to 1200 m altitude. Two subspecies are distinguished, subsp. *rhombifolia*, with an erect habit, rhomboid or lanceolate leaves, pedicels much longer than petioles, corolla 15–17 mm in diameter, and subsp. *retusa* (L.) Borss. Waalk., with a prostrate habit, obovate, often emarginate leaves, pedicels as long as petioles, corolla 20–25 mm in diameter. Because of the differences between the two subspecies some authors recognize them at species level.

Selected sources 74, 135, 143, 215, 407, 418, 739, 785, 786, 788, 810, 943.

Balu Perumal

Sigesbeckia orientalis L.

Sp. pl. 2: 900 (1753).

COMPOSITAE

$2n = 30, 60$

Vernacular names Small yellow crown-beard (En). Guérit-vite, herbe divine, herbe de Placq (Fr). Papua New Guinea: lopalopa (Tobobugu, Southern Highlands Province). Philippines: kaedes (Ivatan), put (Bontok). Thailand: khon cham noi (eastern), saa phaan kon, yaa phom yung (northern). Vietnam: n[uj] [as]o r[if]a, l[uw][owx]i d[oof]ng, hy thi[ee]m.

Origin and geographic distribution *S. orientalis* originates from the tropics and subtropics of the Old World, and is found from Africa to India, China and Japan and further through Malaysia, Java, and the Philippines to Australia and Polynesia. It is now cosmopolitan in warm climates and is sometimes cultivated.

Uses *S. orientalis* extracts are widely used for restoring the blood circulation, stimulating urine secretion and as a renal tonic. The sap is also commonly used in treatments of gangrenous ulcers and sores, skin lesions of leprosy, syphilis and venereal diseases, and as a remedy for ringworm and parasitic infections. The fresh sap leaves a varnish-like covering when it dries. In Indo-China, the Philippines and Tahiti, the extract of *S. orientalis* is used for diarrhoea, leucorrhoea, to facilitate menstruation (as a pain reliever), as a stomachic and a cardiotonic, and to cure snake, insect or dog bites. In Vietnam, the whole plant is used as an antiphlogistic, and applied in the treatment of rheumatism, ostalgia, lumbago and impetigo. In Thailand, the extract is used in the treatment of sprains, dislocations and contusions, and also for bee stings and snake bites. In China, the plant is used as a remedy for ringworm, scabies, and other skin diseases, and is also used as an anodyne, alterative (for blood pressure), and used to treat convulsions, strokes, paralysis, arthritis and neuralgic pains, and for chronic malaria. In Africa, *S. orientalis* is considered cardiotonic, diaphoretic, antiscorbutic, sialagogic and anthelmintic. In Nigeria, it is used externally to treat leprosy, venereal diseases and ulcers, and internally as a laxative. In the Mascarenes, the syrup is used for the treatment of gout and scrofula. In India, a decoction of the stem is used to treat constipation in children, and a decoction of the dried leaves and flowers for the treatment of dysentery.
The seed oil of *S. orientalis* is rich in epoxy acids, which are of potential interest as replacements for synthetic epoxy compounds, used as stabilizers for plastic materials.

Production and international trade In Vietnam, *S. orientalis* is cultivated, but no statistics are available.

Properties The aerial parts contain an essential oil, that has been recommended for use in perfumery. Among the main constituents of the aerial parts of *S. orientalis* are diterpenes, e.g. darutoside (0.17 %), darutigenol, 3-geranylnerol derivatives and 3-ent-pimarenes, together with sesquiterpenes, e.g. orientalide (a melampolide), orientin, other melampolides and germacranolides. The bitter glucoside darutine (a salicylic derivate) has also been isolated. The seeds contain a fatty oil, consisting of about 20% epoxy acids (16% coronary-epoxyacid, 4% vernolic-epoxyacid).
Extracts of the aerial parts exhibit some hypoglycaemic activity when given orally to rats at a dose of 250 mg/kg; some hypotensive activity in dogs when given intraperitoneally at a dose of 50 mg/kg; some antispasmodic activity against acetylcholine- and histamine-induced spasms in isolated guinea-pig ileum, and weak action against Rhaniket disease in poultry at a concentration of 50 μg/ml. The aqueous extract of the dried aerial parts do not show any analgesic activity when given intraperitoneally to mice at a dose of 9 g/kg, but shows a weak inhibitory effect on angiotensin II and cholecystokinin receptor binding. The 95% ethanolic extract of the dried aerial parts shows significant bactericidal activity against *Trypanosoma cruzi* at a dose of 12 μg/ml.
An extract of *S. orientalis* was also found to show significant antifeedant and insecticidal properties on 3rd-instar larvae of *Crocidolomia binotalis*, an important pest on cruciferous crops in Mauritius. Finally, the ethanol or aqueous extract of the dried aerial parts shows anti-hepatotoxic activity in vitro at a concentration of 1 mg/ml. Toxicity assessment of the whole plant in mice shows a maximum tolerated dose of 1 g/kg intraperitoneally.

Description An erect, annual herb, 20–110 cm tall, with an unpleasant odour; stems and branches widely ascending-spreading, dichotomously forked above, densely short pubescent, branches tinged purple. Leaves opposite, simple, ovate-oblong to deltoid-ovate, 5–14 cm × 3–10 cm, base truncate to cuneate or narrowed into the petiole, apex short acuminate to acute, margins irregularly obtuse-dentate, distinctly 3-veined, chartaceous, densely short-pubescent on both sides, glandular dotted beneath, upper leaves gradually smaller and narrow, oblong, apex obtuse; petiole of lower leaves long, winged, of upper leaves short; stipules absent. Inflorescence a small head, 16–21 mm across, many together in a loose panicle; peduncles 1–3.5 cm long, the longest peduncle sometimes glandular-pilose; outer involucral bracts 5, spreading, 5–15 mm × 1–2 mm, glandular-pilose, inner involucral bracts 5, 5 mm long, glandular outside, enclosing the individual flowers like a boat. Ligulate flowers 5, female, corolla 2.2–2.5 mm long, trifid, yellow, reddish beneath, tubular flowers about 10, bisexual, corolla 1.5 mm long, apex 5-dentate, yellow; anthers 5, linear, sagittate; ovary inferior, 4–5-angled; style-arms in ligulate flowers 2.5 mm long, in bisexual flowers

Sigesbeckia orientalis L. – 1, flowering stem; 2, flower head; 3, ligulate flower; 4, tubular flower with bract; 5, achene.

short, flattened, acute. Fruit an oblong, curved, truncate, 4-angular achene, 3 mm long, blackish, smooth; pappus absent.

Growth and development Under favourable growing conditions 2 life cycles of *S. orientalis* per year can be reached, e.g. in Russia.

Other botanical information *Sigesbeckia* consists of about 6 species, of which 3 originate from the Old World tropics. *Sigesbeckia* belongs to the tribe *Heliantheae*, and is morphologically close to *Trigonospermum*. A common annotation of *Sigesbeckia* is *Siegesbeckia*.

Ecology *S. orientalis* is widespread along roadsides, in wastelands and cultivated land, young secondary forests, tea and coffee plantations, and prefers moist, fertile localities. It grows mostly at low altitudes, but can be found up to 2100 m altitude. In Vietnam, it is sometimes cultivated on heavy and sandy soils, between 50–700 m altitude, but it is mainly found between 200–300 m, in sunny locations with moist soils. The optimum temperature for growth is 10–27°C. *S. orientalis* can flower throughout the year, but has its peak during the rainy season. Proliferation of the flowers can occur under humid conditions.

Propagation and planting *S. orientalis* is propagated by seed.

Harvesting In Vietnam, *S. orientalis* is harvested before flowering, from March–June.

Handling after harvest After the roots of *S. orientalis* are removed, plants are dried in the shade.

Genetic resources and breeding *S. orientalis* has a wide distribution and is a common weed in anthropogenic habitats. Therefore the risk of genetic erosion seems limited. No germplasm collections or breeding programmes are known to exist.

Prospects Very little is known about the phytochemistry and pharmacology of *S. orientalis*. As it shows some antibacterial activity, more research in this direction seems appropriate. The essential oil is valued in perfumery, therefore it might be of some interest for small scale trade.

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Wongsatit Chuakul, Noppamas Soonthornchareonnon, Orawan Ruangsomboon

Solidago virgaurea L.

Sp. pl. 2: 880 (1753).
COMPOSITAE
$2n = 18$

Vernacular names Woundwort, European golden rod (En). Verge d'or, herbe des juifs (Fr). Philippines: tantaduk (Igorot). Vietnam: ko[af]ng kim ph[uw][owj]ng hou.

Origin and geographic distribution *S. virgaurea* occurs in the wild in the northern temperate zone of the Old World, extending through Japan to southern China, Indo-China and Taiwan. It is widely cultivated as an ornamental in the temperate zone, and to a lesser extent in the tropics.

Uses In general, *Solidago* comprises many species with medicinal properties. The 'simplex solidaginis herba', which is derived from either *S. virgaurea*, *S. canadensis* L. or *S. gigantea* Aiton or a mixture of these species, is quite well known as a diuretic in western herbal medicine. Besides this diuretic effect, *S. virgaurea* is known in the northern temperate zone and in India for its lithotriptic, vulnerary, sudorific, spasmolytic, antihypertensive and carminative properties. It has been used for the treatment of asthma, whooping cough, internal lesions, oedema, chronic eczema, acute and chronic nephritis, and as an antipyretic in rheumatism. The powdered plant is applied to old ulcers, and a tea made from the leaves is administered against dysmenorrhoea and amenorrhoea. The dried and powdered root is used against diarrhoea and dysentery. In China, a decoction of the entire plant is used for the treatment of malaria and for expelling worms.

The medicinal properties of *S. virgaurea* are apparently unknown to the local inhabitants of Indo-China, Indonesia or the Philippines.

S. virgaurea is grown for ornamental purposes in Europe, Korea and China. In Korea, *S. virgaurea*, being a wild edible vegetable, has been tested for planting.

Production and international trade Dried *S. virgaurea* plants are imported from China and are occasionally found in the Chinese markets in Vietnam and in Peninsular Malaysia.

Properties Monographs of *Solidago* species, including *S. virgaurea*, can be found in several pharmacopoeias. The aerial parts of flowering *S. virgaurea* contain a volatile oil (0.4–0.5%). Over 60 components have been identified, of which the terpene γ-cadinene is the most abundant (40–46%). Other constituents include α-pinene (27–34%), myrcene (8–18%), germacrene-D (8–17%), β-pinene (5–8%), limonene (3–14%), sabinene (0.4–12%), α-humulene (3–4%), β-caryophyllene (2–3.5%) and α-muurolene (0.6–4%).

S. virgaurea is also very rich in flavonoids (1.5–2%). So far, about 20 flavonoid-glycosides have been identified e.g. rutin (also known as rutoside or quercetin-3-rutinoside, 0.8%), isoquercitrin, hyproside, kaempferol and astralagin. It also contains 0.2–0.3% oleane type triterpene saponins, which are all mono- or bis-desmosides of polygalacic acid. Examples are virgaureasaponins 1, 2 and 3 and monodesmoside-A and -B, which have been isolated from all parts of *S. virgaurea* subsp. *virgaurea*. Other constituents include glycosides of benzylbenzoate: virgaureoside A and leiocarposide, isolated from the methanolic extract of the leaves and stalks before flowering.

The triterpene saponins exert fungicidal effects; they inhibit the growth of several *Candida* spp. and of *Cryptococcus neoformans*. In addition, virgaureasaponin 1 has cytotoxic properties. The saponins, as well as related carbohydrate modified glycosides of polygalacic acid and echinicystic acid, were investigated in view of their immunomodulating and anti-tumour effects. Mitogeneic effects on murine spleen and thymus cells, as well as on human mononuclear cells were demonstrated in vitro. The activity of murine bone marrow macrophages could be stimulated. An induction of cytotoxic macrophages and a TNF-α release from murine macrophages were observed. The mitogeneic and TNF-α releasing virgaureasaponin E shows in vivo antitumour effects in the allogeneic sarcoma 180 tumour model and in the syngeneic DBA/2-MC.SC-1 fibrosarcoma tumour model. In mice, phagocytosis of bone marrow cells and proliferation of spleen and bone marrow cells were stimulated in an ex vivo assay, whereby the TNF-α concentration in blood considerably increased.

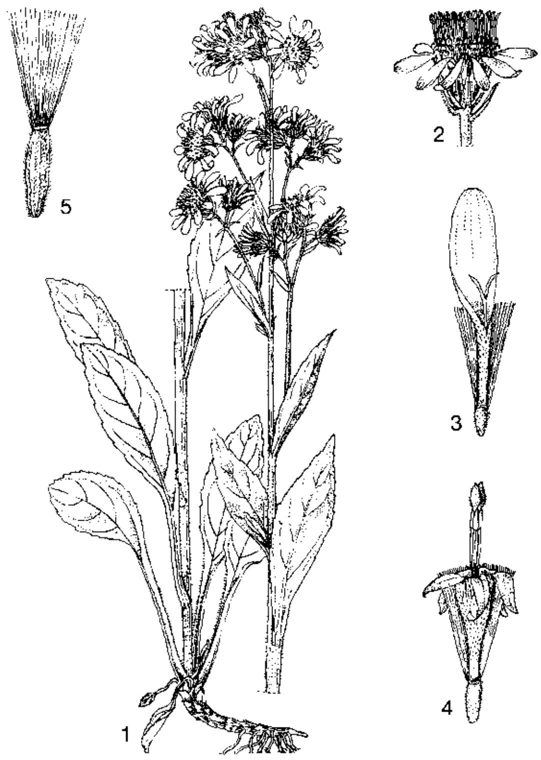
The leiocarposide content of different parts of *S. virgaurea* grown in Germany was determined, and showed to be highest in leaves and flowers. Leiocarposide is a diuretic, an anti-inflammtory and an analgesic, but its intestinal resorption is very low: after oral administration to rats it was mostly excreted unchanged. Local application of leiocarposide to mice with arachidonic acid-induced ear oedema had a significant antiphlogistic effect at a concentration of 10^{-7} mol/ear. Flavonoid fractions of *S. virgaurea* and *S. canadensis* flowers were administered orally to rats and resulted in diuretic activity. Increase in overnight diuresis

reached 57–88%, and calcium excretion also increased.
The extracts of *Fraxinus excelsior* L., *Populus tremula* L. and *Solidago virgaurea*, in a combination of 1 : 3 : 1, are a well known phytomedicine in Germany, which possesses antipyretic, analgesic, anti-inflammatory and antirheumatic activity. In a test with carrageenan induced oedema and/or adjuvant induced arthritis of the rat paw, significant anti-inflammatory action was found for the 3 extracts separately and in combination.
The anti-oxidative properties of an *S. virgaurea* extract were further confirmed through its ability to inhibit lipid peroxidation of phosphatidylcholine liposomes as a model of biological membranes, and also through 1,1'-diphenyl-2-picrylhydrazyl radical or OH radical scavenging activity assays. A water extract of the dried aerial parts was found to be active against herpes simplex type 2, influenza and polio viruses.
Finally, *S. virgaurea* shows a medium sensitizing capacity in tests with the open epicutaneous method and the guinea-pig maximization test.

Adulterations and substitutes European pharmacopoeias do not differentiate between the 3 species normally used, i.e. *S. virgaurea*, *S. canadensis* or *S. gigantea*. Furthermore, the leaves of *S. virgaurea* are sometimes used as a substitute for tea, because of their aromatic odour and somewhat bitter, astringent taste.

Description A graceful, variable, perennial herb, with an erect, rarely branched stem, 60–100 cm tall, glabrous or hairy, roots short, without rhizomes. Leaves alternate, simple, lanceolate to ovate, 3.5–7 cm long, base attenuate, apex pointed, margins somewhat toothed, cauline leaves decreasing in size upwards, entire, glabrous above, usually pubescent beneath; petiole of lower leaves winged, upper leaves sessile; stipules absent. Inflorescence consisting of numerous heads in a terminal, long leafy panicle, with short ascending racemose branches; peduncles short; involucral bracts narrow and pointed, 3-seriate, yellowish-green; heads small, 4.5–8 mm in diameter. Ligulate flowers 6–12, female, corolla 7–9 mm long, spreading; tubular flowers 10–30, bisexual, corolla 4–7 mm long, golden yellow; stamens 5, connate; ovary inferior; style exerted, bifid. Fruit an oblong achene, 1–2.5 mm long, with about 8 ridges, glabrous or slightly hairy; pappus up to 3 mm long, white and silky. Seedling with epigeal germination.

Growth and development *S. virgaurea* grows in clumps and reproduces through seeds. It is pollinated by insects, while the fruits are distributed by wind.



Solidago virgaurea L. – 1, flowering plant; 2, flower head; 3, ligulate flower; 4, tubular flower; 5, achene.

Other botanical information *Solidago* belongs to the large tribe *Astereae*. *S. virgaurea* is the only Eurasian species of a mainly North American genus of about 80 species. Several species of *Solidago* are cultivated as ornamental perennials, of which *S. canadensis* is the most common. Hybrids between *S. canadensis* and *S. virgaurea* are often found, and are easily naturalized because of their weediness.
S. virgaurea (with *S. virga-aurea* as orthographic variant) is a very variable species and has been divided into a number of varieties, of which var. *virgaurea* occurs in Eurasia and North America. Var. *leiocarpa* (Benth.) Miq., with linear-lanceolate leaves, is the commonest variety in South-East Asia, and is distributed from Korea, through China and Japan, to the Philippines. Var. *asiatica* Nakai, with narrowly campanulate involucres, occurs in China and Japan.
In Java, 3 species of *Solidago* are cultivated as ornamentals: *S. nemoralis* Aiton, *S. canadensis*, and

S. gigantea var. *leiophylla* Fernald. *S. microglossa* DC. is grown as an ornamental in Peninsular Malaysia.

Ecology In the Philippines, *S. virgaurea* is found on open grassy slopes and in thin pine forests, at an altitude of 1400–2100 m. In Europe, *S. virgaurea* grows on light soil, from sea-level to mountain tops. There are many eco-types of this species. When cultivated, it prefers sunny or partially shaded locations, with humid, well drained soils.

Propagation and planting True to its weedy nature, *S. virgaurea* propagates through seed which is produced in abundance. When planted for ornamental purposes, it is propagated by seed or root cuttings. Time of planting affects the yield of flowering branches.

Husbandry *S. virgaurea* is regarded as a plant that is easily grown. In Korea, plants sown in June as an ornamental have a higher yield of flowering branches than those sown in May, because of a higher bolting rate. The most effective N treatment is 40% of 180 kg/ha applied as a basal dose and 60% as a top dressing. In Finland, *S. virgaurea* is also cultivated for medicinal purposes, and gives the highest yields when seedlings are transplanted on ridges.

Harvesting The aerial parts of *S. virgaurea* are mechanically harvested in Finland, 1–2 times per year. Seed production is high; 60–100% of the seeds are viable.

Yield Dry herb yield of *S. virgaurea* planted on ridges in Finland was 45–60 g/plant.

Handling after harvest The aerial parts of *S. virgaurea* are dried for further processing.

Genetic resources and breeding *S. virgaurea* is widespread in the northern temperate zone, both in the wild and cultivated, and does not seem to be liable to genetic erosion. There are small gene bank collections in Germany, Poland and the United Kingdom. For the cultivated species, breeders concentrate mainly on a fuller and richer bloom.

Prospects *Solidago* species are well known in traditional medicine e.g. for their diuretic effect, which has been experimentally confirmed. Furthermore, *S. virgaurea* shows some interesting anti-inflammatory effects, thus meriting further research. The pharmacological effects make *S. virgaurea* locally important, and a potential medicinal crop for small-scale production.

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Other selected sources 74, 121, 130, 135, 216, 306, 309, 321, 500, 534, 535, 663, 711, 750, 773, 788, 797, 1121.

Slamet Sutanti Budi Rahayu

Soulamea amara Lamk

Encycl. 1(2): 449 (1785).
SIMAROUBACEAE
$2n$ = unknown

Vernacular names Indonesia: buwa hati, kayu sulamu (Moluccas), sulamu pohon (Ternate). Papua New Guinea: dschiri pangpang (Tami, Morobe Province).

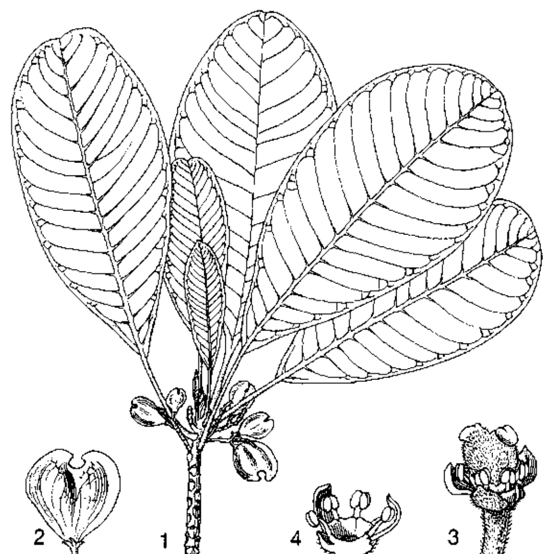
Origin and geographic distribution *S. amara* is a coastal species widespread from Borneo eastward to Micronesia and Melanesia, but not found in New Caledonia. In Malesia *S. amara* is recorded for Borneo, the Moluccas and New Guinea only.

Uses The roots and fruits of *S. amara* are the parts usually employed in traditional medicine. They are intensely bitter, and are used especially to treat cholera and pleurisy. The fruits are considered a general febrifuge, and ground with roots and water they are used to treat colic and cough, including asthma. In cases of poisoning the roots are used as an emetic, similar to *Eurycoma* root, another representative of *Simaroubaceae*, often as a substitute for snakeroot (*Strychnos*). As with many other bitter tasting plants the roots are considered to strengthen the stomach, restore appetite, and be a healthy laxative, if taken in appropriate quantities. In Papua New Guinea, juice from heated leaves is applied externally to get rid of lice.

Properties Though *S. amara* is reputed for its application in traditional medicine, modern research has focused on the *Soulamea* species from New Caledonia and Fiji. The quassinoids (sometimes also called simaroubolides) glaucarubolone, holacanthone and isobrucein A were found to be responsible for the cytotoxic and antileukaemic activities observed for extracts of the wood, stem bark, and twigs of the Fijian *S. soulameoides* (A. Gray) Noot. (synonym: *Amaroria soulameoides* A. Gray). Other cytotoxic constituents isolated include cleomiscosin A (a coumarinolignan) and a hydroxy canthin-6-one alkaloid. The alkaloid cleomiscosine A showed activity against P-388 lymphocytic leukaemia cells in vitro. Several quassinoids from *S. soulameoides* were evaluated for growth inhibitory and insecticidal effects against the tobacco budworm (*Heliothis virescens*) and for antifeedant effects against *H. virescens* and the fall armyworm (*Spodoptera frugiperda*). The relative activity of the quassinoids as insect growth inhibitors generally parallelled their known relative potency as antileukaemic and cytotoxic agents.
Soularubinone, the C-15 β-hydroxy-isovaleric ester of glaucarubolone, isolated from the New Caledonian *S. tomentosa* Brongn. & Gris showed significant antineoplastic activity against mouse leukaemia P-388 and inhibits cell transformation induced by Rous sarcoma virus. The quassinoids chaparrinone I, isobrucine A, isobrucine B, 15-O-benzoyl brucein D and picrasin B have also been isolated.

Adulterations and substitutes Quassinoids and canthin-6-one alkaloids showing cytotoxic and anticancer activity can also be found in other *Simaroubaceae* including *Brucea*, *Eurycoma*, *Picrasma* and *Quassia*. Some species may well used for certain applications of *S. amara*.

Description A shrub or small tree up to 5(–15) m tall; young shoots and buds rusty tomentose. Leaves simple, spirally arranged, crowded at the apex of the branchlets, leaving large scars, blade obovate-oblong, 10–35 cm × 4–12 cm, base cuneate, apex obtuse, sometimes mucronate, margin entire, hairy, midrib prominent below, lateral veins parallel ending in an intramarginal looped vein; petiole 3–8 cm long; stipules absent. Inflorescence an axillary erect raceme, 3–12 cm long. Flowers bisexual, 3(–5)-merous, small; sepals puberulous, erect, appressed, 0.5–1 mm long; petals concave, spreading, finally reflexed, accrescent to 2.5 mm × 1 mm; stamens twice as many as petals, up to 2 mm long; intrastaminal disk present; ovary superior, consisting of 2(–3) carpels, not more than 2 fertile, connate, except at the top, stigma sessile. Fruit an obcordate samara, up to 2.5 cm × 2 cm, pericarp hard corky. Seed round, 0.5–1 cm across, testa thin, cotyledons plano-convex.



Soulamea amara Lamk – 1, fruiting twig; 2, fruit; 3, flower; 4, flower in section (pistil removed).

Other botanical information *Soulamea* comprises 10 species, with 1 species endemic to the Seychelles, 1 endemic to Fiji, 7 species confined to New Caledonia and 1 widespread species (*S. amara*). *S. amara* is a littoral species, whereas all other species of the genus occur inland. *Soulamea* very much resembles *Lunasia* (*Rutaceae*) in habit.

Ecology *S. amara* is a typical constituent of the *Barringtonia* formation, which occurs specifically on sandy beaches and behind coral reefs. It is sometimes found as a scattered treelet more inland. Under the parent plants, seedlings may be found in great profusion. The fruits seem well adapted to dispersal by seawater.

Propagation and planting *S. amara* can be propagated easily by seed.

Harvesting The fruits must be picked when they start to yellow or blacken, since they become less medicinally effective after they have fallen. The roots can be harvested when needed.

Genetic resources and breeding As *S. amara* is a widespread species, the risk of genetic erosion seems to be limited.

Prospects In general, quassinoids are known to possess cytotoxic, antimalarial, and insecticidal activities. Although their use as such is often limited by their cytotoxic potential, quassinoids found in *Soulamea*, including *S. amara*, might be interesting lead compounds in research and development of future antimalarial or chemotherapeutic agents.

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J.L.C.H. van Valkenburg

Sphaeranthus L.

Sp. pl. 2: 927 (1753); Gen. pl. ed. 5: 399 (1754).

COMPOSITAE

$x = 10$; *S. africanus*, *S. indicus*: $2n = 20$

Major species *Sphaeranthus africanus* L., *S. indicus* L.

Vernacular names Globe thistle, hardheads (En). Philippines: sambong-gala (Tagalog). Thailand: matom seua, yaa khon klong.

Origin and geographic distribution *Sphaeranthus* consists of 38 species, distributed throughout the tropics of the Old World from Africa to Australia, with a small outlying area in Iraq and Iran. Most species are confined to Africa; 4 species do not occur in Africa. The wide range of the genus is due to 3 species, of which 1 does not occur in Africa, whereas 3 other species have a narrow, non-African distribution.

Uses *Sphaeranthus* species occurring in South-East Asia and India are widely used in decoction or as a powder for their tonic, diuretic and stimulant effects in stomach, liver and intestinal problems. The young parts, roots, flower heads or seeds are also used, often in combination with sugar to counteract the bitterness, against worms or as a gargle to cure a sore throat and against cough. The odour is transmitted to urine and sweat.

In India and Indo-China, *S. africanus* is further used as an emollient and resolvent, applied as a poultice, and in India a decoction of the leaves and tops is employed against venereal diseases.

In India, the paste of *S. indicus*, prepared with cooking oil, is applied against itch and skin diseases. The red oil, obtained through steam-distillation, may possess antibacterial properties, and is administered against *Vibrio cholerae*, *Micrococcus pyogenes* var. *aureus*, and against tuberculosis. In Pakistan, the plant is used in the treatment of glandular swellings, bronchitis, jaundice and nervous depressions.

In Indonesia, the leaves of *S. indicus* are eaten as a pot herb. In India the seeds fried in sesame oil or the cooked roots are considered a strong aphrodisiac. The young plant is also mashed with butter and flour and applied against decolouration and loss of hair. In Indonesia, the herb is also used as fodder for cattle.

An aqueous extract of the stem and leaves of *Sphaeranthus* is used as an insecticide, especially against American cockroaches. The leaves are mixed with rice to prevent damage by insect pests during storage.

S. indicus is also employed as a fish poison, or stuffed in the holes of crabs to kill them.

Production and international trade *Sphaeranthus* is only used in local medicine and is not traded on the international market.

Properties Upon steam distillation, *S. indicus* yields a red, viscous essential oil (0.01–0.02%)

with a bitter taste. Its major constituents are the terpenes cadinene, α-ionone and β-carophyllene and the phenylpropanoid p-methoxycinnanaldehyde. Further compounds include ocimene, α-terpinene, citral, geraniol, geranyl acetate, β-ionone. The essential oil of *S. indicus* shows in vitro antibacterial activity against *Salmonella* spp., *Shigella* spp. and *Vibrio cholerae*.

Other compounds isolated from the areal parts or flower heads are sesquiterpene lactones, mainly 7-hydroxylated eudesmanolides (e.g. 7α-hydroxyfrullanolide) and the sesquiterpenoids cryptomeridiol and 4-epicryptomeridiol. 7α-Hydroxyfrullanolide shows cytotoxicity and anti-tumour activity against a number of human cancer cell lines. The compound can also be transformed by *Aspergillus* into 7α-hydroxy-11,13-dihydrofrullanolide and 13-acetyl-7α-hydroxyfrullanolide.

The sesquiterpene glycoside sphaeranthanolide, isolated from *S. indicus* flower heads, exhibits immune-stimulating activity in the Jerne plaque assay (examination of antibody production ability of mice plasma cells).

A bicyclic sesquiterpene lactone, isolated from a petroleum ether extract of *S. indicus*, caused longer larval and pupal developmental periods and larval mortality of *Culex quinquefasciatus* (causing filariasis) at increasing concentration. A *S. indicus* extract of moderate concentration is mentioned as causing an increase of seedling growth of wheat, although it has no effect on the germination rate.

Very little is known about the phytochemistry of *S. africanus*. Its leaves and flowers demonstrate a moderate toxic effect on the oriental fruit fly.

Adulterations and substitutes Lavender oil (*Lavandula angustifolia* Miller) resembles the essential oil of *S. indicus* and could be used as a substitute. *Spilanthes acmella* Murray (*Compositae*) seems to possess the same properties as *Sphaeranthus africanus*.

Description Erect annual, fragrant herbs with spreading branches, more or less hairy, often glandular; taproot well developed. Leaves alternate, simple, obovate to oblong, margins dentate to almost entire, mostly forming broad wings along the stem; petiole with decurrent wings; stipules absent. Inflorescence composed of tiny heads, forming globose, terminal clusters, surrounded by a few involucral bracts, heads subsessile on a common receptacle, bracts of heads, when present, more or less membranous, narrow, acute, dry, hairy or not. Flowers all tubular; marginal flowers female, few to many, fertile, slender, minutely 2–3-toothed; disk flowers bisexual, solitary or few, fertile or sterile, lower half of tube thickened, upper part soft, 4–5-toothed; stamens 5, anther-bases sagittate, auricles acute or tailed, style shortly bifid in female flowers, subentire in the others. Fruit an oblong achene, angular, tipped by the persistent, hardened part of the corolla; pappus absent. Seedling with epigeal germination; hypocotyl glabrous; cotyledons subsessile, glabrous; first pair of leaves opposite, subsequent leaves alternate.

Growth and development *Sphaeranthus* often grows gregariously, forming large patches.

Other botanical information *Sphaeranthus* belongs to the tribe *Inuloideae* and is characterized by having a large number of heads crowded together and forming a glomerule. There are no ligulate flowers but 2 kinds of tubular flowers are present.

Ecology *Sphaeranthus* prefers humid and sunny localities on light to heavy soils. They are often weedy, and can be controlled through manual weeding and herbicides.

Propagation and planting Seeds of *Sphaeranthus* are hydrochorous, and germinate at the beginning of the rainy season, or when the water level in rice fields is low.

Husbandry *Sphaeranthus* is harvested for local use from rice fields and along ditches whenever the need arises.

Diseases and pests In India, the caterpillars of *Diacrisia obliqua* survive on *S. indicus*, after the harvest of soya bean, and before they enter pupal diapause. *S. indicus* is also a host for the cicadellid *Orosius albicinctus*, the vector of sesame phyllody disease.

Harvesting *Sphaeranthus* is harvested in any of its developmental stages.

Genetic resources and breeding *Sphaeranthus* occurs widely in anthropogenic habitats as a weed and the species described here are not at risk of genetic erosion. No germplasm collections are known to exist and no breeding work has been executed.

Prospects Sesquiterpene lactones in general display interesting pharmacological activities, e.g. in the field of anti-tumour or immuno-modulating action. Genera like *Sphaeranthus* which contain these compounds, might thus be potentially of interest in the development of new lead compounds.

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Selection of species

Sphaeranthus africanus L.

Sp. pl. ed. 2: 1314 (1762).

Synonyms *Sphaeranthus cochinchinensis* Lour. (1790).

Vernacular names Indonesia: sembung gantung (Sundanese), kamandhin (Madurese). Malaysia: gelang liat lembu. Philippines: botobotonisan, sambong-gala (Tagalog), talababako (Bisaya). Thailand: kaarabuun (southwestern), phak khraat hua waen (peninsular), ra-ngap (central). Vietnam: b[oj] x[is]t, ch[uw]n v[ij]t.

Distribution *S. africanus* is distributed from eastern and southern Africa, Madagascar, India and Sri Lanka to tropical Asia and Australia.

Uses In Malaysia, pounded leaves of *S. africanus*, with seeds of black cumin (*Nigella sativa* L.), are rubbed upon the gums to relieve toothache. The plant is chewed in the Philippines as a stomachic.

Observations A slender, glabrous or pubescent herb, 40–50(–110) cm tall; leaves obovate to elliptical, 4.5–9 cm × 2–3.2 cm, margins finely toothed or subentire, wings entire or with a few mucronate teeth; glomerule globose, 7–12 mm across, receptacle orbicular to elliptical, involucral bracts about 10, lanceolate, acuminate, concave, 3–4 mm long, glandular-puberulous to glabrous; heads large and distinct, on short secondary receptacles, bracts 6–15, narrowly to broadly spathulate, 1.5–3 mm long, rounded or acuminate, sometimes glandular; marginal flowers 15–20(–30), corolla 1–2.5 mm long, broadly cylindrical or obovoid, or inflated, hardened and persistent in the lower half and suddenly constricted into a terminal slender tube, white or purple, green at the base, disk flowers 1–3, funnel-shaped with a constriction near the middle, 2–3 mm long, lobes triangular, glandular or not, base hardened and persistent, white or purple, green at the base; achenes similar for both types of flowers, oblong, glandular-punctate. *S. africanus* commonly occurs in marshy locations along the coast, in damp waste places, in and around towns, in fallowed rice fields, from sea-level up to 700 m altitude. Flowering time in Java is from March till October, in Sri Lanka from November till May.

Selected sources 62, 215, 407, 604, 739, 951.

Sphaeranthus indicus L.

Sp. pl. 2: 927 (1753)

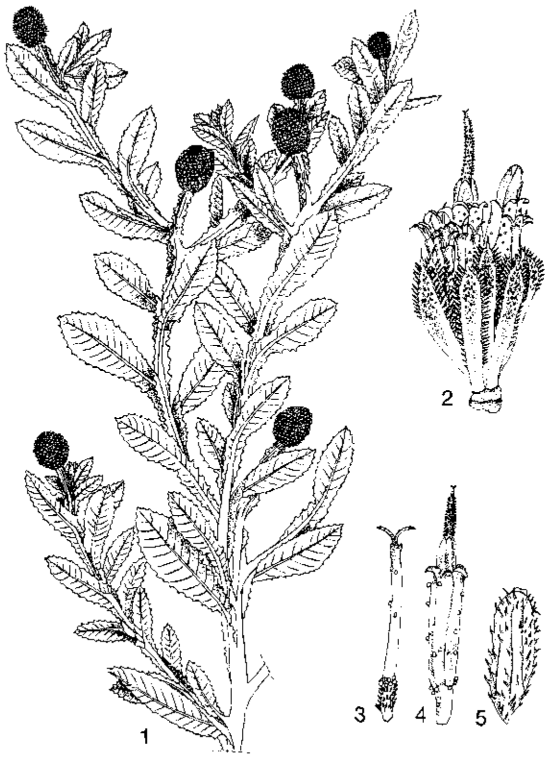
Synonyms *Sphaeranthus hirtus* Willd. (1801), *Sphaeranthus mollis* Roxb. ex DC. (1814).

Vernacular names East Indian globe thistle (En). Indonesia: sembung, ki heuleut (Sundanese), brincil (Javanese). Laos: khi khoay (Louang-Prabang). Thailand: matom suea. Vietnam: c[us]c ch[aa]n v[ij]t, c[or] tr[uws]ng v[ij]t.

Distribution *S. indicus* originates from India, and is now spread throughout the Old World tropics, including China and Australia, as a weed. In Malesia, it is not recorded for Borneo, the Moluccas or Papua New Guinea.

Uses The red essential oil of *S. indicus* is widely used for its antibacterial properties. In India, the ground bark may be a useful application for haemorrhoids, the juice is taken for liver and gastric disorders; the paste made with oil is applied in itch; the powdered seeds and roots are given as an anthelmintic; the root decoction is used in chest pains, cough and bowel complaints, while the flowers are credited with alterative, depurative and tonic properties.

Observations An annual, sticky-glandular, hairy herb, 30–60 cm tall, stem divaricately branched, especially in the top part; leaves obovate-oblong, 1–8 cm × 0.5–2.5 cm, margins serrate, wings irregularly serrate; glomerule globose-ellipsoid, 12–15 mm across, receptacle ovate, involucral bracts about 20, lanceolate, whitish, purple-tipped, upper half densely hairy; heads small and numerous, on very short secondary receptacles, bracts 13–17, linear, 3 mm long, hairy and glandular; marginal flowers 10–13, corolla 2–3 mm long,



Sphaeranthus indicus L. – 1, flowering branch; 2, flower head; 3, marginal flower; 4, disk flower; 5, achene of marginal flower.

2–3-dentate, disk flowers 3(–5), corolla flask-shaped, lower part becoming swollen, hardened and persistent at maturity, 1 mm across, upper part narrowly cylindrical, glandular, 3 mm long, 5-dentate, flowers purple; achenes of the marginal flowers ovoid-oblong, 4–5-angled, with hairy angles, brown, achenes of the disk flowers obconical, 4–5-angled, glabrous or hairy. *S. indicus* is abundant in damp situations, ascending to an altitude of about 1500 m, especially as a weed in and along (fallowed) rice fields, along ditches, often in groups, especially on heavy soils. In Java, it flowers from May to February, in India from September to March.

Selected sources 43, 69, 215, 339, 407, 604, 739, 767, 951.

Wongsatit Chuakul, Noppamas Soonthornchareonnon, Orawan Ruangsomboon

Stachytarpheta jamaicensis (L.) Vahl

Enum. Pl. 1: 206 (1804).
VERBENACEAE
$2n$ = unknown

Synonyms *Stachytarpheta indica* auct. non (L.) Vahl

Vernacular names (Blue, Jamaican) Snake-weed, (bastard) vervain (En). Queue de rat, vervaine (Fr). Indonesia: jarong (Javanese, Sundanese), gajihan, ngadi rengga (Javanese). Philippines: kandikandilaan (Tagalog), bolo moros (Bikol), albaka (Panay Bisaya). Cambodia: mo mi scha. Thailand: phan nguu khieo (central), yaa nuat suea (northern), yaa haang nguu (peninsular). Vietnam: du[oo]i chu[ooj]t, h[ar]i ti[ee]n.

Origin and geographic distribution *S. jamaicensis* originates from the New World tropics, and at present has a pantropical distribution.

Uses The juice of the leaves, roots or the entire plant of *S. jamaicensis* is used in many countries as a tonic, emetic, expectorant, sudorific, stimulant, purgative, emmenagogue, emollient and cooling agent. It is used locally in various parts of its range in the treatment of headache, earache, malaria, yellow fever, syphilis, jaundice, contusions and wounds caused by blows, liver trouble, intestinal worms, and nervous pains. It is widely used in the treatment of dysentery. In Peninsular Malaysia, a decoction of the leaves is drunk against ulcers in the nose and as an antiperiodic in malaria. In Java, a decoction of the root is used for gonorrhoea and as an abortifacient. In Indo-China, the pounded leaves are rubbed on the body as a febrifuge. In West Africa the leaf sap is used in the treatment of ophthalmia and applied to sores in children's ears; internally it is taken in the treatment of heart troubles. In Java, it is fed to cattle and horses as fodder. The young shoots are eaten as a side dish. The dried leaves are used as an adulterant in tea. *S. jamaicensis* is also often planted as an ornamental and for hedges.

Production and international trade *S. jamaicensis* is only used on a local scale.

Properties As is the case with many *Verbenaceae*, *Stachytarpheta* species are also known to accumulate iridoids and phenylpropanoids. Ipolamiide is an example of an iridoid-glucoside found in e.g. *S. jamaicensis*, *S. mutabilis* (Jacq.) Vahl and *S. cayennensis* (Rich.) Vahl. 6β-Hydroxyipolamiide was isolated and characterized from the roots of *S. indica*. The phenylpropanoid verbascoside, which is also known as acetoside, is reported for *S. jamaicensis* and *S. cayennensis*.

In a general pharmacological screening, gradual doses of an aqueous extract of *S. jamaicensis* leaves were intraperitoneally administered to rats. The following effects were noted: a reduction of motor activity and the alarm reaction, ataxia, sedation, analgesia, anaesthesia, ptosis, piloerection, head tremors and a significant reduction of body temperature of about 8.4°C. Robichaud's sign was present, probably due to some muscular relaxation. There were appreciable changes in respiration, with an increase in amplitude and reduction of frequency, followed by apnoea and the death of the animals, probably due to asphyxia. It is furthermore reported that ipolamiide and verbascoside are present in the extract, but no further information is available on their relation, or other compounds with the effects observed. The ethanol extract from fresh leaves and stem parts of *S. jamaicensis* exhibited spasmolytic and vasodilating activities.

In addition, the petroleum ether extract of *S. jamaicensis* showed no antibacterial activity using the agar dilution streak method on 6 bacteria: *Enterococcus faecalis*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella typhimurium*, *Staphylococcus aureus* and *Staphylococcus epidermidis*. However, in a toxicity test on 4-stage larvae of the mosquito *Aedes aegypti* the ethyl acetate extract of the leaves showed strong growth retardant and anti-feedant activity. Likewise larvicidal activity was observed on the tick *Boophilus microplus*.

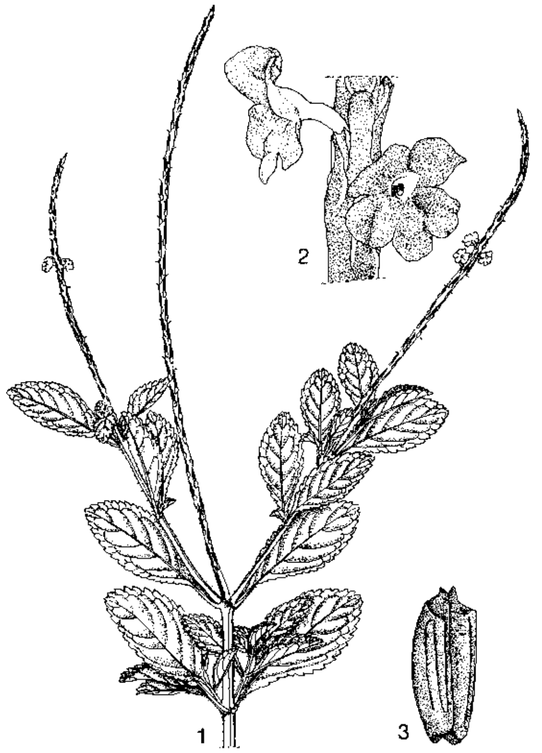
The ethanolic- and n-butanolic extracts of dried leaves of *S. cayennensis* were investigated using anti-inflammatory and antinociceptive in vivo models. Intraperitoneal pretreatment with the dried extracts, at doses ranging from 100 to 200 mg/kg, significantly inhibited carrageenan induced oedema formation in rats. The active extracts were further fractionated and monitored with the same bioassay: ipolamiide and verbascoside were isolated and subsequently shown to inhibit histamine- and bradykinin induced contractions of the guinea-pig ileum in vitro. In addition, the compounds also showed in vivo anti-inflammatory activity when administered orally to rats, mainly in the fourth hour after the administration of the phlogistic agent (70% and 94%, respectively). These results indicate that ipolamiide and verbascoside from *S. cayennensis* show anti-inflammatory properties which seem to be due, at least partly, to the inhibition of bradykinin and histamine. The extracts also exhibited antinociceptive activity measured by the hot-plate test, both i.p. and p.o. and in doses ranging from 100 to 300 mg/kg. Furthermore, acute (48 h) and subchronic (30 days) evaluation of the aqueous and ethanolic extracts in mice showed no significant effects for doses up to 300 mg/kg. For the butanol extract, however, tested at 100 mg/kg in the acute model, abdominal contractions and difficulties in locomotion have been observed immediately, and for up to 2 hours following injection.

In some regions of the world, *S. cayennensis* is used in folk medicine to treat gastric and intestinal disturbances. Freeze-dried aqueous extracts of the whole plant (0.5–2 g/kg, orally) were shown to increase the intestinal motility and protect mice against ulcers induced by e.g ethanol or indomethacin. Injected into the duodenal lumen, the extract inhibited the basal acid secretion as well as that induced by histamine and bethanecol in pylorus-ligated mice. Partition of the aqueous extract in organic solvents yielded semipurified fractions whose anti-acid activity guided further chemical purification. All the fractions were chromatographically characterized, the main substances in the active extract being flavonoids and amines. The most purified active fraction obtained presented a specific activity 5–10 times higher than that detected in the original extract.

Subsequent pharmacological studies indicate that the anti-ulcer activity of *S. cayennensis* is related to a specific inhibition of the gastric acid secretion. Cholinergic and histaminergic stimulation of acid secretion were similarly reduced by the extracts, suggesting inhibition of common steps in both pathways, possibly at the level of histamine release/H2 receptor interaction, or at the proton pump. In addition, the freeze-dried aqueous extract of the whole plant tested in rodents up to doses of 2 g/kg orally, produced no signs of toxicity.

Finally, ipolamiide isolated from *S. mutabilis* inhibited feeding by the locusts *Schistocerca gregaria* and *Locusta migratoria* and larvae of the noctuid *Spodoptera littoralis*. It was active at concentrations well below those occurring naturally.

Description An erect perennial herb, up to 1.2(–2) m tall, sometimes woody at the base, often dichotomously branched from the base and spreading; young stems obtusely quadrangular, sparingly hairy. Leaves opposite, simple, obovate to oblong-elliptical, (2–)4–9 cm × (1–)2–5 cm, base cuneate to wing-like decurrent, apex obtuse to slightly acute, margin serrate-dentate, glabrous above, sometimes sparingly hairy below; subsessile to shortly petiolate; stipules absent. Inflorescence a spike, solitary, terete, stout, often flexu-



Stachytarpheta jamaicensis (L.) Vahl – 1, plant habit; 2, detail of inflorescence; 3, fruit.

ous, 15–50 cm long, rachis up to 7 mm in diameter, the furrows of the half immersed flowers much narrower than the mature rachis; peduncle (0.5–)1–2.5(–3.5) cm long, glabrous. Flowers sessile, at first erect, later immersed in the thickened rachis, bracteate; calyx compressed, completely embedded, about 5–7 mm long, the rim bilobed with 4 equal and 1 smaller tooth; corolla pale bluish, violet or purple, with a whitish spot at the throat, hypocrateriform, the tube about 1 cm long, slightly curved, 2-lipped, the upper lip 2-lobed, the lower 3-lobed, lobes subequal, the limb about 8 mm wide; fertile stamens 2, staminodes 2; ovary superior, 2-locular, style included. Fruit a schizocarp, oblong-linear, 3–5(–7) mm × 1.5–2 mm, enclosed in the fruiting calyx, splitting at maturity into 2 hard mericarps, each 1-seeded. Seed linear, without endosperm.

Growth and development *S. jamaicensis* flowers and fruits throughout the year. Only a few flowers of a spike are open simultaneously. They are ephemerous, expanding in the early morning and falling off in the afternoon of the same day. The flowers are specialized for butterfly pollination, but other pollinators may also affect pollination. When flowers or spikes are detached the corolla is shed within a few minutes, if put in water in time new flowers will open the following morning. Seeds are easily dispersed by rainwater.

Other botanical information *Stachytarpheta* is most abundant in the New World tropics and subtropics, and comprises some 65 species and many infraspecific and hybrid taxa. Great confusion exists in the South-East Asian literature with respect to the names *S. indica* (L.) Vahl and *S. jamaicensis*. In most cases the name *S. indica* has been misapplied to *S. jamaicensis*, and quite often *S. jamaicensis* has been misapplied to *S. urticifolia* Sims. Some adhere to the view that *S. urticifolia* and also *S. dichotoma* (Ruiz. & Pav.) Vahl should be considered synonyms of *S. cayennensis* (Rich.) Vahl. The three species are distinguished based on vegetative and floral characters, like the general stature of the plant, dimensions and serration of the leaf, the dimensions of the calyx teeth and the colour of the corolla mouth and curvature of the tube. Mention is made of plants in mixed populations showing intermediate characters, often ascribed to hybridisation. The common weed *Stachytarpheta* used in folk medicine is in the majority of cases *S. jamaicensis*. In view of the taxonomic complexity of this closely related group of species, only *S. jamaicensis* is treated here but properties and uses may equally apply to the other species in this complex.

Ecology *S. jamaicensis* is a common weed of disturbed soils on roadsides, waste places, especially in pastures but also in plantation crops throughout Asia and Oceania. The main habitat is sunny, to lightly shaded, preferably not too heavy soils with a pronounced dry season, from sea-level up to 1500 m altitude.

Propagation and planting *S. jamaicensis* is propagated by seed and produces on average about 2000 seeds per plant. There are about 430 seeds per gram. A field trial for seed viability in the Philippines gave viable seeds after 6.5 years of burial.

Harvesting In general *S. jamaicensis* is harvested whenever the need arises.

Handling after harvest Plant parts of *S. jamaicensis* are usually used fresh but roots and aboveground parts may well be dried for future use.

Genetic resources and breeding *S. jamaicensis* is widespread and common throughout South-East Asia, and therefore not endangered.

Prospects Extracts and purified compounds (ipolamiide, verbascoside) from *Stachytarpheta* species display a range of interesting pharmacological effects, e.g. in the field of anti-inflammation and gastric disturbance. More detailed pharmacological investigation, and full toxicological screening will be needed however, in order to fully evaluate future possibilities of selected species.

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Other selected sources 74, 105, 134, 135, 201, 228, 252, 302, 380, 407, 440, 662, 688, 786, 788, 810, 951, 1071.

J.L.C.H. van Valkenburg & N. Bunyapraphatsara

Stemona tuberosa Lour.

Fl. cochinch. 1: 404 (1790).

STEMONACEAE

$2n$ = unknown

Synonyms *Roxburghia gloriosoides* Roxb. (1795), *Roxburghia gloriosa* Pers. (1805), *Stemona moluccana* (Blume) C.H. Wight (1896).

Vernacular names Indonesia: kanyalut (Moluccas), ngabalo (North Halmahera), isoratu (Ternate). Thailand: non taai yaak. Vietnam: b[as]ch b[ooj], c[ur] ba m[uw][ow]i, d[aa]y d[ej]t [as]c.

Origin and geographic distribution *S. tuberosa* is found from continental South-East Asia, Hainan and Taiwan throughout Malesia from the Philippines southward to the Lesser Sunda Islands, the Moluccas and Papua.

Uses The tuberous roots of various *Stemona* are used throughout South-East Asia, China and Japan as insecticides and therapeutical agents (especially for coughs). In South-East Asia, *S. tuberosa* is by far the most important species. In the Moluccas the ground fresh tuberous roots are used to repel lice from body and clothing. In Thailand, the tuberous roots, crushed and soaked in water, are topically applied to treat scabies and kill head lice. In Vietnamese folk medicine the tuberous roots are used internally as an antitussive and anthelmintic, and externally as an insecticide. As an anthelmintic it is applied as an enema or as a decoction in combination with a purgative.

S. javanica (Kunth) Engler (synonym *Stemona asperula* J.J. Smith) from the south coast of Java, the Moluccas and New Guinea is only occasionally used medicinally in the Moluccas. The tuberous roots are used as a fish poison and an extract from the stem is given as a drink after childbirth for purification. In the Central Province (Papua New Guinea) crushed leaves of *S. australiana* (Benth.) C.H. Wright are used to treat snakebite. In Burma (Myanmar), the tuberous roots of *S. burkillii* Prain are used as an insecticide. In Thailand, the tuberous roots of *S. burkillii*, *S. tuberosa* or *S. collinsae* Craib (a low erect herb), and probably also *S. curtisii* Hook.f. (a tall climber) are used indiscriminately to treat skin diseases. The root of *S. phyllantha* Gagnep. is applied as a shampoo to kill head lice.

Production and international trade Although *Stemona* tuberous roots figure in prescriptions for herbal medicine traded worldwide, no trade statistics are available.

Properties The tuberous roots of various *Stemona* species are known for their presence of series of alkaloids. The tuberous roots of *S. tuberosa* are reported to contain stemonine, bisdehydro-stemonine, stemonidine, stemotinine, isostemotinine, tuberostemonine, bisdehydro-tuberostemonine, tuberostemonone, tuberostemonol, neotuberostemonine and bisdehydro-neotuberostemonine. In addition, 3-hydroxyflavone and 3 bibenzyls have also been isolated: 3-hydroxy-2′,5-dimethoxy-2-methylbibenzyl, 3,5-dihydroxy-2′-methoxy-4-methylbibenzyl and 3,5-dihydroxy-4-methoxy-4-methylbibenzyl. The root of *S. japonica* Franch. & Savigny furthermore contains the alkaloids neostemonine, bisdehydro-neostemonine, bisdehydro-protostemonine, isoprotostemonine and tuberostemonine.

The effects of tuberostemonine on the motility of parasitic helminths and isolated frog rectus and mouse ileum were studied in vitro. Tuberostemonine (2×10^{-5} M) paralyzed the motility of the helmint *Angiostrongylus cantonensis*, and at a concentration of 6.7×10^{-5} M showed contractive effects on the motility of *Dipylidium caninum* and *Fasciola hepatica*. However, treatment with the alkaloid at 4.8×10^{-4} M had little effect on the motility of *Schistosoma japonicum*. Tuberostemonine (6.7×10^{-5} M) paralyzed the motility of the mouse isolated ileum preparation, and at concentrations of 6.7×10^{-7} – 6.7×10^{-6} M, stimulated the twitch response induced by guanidine in the frog isolated rectus preparation. Furthermore, both eserine and tuberostemonine acted antagonistically on all preparations with the exception of *Schistosoma japonicum*, and both tuberostemonine and strychnine were antagonistic in isolated host tissues, whereas these compounds acted similarly on parasitic helminths. It is therefore suggested that some of the experiential effects of the crude extracts of *Stemona*, especially the anthelmintic effects, are caused through the action of tuberostemonine on parasitic helminths and host tissues.

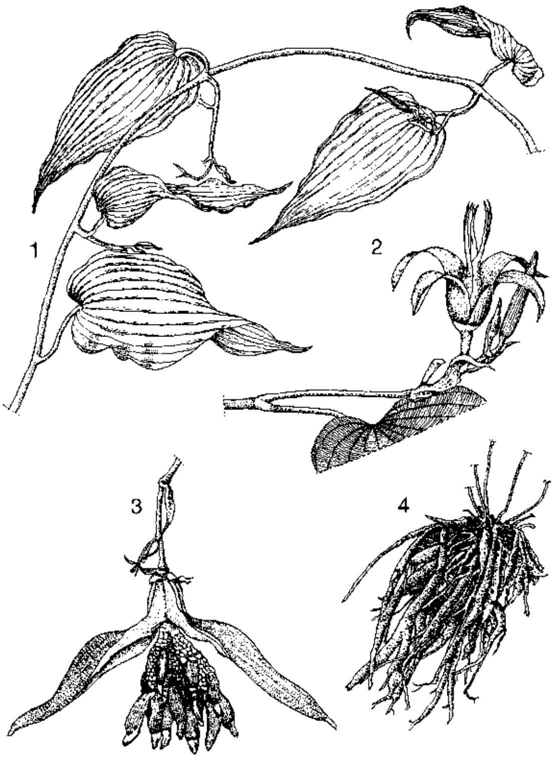
At the crayfish neuromuscular junction, tuberostemonine reduced the amplitude of both the excitatory junctional potential (e.j.p.) and the glutamate response in a dose-dependent manner at concentrations above 0.1 mM. Tuberostemonine acted presynaptically on the crayfish neuromuscular junction to reduce a quantal content of extracellularly recorded e.j.p.s, and post-synaptically to reduce their unit size. The decay of the excitatory synaptic current was accelerated by tuberostemonine. The gradual decline of the successive glutamate currents induced by a train was facilitated by the presence of tuberostemonine even in the muscle fibre pre-treated with concanavalin A. The rate of recovery from the refractory form of the glutamate receptor to the free reactive one was slightly affected by tuberostemonine when it was determined by using a paired pulse method. The inhibitory action of tuberostemonine on glutamate responses was voltage-dependent and hyperpolarization increased the drug action. These results indicate that tuberostemonine acts in part as an open-channel blocker at the crayfish neuromuscular junction.

A water extract of the tuberous roots of *S. sessilifolia* Franch. & Savigny shows a relaxation effect on the airway smooth muscles. It concentration-dependently reduced contractions in guinea-pig isolated tracheal preparations acting on the muscarinic receptors and dihydropyridine binding sites. An aqueous extract of the tuberous roots of *S. tuberosa* showed strong larvicidal activity against the mosquitos *Aedes aegypti*, *Anopheles maculatus* and *Culex quinquefasciatus*. In addition, a crude ethanol extract from the tuberous roots of *S. collinsae* has a strong larvicidal activity against the cattle tick *Boophilus microplus*. However, information on its efficacy against the adult is somewhat contradictory. Effectiveness of the crude ethanol extract against the third instar larvae of the diamond-back moth was 100% at 20 mg/ml under laboratory conditions.

Reports on the presence of rotenoids in *Stemona* tuberous roots are probably based on the papilionaceous substitute *Clitoria hanceana* Hemsl. (synonym *Clitoria macrophylla* auct. non Wallich ex Benth.), an erect treelet with tuberous roots, or the climbing herbaceous *Clitoria macrophylla* Wallich ex Benth. Information may be based on the Thai crude drug 'non-taai-yaak' that contains the tuberous roots of the above-mentioned *Clitoria* or tuberous roots of *S. burkillii*, *S. collinsae* or *S. tuberosa* and probably also *S. curtisii*.

Description A glabrous, perennial, herbaceous twiner to 4(–10) m long; roots forming a fascicle of many thick, fleshy, yellow or black tuberous roots up to 15–20 cm long. Leaves opposite, those at the lower part of shoots often alternate, ovate or broadly ovate, 9–20 cm × 3–14 cm, base cordate, apex acuminate, veins 9–13, all basal; petiole 1.5–7 cm long, not sheathing; stipules absent. Inflorescence axillary, racemose, (1–)2–6-flowered; peduncle 2–8 cm long, free or fused with the petiole for 0.5–3 cm; bracts 0.5–1.5 cm long. Flowers 4-merous, pedicel 0.5–3 cm long, tepals in 2 rows of 2 tepals, free, valvate, persistent, 2.5–4 cm × 0.4–1 cm, outside green or yellowish with dark green or purple stripes, inside brown or brown-red with red stripes; stamens 4, 2.5–4 cm long, filaments short, anthers 0.8–1.5 cm long, appendix of anthers 5–12 mm long, tips fused, purple; ovary superior; style absent. Fruit a pendulous capsule, 4–7 cm × 1.5–2 cm, opening with 2 valves, 10–20-seeded. Seed 1–1.7 cm long, with an acumen about 4 mm long, basally inserted, dangling on a 8 mm long funicle, the base surrounded by a vesicular aril.

Growth and development *S. tuberosa* can be found flowering and fruiting throughout the year; locally some seasonality can be observed. Flowers have an unpleasant smell and are visited by small flies belonging to the family *Longhaeidae*.



Stemona tuberosa Lour. – 1, leafy stem; 2, inflorescence, the peduncle partly fused with the petiole; 3, dehisced fruit; 4, tuberous roots.

Other botanical information *Stemona* comprises about 20–25 species and is found from continental Asia and Japan throughout Malesia to northern Australia. The species mostly prefer a seasonal climate and can be found in rather dry locations, generally not very far from the coast, at altitudes below 500 m. In *S. tuberosa* 2 varieties can be distinguished, based on the peduncle of the inflorescence being fused with the petiole or not. Var. *tuberosa* is found in continental South-East Asia, the Philippines, Flores and Ambon (collected once); var. *ternatensis* (J.J. Smith) Duyfjes is found in the Philippines, Lesser Sunda Islands, the Moluccas and Papua. The flowers of *S. collinsae* (a low erect herb) and *S. curtisii* (a tall climber) are identical.

Ecology *S. tuberosa* is found in beach vegetation, coastal forest, undergrowth in thick scrub, primary forest along rivers and fields at low altitudes not far from the coast, on loamy soils and sandy tuff.

Harvesting The tuberous roots of *S. tuberosa* can be collected throughout the year, by uprooting the plant. However, tuberous roots are generally harvested from the time shoots start wilting until the new shoots appear.

Yield Elaborate sampling for stemona alkaloid content of various *Stemona* species in China revealed a considerable variation between species and regional variation within species. Alkaloid content for *S. tuberosa* ranged from 0.5–3.1%.

Handling after harvest After uprooting the tuberous roots of *S. tuberosa* are washed, proximal and distal ends are removed and immersed in boiling water for several minutes. They are dried for storage purposes and later use.

Genetic resources and breeding *S. tuberosa* is widespread throughout South-East Asia, and can be found in disturbed open habitats. However, locally, populations may be suffering from overexploitation.

Prospects The alkaloids from *Stemona* show interesting activities, especially in the field of parasitic infections of humans and livestock. Since there is an ever growing need for effective anthelmintics, with an emphasis on tropical regions, *Stemona* merits further research to evaluate and develop this potential for the region. In addition, the effects of *S. sessilifolia* on the isolated airway smooth muscles may also be of interest for additional research.

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Other selected sources 135, 264, 407, 483, 594, 615, 739, 786, 867, 1047, 1107.

Nguyen Nghia Thin

Streblus Lour.

Fl. cochinch.: 615 (1790).

MORACEAE

$x = 13, 14$; *S. asper*: $2n = 26$

Major species *Streblus asper* Lour.

Vernacular names Thailand: khoi (general). Vietnam: ru[oos]i.

Origin and geographic distribution *Streblus* comprises 22 species and occurs in Africa and Madagascar, and from Nepal, India and Sri Lanka to Indo-China, southern China, Thailand, throughout the Malesian region towards the Solomon Islands, Australia, New Zealand and the Pacific Islands, east to Fiji, Samoa and the Cook Islands, and north to Hawaii. Only 7 species occur within Malesia.

Uses *S. asper* is a well-known medicinal plant, also in South-East Asia. Its bark is traded as a medicine used to treat leprosy, piles, diarrhoea, dysentery and elephantiasis, and it shows anti-cancer and anti-malaria activities. In Ayurvedic medicine it is used for cardiac disorders, epilepsy and oedema. In India, the latex is put on sore heels and chapped hands, and on glandular swellings; it is credited with antiseptic and astringent properties. In Thailand and Indo-China the latex is employed as a sedative. A paste of the leaves is applied to swellings. A poultice of the roots is applied to ulcers, boils and inflamed swellings. The powdered root is prescribed in dysentery. A decoction of the roots is given in syphilis, and that of the bark in fevers, dysentery and diarrhoea; externally it is applied as a wound disinfectant. Seeds are used in nosebleed, haemorrhoids, diarrhoea and as a carminative; externally a paste is applied in leucoderma.

In Malaysia, an extract of the leaves of *S. asper* is used to make milk coagulate with a texture similar to that of yoghurt. Old leaves have been applied for polishing ivory and cooking utensils. In Thailand, the bark is also used to manufacture paper; elsewhere in Indo-China it is also used to make rope and for rough clothing. Ripe fruits of *S. asper* can be eaten raw or boiled. Young leaves are fed to cattle and goats in India and Indo-China. In the Philippines it is planted as an ornamental; in Indonesia it has been grown as a cover crop in forest plantations. The wood is hard with a fine grain but can only be used for small objects.

Production and international trade Although mention is made of the trade in bark of *S. asper* as well as plantings for this purpose, no trade statistics are available. Most likely bark and other parts of *Streblus* are traded on a local scale only.

Properties Preliminary pharmacological investigations showed stem- and root bark extracts of *S. asper* to have a definite action on the isolated rabbit myocardium, or a pronounced action on smooth musculature including cardioactivity in general. Subsequent phytochemical investigations of the stem bark revealed the presence of about 0.03% of cardiac glycosides (cardenolides): 10 were isolated from the ether and chloroform extracts and 21 from the water soluble portion. In addition, the main components, i.e. strebloside, asperoside and mansonin, as well as various extracts showed a wide range of defined pharmacological activities. Strebloside and mansonin displayed significant cytotoxic activity in the KB cell system. The methanol extract of *S. asper* can be classified as an antibiotic with a cytotoxicity at 200 μg/ml. It also shows complete in vitro inhibition of herpes simplex virus at 50 μg/ml, complete inhibition of the Sindbis virus at 100 μg/ml in the dark, and partial inhibition at 50 μg/ml, and partial inhibition of polio virus at 50 μg/ml.

The antimalarial activity was evaluated in Balb/c mice infected with *Plasmodium berghei* (strain NK 65), which were treated intraperitoneally with 100 μl of a diluted bark extract every 48 hours from day 7 after infection. The extract significantly suppressed parastaemia. All mice in the control group died within 18 days, but none of the treated mice. 70% of treated mice died 25–32 days after infection, but the remaining 30% cleared the parasites completely from their blood and recovered. This group when rechallenged with *P. berghei* also resisted the infection.

The in vitro antifilarial effects of asperoside and strebloside isolated from *S. asper* were studied on females of the bovine filarial parasite *Setaria cervi*. Both compounds caused death of the worms within 2–3 hours at concentrations of 10 μg/ml (1.7 pmoles) and were also found to inhibit motility and glucose uptake of the parasites at lower concentrations (0.1 μg/ml; 0.17 pmoles). Parasites preincubated with either asperoside or strebloside also had lowered profiles of glucokinase, malate dehydrogenase and succinate dehydrogenase activities, suggesting that their lethal effects were due to effects on glucose metabolism. Both glycosides were subsequently shown to interfere with the glutathione metabolism of the adult filarial parasites, which disturbed various vital activities, ultimately resulting in death of the parasites.

Macrofilaricidal activity of the crude extract of the stem bark of *S. asper*, asperoside and strebloside were studied in infected rodents: *Litomosoides carinii*-infected *Sigmodon hispidus*, *Brugia malayi*-infected *Mastomys natalensis* and *Acanthocheilonema viteae*-infected *M. natalensis*. Both asperoside and strebloside showed antifilarial activity, of which asperoside was the more effective. It was found to be active at 50 mg/kg orally against *L. carinii* (90%), *B. malayi* (70%) and *A. viteae* (70%).

A 10% solution of the crude extract of *S. asper* also exhibited a 100% mortality rate of *Boophilus microplus* cattle ticks after 48 hours using the dipping method. The larvae left in contact with a dry film of plant extract (1.11 mg/m^2) showed a relatively high mortality of 71–85%.

In order to determine the antimicrobial effectiveness of a mouthwash containing *S. asper* leaf extract on *Streptococcus mutans* and total salivary bacteria, a single blind clinical study was conducted in 30 humans. At each experimental session, a pretest saliva sample was taken. After giving the pretest samples, the subjects rinsed with *S. asper* leaf extract or distilled water control for 60 seconds, then the post-test saliva samples were collected at 0, 0.5, 1, 3, 5 and 6 h. The results indicated that *S. asper* leaf extract significantly reduced *S. mutans* counts compared to the placebo, although there were no significant differences in total salivary bacterial counts between the groups. It was concluded that mouthwash containing *S. asper* leaf extract can reduce *S. mutans* without changing the oral ecology.

The crude extract of the leaves of *S. asper* was found to coagulate milk. There was no significant change in the milk pH after coagulation by the extract. The milk coagulating activity of the crude extract remained stable upon heating up to 70°C, above which activity was lost. Coagulation at 28°C occurred within 1–2 h, at 70°C within a few minutes. The extract was also stable when prepared in media with a pH ranging from 5.5–9.0. Furthermore, the addition of calcium chloride did not affect coagulating activity of the extract.

Description Evergreen, monoecious or dioecious, armed or unarmed, shrubs or small to medium-sized trees up to 30 m tall; bole often irregular and fluted, branchless for up to 15 m, up to 60(–75) cm in diameter, without distinct buttresses; bark surface smooth, becoming finely and irregularly cracked or fissured, grey, inner bark yellowish or whitish, with or without milky latex; crown compact, dense. Leaves distichous or sometimes arranged spirally, simple, entire to toothed; stipules free or connate, lateral to completely amplexicaul. Inflorescence axillary, bisexual or unisexual, solitary or paired, racemose, spicate or subcapitate, sometimes the female flower solitary. Flowers unisexual; male flowers 3–5-merous; tepals imbricate or valvate in bud; stamens bending outward at anthesis; pistillode present; female flowers 4-merous; tepals free or almost free, variably unequal; ovary superior, free, 1-locular with a single ovule, stigmas 2 or 4. Fruit drupaceous or a dehiscent or indehiscent capsule; fruiting tepals enlarged or not, not to slightly fleshy. Seedling with hypogeal germination; cotyledons unequal, the larger not emergent, the smaller emergent; hypocotyl not elongated; first few leaves scale-like, lower leaves arranged spirally, subsequent ones distichous.

Growth and development Seedlings of *S. asper* may develop into creeping shrubs that only later develop an upright branch that becomes the trunk. The seeds of *S. asper* are often dispersed by white ants which drag them into their nests, where they often germinate. In Java, *S. taxoides* flowers and fruits throughout the year, whereas flowering and fruiting of *S. asper* is confined to June–September.

Other botanical information *Streblus* is a variable genus divided into 5 sections, and includes the former genera *Phyllochlamys*, *Sloetia* and *Taxotrophis*. It is very closely related to *Trophis*, from which it mainly differs by the free tepals.

Ecology *Streblus* is mostly found in lowland and hill forest up to 900 m altitude. *S. asper* is a characteristic element of monsoon forest; it also occurs in areas disturbed by man.

Propagation and planting *S. asper* has been propagated by cuttings to establish a cover crop in forest plantations. Semi-hardwood cuttings treated with indole butyric acid at 10 000 ppm showed good rooting ability when propagated in a mist box using sand and rice husk charcoal in a 1:1 ratio as a rooting medium.

Husbandry *S. asper* responds well to coppicing.

Harvesting Leaves of *Streblus* are plucked or branches are simply cut. Likewise, strips of bark are obtained and sap is collected by making incisions in the bark. Roots are dug up and fruits are collected when mature.

Handling after harvest Plant parts of *Streblus* are used fresh or dried for future use.

Genetic resources and breeding *S. asper* and *S. taxoides* are both widespread and common in monsoon areas throughout South-East Asia, and therefore certainly not endangered. There are no known breeding programmes of *Streblus*.

Prospects Extracts and isolated cardenolides from *Streblus* show interesting activities. The in vivo antifilarial activity of cardenolides opens up possibilities for generating new leads. The extract of *S. asper* leaf shows some potential as a natural oral hygiene product against dental caries in human. More information is however needed in the field of toxicology in order to fully evaluate this potential.

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Selection of species

Streblus asper Lour.

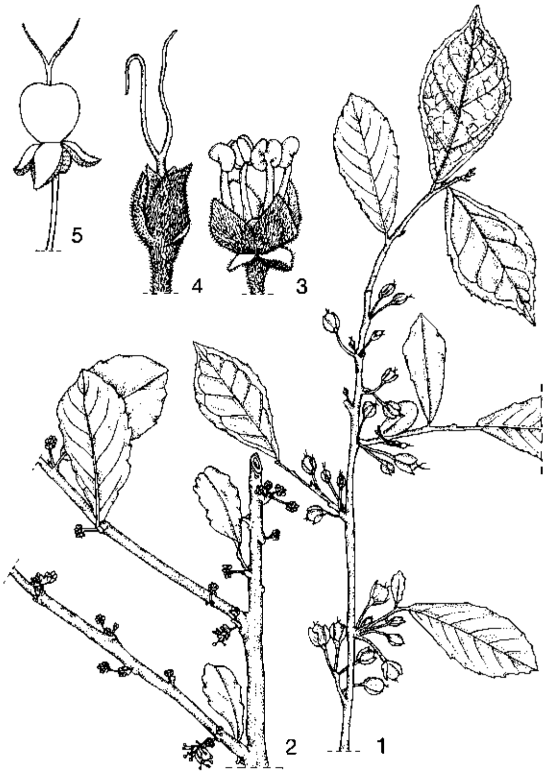
Fl. cochinch.: 615 (1790).

Synonyms *Diplothorax tonkinensis* Gagnep. (1928), *Streblus monoicus* Gagnep. (1950).

Vernacular names Sandpaper tree, Siamese rough bush, tooth brush tree (En). Indonesia: peleh (Madurese), serut (Javanese). Malaysia: kesinai, serinai (Peninsular). Philippines: kalios (Tagalog). Burma (Myanmar): okhne. Laos: 'som pho. Thailand: khoi (general), kak mai foi (northern). Vietnam: ru[oos]i, ru[oos]i nh[as]m.

Distribution From Sri Lanka and India to Burma (Myanmar), Indo-China, southern China, Thailand, Peninsular Malaysia, Indonesia (Sumatra, Java, Sulawesi, the Lesser Sunda Islands and the Moluccas) and the Philippines.

Uses In Java, the leaves with a little salt are given after childbirth and considered a depurative; in a mixture with other plants they are given as a galactagogue. In the Philippines and Thailand, the bark is used as a disinfectant for wounds, and as a depurative in certain skin diseases. In Thailand, a decoction of the stem bark is drunk as an antidiarrhoeal, antidysenteric and antipyretic. The seed is considered tonic and carminative, as well as an appetizer. An infusion of the leaves is taken as a laxative. The smoke from the wood is used to treat nose polyps. In Thailand and Indo-China, the root bark powdered or in decoction is used against toothache and to cure peridontitis. The latex rubbed on the temples is considered ef-



Streblus asper Lour. – 1, flowering twig female plant; 2, flowering twig male plant; 3, male flower; 4, female flower; 5, mature fruit.

fective in treating neuralgia. In Indo-China a decoction of the branchlets is drunk to relieve a swollen abdomen, and a decoction of the roots to treat diphtheria. An infusion of the leaves is drunk as a tea. The fruit is sweet tasting and edible.

Observations An unarmed, evergreen, monoecious or dioecious, shrub or small tree up to 15 m tall; crown resembling an umbrella, composed of twiggy, drooping, straggling branches, twigs and leaves rough hairy, with copious white latex; leaves alternate, elliptical to obovate, 1.2–13 cm × 0.6–6.5 cm, base subcordate to subcuneate, often slightly asymmetrical, apex acute or subacute, margin serrate, dentate or crenulate, scabrid on both sides, petiole 1–3(–5) mm long, hairy; inflorescence axillary, male flowers in small, peduncled heads, 4–10 mm in diameter, 4–15-flowered, stamens 4, female flowers solitary or several together, pedicel long, ovary with prominent bifid stigmatic arms; drupe globose, 6–8 mm long, yellow to orange, at first enclosed by the enlarged tepals, 5–8 mm long, exposed at maturity, and the tepals reflexed; seed globose, 4–5 mm in diameter. *S. asper* is found in seasonal climates and is absent from rain forest. It is found in the surroundings of villages, open areas, borders of rice fields and secondary forest from sea-level up to 1000 m altitude.

Selected sources 74, 103, 135, 167, 201, 202, 205, 206, 207, 215, 305, 330, 407, 645, 703, 738, 786, 810, 934.

Streblus taxoides (Roth) Kurz

Forest fl. Burma 2: 465 (1877).

Synonyms *Phyllochlamys spinosa* (Roxb.) Bureau (1873), *Phyllochlamys wallichii* Hook.f. (1888), *Phyllochlamys taxoides* (B. Heyne) Koord. (1912).

Vernacular names Fig-lime (En). Malaysia: merlimau, limau limau. Vietnam: ru[oos]i qu[is]t gai.

Distribution From Sri Lanka and India to Burma (Myanmar), Indo-China, southern China, Thailand, Peninsular Malaysia, Indonesia (Java, Sulawesi, Flores, Timor) and the Philippines (Mindoro, Palawan).

Uses In Malaysia the boiled bark is applied as a poultice to ulcers, and the smoke of the burned bark is inhaled to cure a cold. Powder of the wood or bark is rubbed on the jaw to soothe toothache. In Thailand, the root, wood, stem or leaf is used as a diuretic and antipyretic.

Observations An evergreen, dioecious shrub or small tree up to 5(–10) m tall; crown bushy, consisting of gnarled, profuse branches and thorny twigs, trunk often set with short thorny twigs, latex white, all parts glabrous; leaves distichous, elliptical, ovate to obovate, often asymmetrical, (1–)2–10(–18) cm × (0.5–)1–4.5(–6.5) cm, base cuneate or slightly rounded, apex acute to long acuminate, dentate especially in the upper part, smooth, coriaceous, petiole 2–5 mm long; inflorescence axillary, male flowers in small, peduncled heads or racemes, 1–4 together, 8–14-flowered, stamens 4, female flowers solitary, pedicel 3–6 mm long, ovary with shortly bifid stigmatic arms; drupe ellipsoid, 5–10 mm in diameter, asymmetrical, very fleshy at base, covered and exceeded by the foliaceous enlarged tepals 20 mm long. In Java, *S. taxoides* is found in dry open forest below 300 m altitude.

Selected sources 74, 103, 135, 205, 206, 207, 215, 215, 330.

Titi Kalima

Strophanthus DC.

Bull. Soc. Philom. 3: 122, t. 8 (1802).

APOCYNACEAE

$x = 9$; *S. caudatus*: $2n = 20$, *S. divaricatus*, *S. gratus*, *S. hispidus*: $2n = 18$

Major species *Strophanthus gratus* (Wallich & Hook.) Baill.

Origin and geographic distribution *Strophanthus* is an Old World genus comprising 38 species; represented by 30 species in continental Africa, 1 species on Madagascar, 2 species in India, and 6 species in South-East Asia. *S. caudatus* has the widest distribution in Malesia, whereas *S. puberulus* Pax is endemic to Sumbawa.

Uses *Strophanthus* seeds and latex have been used in Africa and Asia for the preparation of dart and arrow poison since time immemorial. The poison acts quickly, and even very small quantities are effective; the usual practice is to crush a single seed and to smear the resulting pulp on the tip or barbs of an arrow, sometimes with an adhesive added. When the poison enters the bloodstream death results, in humans usually within a quarter of an hour, in large animals like elephant after a longer time. When the animal killed in this way is to be eaten, the meat directly around the wound is cut away.

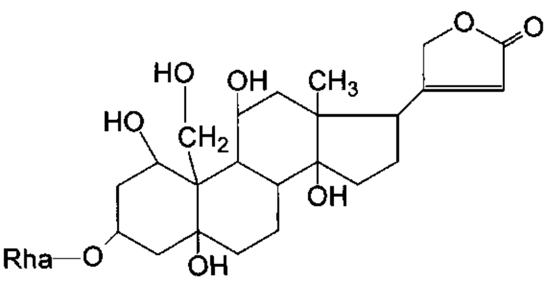
Nearly a third of the African *Strophanthus* species have been used for dart and arrow poison. Medicinal use of many species includes treatment of a wide range of afflictions including rheumatism, venereal diseases, worms, fever, and snakebite. The most important ones, *S. hispidus* DC. and *S. sarmentosus* DC., are cultivated in West Africa and *S. gratus* and *S. kombe* Oliv. in Central and East Africa. The latter two species are used in modern medicine.

Production and international trade Recent information is lacking. Information from the 1970s is present for Africa only.

Properties The seeds of *S. gratus* contain 4–8% of a mixture of cardiac glycosides (cardenolides), of which 90–95% is g-strophantin (= gratus-strophantin). This compound is better known under the name ouabain, and should not be confused with k-strophantin (= kombe-strophantin, from *Strophanthus kombe*) which is also a cardiac glycoside, but has a different chemical structure. Other glycosides include acolongifloriside K, strogosidea nd the sarmentosides (only very small amounts). The aglycone of both ouabain and acolongifloriside K is ouabagenin. This aglycone has 6 OH groups, with a correspondingly high water-solubility. Several cardenolides were isolated from *S. divaricatus*.

S. gratus is the ideal arrow poison plant. It fulfills all conditions for a perfect hunting poison: extremely high toxicity, fast and sure effect, unusually high concentrations of the active principle in the seeds, very easily water-soluble and thus easy and unproblematic extraction from the seed. The most important secondary glycoside, acolongifloriside K, is comparable in its toxic properties to ouabain; strogoside, however, present in about equal amounts, shows only low toxicity. The sarmentosides are also highly toxic but because of the very low concentration they play only a small role.

In medicine, ouabain is used as a remedy for congestive heart failure, like the 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



ouabain (Rha = rhamnose)

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 given to a patient suffering from congestive heart failure, the stroke volume of the heart is increased (positive inotropic effect), causing a more effective emptying of the ventricles, and a lowering of the diastolic pressure. In higher doses, cardiac glycosides also have a direct inhibiting action on atrioventricular conduction (negative dromotropic effect) together with a decrease of the heart rate (negative chronotropic effect), and are employed in the treatment of atrial flutter, atrial fibrillation and paroxysmal atrial tachycardia. 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 cumulation. It is mainly administered by injection, because it is poorly absorbed orally. 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, and larger doses lead to cardiac arrest and death, which also explains their success as arrow poisons.

In addition, the reported interaction between ouabain and reserpine (from *Rauvolfia* spp.) is remarkable. Pretreatment with this alkaloid reduces toxicity of ouabain, simultaneous treatment increases it. This may well explain the success of these mixtures as hunting poison.

Aqueous extracts of the leaves of *S. gratus* and *S. hispidus*, a folk medicine against snakebite in Africa, show a dose-related ability to prolong the time taken to clot the blood treated with a standardized dose of the venom of the snake *Echis carinatus*. The venom of *Echis carinatus* causes rapid intra-arterial clotting of blood, resulting in the death of small animals; death occurs in larger animals and in man, due to depletion of fibrinogen reserves, which leads to internal haemorrhage.

Extracts of *S. hispidus*, a species used in African folk medicine for its antirheumatic activity, show significant anti-inflammatory activity against acute inflammation induced by phlogistic agents.

The extracts of both the roots and leaves of *S. hispidus* show in vitro inhibition of the bacteria *Escherichia coli*, *Klebsiella pneumoniae*, *Neisseria gonorrhoeae*, *Proteus mirabilis*, *Pseudomonas* *aeruginosa*, *Staphylococcus aureus* and *Streptococcus pyogenes*. Strains of the various pathogens with laboratory induced antibiotic resistance were also sensitive to the aqueous and ethanolic extracts of *S. hispidus*.

Adulterations and substitutes Another cardiac glycoside-yielding plant often used as ingredient of arrow poison is *Antiaris toxicaria* Lesch. g-Strophantin (ouabain) (obtained from the seeds of *S. gratus*) is also found in the wood and bark of *Acokanthera schimperi* (A.DC.) Schweinf., another famous arrow poison from *Apocynaceae* in East Africa. Several other members of the *Apocynaceae* also contain cardiac glycosides, e.g. *Cerbera* spp. and *Thevetia* spp. (peruvoside).

Description Lianas or sarmentose shrubs; branches lenticellate, usually glabrous. Leaves opposite or ternate, simple, glabrous, with glands in the axils, resembling small stipules; stipules absent. Inflorescence a terminal cyme; bracts mostly caducous. Flowers 5-merous, actinomorphic; calyx mostly caducous, sepals with colleters inside; corolla lobes overlapping to the right in bud, often forming a long twisted acumen, tube widening around the middle, corona 10-lobed, inserted at the base of the lobes, lobes ovate or elongated into narrow tails; stamens included or partly exserted; ovary consisting of two free carpels, often partly connate at base, ovules numerous, style glabrous. Fruit consisting of 2 divergent follicles, connate at base. Seed flattened, with a caducous basal coma and a beaked apical coma. Seedling sometimes with a swollen primary root, cotyledons elliptical or ovate, obtuse at the apex, primary and first leaves resembling mature leaves, but often more narrow.

Growth and development In areas with distinct dry and rainy seasons, *Strophanthus* flowers towards the end of the dry season and the beginning of the rainy season; fruits are mature in the dry season. If no distinct dry period occurs, some species flower throughout the year with a peak in the relatively driest period. *S. gratus* is a compulsory cross pollinator. Fruit maturation takes about 1 year.

Other botanical information Traditionally the genus *Strophanthus* is placed in the subfamily *Apocynoideae*, tribe *Wrightieae* and subtribe *Wrightiinae* along with *Wrightia*, *Vallaris*, *Spirolobium* and *Beaumontia* amongst other Asian representatives of this subtribe. Recently, however, some of these genera have been removed from this tribe.

Ecology The *Strophanthus* species of medicinal importance can be found in primary and secondary forest, often in forest margins and thickets from sea-level to about 1000 m altitude.

Propagation and planting *Strophanthus* is usually propagated by seed but can also be propagated by ripewood cuttings. Under glasshouse conditions in temperate climates ripewood cuttings in early spring are rooted in moist sand in a closed case with bottom heat. *Strophanthus* should preferably be grown in full light in a fertile moist but well-drained fibrous loam with additional leaf mould.

In vitro production of active compounds Cardenolide production in *Strophanthus* is strictly correlated to morphological differentiation of the tissue or callus culture.

Husbandry Cultivation of *S. gratus* for seed production in South-East Asia is feasible, using clonal material from at least 2 different parental plants. Plants should preferably be grown on trellises to facilitate the work involved for artificial cross pollination. For successful fertilization pollen should be applied to the base of the pistil head.

Harvesting In Vietnam, ripe fruits of *S. divaricatus* are collected in November–December. Leaves can be harvested throughout the year.

Yield Seed weight of naturally grown *S. gratus* ranges from 25–30 mg containing 3.6–7.7% g-strophantin. Seed weight of cultivated, artificially cross-pollinated *S. gratus* from Java is about 20 mg, containing 3.6–7.2% g-strophantin.

Handling after harvest Ripe fruits of *S. divaricatus* are opened, the seeds removed, their feathery awn (coma) detached and seeds are dried in the sun or artificially. The seeds serve as a basic source for the extraction of d-strophantin.

Genetic resources and breeding Several *Strophanthus* species, in particular those of ornamental value, are represented in botanical gardens or university collections, in both tropical and temperate regions. However, no concerted efforts to conserve genetic resources or breeding programmes are known.

Prospects At present in medicine, cardiac glycosides are only applied in distinct, 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 lanatae* Ehrh.), but in acute situations ouabain is often preferred and used. g-Strophantin or ouabain is exclusively extracted from the seeds of *S. gratus*, which is cultivated for that purpose. In rural communities, however, cardiac glycosides may not be readily available at all times, and therefore local sources may play a role of interest. This is the case with d-strophantin from *S. divaricatus* in Vietnam, which is used as an alternative for ouabain, as the latter has to be imported.

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Selection of species

Strophanthus caudatus (L.) Kurz

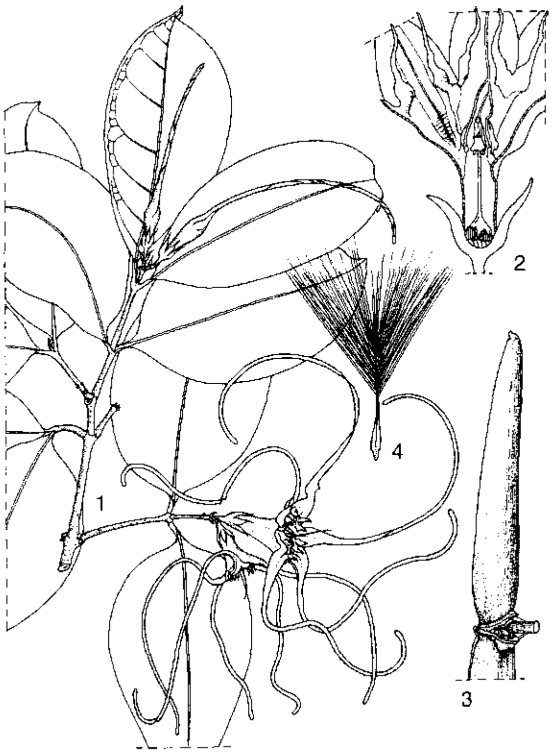
Journ. Asiat. Soc. Bengal 46: 257 (1877).

Synonyms *Strophanthus dichotomus* DC. (1802), *Strophanthus scandens* (Lour.) Roem. & Schult. (1819), *Strophanthus cumingii* A.DC. (1844), *Strophanthus giganteus* Pierre (1905), *Strophanthus letei* Merr. (1926).

Vernacular names Malaysia: tandok-tandok, akar tandok hitam, akar sewai. Philippines: abuhab-baging (Tagalog), lanot (Iloko), lasuiu (Ibanag). Thailand: khruea nong, yaang nong khruea. Vietnam: d[aa]y v[of]i, s[uwf]ng tr[aa]u du[oo]i.

Distribution *S. caudatus* occurs naturally throughout South-East Asia, from northern Vietnam, Burma (Myanmar) and the Philippines southward to Timor and Waigeo west of New Guinea; it is also cultivated as an ornamental.

Uses In the Philippines, Thailand and Vietnam, the latex or bark is traditionally used as an ingredient of arrow poison. In Vietnam it is known as a fish poison as well. In the Philippines and Thailand the seeds are locally used as a heart stimulant.



Strophanthus caudatus (L.) Kurz – 1, flowering branch; 2, dissected flower; 3, fruit; 4, seed.

Observations A sarmentose shrub 1–3 m tall, or woody liana up to 12 m long, stem to 15 cm in diameter, branches dark brown, lenticellate; leaves elliptical, obovate or ovate, 5–24 cm × 2.5–11 cm, base cuneate, apex acuminate to emarginate, petiole 3–13(–18) mm long; cyme 5–15(–25) cm long, 5–25-flowered (1–5 flowers open at a time); calyx with 1–8 colleters per sepal, sepals acute, glabrous to ciliate; corolla tube 1.5–4.2 times as long as the calyx, white, turning yellow, then red, at the mouth 7.5–15(–22) mm wide, corona lobes ligulate or subulate, red turning purple, corolla lobes broadly ovate, abruptly narrowed into the tails, white, turning red, via yellow, tails pendulous, yellow, turning purple via red, lobes including the tails 0.5–25 cm long, stamens 5–14 mm, exserted; follicles divergent at an angle of (150–)180–200°, (10–)13–30 cm × 2–4.8 cm, tapering into a broad or narrow obtuse apex; seed 10–25 mm × 3–4 mm, beak glabrous for 5–14 mm and bearing a coma for 18–32 mm, coma 50–90 mm long. *S. caudatus* is found in primary or secondary forest, often in forest margins from 0–900 m altitude. In southern China it flowers from

April–June, in Java from February-April and July–December.

Selected sources 128, 135, 201, 380, 672, 786, 788.

Strophanthus divaricatus (Lour.) Hook. & Arn.

Bot. Beechey Voy.: 199 (1837).

Synonyms *Strophanthus divergens* R. Graham (1827).

Vernacular names Vietnam: s[uwf]ng d[ee], thu[oos]c b[aws]n, s[uwf]ng d[ee].

Distribution Native to south-eastern China and Vietnam, occasionally cultivated in South-East Asia.

Uses In Vietnam, the leaves and seeds are used in folk medicine to treat scabies, rheumatism and swellings caused by falling or bites. In China, the seeds are the main constituent of the drug 'yang-chi'ao-ou' or 'yang jiao ao zi'. They are used to quicken the blood and disperse swelling, relieve itching and kill worms. The seeds are also used as an insecticide.

Observations A liana or sarmentose shrub up to 5 m tall, stem up to 4 cm in diameter, branches dark grey, densely lenticellate; leaves elliptical or slightly obovate, 3–10 cm × 1.5–5 cm, base cuneate or decurrent, apex rounded, acute or acuminate, petiole 5–10 mm long; cyme 1–15-flowered (1–3 flowers open at a time); flowers sometimes fragrant, calyx with 0–5 colleters per sepal, sepals narrowly triangular, subscarious; corolla tube 1.1–2.8 times as long as the calyx, white, turning yellow, red-spotted inside, at the mouth 5–12 mm wide, corona lobes triangular or subulate, white or greenish yellow, corolla lobes ovate, abruptly narrowed into the tails, white turning yellow, tails spreading or pendulous, yellow, lobes including the tails 3.5–10 cm long, stamens from 1.2 mm long and included, to 2.5 mm long and exserted; follicles divergent at an angle of 200–250°, 9–15 cm × 1.7–3 cm, tapering into a rather narrow apex, with an obtuse tip; seed 13–18 mm × 3–3.5 mm, beak glabrous for 1–7 mm and bearing a coma for 11–27 mm, coma 35–55 mm long, erect or reflexed. *S. divaricatus* is found in primary and secondary forest as well as thickets from 0–900 altitude. In Vietnam it flowers from June–July and fruits from November–December. In southern China flowering takes place from November–May, with a distinct peak in April–May, and fruiting from July–February.

Selected sources 135, 186, 264, 515, 516, 739, 786, 788, 812, 1097.

Strophanthus gratus (Wallich & Hook.) Baill.

Hist. Pl. 10: 171 (1889).

Vernacular names Climbing oleander (En). Thailand: baan thon, hom peenang, yan peenang.

Distribution *S. gratus* is indigenous in West and Central Africa, from Senegal to Congo. It is cultivated for its medical and poisonous applications in Nigeria, Cameroon and Gabon; it is planted primarily for its ornamental value throughout South-East Asia.

Uses In folk medicine in West Africa, a decoction of various plant parts is drunk as a treatment for gonorrhoea; the extracts are used as a liniment in the treatment of syphilis and all kinds of tumours. The seeds, less often the bark or the roots, are the first choice ingredient for hunting poison, throughout its natural range. The seeds are used as a cardiac stimulant.

Observations A woody liana up to 25 m tall, stem to 10 cm in diameter, or less often a shrub, 2–3 m tall, branches dark or purplish brown, densely lenticellate; leaves ovate, obovate or elliptical, 5–18 cm × 2–9 cm, base rounded or cuneate, apex acuminate, petiole 5–32 mm long; cyme 3–32-flowered (1–6 flowers open at a time); flowers fragrant, calyx with 10–20 colleters, sepals obovate to broadly obovate, glabrous; corolla tube 1.9–4.2 times as long as the calyx, white, turning yellow near the base outside, reddish or purple near the mouth outside, red- or purple-streaked inside, at the mouth 13–22 mm wide, corona lobes narrowly triangular or subulate, pink turning purple, corolla lobes orbicular or nearly so, 14–35 mm × 15–32 mm, white with a purple stripe outside turning reddish or purple all over, white and turning yellow inside, stamens 3–15 mm long, exserted; follicles divergent at an angle of 180°, 23–41 cm × 3–4.3 cm, tapering towards the apex, ending in a narrow, obtuse tip; seed (9–)12–20 mm × 2.5–4.5 mm, beak glabrous for 6–15 mm and bearing a coma for (10–)23–47 mm, coma 83–102 mm long, spreading, erect or reflexed. *S. gratus* is found in primary and secondary forest, forest margins and river banks from sea-level to 650 m altitude. In Java, where it is cultivated, it grows well up to 1000 m altitude.

Selected sources 135, 201, 244, 459, 672.

R. Hendrian

Symphytum officinale L.

Sp. pl. 1: 136 (1753).
BORAGINACEAE
$2n = 24$, (26, about 36), 40, 48, (54), 56

Synonyms *Symphytum consolida* Gueldenst. (1787), *Symphytum uliginosum* A. Kern. (1868).

Vernacular names Common comfrey, consound, knitbone (En). Grande consoude, oreille de vache (Fr). Indonesia: komring.

Origin and geographic distribution *S. officinale* is widely distributed in Europe, rare in the south and naturalized in the north. It has long been naturalized in North America, and cultivated in several Mediterranean (Turkey, Egypt), Asian (Japan) and South-East Asian countries (Indonesia, the Philippines).

Uses All parts of *S. officinale* are medicinally used in its area of natural distribution, and the flowers, leaves and rhizomes are official in several European pharmacopoeia. The fresh leaves are widely poulticed on bruises and sprains, burns, wounds and cuts, insect bites, sore joints, pulled tendons, broken bones, dry skin, itch, redness and swellings. An infusion of the leaves has been used as a mouthwash and gargle for gum problems, pharyngitis, pneumonia and angina. As a tea, it was used for gastritis and gastro-intestinal ulcers, as well as rheumatism, bronchitis, scrofula, calcium deficiency, pleuritis, leucorrhoea, as a vulnerary, demulcent, anti-inflammatory, astringent, expectorant and also as a general cleanser.

However, internal use of *S. officinale* preparations is no longer recommended, due to the presence of the extremely hepatotoxic pyrrolizidine alkaloids. As a result of their cumulative effect, liver damage has been known to occur from extended ingestion as a herbal tea. For this reason pyrrolizidine alkaloid-containing plants, including *S. officinale*, are now forbidden by law to be used as internal herbal remedies in many European countries.

An infusion of the flowers, which contain much mucilage, is used for coughs and to soothe the intestine in diarrhoea and dysentery. In Japan, it is taken to tone the muscles, as a tonic.

The fresh rhizomes are widely used for healing wounds. The wound-healing properties are partially due to the presence of allantoin, which stimulates cell proliferation, and is biologically active for dandruff, in addition to being an anti-inflammatory, antipeptic, antipsoriac, anti-ulcer, immunostimulant, and a vulnerary. The presence of much mucilage has made *S. officinale* a powerful healing agent in gastric and duodenal ulcers, hernia, chronic varicose ulcers and ulcerative colitis.

In the Philippines, where *S. officinale* is mainly cultivated as a medicinal for human use, a decoction of the leaves is also used in veterinary medicine, as a drench for pigs to treat fevers. It has also been used to treat rickets, arthritis and rheumatism in dogs. For livestock, the bruised fresh rhizomes have been recommended as a treatment for internal haemorrhaging, ulcers, arthritis, broken bones and rheumatism.

In the western Highlands of Papua New Guinea, a decoction of the leaves of *S. peregrinum* Lebed. (probably a misidentification of *S.* ×*uplandicum* Nyman) is reported to be taken as a sedative and for nervous complaints, upset stomach and externally for ulcers and boils.

In Malaysia, the cultivation of the temperate species *S. tuberosum* L. and *S. asperum* Lepech. (synonym *S. asperrimum* J. Donn ex Sims) as fodder plants has failed. Both have medicinal uses similar to those of *S. officinale*.

S. officinale is also grown as an ornamental in the temperate region, and several cultivars exist, e.g. cv. Rubrum with red flowers and a compact growth habit.

Production and international trade Most *S. officinale* is cultivated in Europe and the United States. In 2001, in the United States, about 120 g of dried leaf fetched US$ 3.25 and 120 g of dried rhizome fetched US$ 4.75. The industrial manufacture of extracts virtually free of the alkaloids is nowadays possible.

Properties All parts of *S. officinale* contain allantoin (0.5–1.7%, mostly in the leaves), 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, 0.2–0.4% in the rhizomes). The major pyrrolizidine alkaloids are intermedine, lycopsamine, 7-acetyllycopsamine and 7-acetylintermedine, followed by echimidine, echinatin, lasiocarpine, symphytine, (and minor isomers symlandine, symveridine), echiumine, myoscorpine and heliosupine. The minor compounds do not occur in all specimens analyzed and they are even often absent in dried leaves. The leaves also contain the phenolic acids rosmarinic-, chlorogenic-, caffeic- and lithospermic-acid. The aerial parts also contain the toxic alkaloid symphytocynoglossine and a toxic gluco-alkaloid, consolidine, which can paralyze the central nervous system. Consolicine, the aglycone, occurs in the free state and is said to be three times stronger than consolidine. The protein

content of *S. officinale* may be as high as 36%, including the amino acid methionine, which helps in wound healing and in the formation of epithelian tissue.
The triterpenoid saponin symphytoxide A is reported from the rhizomes.
Many pyrrolizidine alkaloids (PAs) are toxic and several have been shown to be hepatotoxic, pneumotoxic, carcinogenic and mutagenic. The presence in the molecule of a 1,2-unsaturated retronecine skeleton, together with an esterification at the C9-hydroxy group, is a prerequisite for the toxic effects, as is found in more than 80% of the naturally occurring PAs. In man, PAs can cause obstruction of the hepatic venous system which leads to hepato-necrosis. Human poisoning most often results from ingesting contaminated foods (milk, honey), or when PA-containing plants are used for internal medicinal purposes. In the past, *S. officinale* has been used freely in herbal teas. The most common disease associated with consumption of pyrrolizidine alkaloids in man is veno-occlusive disease (a form of Budd-Chiari syndrome). Clinical manifestations include abdominal pain, ascitis, hepatomegaly and raised serum transaminase levels. Prognosis is often poor with death rates of 20–30% being reported. No alkaloid-free rhizomes were found in more than 300 samples from over 150 different natural habitats in Germany. The alkaloid concentrations varied from 0.05–0.6%. The PAs are not distributed uniformly within the plants, but are concentrated in the underground parts, especially at the extreme exodermis and in the centre of the rhizome, in light young roots and in hairy roots. These PA concentrations were a 100-fold higher than those of the aerial parts. For external application, *S. officinale*-containing preparations were positively evaluated for use in case of contusions, strains and spraining. Absorption of PAs through the skin is negligible, therefore their application is considered safe.
Many PAs 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. Common clinical signs of toxicity are jaundiced skin, rough unkempt appearance, diarrhoea, prolapsed rectum, oedema of tissues of the digestive tract, dullness, photosensitization and abnormal behaviour.
In the literature, *S. officinale* is reported to have anti-inflammatory, analgesic and tissue regenerating properties. The percutaneous efficacy of an ointment of comfrey extract (4 treatments per day for 8 days) was investigated in a double-blind, multi-centre, randomized, placebo-controlled group comparison study in Germany using patients suffering from unilateral acute ankle sprains. Compared to the placebo, the active treatment was clearly superior regarding the reduction of pain and ankle oedema. Statistically significant differences between active treatment and placebo were also shown for ankle mobility (neutral zero method), and global efficacy. No adverse drug reactions were reported.
Several extracts and fractions of *S. officinale* have been evaluated on immunological parameters. For instance, the effect of in vivo stimulation with an aqueous rhizome extract on mouse peritoneal macrophages was investigated. The results showed that these products initially activated the respiratory burst of the cells and later inhibited it, activating the synthesis of catalase, SOD etc., suggesting that macrophages challenged by various ingested antigens destroy them initially through oxygen dependent mechanisms and later through enzymatic digestion in order to retain their epitopes unimpaired. The crude watery extract and its protein fraction were studied for their effect upon the in vivo and in vitro proliferation of Ehrlich ascites cells, EL-4 cell line and of human T lymphocytes and upon the respiratory burst of human PMN granulocytes stimulated via Fc receptors. The results indicate that the crude extract and its proteic fraction stimulate the in vivo proliferation of the studied neoplastic cells and exert an antimitotic effect on in-vitro human T lymphocytes stimulated with phyto haemagglutinin. The vegetal preparations have remarkable effects on the respiratory burst of the granulocytes non-stimulated and stimulated via Fc receptors.
A crude extract of adult comfrey leaves only showed a slight analgesic activity, and did not show anti-inflammatory activity in rats. Use was made of Wistar albino rats in which an inflammation was induced through the simultaneous injection of carageenan and prostaglandin E1 in order to evaluate the anti-inflammatory activity of freeze-dried plant extracts. The extract did not inhibit the inflammation, however, but suppressed the leukocyte infiltration during the 3rd and 4th hour of the induced inflammation.
The aqueous extract of the leaves markedly increased the production of prostaglandins (PGF2α, 6-keto-PGF1α) in rat gastric mucosa homogenates.
Two arabino-pyranosides, leontosides A and B,

were isolated from the dried rhizomes collected in Turkey. Both compounds were tested for their antibacterial activity against 6 Gram-negative and 6 Gram-positive bacteria. Leontoside A at 100 and 200 μg/100 μl showed activity against *Salmonella typhi*, *Staphylococcus epidermidis* and *Streptococcus faecalis*. However, leontoside B was only active against *Escherichia coli*, at 200 μg/100 μl. In another test, an aqueous extract of the rhizomes inhibited the release of oxygen free radicals by human polymorphonuclear leukocytes (PMNLs) stimulated with either opsonized zymosan or concanavalin A. However, it enhanced the generation and release of OFRs by unstimulated PMNLs. When injected into anaesthetized rats, symphytoxide-A (from the rhizomes) produced a fall in mean arterial blood pressure which was abolished by pre-treatment with atropine (1 mg/kg). In isolated guinea-pig atria, symphytoxide-A produced inhibitory effects on force and rate of contractions while in smooth muscle preparations such as guinea-pig ileum and rat uterus, it induced stimulant responses. All these responses were abolished in the presence of atropine (80 ng/ml), similarly to acetylcholine. In skeletal muscle preparation (frog rectus abdominis) symphytoxide-A produced contractions which were blocked by δ-tubocurarine, similar to those produced by acetylcholine, carbachol or nicotine. These results indicate the mechanism of action of symphytoxide-A to be mediated via the parasympathetic system.

Crushed aerial parts reduced the induction of micronucleated polychromatic erythrocytes by mitomysin C, dimethylnitrosamine and tetracycline, showing that the plant has antimutagenic effects. Heating did not affect its antimutagenic properties. An acetone extract was evaluated for mutagenic activity with the Salmonella/mammalian-microsome mutagenicity test (Ames), using tester strains TA98 and TA100 and in the presence and absence of induced rat liver microsomes. The extract produced toxic responses that were abolished in the presence of the microsomal bioactivation system. Furthermore, an alkaloid fraction was investigated for its chromosome-damaging effect in human lymphocytes in vitro. In concentrations up to 14 μg/ml the alkaloids had no effect, in concentrations of 140–1400 μg/ml the alkaloids induced sister chromatid exchanges (SCE) as well as chromosome aberrations. The influence of rat liver enzymes (S9) was also tested. The SCE-inducing capacity and the clastogenic effect of *Symphytum* alkaloids were increased by simultaneous application of S9-mix.

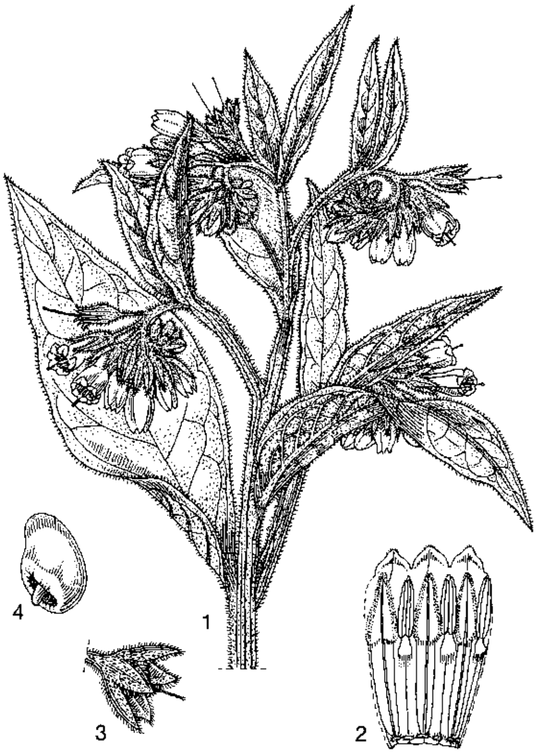
The toxicities of 5 different concentrations of saponin and crude saponin, isolated from *S. officinale*, and mercaptodimethylether (positive reference) to the snail *Physa acuta* were determined after exposure for 24 h. The LC_{50} for saponin, crude saponin and mesurol was 11.2, 10.7 and 3.4 ppm, respectively. Topical application of a crude ethanol extract of the leaves produced striking acaricidal effects on engorged *Boophilus microplus*, including mortality, inhibition of oviposition and inhibition of embryogenesis.

Egg yolk of Leghorn hens given *S. officinale* leaves was a more intense yellow colour than that of the controls. Chickens given 8% leaves showed no difference in weight gain from the controls but those given 2% decoction in their water showed an increase in weight gain. When up to 80% leaves was given in the feed or 20% in the water some chickens had diarrhoea and there were slight signs of congestion and haemorrhage in internal organs. With 8% comfrey in the diet, calcium and phosphorus balances were positive and bone mineralization was normal.

Adulterations and substitutes More than 350 pyrrolizidine alkaloids have been identified in over 6 000 plants in the *Boraginaceae*, *Compositae*, and *Leguminosae*.

Description A perennial, rough hairy herb, (30–)50–120 cm tall, stems stout, often branched, tillering; rhizome vertical, fleshy. Leaves alternate, simple, ovate-lanceolate to lanceolate, up to 25 cm × 15 cm, apex acuminate, base decurrent into petiole and stem, forming a wing, upper leaves sessile; stipules absent. Inflorescence a short terminal scorpioid cyme, many-flowered, bracts absent. Flowers bisexual; calyx 5-lobed, lobes lanceolate; corolla tube cylindrical, 12–18 mm long, lobes small, deflexed, purple-violet, dirty pink or white, scales 5 at throat, broadly triangular-lanceolate, papillate, lower marginal papillae shortly cylindrical-conical, upper much smaller and shorter; stamens 5, included, inserted at the middle of the tube, with connective projecting beyond thecae, filaments as wide as anther; ovary superior, 4-locular, style exserted, stigma very small, entire. Fruit dry, composed of 4 nutlets, calyx persistent. Nutlet ovoid, 5–6 mm long, very smooth, black, shining. Seedling with epigeal germination; cotyledons ovoid; first leaves alternate, hairy.

Growth and development *S. officinale* can be found flowering and fruiting throughout the year in the tropics. In temperate regions it flowers during spring and summer. Flowers are self-incompatible and are mainly pollinated by bees and bumble-bees.



Symphytum officinale L. – *1, flowering stem; 2, part of opened corolla; 3, fruit; 4, nutlet.*

Other botanical information *Symphytum* is native of Eurasia, and comprises 35 species. Morphological and chemotaxonomic studies indicated that *S.* ×*uplandicum* ($2n$ = 36 and 40) is a hybrid between *S. officinale* ($2n$ = 40 and 48) and *S. asperum*. The $2n$ = 40 cytotype of *S. officinale* is regarded as conspecific with *S. officinale* ($2n$ = 48) and not as its hybrid with *S. asperum*.

Ecology *S. officinale* occurs in its natural distribution area on river banks and damp grassland. It tolerates most soils, and even grows well on heavy clay soils.

Propagation and planting *S. officinale* can be propagated by seed, division or through in-vitro propagation from root explants. Seeds germinate easily on peat in water or watered loam. Optimal planting is at 70 cm × 70 cm.

In vitro production of active compounds Primary calluses were induced from roots, petioles, peduncles, stems and leaves cultured on solid Murashige & Skoog (MS) medium with 1.0 mg/l butyric acid (BA) + 0.01–1.0 mg/l indole acetic acid (IAA) or on solid Gamborg B5 medium with 2 mg/l 2,4-D + 1.0 mg/l BA or kinetin. The calluses were further subcultured on B5 medium. Calluses and cell suspension cultures regenerated whole plants on solid MS medium with 1.0 mg/l BA + 0.1 mg/l IAA. Plants regenerated from short-term cultures were identical in morphology and chromosome number to plants from which cultures were initiated. Pyrrolizidine alkaloid production ceased on prolonged subculturing of suspensions, although polyamines, which might act as precursors, were still detectable. Regenerated plants, however, produced the original alkaloids.

Husbandry *S. officinale* grows best in open localities, or with partial shade, in a deep, rich soil, at 70 cm intervals. In field trials with plants from root cuttings or seedlings, growth was most vigorous on rich garden soils, or alluvial soils, followed by brown soils, rendzinas and pseudo-podzolic soils.

Diseases and pests Comfrey rust (*Melampsorella symphyti*) is the biggest problem in *S. officinale*. The infection can be reduced by removing the infested leaves. In China, bacteria and mycoplasma-like organisms cause wilt and root rot. *S. officinale* is a host for the nematode *Meloidogyne incognita*.

Harvesting The roots of *S. officinale* should be harvested at the beginning or end of the growing season, when the allantoin levels are the highest. Leaves and flowers are harvested when needed.

Yield Dry root yields of *S. officinale* vary from 5 to 12 t/ha depending on soil type. The highest average allantoin content was found in roots from rendzinas (1.7%) and the lowest in those from pseudo-podzolic soils (0.9%).

Handling after harvest Harvested plant parts of *S. officinale* are used fresh or dried in the shade for future use. The roots can also be split down the middle and dried in an oven at 40–60°C.

Genetic resources and breeding *S. officinale* is widespread and common throughout its natural distribution area. In South-East Asia it is only cultivated on a small scale, and as the plants are probably mainly propagated through division, the genetic base may be small.

There are no known breeding programmes of *S. officinale*.

Prospects The possibilities for cultivation of *S. officinale* in other South-East Asian countries need further investigation, but do not seem very promising. The hepatotoxocity of the pyrrolizidine alkaloids limits application of *Symphytum* preparations to external applications, for instance in the treatment of contusions, strains and sprains.

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Other selected sources 2, 26, 98, 179, 208, 243, 252, 266, 308, 611, 648, 653, 696, 698, 723, 759, 815, 1065.

G.H. Schmelzer & S.F.A.J. Horsten

Synedrella nodiflora (L.) Gaertner

Fruct. sem. pl. 2: 456, t. 171 (1791).
COMPOSITAE
$2n = (36, 38), 40$

Vernacular names Pig's grass (En). Herbe à feu (Fr). Indonesia: bruwan (Javanese), jotang kuda (Sundanese), gofu makeang (Ternate). Papua New Guinea: walapon (Lontis, Buka Island, North Solomons Province), hosihaena (Pokama, Central Province). Philippines: fantankuen (Iloko). Thailand: phak kroet, sap kaa, yaa khu maa. Vietnam: b[oj] x[is]t, c[or] th[or].

Origin and geographic distribution *S. nodiflora* originates from the New World tropics, but became naturalized in the Old World in the 19th Century.

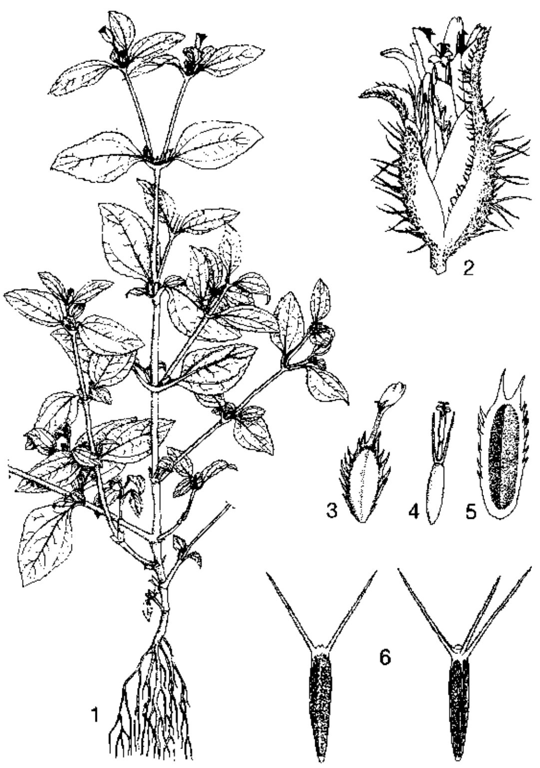
Uses In Indonesia, the leaves of *S. nodiflora* are used as a poultice for sore legs and rheumatism; in Africa the leaves are applied as an embrocation for different oedemas. In Ghana, an infusion of young leaves is used as a laxative. In Indonesia, the juice of the leaves is used for the treatment of earache, and in Africa for treatment of mouth affections such as infected gums. In Papua New Guinea, the root is chewed against diarrhoea, together with some other herbs. Dislocated bones are massaged daily with sap from the squeezed leaves. In Fiji, a decoction of the leaves is used to treat haemorrhoids and diarrhoea. A decoction of the pounded and cooked roots is drunk as a cough-mixture in Africa and in Barbados. In Colombia, the entire plant is used as an emmenagogue. *S. nodiflora* is not known to be used in Indo-China.
In Indonesia, tender leaves are used in salads. Horses, cattle, pigs and rabbits eat the plant readily.

Production and international trade *S. nodiflora* is not traded commercially, and is rarely found in local markets. Chinese herbalists in Indonesia stock the herb.

Properties Upon steam distillation of the leaves, *S. nodiflora* yields a yellow coloured essential oil (0.02%), with the terpenes β-caryophyllene, β-farnesene, germacrene-D and β-cubebene as major components. From the ethanol extract of the whole plant, the triterpenoid saponin nodifloside A (oleanolic acid-3-O-β-D-xylopyranosyl-(1 forward 4)-β-D-glucopyranuronosyl methylate) was isolated, together with the triterpenoid oleanic acid-3-O-β-D-glucopyranuronosyl methylate, and the steroids β-sitosterol, stigmasterol, stigmasterol-3-O-β-D-glycoside and rosasterol. *S. nodiflora* also contains a high content of estradiol.
An orally administered dried leaf extract of *S. nodiflora* was found to be active as an anti-inflammatory against adjuvant-carrageenan-induced inflammation in rats. It inhibited both acute and chronic phases, especially the chronic phase. The ethanol extract of the entire plant showed analgesic and antipyretic activity in rodents.
Furthermore, chloroform extracts of the foliage of *S. nodiflora* acted as a deterrent when tested on three pests of stored grain products: larvae and imagos of *Tribolium confusum*, larvae of *Trigoderma granarium*, and imagos of *Sitophilus granarius*. Water-soluble leaf extracts are effective against the egg-masses of the nematode *Meloidogyne arenaria*.

A substrate either of pure *S. nodiflora* plants or a mixture with other plants, and mixed with rice straw at a ratio of 1:1, produces a high yield of the edible mushroom *Pleurotus flabellatus*.

Description An annual herb, 25–90 cm tall, with a tough erect, subangular stem, sometimes prostrate and rooting at the nodes, repeatedly forked, appressed pilose. Leaves opposite, simple, elliptical to ovate, 1.5–12.5 cm × 0.5–9 cm, base cuneate, suddenly narrowed into the petiole and decurrent along it, apex acute, margins crenate-serrate, more or less hispidulous on both surfaces, distinctly triveined; petiole 0.5–5.5 cm long, the 2 opposite petioles connected by a small rim; stipules absent. Inflorescence an axillary or terminal head; involucral bracts 4–5, 2-seriate, narrowly oblong, outer ones about 9 mm long, acute, thinly white-hairy, finely glandular, pale green, inner ones about 7 mm long, subobtuse, glabrous, bracts clasping the flowers; peduncle absent or up to 4.5 cm long; heads 1(–7) per axil, 10–20-flowered, cylindrical when young, afterward campanulate, about 4 mm across. Ligulate flowers 3–8, accrescent during anthesis, about 4.5 mm long, very obtusely toothed, yellow; tubular flowers 6–10, 4 mm long, 4–5-lobed, yellow; anthers 4, connate, with an entire base and an obtuse top, blackish-brown; style-arms 2, long, pubescent, with acute, glabrous tips. Fruit an achene, of ligulate flowers oblong, 4–5.5 mm × 3 mm, dorsally flattened with a broad wing along the margins, with 5–9 acute erect-patent lobes, and 2 apical bristles, 2–2.5 mm long, the wings first black, later yellow, glabrous; achene of tubular flowers slender, narrowly wedge-shaped, 4–5 mm long, ribbed, often warty, with 2–3 bristles, 3–5 mm long, glabrous or with short hairs, black or dark-brown; pappus absent. Seedling with epigeal germination; hypocotyl up to 2 cm long, purplish red; cotyledons 2, petiole 1–2 cm long, blade elliptical to ovate, up to 7 mm long, glabrous, midvein distinct; epicotyl short, densely appressed hairy; first leaves opposite, subsessile, ovate, up to 10 mm long, margins shallowly toothed, sparsely hairy.



Synedrella nodiflora (L.) Gaertner – 1, plant habit; 2, flower head; 3, ligulate flower; 4, tubular flower; 5, achene of ligulate flower; 6, achenes of tubular flower.

Growth and development The life cycle of *S. nodiflora* can be completed in less than 2 months. Flower heads and fruits may be present throughout the year. The achenes are easily dispersed clinging to clothes and fur. It is a weed of minor importance, because it does not root deeply.

Other botanical information *Synedrella* is a monotypic genus, belonging to the tribe *Heliantheae*, and taxonomically close to *Wedelia*. *S. nodiflora* is a highly variable, weedy species.

Ecology *S. nodiflora* is found throughout South-East Asia from sea-level up to 1200 m altitude, on open waste places, along roadsides and as a common weed.

Propagation and planting *S. nodiflora* propagates by achenes, and has no dormancy.

Husbandry *S. nodiflora* has been cultivated in trials in Benin, as fodder for rabbits.

Diseases and pests *S. nodiflora* is a host for *Meloidogyne* species, and the yam nematode (*Scutellonema bradys*). It is also a host for the fungus *Corynespora cassiicola*, which attacks tomato and eggplant severely, and cotton and sesame moderately. *S. nodiflora* is often attacked by a mottle virus, leaving a distinct pattern on the leaves.

Harvesting The leaves of *S. nodiflora* are collected from the wild whenever the need arises.

Genetic resources and breeding *S. nodiflora* has a large area of distribution and often inhabits anthropogenic localities. It does not seem to be at risk of genetic erosion. There is a small germplasm collection of *S. nodiflora* in Bogor (Indonesia).

Prospects Very little is known about the chemistry and pharmacology of *S. nodiflora*. It will therefore probably remain of minor local importance.

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Other selected sources 74, 102, 134, 135, 215, 315, 336, 370, 407, 418, 477, 560, 647, 696, 761, 788, 951.

Syamsul Hidayat

Tabernaemontana L.

Sp. pl. 1: 210 (1753); Gen pl. ed. 5: 100 (1754).

APOCYNACEAE

$x = 11$; for most species: $2n = 22$, *T. divaricata*: $2n = 22, (23), 33, (34)$, *T. sphaerocarpa*: $2n = 66$

Major species *Tabernaemontana divaricata* (L.) R.Br. ex Roem. & Schult., *T. pandacaqui* Poir.

Vernacular names Malaysia: susun kelapa.

Origin and geographic distribution *Tabernaemontana* comprises 99 species and has a pantropical distribution. 44 species are found in the New World, 18 in Africa, 15 in Madagascar, 1 in the Mascarene Islands and 21 in Asia, Oceania and Australia. All species are restricted to one of the five geographical areas. *T. pandacaqui* is by far the most widely distributed. It is known from Thailand to the Pacific, and from Taiwan to south-eastern Australia, with the exception of more humid areas. The closely allied *T. pauciflora* Blume is found where *T. pandacaqui* is absent, although there are areas of overlap. *T. divaricata*, mostly the double-flowered form, is commonly grown throughout the tropics. *T. corymbosa* Roxb. ex Wallich is known from southern China to Indonesia. Three geographically separate species share the Malesian region. *T. macrocarpa* Jack is confined to western Malesia, the closely allied *T. sphaerocarpa* Blume occurs exclusively in Java, Sulawesi and nearby islands to the north and south, and *T. aurantiaca* Gaud. occurs in the eastern Moluccas, New Guinea and further eastward. Local endemics are also common.

Uses The most common use of *Tabernaemontana* in Malaysia is for the treatment of ulcerations of the nose. In general pulped roots, or less commonly leaves, are simply drawn into the nostrils. Poultices of leaves and roots of various species are applied to boils. Leaves, bark or latex of several species are an ingredient of mixtures used as dart poison. In Malaysia, a decoction of the leaves of *T. pauciflora* is used to treat hypertension, while the roots are applied during and after confinement. In Thailand, the roots of *Tabernaemontana* have been employed in folk medicine, mostly for the treatment of inflammations and fever. *T. bufalina* Lour. (synonyms *T. luensis* Pierre ex Pitard, *T. microphylla* Pitard) is used in Indo-China for its emollient and laxative properties. In China the plant is used against rheumatoid arthritis, and is applied to boils, swellings, sprains and bruises. The latex of *Tabernaemontana* coagulates into a resinous rubber. However, collecting latex of even the most prolific species proved too laborious to be economically feasible. Flowers of *Tabernaemontana*, in particular *T. pandacaqui* and *T. divaricata*, are used for decoration.

Production and international trade *Tabernaemontana* is used at the local level only. Plants for ornamental purposes are occasionally sold in local nurseries.

Properties By far the most important group of phytochemical constituents of *Tabernaemontana* are the alkaloids, sometimes also referred to generally as Iboga alkaloids. All of them belong to a group of monoterpenoid indole alkaloids, of which the biosynthetic precursors are the amino acid tryptophan (alkaloid part) and the iridoid secologanin (monoterpenoid part). Extensive reviews of the numerous different compounds isolated can be found in literature; for the important South-East

Asian species this is condensed into the following summary.

From *T. aurantiaca* ibogaine, voacangine, and vobtusine, from *T. corymbosa* conodiparine A–D (vobasine type) and ervatamine, and from *T. dichotoma* apparicine, coronaridine, (–)-heyneanine, perivine, tabersonine and vobasine have been isolated. *T. divaricata* contains apparicine, coronaridine, (+)-heyneanine, (–)-heyneanine, ibogamine, vobasine, voacamine and voacangine, and *T. macrocarpa* coronaridine, voaphylline, voacangine. *T. pandacaqui* contains apparicine, coronaridine, ervatamine, iboganine, isovoacangine, pericyclivine, tabernaemontanine, tabernanthine, voacristine and voacangine, *T. pauciflora* contains coronaridine, and *T. sphaerocarpa* dregamine and tabernaemontanine.

At present, of the numerous different compounds isolated, some 83 of them have also been studied pharmacologically in more detail and information is summarized here. Many pure alkaloids show chemotherapeutic activity, such as cytotoxic, antimicrobial, antiprotozoal and antiviral effects. For instance apparicine showed activity against Polio III virus in vitro at a concentration of 250 μg/ml, and at a concentration of 1.2% the alkaloid exhibited antimicrobial activity against *Corynebacterium*, *Escherichia*, *Proteus*, *Pseudomonas*, *Salmonella* and *Staphylococcus*. Examples of alkaloids which have antitumour effects include apparicine (P-388 leukaemia, in vitro), camptothecine (from the Indian species *T. heyneana* Wallich; P-388 and KB cells, in vitro) and olivacine (from the Brazilian *T. hystrix* Steud.; KB cells, in vitro, L1210 leukaemia in vivo). The latter compound also inhibited the growth of the protozoa *Trypanosoma cruzi* in culture.

Apart from the chemotherapeutic activity, many alkaloids possess other activities, mostly related to the central nervous system (CNS), such as hypotensive- and cardiac depressant, analgesic and local anaesthetic activities. Coronaridine showed autonomic and CNS activity. In mice it produced analgesia and was effective in suppressing rage caused by foot-shock. The substance showed oestrogenic activity, and there was a partial inhibition of the oxytocin-induced uterine response. Ervatamine and perivine are both examples of alkaloids with local anaesthetic effects, acting by their influence on Na^+-channels. In cats and dogs, ibogaine has distinct central-stimulating properties, different from those of strychnine, which can be abolished by atropine. In mice, it has weak but definite anticonvulsant properties. Ibogaine furthermore has a transient hypotensive effect. It also acts as a true hallucinogenic agent, and it can be used as a substitute for cocaine. When administered intravenously to anaesthetized guinea-pigs, ibogaine produced a bradycardia that was resistant to vagotomy and administration of atropine. The blood pressure was lowered, but there was no alteration in the electrocardiogram (ECG). In addition, the pharmacology of ibogamine is quite similar to that of ibogaine. Finally, voacamine (as its sulphate) has pharmacological properties comparable with those exhibited by cardiac glycosides. It may therefore be useful in treating cardiac insuffiency. Voacangine exhibited a slight central stimulating effect in a general screening procedure. When injected into guinea-pigs, it produced the same effects as ibogaine.

The effects of a crude alkaloidal (CA) fraction from the stem of *T. pandacaqui* on the blood pressure and heart rate were investigated in conscious as well as anaesthetized rats. The CA fraction exerted a hypotensive activity in both experimental models. In pentobarbital anaesthetized rats, an intravenous administration of the CA fraction caused two consecutive hypotensive and bradycardiac responses. In order to investigate the mechanism of the responses, the effect of the CA fraction on the blood pressure and the heart rate was tested in various experimental animals such as pithed rats, reserpinized rats under pentobarbital anaesthesia and atropine- or chlorpheniramine-treated rats under pentobarbital anaesthesia. The results obtained suggest that the hypotensive and bradycardiac responses of the first phase might involve cholinergic and central mechanisms, whereas those of the second phase involve mechanisms which are mediated by central, biogenic amines, acetylcholine and histamine. In addition, an alkaloidal fraction of *T. dichotoma* showed hypotensive activity, and the crude alkaloids from the leaves of *T. pauciflora* also showed slight but lasting hypotensive effects.

The crude alkaloidal (CA) fraction from the stem of *T. pandacaqui* was further studied for its pharmacological activity on the central nervous system (CNS) of animals. The CA fraction was found to produce symptoms of CNS depression in conscious rats and mice, in the form of decrease in spontaneous motility, potentiation of pentobarbital sleeping time, prolongation of latency of convulsions induced by pentylenetetrazole, and antinociception; the fraction could not antagonize oxotremorine-induced tremor. The observations suggest that the CA fraction possesses CNS-depressant activity. Sedative effects were also found in experiments with an alkaloid fraction of *T. dichotoma*.

A screening of ethanolic extracts from 19 *Tabernaemontana* species indicated that most of them showed a broad spectrum of antibacterial activities; some species also showed antiviral and antiamoebic activities. In particular *T. divaricata* and *T. pandacaqui* were strongly active against gram-negative bacteria at low concentration and strongly active against gram-positive bacteria. *T. aurantiaca* was strongly active against gram-positive bacteria and moderately active against gram-negative bacteria. In addition, the dimeric indole alkaloids seemed to play an important role in the antibacterial activity.

Crude extracts of *T. divaricata* and *T. dichotoma* had anticancer activity. Alkaloidal fractions from the seed, roots and pods depressed bone-marrow activity in rats, resulting in temporary leukopenia.

The alkaloid fraction of the methanol extracts of dried twigs of *T. divaricata* showed hypotensive activity in rats owing to interference in sympathetic transmission, almost abolished the reflex response to bilateral occlusion of the common carotid, and depressed the effect of norepinephrine; it also showed uterine relaxant activity in vitro and in vivo.

Pharmacological effects of *Tabernaemontana*, without direct mention of the presence of alkaloids include: ethanolic extracts of roots, stems, leaves and flowers of *T. divaricata* and *T. pandacaqui* caused sedation, decreased respiration and decreased skeletal muscle tone in rats. All extracts of *T. pandacaqui*, except for the leaf extract caused vasodilatation of ear vasculature. Analgesic activity was found for all extracts except for the flower extract of *T. divaricata*. Lethal doses of the extracts caused the animals to die from respiratory paralysis. Root and stem extracts showed the greatest activity. *T. pandacaqui* extracts were more potent than those of *T. divaricata*.

Intravenous injection of ethanolic extracts of the stem, leaves and flowers of *T. pandacaqui* caused hypotension in pentobarbital anaesthetized rats. At high doses (100–300 mg/kg), the flower extract showed a transient hypertensive effect preceding hypotensive activity. The effects of the extract on the heart rate of anaesthetized rats correlated well with the negative chronotropic and inotropic activity observed with isolated atrium. The hypotensive activity was not inhibited by antihistaminic and antimuscarinic agents. The extracts had no effect on the pressor effects induced by norepinephrine or dual carotid occlusion. These results suggest that the hypotensive action of the extracts is not mediated through histaminic and muscarinic receptors stimulation, α-adrenoceptor blockade or interference of sympathetic transmission.

Ether and ethanol extracts of *T. divaricata* at 1.5% concentration have insecticidal and ovicidal activity against *Dysdercus koenigii* (red cotton bug) comparable to or even stronger than those of neem extract (*Azadirachta indica* A.H.L. Juss.).

In a screening experiment to identify possible agents of therapeutic value in immunoglobulin A nephropathy (IgA-N), a crude methanol extract of *T. divaricata* was tested for its effect on human mesangial cell proliferation. The crude extract inhibited human cells proliferation activated by interleukin-1β (IL-1β) and IL-6 at a median inhibitory concentration of 50.0 ± 2.1 μg/ml. The herb also decreased IL-1β and tumour necrosis factor (TNF-α) production. It is unlikely that cytotoxicity was involved, because no cell deaths were observable. It is hypothesized that the inhibitory mechanisms of the herb may be related to the impairments of gene expression and production of cytokines in human mesangial cells.

Adulterations and substitutes Plants producing alkaloids of the ibogan and bis-indole type are mostly confined to closely related genera of the tribe *Tabernaemontaneae* (e.g. *Voacanga*), with the exception of e.g *Catharanthus roseus* (L.) G. Don. Alkaloids such as vincamine are found in large amounts in *Vinca minor* L. (*Apocynaceae*), and yohimbane found in South-American *Tabernaemontana* species is also found in the African *Corynanthe johimbe* K. Schum. (*Rubiaceae*).

Description Shrubs or trees, repeatedly dichotomously branched from low down; trunk terete, bark with much white latex, wood rather soft, branches with conspicuous leaf scars, with usually 2 inflorescences just above each ramification. Leaves simple, opposite, those of a pair equal or subequal, broadly to narrowly elliptical or obovate, base equal or unequal-sided, entire or sometimes sinuate or undulate; petiolate or sessile, petioles of a pair usually connate into a conspicuous ocrea, ocrea frequently widened into intrapetiolar stipules. Inflorescence corymbose, rather lax to congested. Flowers 5-merous, actinomorphic except for the subequal sepals, fragrant; sepals very variable in size, colour and shape; corolla white, pale yellow or mauve, the tube often greenish, the throat often pale yellow, the tube mostly at least twice as long as the calyx, twisted or not, lobes overlapping to the left and folded inwards; stamens included or less often exserted; ovary superior, composed of 2 carpels variably connate at the base; pistil head not coherent with the anthers. Fruit composed of two mericarps variably united at the base, subglobose to pod-like, many-seeded. Seed obliquely ellipsoid, covered by an aril. Seedling with epigeal germination.

Growth and development *Tabernaemontana* flowers and fruits throughout the year, with some species flowering and fruiting simultaneously, particularly in areas without a pronounced dry season. However, some periodicity can be observed. Flowering and fruiting of relatively widespread species vary between regions. Flowering and fruiting of various species within a region is not always synchronized.

Other botanical information *Tabernaemontana* belongs to the tribe *Tabernaemontaneae* of the subfamily *Plumerioideae*. It is closely related to the Old World genus *Voacanga* and the New World genus *Stemmadenia*. *Tabernaemontana* has been further divided into 7 sections, of which the following are represented in Malesia: section *Ervatamia* (e.g. *T. corymbosa*, *T. divaricata*, *T. pandacaqui*, *T. pauciflora*), section *Pagiantha* (e.g. *T. macrocarpa*, *T. sphaerocarpa*) and section *Rejoua* (*T. aurantiaca*). Sinking *T. orientalis* R.Br. in the synonymy of *T. pandacaqui* is disputed by some authors on the basis of morphological characters of leaves and stamens and habitat preferences, the species being allopatric on the local scale. *T. orientalis* in Australia is found in habitats near the sea, whereas *T. pandacaqui* is found on volcanic soils away from the sea.

Ecology *Tabernaemontana* species can be found in a wide range of habitats from relatively open scrub vegetation to forest understorey, from dry limestone outcrops to periodically inundated riverine and swamp forest, ranging from sea-level to 1800 m altitude.

Propagation and planting *Tabernaemontana* is usually propagated by seed. Double-flowered forms and desired cultivars are propagated by semi-ripe cuttings during the growth season or by layering before the new growth starts.

Husbandry *T. divaricata* and *T. pandacaqui* are widely cultivated as ornamentals. They are grown outdoors in frost-free climates, in borders or informal hedges. They may also be grown in large pots or tubs as conservatory plants, moved outdoors for the summer. They prefer full sun or light shade and a well-drained but moisture retentive, high-fertility, loam-based mix. Grown as pot plants, they should be repotted and pruned when necessary to restrict size, before the new growth starts, cutting back flowered stems by about one half.

Diseases and pests Aphids, scale insects and mealybug may be pests in pot plants of *Tabernaemontana*.

Harvesting Roots of *Tabernaemontana* are dug up, bark is stripped from the trunk, fruits are collected when ripe and leaves are harvested whenever the need arises. Latex can be obtained by tapping the trunk or by crushing the leaves.

Yield Although the alkaloid composition of *T. dichotoma* from different localities is fairly constant,the percentage of the alkaloids may vary.

Genetic resources and breeding Double-flowered *T. divaricata* is sometimes traded as cv. 'Flore Pleno', double-flowered and large-leaved plants as cv. 'Grandifolia'.

Prospects Many of the alkaloids of *Tabernaemontana* display various interesting pharmacological effects, which may explain the actions of crude extracts, or even of the simplicia themselves. Some alkaloids or even the plants themselves have been tested in a clinical setting (e.g. voacamine), but in general more informaton is needed, especially on toxicology and/or long term effects of these compounds to evaluate their potential in medicine. Some compounds e.g. the ones with chemotherapeutic activity might be of interest as lead compounds in drug research.

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Beek, T.A., Verpoorte, R., Baerheim Svendsen, A., Leeuwenberg, A.J.M. & Bisset, N.G., 1984. Tabernaemontana L. (Apocynaceae): a review of its taxonomy, phytochemistry, ethnobotany and pharmacology. Journal of Ethnopharmacology 10: 1–156.

Selection of species

Tabernaemontana aurantiaca Gaud.

in Freycinet, Voy. Uranie: 50, 55 (1826).

Synonyms *Tabernaemontana novoguineesis* Scheff. (1876).

Distribution From the Moluccas (Seram) eastward throughout New Guinea to Vanuatu.

Uses In Bougainville Island and Solomon Islands, plant sap mixed with coconut oil is employed as a vesicant.

Observations A tree or less often a shrub, 3–15 m tall; trunk 5–30 cm in diameter; leaves of a pair equal or unequal, elliptical or obovate, 5–33 cm × 3–15.5 cm, 1.5–3.5 times longer than wide, apex apiculate or acuminate, petiole 8–45 mm long, ocrea not widened into intrapetiolar stipules; inflorescence rather lax, few-flowered, 8–20 cm × 3–11 cm; flowers sweet-scented, open during the night, sepals pale green, corolla in mature bud 21–28 mm long with a wide ovoid head for 20–30% of the length, apex blunt or acute, tube 5–10 times longer than the calyx, 12–24 mm long, not twisted; fruit consisting of 1–2 separate mericarps, variably shaped, orange or red, 10–20-seeded, aril white. *T. aurantiaca* is found in coastal flood plains, periodically inundated riverine and swamp forest and occasionally on limestone, from sea-level up to 125 m altitude. It flowers and fruits simultaneously throughout the year.

Tabernaemontana corymbosa Roxb. ex Wallich

Bot. Reg. 15: sub t. 1273 (1829).

Synonyms *Tabernaemontana hirta* Hook.f. (1882), *Ervatamia hirta* (Hook.f.) King & Gamble (1908), *Pagiantha peninsularis* Kerr (1937).

Vernacular names Malaysia: susun kelapa, jelutong badak, pokok restong. Thailand: sang laa (peninsular). Vietnam: l[af]i tr[aa]u t[as]n.

Distribution From southern China, southward to Indo-China, Burma (Myanmar), Thailand, Peninsular Malaysia, Borneo, Sumatra and Flores.

Uses In Peninsular Malaysia, sap of the leaves is applied to sores. Pounded roots, a poultice of the leaves, a decoction of the bark, juice from the plant, or an infusion of the inner bark or the roots are all used to remedy various syphilitic afflictions. The roots are used during and after confinement. In Thailand and Malaysia, the roots are an ingredient of arrow poison.

Observations A shrub or small tree, 0.8–8(–12) m tall, stem 3–10(–20) cm in diameter; leaves elliptical to obovate, 7–30 cm × 2–14 cm, 2–4 times longer than wide, apex acuminate or caudate, petiole 3–20 mm long; inflorescence lax, 5–13 cm × 4–6 cm, 2–25-flowered; flowers fragrant or not, open during the day, sepals green, corolla in mature bud 17–32 mm long with a wide broadly ovoid head for 25–30% of the length, apex blunt, tube 6–11 times longer than the calyx, (15–)18–28(–31) mm long, twisted 0.25–0.5 turn or not just below or around the anthers; fruit consisting of 2 separate mericarps, obliquely ellipsoid, orange, red or yellow, 5–20-seeded, aril orange or red. *T. corymbosa* is found in scrub or forest from sea-level to 1500 m altitude. It flowers and fruits throughout the year in areas without a pronounced seasonal climate.

Selected sources 135, 407, 672, 786.

Tabernaemontana dichotoma Roxb. ex Wallich

Bot. Reg. 15: sub t. 1273 (1829).

Synonyms *Ervatamia polyneura* King & Gamble (1908), *Ervatamia dichotoma* (Roxb.) Burkill (1935).

Distribution Sri Lanka, Burma (Myanmar) and Peninsular Malaysia.

Uses In Sri Lanka, the fruits are used in the treatment of ulcers and fistulae. The latex is used to soften and ripen boils and carbuncles. Pounded leaves and bark are externally applied on snake and centipede bites. A preparation of the bark is poulticed on grazed skin as an antiseptic and astringent. Chewing the roots is said to relieve toothache. The seeds induce delirium and symptoms similar to those induced by *Datura*.

Observations A small tree or shrub, 2–12(–20) m tall, trunk 15–30 cm in diameter; leaves elliptical to oblong, 3.5–23 cm × 1.4–9.5 cm, 2–5 times longer than wide, apex rounded, obtuse or rarely clearly acuminate, petiole 10–30 mm long; inflorescence rather lax, 6–20 cm × 5–10 cm, few-many-flowered; flowers sweet-scented, open during the night, sepals pale green, corolla in mature bud 20–38 mm long with a comparatively wide ovoid head for 25–40% of the length, apex blunt, tube 3–6(–8) times longer than the calyx, 13–26 mm long, not twisted; fruit consisting of 2 separate mericarps, obliquely ellipsoid, with two lateral ridges, orange, 4–40-seeded. *T. dichotoma* is found in montane forest and scrub from 750–1500 m altitude.

Selected sources 135, 783.

Tabernaemontana divaricata (L.) R.Br. ex Roem. & Schult.

Syst. veg. 4: 427 (1819).

Synonyms *Tabernaemontana coronaria* (Jacq.) Willd. (1809), *Ervatamia divaricata* (L.) Burkill (1925), *Tabernaemontana siamensis* Warb. ex Pitard (1933).

Vernacular names Coffee rose (double-flowered plants, En), East-Indian rose-bay, crape jasmine (En). Indonesia: mondokaki (Javanese), bunga nyingin (Balinese), bunga manila (Moluccas). Malaysia: susun kelapa, bunga susu, susok ayam. Philippines: pandakaking-tsina (Tagalog). Thailand: phut sa, phut suan (central). Vietnam: b[as]nh h[or]i, ng[oj]c b[us]t.

Distribution. Native to northern and eastern India, Nepal, Bhutan, Bangladesh, Burma (Myanmar), northern Thailand and southern China. Cultivated throughout the tropics for its ornamental and fragrant flowers.

Uses In Peninsular Malaysia and Thailand, the pounded leaves are an ingredient of a cough medicine taken as an infusion. The pounded roots are applied to sore eyes, but in India, the same complaint is treated using the flowers mixed with oil. In Indonesia, a decoction of the roots is used as an astringent for diarrhoea and various abdominal complaints. In Thailand, the plant is used as an emetic. In Indo-China, an infusion of the roots is applied as a remedy for jungle fever. In India, the applications in traditional medicine are so numerous the plant may well be classified as a panacea for gastro-intestinal, urogenital and skin affections. In northern India, the latex of the leaves is used as a cooling application for wounds to prevent inflammation. The root is employed as a local anodyne and chewed for the relief of toothache. The plant is a constituent of various medicines for the treatment of eye conditions. The wood is used as a refrigerant. The wood is also used as incense and for perfumery.

Observations A shrub or small tree, 0.5–2(–5) m tall, stem 3–10 cm in diameter; leaves elliptical to narrowly elliptical, 3–18 cm × 1–6 cm, 2.2-4 times longer than wide, apex acuminate, petiole 3–10 mm long; inflorescence rather lax, 3–14 cm × 3–8 cm, 1–30-flowered; flowers sweet-scented, open during the day, sepals pale green, corolla in mature bud 21–35 mm long with a comparatively wide ovoid or sometimes globose head for 25–40% of the length, apex acute or obtuse, tube (6–)7–10 times longer than the calyx, 15–27 mm long, twisted 0.1 turn or not just below the anthers; fruit consisting of 2 separate mericarps, obliquely and narrowly ellipsoid or pod-like, with 2 lateral ridges at each side and an adaxial indented line of dehiscence, orange, red or green, 2–10-seeded, aril deep orange or red. *T. divaricata* is found in light forest usually in the hills from sea-level to 1400 m altitude.

Selected sources 135, 215, 241, 300, 374, 380, 407, 672, 786, 810.

Tabernaemontana macrocarpa Jack

Mal. Misc. 2(7): 80 (1822).

Synonyms *Tabernaemontana megacarpa* Merr. (1909), *Tabernaemontana plumeriaefolia* (Elmer) Merr. (1923).

Vernacular names Indonesia: simbar badak.

Distribution Thailand (peninsular), Peninsular Malaysia, Sumatra, Borneo and the Philippines.

Uses In Sabah, the fruit is used to relieve toothache. In Kalimantan, the chopped root is an ingredient of arrow poison. In Sumatra, the sticky latex is applied as birdlime.

Observations A tree, 5–25 m tall, trunk 10–50(–100) cm in diameter; leaves elliptical to narrowly elliptical, (5–)10–41 cm × (2–)4–22 cm, (1.5–) 2–4.4 times longer than wide, apex acuminate or less often apiculate or rounded, petiole 10–40 mm long; inflorescence lax, 7–20 cm × 5–15 cm, few–many-flowered, pedicel (3–)10–45 mm long, bracts absent; flowers fragrant, open during the night, sepals pale green or orange, with 12–30 colleters in 1–3 rows, corolla in mature bud 15–31 mm long with a comparatively broadly ovoid or subglobose head for 25–40% of the length, 2–3 times as wide as the narrowest part of the tube, apex acute or blunt, tube 2.5–5 times longer than the calyx, 10–21 mm long, not twisted; fruit consisting of 2 separate mericarps, subglobose or less often obliquely ellipsoid, dehiscent, orange or red, many-seeded, aril crimson or pale red. *T. macrocarpa* is found in forest understoreys or less often scrub from sea-level to 1000 m altitude. It flowers and fruits throughout the year.

Selected sources 407, 672.

Tabernaemontana pandacaqui Poir.

in Lamarck, Encycl. 7: 529 (1806).

Synonyms *Tabernaemontana orientalis* R.Br.

(1810), *Tabernaemontana cumingiana* A.DC. (1844), *Ervatamia pandacaqui* (Poir.) Pichon (1949).

Vernacular names Papua New Guinea: oru (Hulu, Central Province), karaban (Nyamikum, Sepik). Philippines: kampupot (Tagalog), pandakaki (Tagalog, Bisaya, Pampangan). Thailand: put farang (Bangkok), phut tum (northern).

Distribution From Thailand and southern Taiwan throughout the Philippines to Sabah, from East Java and Sulawesi eastward throughout New Guinea into the Pacific and northern and eastern Australia.

Uses In the Philippines a poultice of the leaves is applied as an emmenagogue and to hasten parturition. A decoction of the leaves is added to the bath of women after parturition. A decoction of the root and bark is taken to relieve affections of the stomach and intestines. The latex is applied as an emollient to bruises and wounds, and to swellings. In Thailand, the roots are used as an antidiarrhoeal. In Papua New Guinea, the root is scraped and rubbed onto a sore nose. Sap from the ripe fruit is applied to skin affected by ringworm

Tabernaemontana pandacaqui Poir. – 1, flowering and fruiting branch.

(*Tinea imbricata*). In Fiji, a poultice of the plant is used to reduce swellings and abscesses.

Observations A shrub or small tree, 1–14 m tall, trunk up to 20 cm in diameter; leaves elliptical to narrowly elliptical, (1.5–)3–25 cm × (0.4–) 1–10 cm, 1.7–4(7) times longer than wide, apex obtuse or sometimes rounded, secondary veins usually pale green on both sides, petiole 3–20 mm long; inflorescence rather lax or more or less congested, 3–11 cm × 3–16 cm, 1-many-flowered; flowers slightly scented or not, open during the day, sepals pale green, corolla in mature bud 10–31 mm long with a comparatively wide subglobose or mostly broadly ovoid head for 15–40% of the length, apex blunt or rounded, tube 3.7–11 times longer than the calyx, 8–22 mm long, twisted 0.25–0.5 turn or not just below the anthers; fruit consisting of 2 separate mericarps, obliquely ellipsoid or less often subglobose, with 1 adaxial and 1–2 lateral ridges or wings, orange, red or yellow, 2–40-seeded. *T. pandacaqui* is found in forest or bush, often on limestone from sea-level to 1800 m altitude. It flowers and fruits throughout the year. In the Philippines flowering peaks in March-June and fruiting in September-November; in Papua New Guinea flowering peaks in March and November-December and fruiting in January and September.

Selected sources 128, 241, 317, 380, 418, 672, 758, 786, 810.

Tabernaemontana pauciflora Blume

Bijdr. fl. Ned. Ind. 16: 1028 (1826).

Synonyms *Tabernaemontana malaccensis* Hook.f. (1882), *Tabernaemontana polysperma* Merr. (1922), *Tabernaemontana dinhensis* Pitard (1933), *Tabernaemontana harmandiana* Pierre ex Pitard (1933), *Tabernaemontana sralensis* Pierre ex Pitard (1933).

Vernacular names Malaysia: lelada, susun kelapa, pokok restong. Thailand: prik paa, mok (south-eastern). Vietnam: l[af]i tr[aa]u [is]t hoa.

Distribution Burma (Myanmar), Thailand, Indo-China, Peninsular Malaysia, Singapore, Sumatra, West and Central Java and Borneo.

Uses In Peninsular Malaysia, various parts of the plant are applied as a poultice for boils. A decoction of the bark, juice from the plant, or steam from boiling the plants is used to remedy various syphilitic afflictions. In Cambodia, fruits are used to treat eruptions of the skin, and the root is used against snakebites. Shavings of the root are sometimes included in preparations for dart poison. In Sabah, the plant is used to cure headaches. In

Vietnam, an infusion of the root is prescribed for indigestion and colic. In Thailand, the roots, leaves and fruits are used to remedy internal abscesses, they may be taken internally or made into a poultice and applied externally. The roots are also used as an antipyretic.

Observations A shrub or small tree, 0.5–2(–6) m tall, stem 2–10 cm in diameter; leaves elliptical to narrowly elliptical, 3–26 cm × 0.6–10 cm, 1.9–4.2 times longer than wide, apex acuminate or caudate, petiole 2–7 mm long; inflorescence lax, 3–10 cm × 2–5 cm, 3–15(–20)-flowered; flowers sweet-scented, open during the day, sepals pale green, more or less leafy, corolla in mature bud 14–38 mm long with a comparatively wide ovoid head for 20–30% of the length, apex acuminate or obtuse, tube 4–8(–20) times longer than the calyx, 12.5–23(–32) mm long, twisted for 0.25–0.5 turn or not just below the anthers; fruit consisting of 2 separate mericarps, obliquely ellipsoid or narrowly so, with 1–2 lateral and 1 adaxial ridges as line of dehiscence, orange or yellow, several-seeded, aril red. *T. pauciflora* is found in the forest understoreys, often on stream banks from sea-level to 600 m altitude. In Malaysia and Indonesia it flowers and fruits throughout the year with a peak of flowering in March–May and of fruiting in September–November.

Selected sources 135, 672, 758.

Tabernaemontana peduncularis Wallich

Bot. Reg. 15: sub t. 1273 (1829).

Synonyms *Tabernaemontana graciliflora* Wallich (1829), *Ervatamia repeuensis* Pierre (1906), *Ervatamia peduncularis* (Wallich) King & Gamble (1908).

Vernacular names Malaysia: lelada, sejarang. Thailand: phut dong (south-eastern). Vietnam: l[af]i tr[aa]u cu[oos]ng.

Distribution Southern Burma (Myanmar), Thailand, Cambodia, Vietnam, Peninsular Malaysia and Singapore.

Uses In Malaysia a decoction of the roots is used as a steam bath to alleviate ulcerations of the nose. Likewise a decoction is drunk to treat ulceration of the nose in tertiary syphilis. The plant is considered poisonous.

Observations A shrub or small tree, 1–5 m tall, stem 2.5–3.5 cm in diameter; leaves elliptical to narrowly elliptical, 5–28 cm × 1.5–9 cm, 2–4.4 times longer than wide, apex acuminate or caudate, petiole 4–15 mm long; inflorescence delicate, lax, 5–25 cm × 4–12 cm, many-flowered; flowers fragrant, open during the day, sepals yellow-green, corolla in mature bud 7–23 mm long with a comparatively wide subglobose head for 10–20% of the length, apex blunt, tube 8–12 times longer than the calyx, 8–21 mm long, not twisted; fruit consisting of 2 separate mericarps, obliquely ellipsoid or narrowly so, dehiscent, orange, red, yellow or green, 1–2-seeded. *T. peduncularis* is found in forest understoreys from sea-level to 1700 m altitude. It flowers and fruits throughout the year with peaks in March–April in Burma (Myanmar), June in Thailand, and although less clear also June in Malaysia, fruiting mainly in November–February.

Selected sources 135, 672.

Tabernaemontana rostrata Roxb. ex Wallich

Bot. Reg. 15: sub t. 1273 (1829).

Synonyms *Tabernaemontana crispa* auct. non Roxb. (1829), *Ervatamia cylindrocarpa* King & Gamble (1908), *Ervatamia rostrata* (Roxb. ex Wallich) Markgr. (1935).

Vernacular names Indonesia: daggi (Siberut). Malaysia: lelada, tandok-tandok. Thailand: phut (central), khem dong (northern).

Distribution From eastern India, through Burma (Myanmar), Thailand, Peninsular Malaysia, Sumatra, Borneo to the Philippines (Luzon, Palawan).

Uses In Peninsular Malaysia, the leaves pounded with turmeric (*Curcuma longa* L.) and rice are used as a poultice against itch and eczema. A steam bath of the leaves is applied for syphilitic afflictions. In Indonesia, on Siberut (Mentawai Islands), bark and leaves are ingredients of a dart poison, which also includes *Capsicum* fruits and *Derris elliptica* (Wallich) Benth. root. In India, an infusion of the bark or root is used against dysentery and as an astringent. The latex of the root is used against diarrhoea, dysentery and externally applied on abscesses.

Observations A shrub, 0.5–2 m tall, stem 1.5–2 cm in diameter; leaves elliptical to narrowly elliptical, 4–23 cm × 1–8.5 cm, 2.2–4.5 times longer than wide, apex acuminate, petiole 2–20 mm long; inflorescence lax, 2–12 cm × 2–5 cm, 2–15-flowered; flowers fragrant or not, open during the night, sepals pale green, leafy, corolla in mature bud 14–26 mm long with a wide broadly ovoid head for 20–35% of the length, apex blunt, tube 1.8–4(–6) times longer than the calyx, (9–)13–22 mm long, twisted 0.5 turn or not just below the anthers; fruit consisting of 2 separate mericarps, pod-like, orange or red, several-seeded, dehiscent.

T. rostrata is found in forest and scrub from sea-level to 1400 m altitude.

Selected sources 135, 672, 1118.

Tabernaemontana sphaerocarpa Blume

Bijdr. fl. Ned. Ind. 16: 1028 (1826).

Synonyms *Tabernaemontana fagraeoides* Miq. (1857), *Tabernaemontana javanica* Miq. (1857), *Ervatamia sphaerocarpa* (Blume) Burkill (1935).

Vernacular names Indonesia: gembirit, cempirit (Javanese), hamperu badak (Sundanese).

Distribution Java, Sulawesi, Lesser Sunda Islands and Timor.

Uses In Java, all parts of the plant are considered poisonous. It is often planted as an ornamental in gardens and cemeteries. A decoction of the bark is rubbed on the skin against fever. The crushed leaves mixed with chalk are applied to the forehead against eye infections. In the Lesser Sunda Islands, the latex is a cure for various skin afflictions. The leaves are externally applied to sprained ankles.

Observations A tree, 5–15(–20) m tall, trunk 10–40 cm in diameter; leaves elliptical to narrowly elliptical, (5–)8–32 cm × 2.5–13.5 cm, 2–4 times longer than wide, apex rounded or acuminate and with a blunt point, petiole 5–45 mm long; inflorescence rather lax, 5–20 cm × 3–10 cm, many-flowered, pedicel 3–15 mm long, bracts scale-like; flowers open during the night, sepals pale green, with 7–11 colleters in 1–2 rows, corolla in mature bud 15–20 mm long, with a globose, depressed-globose or ovoid head for 15–35% of the length, 1.5–2.7 times as wide as the narrowest part of the tube, apex rounded or less often acute, tube 4–6 times longer than the calyx, 15–19 mm long, twisted for 0.1 turn or not above the anthers; fruit consisting of 2 separate mericarps, obliquely ellipsoid or subglobose, orange or red, 10–50-seeded, aril pale or dark red. *T. sphaerocarpa* is found in forest from sea-level to 1200 m altitude. Flowers and fruits throughout the year.

Selected sources 407.

L.S.L. Chua & S.F.A.J. Horsten

Tadehagi H. Ohashi

Ginkgoana 1: 280 (1973).

LEGUMINOSAE

x = unknown; *T. triquetrum*: $2n = 22$

Major species *Tadehagi triquetrum* (L.) H. Ohashi.

Origin and geographic distribution *Tadehagi* comprises 5 species, and is native to South and South-East Asia. It is found from India eastward to southern China, Taiwan and the Ryukyu Islands and southward throughout Malesia eastward to the Pacific Islands and northern Australia. Only *T. triquetrum* and *T. pseudotriquetrum* (DC.) H. Ohashi are present in Malesia.

Uses In Java, the leaves of *T. triquetrum* subsp. *triquetrum* are a well-known remedy for haemorrhoids, usually taken as a decoction. Externally the leaves are applied to treat lumbago. Both leaves and pods are ingredients of diuretic remedies against gravel in the kidneys and bladder. In Burma (Myanmar) and southern China *T. triquetrum* s.l. is used as a vermicide and insecticide. In southern China, it is considered a medicine for infantile spasms, a tonic for dyspepsia, and applied against abscesses and haemorrhoids. A decoction of leaves and shoots of *T. godefroyanum* (O. Kuntze) H. Ohashi, from Thailand and Indo-China, is used as a mouthwash for dental affections in Cambodia. In Thailand, a decoction is employed as an anti-emetic, antimalarial, antidiarrhoea and in the treatment of bloody discharge, both oral and rectal.

Properties *Tadehagi* is reported to contain up to 8% condensed tannins. Condensed tannins are complex polymers of catechins and flavonoids, which are often esterified with gallic acid. The ability of tannins to form insoluble complexes with proteins, and their astringent properties are the basis for their use in traditional medicine, which includes treatment of e.g. bleeding gums, haemorrhoids and, to some extent, skin injuries.

The high potassium (3%) and silicic acid (2.3%) content may account for mild diuretic (aquaretic) effects.

The ethanol water extract of the aerial parts at a concentration of 50 μg/ml showed antiviral activity (Ranikhet disease virus) in cell culture. At an effective dose of 20 μg/ml, it showed cytotoxic effect against CA-9KB cell line, and the 50% lethal dose (LD_{50}) in mice when injected intraperitoneally is more than 1 g/kg body weight.

Description Subshrubs or shrubs up to 3 m tall. Leaves alternate, unifoliolate; petiole winged; stipules free or connate; stipels present. Inflorescence terminal and axillary or only terminal, racemose, usually 2–3-flowered; bracts dimorphic, primary bracts bearing 2 secondary bracts, secondary bracts bearing flowers at the axil; bracteoles present or absent. Flowers papilionaceous, pedicellate; calyx campanulate, 4-lobed; petals with well-developed veins, standard orbicular or transversely broadly elliptical or obovate, wings elliptical oblong, as long as the keel petals, conspicuously auriculate at the base, claw broad, apex rounded, keel petals acute or obtuse at apex; stamens 10, 1 free or slightly connate at the base; ovary superior, 5–8-ovuled, pubescent. Fruit a pod, exserted, straight or slightly incurved, narrowly oblong, compressed, usually 5–8-jointed, upper suture nearly straight, lower suture shallowly to deeply constricted. Seed transversely (broadly) elliptical, rim-arillate, concave at the hilum.

Growth and development In Java, *T. triquetrum* subsp. *triquetrum* flowers and fruits from February–September. *T. triquetrum* has the ability to form nodules.

Other botanical information The relationship of *Tadehagi* to *Desmodium* and allied genera is rather obscure. However, *Tadehagi* is obviously related to the genus *Droogmansia* of Africa. Several subspecies of *T. triquetrum* are recognized based on the leaf dimensions, and dimensions and indumentum of the pods. Only subsp. *triquetrum* is found in Malesia and subsp. *pseudotriquetrum* (DC.) H. Ohashi was recently raised to species rank.

Ecology *Tadehagi* is found in evergreen and semi-deciduous forest as well as in rather open anthropogenic habitats, on a wide range of soils from sand to heavy clay.

Propagation and planting *Tadehagi* is propagated by seed.

Harvesting Plants and leaves of *Tadehagi* are usually harvested whenever the need arises.

Handling after harvest Leaves of *Tadehagi* can be dried and stored for later use as powder or pills.

Genetic resources and breeding The Centro Internacional de Agricultura Tropical (CIAT) in Colombia houses a total of 9 accessions of *T. pseudotriquetrum* from Thailand, 58 accessions of *T. triquetrum* from China, Indonesia, Papua New Guinea, Thailand and Vietnam and 44 unspecified *Tadehagi* accessions from Indonesia and Thailand. The potential of *T. triquetrum* as a feed plant is very limited as grazing trials indicated a low palatability.

Prospects Very little information on phytochemical or pharmacological properties of *Tadehagi* species is available. They merit further research to evaluate their interest as a local or industrial source of tannin.

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Selection of species

Tadehagi pseudotriquetrum (DC.) H. Ohashi

Journ. Jap. Bot. 70(2): 116 (1995).

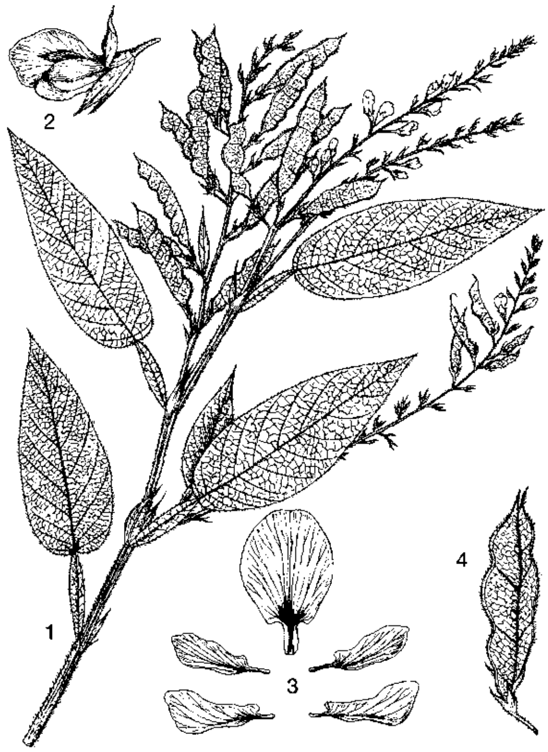
Synonyms *Desmodium pseudotriquetrum* DC. (1825), *Pteroloma pseudotriquetrum* (DC.) Schindler (1924), *Tadehagi triquetrum* (L.) H. Ohashi subsp. *pseudotriquetrum* (DC.) H. Ohashi (1973).

Vernacular names Thailand: Yao khotung (northern). Vietnam: c[oor] b[if]nh gi[ar].

Distribution Northern India, the Himalayas, northern Thailand, southern China and Yunnan, Taiwan and the Philippines (and possibly Papua New Guinea).

Uses *T. pseudotriquetrum* is probably used in the same way as *T. triquetrum*.

Observations A subshrub up to 1 m tall, branchlets pubescent; leaflet narrowly ovate to elliptical, 6–10 cm × 2–4 cm, usually less than 3 times longer than broad, apex acute, upper surface glabrous, lower surface hairy along the veins, petiole 2–3 cm long, prominently winged, stipules 10–20 mm × 2–4 mm; calyx 5 mm long, hairy, corolla 7 mm long, pink; pod distinctly stalked, 6–7-jointed, densely white-pubescent only on both sutures, entirely glabrous and reticulate-veined on the lateral surface, articles 2–3(–3.5) mm × 4–6 mm. In Taiwan, *T. pseudotriquetrum* is found in



Tadehagi pseudotriquetrum (DC.) H. Ohashi – 1, flowering and fruiting twig; 2, flower; 3, details of corolla; 4, pod.

open grassland, margins of thickets, up to 1500 m altitude.

Selected sources 251, 455, 547, 749, 786, 1038.

Tadehagi triquetrum (L.) H. Ohashi

Ginkgoana 1: 296 (1973).

Synonyms *Hedysarum triquetrum* L. (1753), *Desmodium triquetrum* (L.) DC. (1825), *Pteroloma triquetrum* (L.) Desv. ex Benth. (1852) p.p.

Vernacular names Indonesia: daun duduk (general), cocor bebek (Javanese), genteng cangkeng (Sundanese). Cambodia: kô:n dèi bânndöt, krâchâk chahs, lba: chiem. Laos: ha:ng süa, ph'èng kh'am h'o:yz, sa:m ha:ng tônz. Thailand: khaao mao nok, kho kiu (central), yaa khotung (northern). Vietnam: c[or] b[if]nh, tr[af]ng qu[ar] ba c[aj]nh.

Distribution From India and Ceylon eastward through Burma (Myanmar), Thailand, Indo-China, southern China and Yunnan; southward through Malaysia, Indonesia to Papua New Guinea, Solomon Islands, Pacific Islands and possibly northern Australia.

Uses In Cambodia, a decoction of the roots is used as a poultice on bruises. In Laos, a decoction of the roots is used as a febrifuge. In Vietnam, an infusion of the roots is taken to treat kidney complaints, and an infusion of the leaves is drunk for stomach discomfort. In northern Thailand, the aboveground parts as well as the roots are used in decoction as an infusion, simply eaten or used in baths, to heal a wide range of afflictions. These gastro-intestinal and urinary problems range from an upset stomach to hepatitis, and a daily glass of a decoction is considered beneficial for chronic coughs and tuberculosis.

Observations A subshrub up to 3 m tall, branchlets glabrescent; leaflet narrowly elliptical to obovate, 3.5–20 cm × 1–6 cm, usually more than 3 times longer than broad, apex acute, upper surface finely pubescent, lower surface variably pubescent, petiole 1–5 cm long, prominently winged, stipules 8–25 mm × 4–7 mm; calyx 4–5 mm long, hairy, corolla 5–6 mm long, pink, red or blue; pod distinctly stalked, 5–8-jointed, densely clothed with yellowish or whitish soft hairs both on the sutures and the lateral surface, not reticulate-veined, articles mostly 2.5–3.5 mm × 5–6 mm. In Malesia only subsp. *triquetrum* is present. *T. triquetrum* is found on a variety of soils in evergreen or semi-deciduous forest, in the vicinity of watercourses, on bunds of rice fields, savanna and grasslands from sea-level up to 1500(–2000) m altitude.

Selected sources 74, 215, 251, 407, 546, 547, 749, 786, 873, 958, 1028, 1038.

Wongsatit Chuakul, Noppamas Soonthornchareonnon, Orawan Ruangsomboon.

Tetracera L.

Sp. pl. 1: 533 (1753).

DILLENIACEAE

x = unknown

Major species *Tetracera indica* (Houtt. ex Christm. & Panz.) Merr., *T. scandens* (L.) Merr.

Vernacular names Indonesia, Malaysia: mempelas.

Origin and geographic distribution *Tetracera* comprises 45 species and has a pantropical distribution. Fifteen species are restricted to the New World, 15 to Africa and 15 to Australasia. In Malesia 12 species are present.

Uses Various parts of several *Tetracera* species are used for skin afflictions in general, ranging from itch to syphilitic sores and snake bites.

Leaves, stems and roots taken as an infusion are used as a medication for diarrhoea and as a diuretic. Credited with astringent properties *Tetracera* is also taken against haemorrhages. In the Bird's Head region of New Guinea, the young leaves of *Tetracera* are eaten for diarrhoea. Sap from the stem is drunk against stomach-ache and constipation. The scabrid leaves of some species are used as sandpaper, hence the Malay name for sandpaper has been derived from the plant name: mempelas. The stems are sometimes used for cordage.

Production and international trade *Tetracera* is only used and traded at a local level.

Properties Several *Tetracera* are reported to contain general flavonoids, e.g. quercetin and kaempferol. In addition, *T. macrophylla* also contains the flavonoids rhamnetin, rhamnazin and rhamnocitrin, and from the aerial parts of *T. indica*, 5,7-dihydroxy-8-methoxyflavone (wogonin) has been isolated. Triterpenes, betulenic acid and betulin have also been isolated from *T. indica*, *T. sarmentosa* and *T. scandens*.
Leaf extracts of *T. sarmentosa* show partial inhibition of the bacterium *Staphylococcus aureus* and the yeast *Saccharomyces cerevisiae* in vitro.

Adulterations and substitutes Wogonin has also been isolated from *Scutellaria* species.

Description Shrubs, sometimes straggling, or lianas, with flexuous branches, older branches with flaky bark with longitudinal fissures. Leaves spirally arranged, simple, base decurrent, margin dentate to entire, often scabrid on one or both sides; petiole short, furrowed; stipules absent. Inflorescence a terminal or axillary, few- to many-flowered panicle, often with bracts. Flowers actinomorphic, bisexual, fragrant; sepals circular to oval, 4–6(–15), apex rounded, margin usually ciliate, often reflexed when flowering and fruiting, persistent; petals obovate-spathulate, 3–5, apex slightly emarginate, caducous, white or tinged red; stamens numerous, with broadened connective, thereby anther cells divergent towards the base; carpels 1–4, free, with a short style ending in a simple stigma, each carpel 1–10-ovuled. Fruit a coriaceous capsule, opening with longitudinal slits along ventral and dorsal suture in two valves, one- to few-seeded. Seed glossy dark brown to black, endosperm abundant, aril fleshy, cup-shaped, fimbriate or laciniate margin, reddish or purplish.

Growth and development *Tetracera* can be found flowering and fruiting throughout the year. Fruit and seed characters point to dispersal by birds.

Other botanical information As traditional medicinal uses are sometimes a little contradictory, probably some misidentifications have blurred the applicability of *Tetracera* species.

Ecology All South-East Asian *Tetracera* occur in the lowland, and are rarely encountered above 600 m altitude. Some species occur in forests, others in scrub or even more open places.

Harvesting Roots, leaves and stem parts are collected from the wild, whenever the need arises.

Genetic resources and breeding The medicinally important *Tetracera* species have a relatively large natural distribution, are not excessively harvested and are also found in rather open and disturbed habitats. Despite their preference for lowland areas that are most subjected to development projects, their apparent adaptability to disturbance renders the risk of genetic erosion limited.

Prospects *Tetracera* is of limited local importance in South-East Asia. Very little information is available on phytochemical and pharmacological properties of extracts and purified compounds from *Tetracera*. More research is needed to evaluate its potential.

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Selection of species

Tetracera indica (Houtt. ex Christm. & Panz.) Merr.

Interpr. Herb. amboin.: 367 (1917).

Synonyms *Assa indica* Houtt. ex Christm. & Panz. (1779), *Tetracera assa* DC. (1818), *Tetracera dichotoma* Blume (1825).

Vernacular names Indonesia: akar mempelas (Malay), areuy ki asahan (Sundanese), bo (Javanese). Thailand: yaan pot (peninsular), thao orakhon (central), rotsukhon daeng (Bangkok). Vietnam: ch[awj]c ch[if]u [aas]n.

Distribution From Burma (Myanmar) southward to Thailand, Indo-China, Peninsular Malaysia, Sumatra, Bangka, Java and Madura.

Uses In Peninsular Malaysia and India, the roots and leaves are used to treat itch. In Indonesia, the finely crushed young shoots are made into a poultice and put on bites of poisonous snakes and festering fingers. The fruits are taken against a common cold. In India, the plant is reputed to be a fish poison. An infusion of the shoots is given for pulmonary haemorrhages and is used as a gargle for the treatment of aphthae. The rough leaves are used as a substitute for sandpaper, the flexible and tough stem may serve as rough cordage.

Observations A small shrub up to 2 m tall, or a liana up to 5 m long; leaves elliptical to oblong or obovate, (3.5–)6–10(–20) cm × (1.5–)3–5(–9) cm, base acute, apex obtuse to acute, margin more or less dentate to entire, slightly glossy above, not scabrid, petiole (4–)6–10(–15) mm long; inflorescence terminal or on short lateral few-leaved branches up to 8 cm × 6 cm, (2–)4–7(–12)-flowered; flowers 2.5–3 cm in diameter, sepals 4, 8–10 mm × 7–9 mm, glabrous, petals (3–)4(–5), 12–15 mm × 6–8 mm, reddish white, stamens red, white at base, carpels 3–4, with a few rigid hairs on the back; capsule globular, about 1 cm in diameter, with a 2–6 mm long beak, (1–)2(–7)-seeded; seed ovoid, 3–4 mm × 2–3 mm, aril about 1 cm long, fimbriate to its base, bright red. *T. indica* is found in open places in general ranging from open forest, bushland to recently abandoned fields, from sea-level up to 600 m altitude.

Selected sources 135, 216, 227, 390, 407, 786.

Tetracera macrophylla Wallich ex Hook.f. & Thomson

Fl. ind. 1: 63 (1855).

Synonyms *Tetracera scaberrima* Miq. (1859), *Tetracera grandis* King (1889).

Vernacular names Indonesia: akar ampaleh riembu (Sumatra), akar tembara (West Kalimantan). Malaysia: ampelas rimba, ampelas lidah kuching (Peninsular), empalas (Sarawak).

Distribution Peninsular Malaysia, Sumatra, Bangka, Borneo.

Uses In Peninsular Malaysia, the roots and leaves are pounded and applied to the skin for itch, and as a poultice on syphilitic ulcers. In Sarawak root sap is taken orally as a poison antidote.

Observations A liana up to 10 m long, branches strongly scabrid to smooth; leaves elliptical to oblong, (5–)8–15(–30) cm × (3–)5–10(–17) cm, base rounded to obtuse, apex rounded to obtuse, little to very scabrid, petiole 1.5–3 cm long, winged; inflorescence terminal, 10–40 cm × 4–15 cm, 25–200-flowered, often with 1–4 leaves in the basal part; flowers 2–2.5 cm in diameter, sepals 5–6, the outer two 8–9 mm × 7–8 mm, the inner three–four 11–12 mm × 8–9 mm, scabrid outside, accrescent; petals 3, rather thick, carpels 3–4, with a few rigid hairs on the back, 14-ovuled; capsule ovoid, 8–10 mm × 6–8 mm, with a 2–3 mm long beak, 1–2-seeded; seed ovoid, 6–7 mm × 4–5 mm, glossy black, aril unequal-sided, 5–9 mm long. *T. macrophylla* is found in thickets, dry forest and swamp forest from sea-level up to 300 m altitude.

Selected sources 135.

Tetracera sarmentosa (L.) Vahl

Symb. bot. 3: 70 (1794).

Synonyms *Delima sarmentosa* L. (1754), *Tetracera asiatica* (Lour.) Hoogl. (1951).

Vernacular names Indonesia: sengkerit akar (Sumatra). Malaysia: mempelas rimau. Vietnam: d[aa]y chi[eef]u, ch[awj]c ch[if]u.

Distribution From Sri Lanka, eastern India, Burma (Myanmar) to southern China, Indo-China, Thailand, Peninsular Malaysia, Sumatra and Borneo.

Uses In Sumatra, pounded young leaves are added to water and drunk as a medication for diarrhoea. In Cambodia, the entire plant is considered medicinal. It is used as a diuretic, and in a mixture to treat blennorrhoea, and oedema of hepatic and renal origin. In combination with other plants an infusion is drunk as an antifebrile, a tonic or a depurative.

Observations A small shrub up to 3 m tall or a liana up to 12 m long, with scabrid branches; leaves oblong, (3–)5–11(–15) cm × (1.5–)2–5(–7.5) cm, base acute, apex acute to obtuse, margin entire to distinctly dentate, scabrid, petiole 0.5–1(–1.5) cm long; inflorescence terminal, 10–25 cm × 5–15 cm, 30–150-flowered, in the basal part often with 1–4 leaves; flower about 1 cm in diameter, sepals 5, the 2 outer ones 2 mm × 1.5 mm, the 3 inner ones 4 mm × 3 mm, scabrid outside, petals 3, 3–4 mm × 2–3 mm, white, stamens whitish yellow, carpels 1(–2), glabrous, 10–12 ovuled; capsule ovoid, 6–10 mm × 4–6 mm, with a 2–5 mm long beak, glabrous, 1(–2)-seeded; seed ovoid 4 mm × 3

Tetracera sarmentosa (L.) Vahl – 1, flowering twig; 2, flower; 3, opened capsule showing seed and aril.

mm, aril up to 5 mm long, fimbriate for half to two third of its length. *T. sarmentosa* was formerly included in *T. scandens* but can be distinguished by the glabrous fruits and pentamerous calyx. The uses can be assumed to be the same as for *T. scandens*, where they occur sympatrically. *T. sarmentosa* is found in scrub along roadsides, hedges, thickets as well as primary forest, from sea-level up to 1500 m altitude. It flowers from March–November and fruits from May–February.

Selected sources 227, 372, 788.

Tetracera scandens (L.) Merr.

Interpr. Herb. amboin.: 365 (1917).

Synonyms *Tragia scandens* L. (1754), *Tetracera monocarpa* Blanco (1837), *Tetracera hebecarpa* (DC.) Boerl. (1899).

Vernacular names Indonesia: akar mempelas padang(Malay), singaran (Javanese), asahan areuy (Sundanese). Malaysia: ampelas (Peninsular, Sabah), akar ampelas putih (Peninsular). Philippines: malakatmon (Tagalog, Pampangan), malbastigbalang (Tagalog), dangilian (Bagobo) Cambodia: dos koum, dak koum. Thailand: ka pot, pot khaai (peninsular), lin raet (eastern). Vietnam: d[aa]y ch[awj]c ch[if]u, d[aa]y chi[eef]u, u ch[awj]c ch[if]u.

Distribution From southern China southward to Burma (Myanmar), Thailand, Cambodia, Vietnam, Peninsular Malaysia, Sumatra, Bangka, Borneo, Java, Lesser Sunda Islands, Sulawesi and the Philippines.

Uses In Indonesia, the finely crushed young shoots are made into a poultice and put on bites of poisonous snakes. The sap of the stem is drunk as a cough medicine. In Malaysia, the leaves are applied to boils to ripen them. A decoction of the plant is administered after childbirth. The root is used as an astringent in diarrhoea and a traditional ingredient in a mixture against burns. In Terengganu, roots are ground and the juice applied to mouth ulcers. In the Philippines, an infusion of the stem is drunk against haemoptysis in tuberculosis. It is used as a gargle against thrush. Externally the infusion is applied to a sore throat, the action being due to the large amount of tannin it contains. In Cambodia, the stem is used as a diuretic, and in combination with other plants in oedemas of hepatic and renal origin. Due to their harshness the leaves are employed to polish small articles. The flexible and tough young stem may serve as rough cordage. Heated and twisted the stems may serve as bindings for fish traps, and are considered durable.

Observations A small shrub up to 2 m tall or a liana up to 30 m long, trunk up to 16 cm diameter; leaves oblong to obovate, (3.5–)6–15(–20) cm × (1.5–)3–7(–9) cm, base obtuse, apex rounded to obtuse, margin entire to distinctly dentate, scabrid on both sides, petiole (4–)6–12(–15) mm long; inflorescence terminal, up to 40 cm × 20 cm, up to 200-flowered, in the lower part with 1–5 leaves; flower 6–8 mm in diameter, sepals 4(–5), 3 mm × 2 mm, reflexed, scabrid outside, petals 3, 3–5 mm × 2–4 mm, whitish, stamens white, carpels 1(–2), densely hairy, 10-ovuled; capsule ovoid, 10 mm × 6 mm, with a 1–3 mm long beak, hairy, 1(–2)-seeded; seed ovoid, 4 mm × 3 mm, glossy black, aril 2–3 mm long, fimbriate for more than three quarters of its length. *T. scandens* is found in thickets and secondary forest, especially on riverbanks and near the sea coast, from sea-level up to 500(–1000) m altitude.

Selected sources 135, 227, 407, 739, 786, 810, 849.

Cheksum Supiah Tawan

Thevetia peruviana (Pers.) K. Schum.

Engl. & Prantl, Nat. Pflanzenfam. 4(2): 159 (1895).

APOCYNACEAE

$2n = 20$

Synonyms *Cerbera peruviana* Pers. (1805), *Thevetia nereifolia* Juss. ex. Steud. (1841), *Cascabela thevetia* (L.) Lippold (1980).

Vernacular names Yellow oleander, lucky nut tree (En). Oléandre jaune (Fr). Indonesia: ginje, ki hujan (Sundanese). Malaysia: tevetia peru. Philippines: campanero, campanilla (Tagalog). Thailand: sae nawa (northern), ban buri (Bangkok), ram phoei (central). Vietnam: th[oo]ng thi[ee]n, hu[yf]nh li[ee]n.

Origin and geographic distribution *T. peruviana* originates from tropical America and is widely cultivated in South-East Asia as an ornamental.

Uses *T. peruviana* is widely used in folk medicine in Central and South America. The uses recorded for South-East Asia are similar. In the Philippines and India it has become a household remedy for several ailments. A decoction prepared from the bark or leaves is applied in regulated doses to loosen the bowels, as an emetic, and is said to be an effective cure for intermittent fevers. The seeds may be used as a purgative in rheumatism and dropsy. A decoction of the seeds acts as a violent emetic, hinders respiration, and may cause paralysis of the heart. Pulverized seeds are sometimes an ingredient of suppositories to alleviate haemorrhoids. The roots are made into a plaster which is applied to tumours. However, care should be taken in all medical applications, in particular those used internally, as high dosage may result in poisoning. In Vietnam, purified thevetin is employed as a cardiotonic. In Thailand and India, the oil from the kernel is applied topically to treat skin complaints. In India, seeds have been used for committing suicide or homicide. Other reports state its use as abortifacient. The kernels act as a contact poison; mashed with a soap solution they are used as an insecticide. The wood may be employed as fish poison.

Production and international trade Yellow oleander is usually cultivated in home gardens for use in local medicine and as an ornamental. The plants do not enter the international trade.

Properties All parts of *T. peruviana* produce latex which is highly poisonous; the kernels are the most toxic. The active principles are cardiac glycosides of the cardenolide type. The toxic manifestations of yellow oleander-poisoning mainly involve the cardiovascular system (including various types of arrhythmia, e.g. sinus bradycardia) and the gastro-intestinal tract. Vomiting is the common symptom in poisoning in about 30% of all cases. Ischaemic changes occur in about 40% of the cases, as well as palpitations in about 10%. The most serious and immediate cause leading to death is peripheral vascular failure: of the 14 autopsied death cases all showed subendocardial and perivascular haemorrhage with focal myocardial oedema.

The cardiac glycosides of *T. peruviana* are triosides or monosides, i.e. they contain an aglycone unit combined with 3 or 1 sugar moieties, respectively. The aglycones of these glycosides are either digitoxigenin, or the related cannogenin (the 19-oxo form of digitoxigenin) or cannogenol (the 19-oxy form of digitoxigenin). Thevetin, is the major component of the seeds. It was subsequently found to be a mixture of 2 tiosides, cerberoside (= thevetin B) and thevetin A in a 2:1 ratio. A small portion of 2'-O-acetyl cerberoside is also associated with thevetin.

The monosides separated from the seeds include neriifolin, cerberin (= 2'-O-acetylneriifolin), peruvoside, theveneriin (= ruvoside) and perubosidic acid (perusitin).

Of all the *Thevetia* cardiac glycosides, 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 activities and that it showed a strong competitive inhibition on (^{3}H)-ouabain binding to this enzyme isolated from various tissues. A marked difference in reponse of experimental animals was found which was as great as that of *Digitalis*. The inhibitory effects on the enzyme activity were stronger than the positive inotropic effect, while these effects of *Digitalis* were parallel quantitatively.

The first clinical trials with peruvoside were carried out on cases of congestive cardiac failure. Oral administration of the drug produced digitalization in all patients. Since then, clinical testing of peruvoside has been undertaken at a large number of centres, particularly in India and Germany. Large-scale clinical trials with 1600 patients showed 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. Special indications include cardiac insufficiency with bradycardia, latent cardiac insufficiency, insufficiency of the senile heart, and cor pulmonala chronicum. Peruvoside was also beneficial in the treatment of cardiac insufficiency subsequent to myocardial infarction. The drug was tolerated well, and possible side effects were mostly manifested in the form of gastro-intestinal symptoms of irritation.
Of the other *Thevetia* cardiac glycosides, the mixture thevetin is practically identical in effect with ouabain, and about one-eighth as potent (the lethal dose for a cat being 0.85 mg/kg). It has effectively been used clinically in cases of cardiac decompensation, although its effective dose is rather close to its toxic dose. Thevetin A is far less potent than thevetin, and as a cardiac glycoside the potency of neriifolin is only moderate. Finally, cerberoside (thevetin B) is one of the weakest of the *Thevetia* glycosides in its cardiotonic effect.
Furthermore, in screening tests against 6 pathogenic bacteria with solutions of 4 dilutions (1:100, 1:250, 1:500 and 1:1000) and with pure kernel oil, strong bactericidal activity was demonstrated, especially against *Bacillus subtilis* and *Staphylococcus aureus*. The pure oil was more effective than the control, 1000 ppm griseofulvin, against all 6 species; dilutions of 1:500 and above were generally as active as the control or more so, except against *Vibrio cholerae*.
Decoctions, infusions and expressions from the different plant parts did not show any direct DNA damaging capacity. They were not mutagenic before or after metabolic activation, and did not possess chromosome-breaking effects. However, decoctions from leaves and expressions from kernels and seeds exhibited antimutagenic effects in bone marrow cells of mice treated with methylmethane sulphonate, tetracycline and N-nitrosopyrrolidine.

Adulterations and substitutes Cardiac glycosides are present in several other genera of the *Apocynaceae*, e.g. *Cerbera* (structurally very similar; cerberoside (= thevetin B) is also found in *Cerbera odollam* Gaertner) and *Strophanthus*.

Description A shrub or tree up to 8 m tall; branchlets glabrous, exuding white latex. Leaves spirally arranged, simple, linear-lanceolate, 6–15 cm × 0.4–0.7 cm, long-acuminate, venation obscure, coriaceous; petiole very short. Inflorescence subterminal, cymose, few-flowered. Flowers 5-merous, only faintly fragrant; sepals acute, spreading; corolla lobes overlapping to the left in bud, corolla infundibuliform, tube widening around the middle, about 3 cm long with densely pubescent corona lobes near the throat alternating with the stamens, lobes about 3 cm long, yellow; stamens completely included, anthers attached to each other apically across top of pistil head but not adnate to it, yellow to orange or peachy pink; ovary consisting of 2 carpels, several ovules per carpel. Fruit a drupe with mericarps united into an obdeltoid shape, laterally compressed, about 3–4 cm in diameter, yellowish-green turning red, ripening black, exocarp fleshy, mesocarp stony, endocarps free from each other. Seed flattened with a small wing, one seed per mericarp. Seedling with epigeal germination.

Thevetia peruviana (Pers.) K. Schum. – 1, flowering and fruiting branch; 2, frontal view of flower.

Growth and development In areas without a seasonal climate *T. peruviana* flowers and fruits throughout the year. However, a peak in flowering can be observed in a particular time of the year.

Other botanical information *Thevetia* comprises 8 species and originates from tropical America. Some species are widely cultivated outside this area. *T. peruviana* is the only species cultivated in South-East Asia. Ornamental *T. peru-*

viana with white flowers is traded as cv. 'Alba'.

Ecology In its native habitat, *T. peruviana* is found in evergreen lowland or riparian forest from 50–200 m altitude.

Propagation and planting In cooler climates *T. peruviana* can be grown as pot plants in tubs in the glasshouse or conservatory, to be moved outdoors for the summer months. Cultivars are propagated by semi-ripe cuttings of terminal shoots, or by stem sections during the growing season. Propagation by seed should preferably be done at the start of the growing season. 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.

Husbandry *T. peruviana* is grown in full sun or light shade, in fertile, well-drained loams with additional leaf mould. The shallow-rooted plants should be protected from strong winds. Stem tips of young plants are pinched out to encourage a bushy habit, and established specimens are pruned after flowering or shortly before the growing season to shape and restrict size.

Diseases and pests In India, infestation of *T. peruviana* with *Cuscuta reflexa* Roxb. resulted in severe suppression of young leaves, with infected leaves turning yellow and desiccating. Under glass, scale insects, mealybug, red spider mite and aphids may be pests.

Handling after harvest Ripe fruits of *T. peruviana* are sun-dried and split to obtain the seeds.

Genetic resources and breeding The widespread cultivation of *T. peruviana* as an ornamental diminishes the risk of genetic erosion.

Prospects At present in medicine, cardiac glycosides are only applied in distinct, special cases. In the western world, the drug of choice is in general digoxin from *Digitalis lanata* Ehrhart, or in acute situations the strophanthins (e.g. ouabain) from *Strophanthus* spp. Therefore, the cardenolides from *T. peruviana*, although the pharmacological effects of peruvoside are very well documented, are unlikely to play a significant role in future medicine. In distinct cases, however, they may very well serve as a local source of cardiac glycosides, when digoxin and ouabain are not available.

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Other selected sources 135, 241, 263, 380, 407, 696, 739, 786, 810, 1070.

J.L.C.H. van Valkenburg & S.F.A.J. Horsten

Thottea Rottb.

Nye Saml. K. Danske Vidensk. Selsk. Skrift. 2: 529 (1783).

ARISTOLOCHIACEAE

x = unknown; *T. grandiflora*: $2n = 26$

Major species *Thottea grandiflora* Rottb., *T. tomentosa* (Blume) Ding Hou.

Origin and geographic distribution *Thottea* is of Indo-Malesian origin and comprises about 25 species. The species are distributed from India (4 species) and Sri Lanka (1) to Bangladesh (1), Burma (Myanmar) (3), Thailand (4), Vietnam (2), China (Hainan, 1) and Malesia (22). In Malesia, *Thottea* occurs in Peninsular Malaysia (7), Sumatra (10), Java (1), Borneo (11), Sulawesi (1) and the Philippines (2).

Uses In Peninsular Malaysia, the pounded leaves of *T. dependens* are sometimes used for poulticing skin complaints. A decoction of the rhizomes and roots is drunk to treat cough, asthma and bronchitis. The rhizomes of *T. parviflora* are eaten with rice, or chewed with betel nut (*Areca catechu* L.), to treat cough. The stem and leaves of *T. tomentosa* are crushed and applied to the neck and chest against cough, and the juice is also drunk for this purpose. The rhizomes of *T. grandiflora* are considered an excellent tonic, whereas those of *T. corymbosa*, *T. grandiflora* or *T. tomentosa* are given to women after confinement, as a diuretic. In Thailand,a decoction of *T. parviflora* or *T. tomentosa* is used as a diuretic and for the treatment of prostatitis.

In Peninsular Malaysia, the crushed leaves of *T. tomentosa* are renowned as a cure for stings and bites of poisonous animals, especially snakes. In Sarawak, a decoction of the rhizomes of *T. rhizantha* Becc. is taken to cure gonorrhoea.

Production and international trade There are no records on production statistics or any international trade of *Thottea*. The plants are harvested from the forest for personal use, and sometimes traded locally by herbalists.

Properties *Thottea* species contain an essential oil, of which the composition is known to be specific at species level. These oils are comprised of mixtures of mostly monoterpenes with sesquiterpenes and/or phenylpropanoids. In a general screening assay system, *T. grandiflora* was found to give a strong positive reaction to a test on the presence of saponins, triterpenes and steroids.

Also, aristolochic- (and debilic-) acids are present in *Thottea*. Aristolochic acids are a family of closely related compounds, derived from phenanthrene, and bearing a carboxyl function and a nitro substituent. These compounds display a range of pharmacological activities, including antimicrobial- (bacteria, fungi), antitumour- (e.g. mouse sarcoma-37) and immunomodulatory (enhancement of the metabolic activity of guinea-pig peritoneal macrophages and human leucocytes, in vitro). On the other hand, aristolochic acids are known for their nephrotoxicity in humans and several animal species, and their strong mutagenic and carcinogenic activities in vitro and in vivo have also been studied extensively. For the latter reasons, many European countries, e.g. France and Germany, have restrictive regulations on preparations which contain aristolochic acids (for example *Aristolochia* tincture), even including homeopathic preparations with their high dilutions.

Adulterations and substitutes Aristolochic acids are also present in several other *Aristolochiaceae*, especially *Aristolochia*.

Description Erect, sometimes scrambling, perennial herbs, woody at base, or undershrubs, single or tufted, branched or not, rhizomatous. Leaves alternate, simple, entire, in lower half or two-third of stem reduced, small and bract-like, then 1 smaller leaf, followed by normal leaves, veins prominent, variably orientated; petiole grooved above, short; stipules absent. Inflorescence axillary or subradical, spicate or racemose, cymose or corymbose, or cincinnal, normally few-flowered; bract opposite to the flower. Flower actinomorphic, flower buds distinctly triangular in top view; perianth broad-campanulate, urceolate, bowl- or cup-shaped, 3-lobed, lobes valvate, caducous; stamens 6–36(–46), normally in 1 or 2 whorls, rarely 3 or 4 whorls, free or adnate to the style column; ovary inferior, 4-angular, 4-celled, style (2–)5–20-lobed, lobes linear or linear-lanceolate. Fruit a siliquiform capsule, elongate, variable in length, 4-angular, 5–10 mm in diameter, dehiscing apically towards the base, or splitting from the central part towards both ends, puberulous or hairy. Seeds numerous, oblong, ellipsoid or broadly ovoid, 3-angular in cross-section; testa crustaceous or hard, normally rugose, deeply furrowed; endosperm copious and fleshy. Seedling with epigeal germination.

Growth and development *Thottea* flowers are regular and open, not with a complicated structure as in *Aristolochia*. They have a putrid smell, are often dark coloureda nd protogynous, and thus probably pollinated by flies. Cross-pollination might occur during the transition period from the female to the male stage, but self-pollination is also possible. *T. corymbosa*, *T. grandiflora* and *T. tomentosa* flower and fruit throughout the year. *T. dependens* flowers from March–October, and fruits from January–November. *T. parviflora* flowers from March–July, and fruits from March–August. Often, there are only 1 or 2 open flowers at the same time on the same plant. On *T. dependens*, leaves persist for about 3–4 years, and the flowers are receptive for 2–3 days.

Other botanical information *Thottea* is 1 of 7 genera in the *Aristolochiaceae*, of which *Aristolochia* is the largest, with many traditional medicinal uses. *Thottea* and *Apama* were long considered to be very closely related genera, having together about 20 species, mainly from the Malesian region. After a revision in which *Apama* merged with *Thottea*, the genus now has about 25 species. The androecium in *Thottea* is very variable, both in number and position of the stamens, but is more or less constant for each species.

The Indian *T. siliquosa* (Lamk) Ding Hou is allied to *T. tomentosa*, but has 9 stamens in 3 whorls and the style lobes are densely hooked-hairy. Their medicinal use is largely the same.

Ecology *Thottea* is confined mainly to shady, moist forests, sometimes locally abundant, but more often scattered and rather rare.

Propagation and planting *Thottea* propagates by seed, but some species also reproduce vegetatively by rhizomes. Many *Thottea* species from the primary forest, when planted in a garden, grow slowly and do not perform well. *T. tomentosa* however propagates well vegetatively, both planted in gardens and in the wild, but very few fruits are produced.

Diseases and pests Natural stands of *Thottea* exhibit little damage due to diseases and pests. Some caterpillars of papilionid butterflies feed solely on *Thottea*, probably using the phytochemical compounds for their defence, but without pollinating them.

Harvesting *Thottea* is harvested from the wild throughout the year, according to the need.

Handling after harvest The rhizomes, roots and stems of *Thottea* are slightly fleshy and should be cut into smaller pieces and dried soon after harvest. Dried material can be kept for longer periods if moisture content and humidity are kept low.

Genetic resources and breeding As the habitat of most *Thottea* is being rapidly destroyed, urgent measures for saving them from extinction are needed. *T. tomentosa* is planted in the botanical garden of Bogor (Indonesia), but no genebank collections are known to exist.

Prospects *Thottea* has limited medicinal use in the region at present, except for *T. tomentosa*. A major drawback to possible extended use could be the presence of aristolochic acids, which have strong carcinogenic and mutagenic properties. More research is needed to investigate the exact profile of these compounds in *Thottea*, in order to fully elucidate the problem. Since some species have beautiful flowers, they might have additional commercial value as ornamentals.

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Selection of species

Thottea corymbosa (Griff.) Ding Hou

Blumea 27(2): 320 (1981).

Synonyms *Bragantia corymbosa* Griff. (1845), *Apama corymbosa* (Griff.) Willd. ex Soler. (1889).

Vernacular names Indonesia: bandar puluh, andor lasi (Sumatra), kadudu timbu (Asahan). Malaysia: akar julang bukit, akar chambai olar, andor lasi.

Distribution Peninsular Malaysia, Sumatra, Kalimantan.

Uses In Peninsular Malaysia, pounded leaves are put in hollow molars for toothache. The rhizomes are chewed with betel nut (*Areca catechu* L.) by women to hold back urine during childbirth.

Observations A spreading shrub, up to 5 m tall, puberulous; leaves ovate to lanceolate, elliptical to elliptical-oblong, 6.5–17.5 cm × 2.5–8.5 cm, apex cuspidate or long acuminate, almost glabrous above, puberulous beneath, basal veins 2 pairs, inner one as prominent as the midrib (appearing as 3-ribbed), joined by almost parallel and transverse veins; inflorescence terminal and/or axillary in the upper leaves, paniculiform or corymbose, up to 10 cm long; perianth 3–3.5 mm long, when spreading 7 mm in diameter, yellow, greenish or cream coloured outside, pale lilac inside, densely pubescent outside, glabrous inside, veins invisible, lobes broadly ovate, 2.5–3 mm × 2.5–3.5 mm, stamens in 1 whorl, 7–10, filaments absent, style column obscure, lobes 4, glabrous; capsule slender, up to 38 cm long. *T. corymbosa* occurs widely distributed but scattered in forest, sometimes on limestone, from sea-level up to 1050 m altitude.

Selected sources 407, 786.

Thottea dependens (Planch.) Klotzsch

Monatsbl. Akad. Berl.: 589 (1859).

Synonyms *Lobbia dependens* Planch. (1847).

Vernacular names Malaysia: daun telinga beruang, tlinga berwang (Peninsular).

Distribution Peninsular Malaysia.

Uses The pounded leaves are sometimes used for poulticing skin complaints, or put behind the ear for fever. The bark is considered a rubefacient.

Observations An erect shrub, up to 2 m tall, glabrous; leaves elliptical or obovate, 12–29 cm × 5–15 cm, apex acuminate, glabrous above, puberulous beneath, basal veins 2 pairs, inner ones similar to lateral veins, lateral veins 6–9 pairs, prominent below; inflorescence axillary or cauliflorous, simple or sparsely branched, up to 4(–7) cm long; perianth campanulate, contracted at the lower 1/3, then erecto-patent, 15–25 mm long, pale yellow with centre and margin streaked with brown, reddish pink, purple or dark purple outside and pinkish inside, tube urceolate, 10 mm long, lobes triangular, 6–10(–15) mm × 10–15(–25) mm, each with prominent veins, stamens in 2 whorls, lower whorl 13–16, upper whorl 7–10, style column 4 mm long, lobes (4–)6–9, spreading; capsule slender, 5–10 cm long. *T. dependens* occurs in forest, up to 500 m altitude, normally rather rare, but sometimes locally abundant.

Selected sources 786.

Thottea grandiflora Rottb.

Nye Saml. K. Danske Vidensk. Selsk. Skrift. 2: 529 (1783).

Vernacular names Malaysia: seburut, geroboh, sel-wohl (Peninsular).

Distribution Peninsular Burma (Myanmar), Peninsular Malaysia.

Uses In Peninsular Malaysia, the rhizomes are considered an excellent tonic. It is given in decoction for fever, ague and dysentery.

Observations An erect shrub, up to 2 m tall; leaves obovate, elliptical or ovate-oblong, (15–) 20–30 cm × 9–10(–20) cm, apex acute, short acuminate, variously pubescent above, hispid-pubescent beneath, basal veins 2–3 pairs, lateral veins 10–12 pairs, other veins parallel or reticulate; inflorescence axillary, spiciform or racemiform, or fascicled, at the lower part of stem; perianth funnel-shaped, up to 12.5 cm long, deep reddish-purple and purple mottled, reticulate veins prominent, puberulous, tube about half the length of the perianth, lobes triangular, 5–6 cm × 6–7 cm, stamens in 2 whorls, upper whorl 15(–18), lower whorl 15 (–24), style short, lobes 8–19; capsule slender, 10–15 cm long. *T. grandiflora* occurs in lowland forest, up to 600 m altitude.

Selected sources 407, 786.

Thottea parviflora Ridley

Journ. Straits Branch Roy. Asiat. Soc. 57: 89 (1910).

Vernacular names Malaysia: chudok (Pahang). Thailand: huu mee (peninsular).

Distribution Peninsular Thailand and Peninsular Malaysia.

Uses In Peninsular Malaysia, the rhizomes are eaten with rice or chewed with betel nut (*Areca catechu* L.) to treat cough. In Thailand, *T. parviflora* is used as *T. tomentosa*.

Observations A small, erect shrub, 1–2 m tall, pubescent; leaves ovate, obovate to broadly elliptical, 10–26 cm × 4.5–9 cm, apex acuminate, blade puberulous, basal veins 2 or 3 pairs, ascending upwards to 2/3 of the blade, lateral veins 6–9 pairs, other veins parallel; inflorescence a spiciform or racemose cluster, up to 1.5 cm long, in axils of fallen leaves; perianth campanulate, 2–4 mm long, 6 mm in diameter, white, greenish, pinkish to purplish, papillate inside, veins longitudinal and loosely reticulate, lobes semi-orbicular, 1.5–3 mm × 3.5–4.5 mm, stamens in 4 whorls, (15–)20–22, style almost branched from the base, lobes 4–5, glabrous; capsules slender, up to 9 cm long. *T. parviflora* occurs in lowland forest, occasionally in swampy forest, up to 150 m altitude. In Thailand it is also occasionally found on granite rock in forests, up to about 1000 m altitude.

Selected sources 201.

Thottea tomentosa (Blume) Ding Hou

Blumea 27(2): 328 (1981).

Synonyms *Bragantia tomentosa* Blume (1827), *Apama tomentosa* Engler ex Soler. (1889).

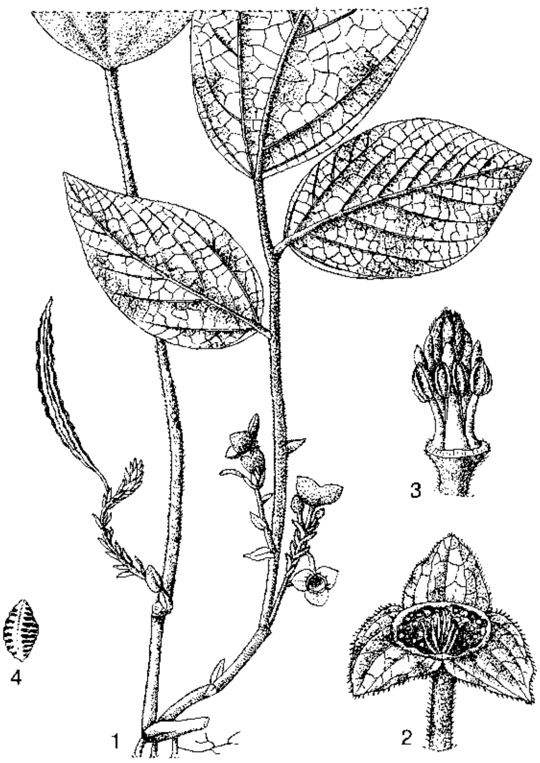
Vernacular names Indonesia: singa depa (Javanese, Sundanese), kaliwaro (Sundanese), singa dapur (Javanese). Malaysia: kaneb, kemed, sereng kong (Peninsular). Thailand: buuduu buulang (peninsular). Vietnam: t[oos]t hoa l[oo]ng.

Distribution From India to Bangladesh, Burma (Myanmar), southern Vietnam and peninsular Thailand; southwards throughout Peninsular Malaysia, Indonesia (Sumatra, West and Central Java) and the Philippines.

Uses The leaves and rhizomes are used for urinary problems of women, and the crushed stem and leaves are widely applied for cough and for treating snakebite. In Java, bundles of leaves are sold in the market.

The crushed aerial parts of *T. tomentosa* are also used as a soap for washing clothes.

Observations An erect, subwoody herb, 10–35 cm tall, simple or branched, densely tomentose; leaves variable on the same plant, elliptical, oblong, ovate or broadly ovate, 8–17 cm × 3–14 cm, apex acute, acuminate or obtuse, glabrous above, densely pubescent beneath, basal veins 2, ascending to halfway, similar to lateral veins, 4–9 pairs, other veins reticulate; flowers in an axillary, racemose cluster or spiciform, near the base of the stem, up to 12 cm long; perianth urceolate-campanulate, 6–12.5 mm long, 12–16 mm in diameter,



Thottea tomentosa (Blume) Ding Hou – 1, plant habit; 2, protogynous flower; 3, pistil and stamens, perianth removed; 4, seed.

purplish brown outside, yellowish brown to reddish inside, pubescent outside, glabrous inside, tube 3–5 mm long, lobes broadly ovate, suborbicular or subreniform, 3–7.5 mm × 4–8 mm, veins prominent, at base of lobes a thin disk at the inside, stamens 6, in 1 whorl, style column 2 mm long, lobes 3(–4), apically hairy; capsule slender, 3.5–5(–15) cm long. *T. tomentosa* occurs in shady, moist localities in forests, sometimes in bamboo, teak or secondary forest, between 90–1200 m altitude, rarely on limestone, sometimes locally abundant.

Selected sources 74, 201, 407, 601, 786.

H.C. Ong

Tinomiscium petiolare Hook.f. & Thomson

Fl. ind. 1: 205 (1855).

MENISPERMACEAE

$2n$ = unknown

Synonyms *Tinomiscium phytocrenoides* Kurz ex Teijsm. & Binnend. (1864), *Tinomiscium tonkinense* Gagnep. (1908), *Tinomiscium philippinense* Diels (1910).

Vernacular names Indonesia: ki koneng (Sundanese), seriawan susun, oyod cacing (Javanese). Malaysia: akar lempaung, akar membulu, kunyit-kunyit. Philippines: bayating (Pampango), lagtang, timbang timbang (Tagalog). Thailand: pharai hothong (peninsular). Vietnam: var kan, d[aj]i di[eej]r d[awf]ng.

Origin and geographic distribution *T. petiolare* is found from India eastward to Burma (Myanmar), Thailand, southern China and Indo-China, throughout South-East Asia eastward to New Guinea.

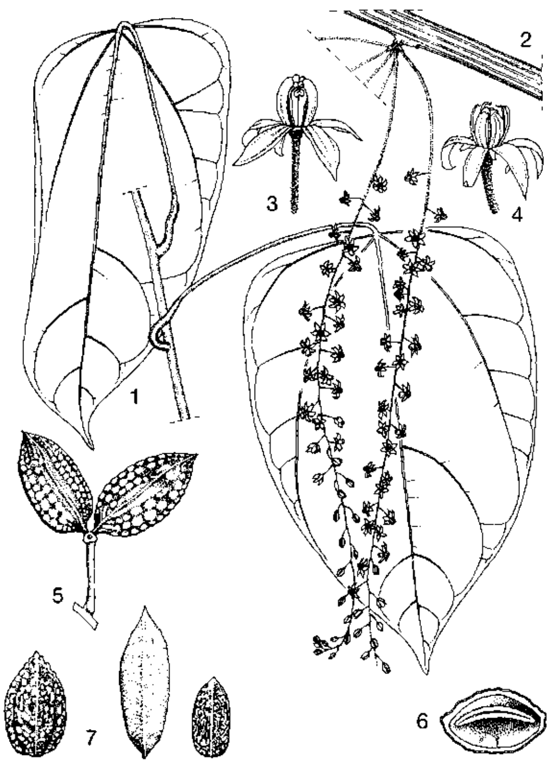
Uses In Malaysia, the roots of *T. petiolare* are boiled and applied externally for rheumatism, whereas a decoction of the roots may be drunk for the same purpose. In Terengganu State, wet, ground roots are applied to a runny nose. In Java, the roots and stems are traded as 'kayu seriawan', meaning wood for sprue; the latex is also taken to alleviate sprue and fever. In Sumatra, the leaves are used as a dressing for severe cuts. In southern Sumatra, the pounded stems mixed with rice are employed as a rat poison, while the pounded bark is employed to stupefy fish. In the Philippines, the white milky sap diluted with water is used as an eyewash. The fruits are used as a fish poison. In Vietnam, mention is made of the latex being used against dental caries.

Production and international trade *T. petiolare* is only used on a local scale.

Properties Phytochemical research on *T. petiolare* has been very scant. From Bornean plant material the tetrahydroprotoberberine alkaloid l-isocorypalmine has been isolated. Stem and root material from East-Javanese plants yielded minute amounts of alkaloids, possibly containing the aporphine alkaloid magnoflorine and the bisbenzylisoquinoline alkaloid homoaromaline. The roots of Philippine material contain tinophyllone, a bitter substance related to the clerodan diterpene columbin. A bark extract of *T. petiolare* shows modest antibacterial activity against *Staphylococcus aureus*.

Adulterations and substitutes Aporphine- and bisbenzylisoquinoline alkaloids are quite common compounds among many *Menispermaceae*, e.g. homoaromaline was also isolated from *Cyclea* and *Arcangelisia* species, while magnophlorine is also reported for *Cyclea* in literature.

Description A large, woody, dioecious climber up to 30 m tall; young stems conspicuously striate, ferruginose-pubescent at first, glabrescent, old



Tinomiscium petiolare Hook.f. & Thomson – 1, habit; 2, male inflorescence; 3, male flower, front petals removed; 4, female flower, all petals and front staminodes removed; 5, fruit; 6, transverse section of drupe containing compressed seed; 7, varying endocarps, dorsal views.

stems coarsely striate, up to 2.5 cm diameter, exuding white latex when cut. Leaves alternate, simple, ovate to broadly ovate or elliptical, 11–25(–29) cm × 4.5–20 cm, base truncate to cordate or obtuse, apex acuminate, base 3–5-veined with 2–4(–4) pairs of distal lateral veins, venation prominent below, lower surface puberulous to glabrous, stiffly papyraceous; petiole 6–21 cm long, bent and slightly swollen at base, sometimes also at the apex; stipules absent. Inflorescences racemose, several arising together from protuberances on old, leafless stems, (5–)8–28(–35) cm long, usually ferruginose-tomentose. Flowers fragrant on pedicels 2.5–5 mm long, puberulous; sepals 9, in 3 whorls of 3, 3 outer ones triangular-ovate to narrowly triangular, 1–2 mm long, 6 inner ones elliptical, 4–5 mm long, reflexed at anthesis, white to yellow; petals 6, broadly elliptical, 2.5–3.5 mm long, erect and contiguous at anthesis; male flowers, stamens 6, 2–2.5 mm long; female flowers, staminodes 6, linear-oblong, acute, 3 mm long, carpels 3, curved-ellipsoidal, stigma lobed. Fruit consisting of 3 drupes, radiating from a discoid carpophore; drupe drying compressed-ellipsoidal, base narrowed into a short stalk, initially green with white spots, later white or yellow or orange; endocarp very variable in shape and surface ornamentation, compressed, elliptical to subovate in outline, 2–3.5 cm × 1–2 cm. Seed flat, endosperm present, cotyledons thin, flat, imbricate.

Growth and development *T. petiolare* can be found flowering and fruiting throughout the year. The pollinators of *Menispermaceae* are in general small *Diptera* and *Hymenoptera* and possibly also small *Coleoptera* and *Lepidoptera*. These insects are undoubtedly attracted by the scent of the flowers.

Other botanical information *Tinomiscium* is a monotypic genus, included in the tribe *Fibraureae*, comprising also *Fibraurea* in South-East Asia. *Fibraureae* is a small ill-defined tribe that is very close to the tribe *Tinosporeae*. Phytochemically *Fibraurea* and *Tinomiscium* can be readily distinguished. *Fibraurea* contains notable amounts of protoberberine alkaloids and *Tinomiscium* seems to have at most only very small amounts of alkaloids. Similarly, from *Fibraurea* a series of columbin-like bitter substances have been isolated, while *Tinomiscium* yields a bitter substance related to columbin, not known to occur elsewhere. The latex present throughout *T. petiolare* retains its elasticity in dried plant material. If any part is broken, fine white strands are evident, connecting the faces of the fracture.

Ecology *T. petiolare* is found on various soils and substrates, including limestone, in evergreen forest from sea-level to 1400 m altitude, but most commonly encountered below 500 m altitude. In view of its lianescent nature *T. petiolare* is most likely a sun-loving plant although some shade may be required in the early stages of growth.

Husbandry Sufficient support must be provided for *T. petiolare* to climb and spread properly so that a maximum amount of leaves can be produced.

Harvesting Leaves of *T. petiolare* are plucked whenever the need arises, and fruits are picked when mature. Roots are simply dug up and stems are cut into pieces.

Handling after harvest Leaves of *T. petiolare* are used fresh, roots and stem pieces are dried for future use.

Genetic resources and breeding In view of the large geographical distribution and its common occurrence on a wide range of soils, *T. petiolare* does not seem to be threatened by genetic erosion. No germplasm collections or breeding programmes are known to exist.

Prospects Since many aporphine- or bisbenzylisoquinoline alkaloids show several interesting biological activities, further investigation of the phytochemistry of *T. petiolare* is needed to fully investigate its potential.

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Other selected sources 128, 135, 316, 372, 407, 788.

S. Brotonegoro & J.L.C.H. van Valkenburg

Trachyspermum ammi (L.) Sprague ex Turrill

Kew Bull. 7: 228 (1929).

UMBELLIFERAE

$2n = (14, 16), 18$

Synonyms *Sison ammi* L. (1753), *Trachyspermum copticum* (L.) Link (1821), *Carum copticum* Hiern (1871).

Vernacular names (True) bishop's weed, carum (En). Indonesia: mungsi (Javanese, Malay), mose (Madurese), musi (Balinese). Malaysia: jemuju, hajimuju, mungsi (Peninsular). Philippines: damoro (Tagalog, Pampangan), lamudio (Tagalog, Bikol). Thailand: phakchee (northern).

Origin and geographic distribution *T. ammi* is probably a native of Ethiopia and Egypt, and occurs semi-naturally in southern Europe, but is found cultivated in northern Africa, Ethiopia, western Asia, India, Iran and the former USSR, as well as here and there in South-East Asia, e.g. in Java (Indonesia), Peninsular Malaysia and the Philippines.

Uses In South-East Asia, *T. ammi* is primarily used as a medicinal plant, and to a lesser extent as a spice. The fruits are aromatic and have a pungent taste. They are considered carminative, antispasmodic and stimulant and are applied in decoction or plasters. They are also used for stomach and liver problems, a sore throat, cough, rheumatism and asthma. The essential oil is considered strongly antiseptic and is used for internal parasites. In Java, the fruits are used in mixtures drunk by women after childbirth and to induce menstruation. A decoction of the dried and crushed fruits is also used for intestinal problems and diarrhoea. In the Philippines, the fresh fruits are chewed for flatulence. In India, the essential oil is known as 'ajowan oil', and enters into the Indian Pharmacopoeia. In Ethiopia, the fruits and roots, mixed with other spices, are used against stomach problems. The fruits are taken as a vermifuge and abortifacient. In Somalia, the fruits are chewed against diarrhoea.

T. ammi is widely cultivated as a spice for curries in India, the Mediterranean and Ethiopia. Usually the fruits are dried, roasted and ground before use. The fruits are also used in pickles, biscuits and sweets. The essential oil is sometimes added to food as a preservative.

The fruit cake left after steam distillation is rich in protein and fat and is used as cattle feed.

T. roxburghianum (DC.) H. Wolff is cultivated on a small-scale for similar culinary and medicinal purposes as *T. ammi*.

Production and international trade Small-scale cultivation is widespread throughout the distribution area of *T. ammi*. In South-East Asia, *T. ammi* is grown on a small scale, in home gardens, in pots, and in small, upland fields. Large-scale cultivation occurs mainly in India, and the fruits are exported to the United Kingdom, Germany, the United States, Japan and South-East Asia. The quantity of *T. ammi* fruits exported from India varied from 2.4–7 t/year between 1966–1973, but recent statistics are not available.

Properties Depending on the origin and cultivar, the content of essential oil in *T. ammi* fruits ranges from 3–10%. The main active constituents of the oil are phenols, mainly thymol (35–60%), which has strong antiseptic properties, and its isomer carvacrol. After extraction of the thymol, the residual mixture, which is called thymene, is used to perfume soap. Thymene contains terpenes like p-cymene, g-terpinene, α- and β-pinene. The lipids in the fruits were extracted using a chloroform/methanol mixture. The lipid fraction consisted of about 1% hydrocarbons, 2% wax esters, 2% sterol esters, 54% triglycerides, 6% fatty acids, 6% 1,2-diglycerides, 7% glycolipids, 4% 2-monoglycerides, 7.5% 1-monoglycerides, 1.5% phosphatidyl-ethanolamines, 1% phosphatidylcholines, 0.5% lysophosphatidylethanolamines and 1% phosphatidylinositols.

The essential oil shows strong antibacterial activity against many gram-positive and gram-negative bacteria. It also showed long-term fungitoxic activity against storage fungi like *Aspergillus flavus*, *A. niger*, *Claviceps oryzae-sativae* and *Helminthosporium oryzae*, and soil-borne fungi like *Macrophomina phaseolina*, *Pythium aphanidermatum* and *Rhizoctonia solani*. Thymol also showed significant dose-dependent molluscicidal effects in *Indoplanorbis exustus* and *Lymnea acuminata*, and nematicidal activity against *Cephalobus litoralis* and *Meloidogyne incognita*. Furthermore, the mosquito larvicidal property of the essential oil was tested against 4th-instar larvae of *Aedes aegypti*, *Anopheles stephensi* and *Culex fatigans* (synonym *C. quinquefasciatus*) at 0.01%, 0.1% and 1.0% concentrations, and showed high mortality after 24 hours. The essential oil is also a strong inhibitor for sprouting of potatoes stored at room temperature.

In addition, the essential oil has a parasympathomimetic effect and produces relaxation of the isolated ileum, tracheal chain and bronchial musculature in guinea-pigs. In anaesthetized rats, thymol (1–10 mg/kg), administered intravenously, produced dose-dependent reduction in blood pressure and heart rate. These effects were not blocked by atropine (1 mg/kg). In the rabbit aorta, thymol caused relaxation of norepinephrine- and potassium-induced contractions. Moreover, atropine, propranolol, indomethacin and glibenclamide did not alter the vasorelaxation caused by thymol. The results suggest that thymol is a calcium channel blocker which may explain the hypotensive and bradycardiac effects observed.

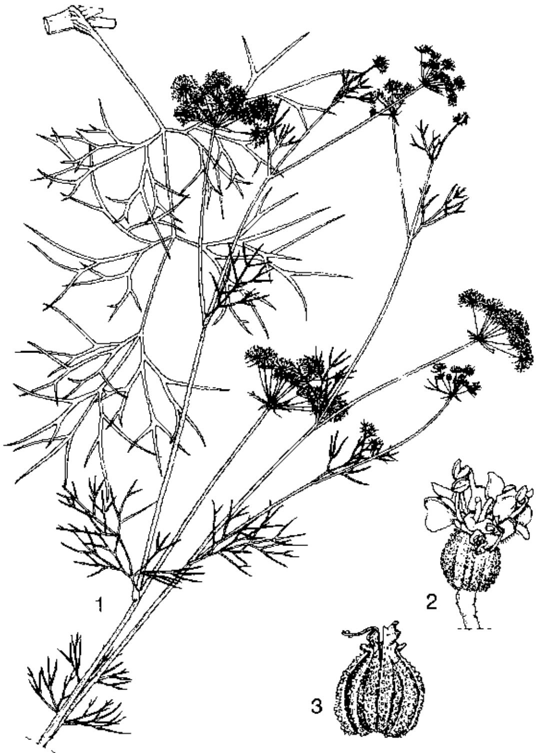
Other pharmacological effects of *T. ammi* extracts include inhibition of the platelet aggregation induced by arachidonic acid, epinephrine and collagen by an ether extract of the fruits.

Aqueous and 90% ethanolic extracts were studied for their anti-reproductive potential in rats, orally dosed for 10 days after insemination, and were found to have moderate teratologic potential. The aqueous extract of the fruits was tested for anti-oxidant properties in human erythrocyte membranes against lipid peroxidation induced by $FeSO_4$-ascorbate, and was found to exhibit 75% inhibition. It was also found to inhibit the formation of diene, triene and tetraene conjugates in human erythrocyte membrane. In addition, the essential oil also showed excellent anti-oxidant effects of stored sunflower and soya bean oil.

An aqueous extract of the fruits was evaluated for the effects on gastric acid secretion in anaesthetized rats. The stomach of anaesthetized rats was perfused at 0.15 ml/min with the extract or with acetylcholine (1 μg/ml or 10 μg/ml). Acute gastric mucosal injury was induced by leaving aspirin, at 125 mg/kg, in the stomach for 2 h before perfusion. The extract increased acid secretion, while atropine abolished the acid secretion induced by acetylcholine and significantly reduced acid induction by the extract.

Adulterations and substitutes Thymol was formerly important as an essential oil, but is now mainly produced synthetically. Natural thymol can also be obtained from *Thymus vulgaris* L. or the thymol type of *Ocimum gratissimum* L.

Description An annual, erect, aromatic herb, 25–60(–140) cm tall, stems striate, glabrous, usually strongly branched. Leaves alternate, pinnately compound; petiole long, sheathing; blade in outline ovate-elliptical, up to 13 cm × 12 cm, 2–3-pinnate, segments linear to narrowly oblong, up to 2 mm long. Inflorescence a terminal or axillary, compound umbel, up to 6 cm in diameter; peduncle 1–10 cm long; involucral bracts 3–6, linear-lanceolate, sometimes divided; rays 5–9(–17) per umbel, 0.5–3 cm long, up to 2 cm in fruit; pedicels (secondary rays) 8–15(–25), 1–6 mm long, bracteoles 4–7; flowers actinomorphic, 5-merous, bisexual, calyx teeth 0.5 mm long, fleshy, petals obcordate, 0.6–0.7 mm long, apex inflexed, white; stamens 5, radiating, anthers reddish-brown, ovary inferior, densely white hairy, styles 2, stigma globose. Fruit a flattened, subglobose schizocarp, splitting into 2 hairy, 1-seeded mericarps, 2 mm × 1 mm, each mericarp with 5 longitudinal ribs, on ribs with broad, warty trichomes, each mericarp with 4–6 oil ducts. Seed tiny, ovoid, embryo straight, endosperm copious, grey. Seedling with epigeal germination; cotyledons oblanceolate, 5–15 mm × 1–2 mm, base attenuate, slightly sheathing, first leaf simple, blade ovate in outline, deeply divided into 3 lobes, each repeatedly incised.



Trachyspermum ammi (L.) Sprague ex Turrill – 1, flowering stem and basal leaf; 2, flower, one petal removed; 3, fruit.

Growth and development In India, flowering of *T. ammi* starts 2–4 months after sowing, and fruits are ripe 2 months later. It is cross-pollinated for 70–80%, and pollination is primarily done by bees. As the plants are widely branched, flowering occurs unevenly, thus fruits mature unevenly, which makes them difficult to harvest.

Other botanical information *Trachyspermum* consists of 15–20 species, distributed from tropical and North-East Africa to Central Asia, India and western China. Several species are cultivated in South-East Asia. *Trachyspermum* is closely related to *Carum*, but the genera have been separated based on differences in life cycle and pubescence of fruits. A general revision of *Trachyspermum* and related genera is needed, as the taxonomy of the group is very confusing. In India, several cultivars of *T. ammi* are known, which are mainly distinguishable by the size of the fruit.

Ecology In South-East Asia, *T. ammi* is grown on the hills, up to 750 m altitude. In Ethiopia, it is cultivated at 1700–2200 m altitude, but when grown at 2000 m fruit setting is less satisfactory. The climate of Central Europe is not considered suitable for *T. ammi*, and cultivation ceased centuries ago, although it is still found here and there in the wild. *T. ammi* prefers not too heavy, loamy soils, but can be grown on all types of soils, although wet-rice-growing soils are considered unsuitable as they promote vegetative development.

Propagation and planting *T. ammi* is propagated by seed. Good seed is difficult to obtain, as many fruits for sale on the market are empty. In India, germination takes 10–15 days, while in Ethiopia it may take as long as 1 month. Cool and cloudy weather and gentle rain after sowing are important for the establishment of the crop. In India, sowing is from September to November, depending on the regions, at the rate of 2.3–3.5 kg/ha. *T. ammi* is often broadcast, as a sole crop or intercropped with grain crops or other *Umbelliferae*. The light fruits need to be covered by a thin layer of soil for good germination, and to prevent flushing. For sowing, the fruits are sometimes mixed with rice husks to ensure even distribution. In India, the fruits are sown in rows 45 cm apart and 30 cm between plants.

An efficient and reliable protocol for in vitro regeneration of *T. ammi* was established, and complete plantlet formation was achieved using shoot tips as explants on Murashige & Skoog (MS) medium supplemented with either indole acetic acid (IAA) at 3 mg/l or naphthalene acetic acid (NAA) at 3 mg/l, within 3–4 weeks.

In vitro production of active compounds Callus cultures were established from mature fruits on MS media to study thymol production in vitro. Undifferentiated white callus was obtained on MS containing 2,4-D at 3 μg/ml, and chlorophyllous callus on MS containing IAA. Addition of NAA and kinetin to the IAA-containing medium resulted in the initiation of organogenesis and the formation of semi-differentiated callus. The undifferentiated and semi-differentiated calluses contained about 0.10% and 0.17% total phenols on a dry weight basis, respectively. The thymol content of both calluses increased with time but was highest in semi-differentiated callus. Addition of monoterpenes to the medium as precursors for thymol is undesirable as they have the opposite effect.

Husbandry Weeding of *T. ammi* is important, and plants are thinned or transplanted if necessary at the first weeding. The crop is irrigated in gardens or small fields if rainfall is insufficient. Although the crop responds well to manure, it is not often fertilized.

Diseases and pests *T. ammi* is not often affected by diseases and pests in the field. Several leaf spot diseases may occur, caused by *Alternaria dauci* and *Cercospora* sp., and also root rot, caused by *Sclerotium rolfsii*. In India, the larvae of the chalcid fly *Systole albipennis* feed on the fruits and can cause about 10% yield loss. When stored, the fruits are often attacked by the drug-store beetle *Stegobium paniceum* and by rot-causing fungi like *Aspergillus flavus*, *A. niger* and *Penicillium nigricans*. It is also susceptible to root-knot nematodes.

Harvesting The fruits of *T. ammi* are often harvested before they are fully ripe, to prevent loss due to shattering. The essential oil quality of these fruits is considered the same as that of the ripe fruits.

Yield In India, yields of traditionally grown *T. ammi* are higher under dry rain-fed conditions than under irrigation, and amount to about 225 kg/ha of fruits. Improved cultivars may give yields of 1.2–2.2 t/ha and in 1997 an improved cultivar yielded 82 kg/ha essential oil.

Handling after harvest The fruits of *T. ammi* are used fresh or dried and stored for later use. The fruits can be ground before storage.

Genetic resources and breeding *T. ammi* is not commonly cultivated in South-East Asia, and could therefore be in danger of genetic erosion. No germplasm collections are known to exist, although populations in India show a large genotypic diversity.

Breeding experiments have been carried out in India to obtain types with higher yield of fruits and oil, resulting in cultivars with an oil content twice as high.

Prospects The potential for *T. ammi* cultivation in the cooler regions of South-East Asian countries needs further investigation. On account of its low toxicity, further research on the properties of the oil as a hypotensive agent is recommended.

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G.H. Schmelzer

Trianthema portulacastrum L.

Sp. pl. 1: 223 (1753).

AIZOACEAE

$2n = 26$, (36)

Synonyms *Trianthema monogyna* L. (1767).

Vernacular names Horse purslane, carpet weed, giant pigweed (En). Pourpier courant (Fr). Indonesia: krokot, telekan (Java), krajep (Madura). Papua New Guinea: pih-suh. Philippines: toston (Tagalog), ngatug (Ilokano), ayam (Bisaya). Cambodia: chonkuëng' praëhs. Thailand: phakbia hin, phakkhom hin (central). Vietnam: c[or] tam kh[oo]i, d[af]n d[af]n.

Origin and geographic distribution *T. portulacastrum* is distributed throughout the tropics. In Malesia, it is found in Peninsular Malaysia, the Philippines, Java, Madura, Lesser Sunda Islands, the Moluccas, and Papua New Guinea.

Uses The roots of *T. portulacastrum* have cathartic and stomachic properties and in the Philippines, Thailand, India and Africa, they are used to relieve obstructions of the liver, and to relieve asthma and amenorrhoea. In Asia they are given as an emmenagogue, and in large doses as an abortifacient. The leaves are diuretic and applied in the treatment of oedema, jaundice, strangury and dropsy. A decoction of the herb is used as a vermifuge and is useful in rheumatism; it is considered an antidote to alcoholic poisoning. The fleshy nature of the leaves makes them suitable for use as a wound-dressing or poultice. In Nigeria the old leaves are used in a treatment against gonorrhoea, in Gabon the powdered herb is taken for venereal discharge.

In India, Vietnam and in Africa, the young tops and leaves are sometimes eaten, but may cause diarrhoea or paralysis. When used as fodder, they can produce similar effects. The seeds are harmful contaminants in food grains and other crop seeds. The plant has a potential value as a source of organic matter because it contains considerable amounts of nitrogen, potassium and phosphorus.

Production and international trade Dried plants of *T. portulacastrum* are only occasionally traded in local markets and by herbalists.

Properties *T. portulacastrum* contains the alkaloid trianthemine and the steroid ecdysterone. The flavonoid C-methylflavone has been isolated from the dichloromethane extract of the herb. The seeds contain 12.5% of a fatty oil, and the leaves contain carotene and oxalates.

Pharmacological investigations of extracts of *T. portulacastrum* revealed effects on the liver. An ethanol extract of the aerial parts showed a significant reduction of CCl_4-induced chronic hepatocellular damage of Swiss albino mice. A chloroform extract showed a significant reduction of diethylnitrosoamine-induced hepatocarcinogenesis in Sprague-Dawley rats. In particular the incidence, numerical preponderance, multiplicity and size distribution of visible pre-neoplastic nodules were reduced. An ethanol extract of the plant has also shown some effects on blood pressure of guinea-pigs and on their ileum.

Ecdysterone is a potential chemosterilant, and possesses moulting hormone activity, giving a full pupation-response for larvae of the housefly.

T. portulacastrum also shows allelopathic effects on other weeds and crops including sorghum, pumpkin, eggplant, radish, several pulses and wheat, by inhibiting seed germination and vigour of seedlings. Interestingly, it is also autotoxic as plant extracts reduce its seed germination, shoot length and vigour.

Adulterations and substitutes *Boerhavia diffusa* L. (*Nyctaginaceae*) roots contain the alkaloid punarnavine and are used as an adulterant for the roots of *T. portulacastrum*.

Description An annual, succulent, prostrate or ascending herb, up to about 60 cm tall, often much branched, glabrous or finely pubescent, with a firm taproot; branches in the axils of the smaller leaf of the leaf-pair, alternating. Leaves opposite, ovate-obovate to obcordate-oblong, 1–5 cm × 0.5–4.5 cm, those of the same pair very unequal in size, margin entire, purple or green; petiole 4–30 mm long, dilated and sheathing at the base, pairwise connate into a funnel-shaped sheath; stipules small, 1 on each side on the petiole. Inflorescence

Trianthema portulacastrum L. – 1, plant habit; 2, flower and secondary bract between petioles; 3, fruit, floral tube removed; 4, seed.

a single flower in the leaf axils, the lower part hidden by the pouch. Flowers bisexual, actinomorphous; sepals (perianth) 5-lobed, tube fused with the petiolar sheath, with the 2 pointed bracteoles, and even with the stem, lobes obtuse with a long dorsal, subapical mucro, pale pink, rarely white, petals absent; stamens 10–25, filaments white, glabrous; ovary superior, turbinate, truncate, style 1.3 mm long, unilateral stigmatose throughout its length. Fruit a capsule, 5 mm × 3 mm, partly exserted from the persistent perianth, apex truncate, bilobed, operculum fleshy, indehiscent, basal part of capsule thin-walled. Seeds 2–8, reniform, 1.5–2.5 mm long, with faint wavy ribs, black. Seedling with epigeal germination.

Growth and development In *T. portulacastrum* the production of flowers and seeds starts 20–30 days after germination.

Other botanical information *Trianthema* is a small genus of about 17 species, and is closely related to *Sesuvium* and *Cypselea*. These genera are thought to link the *Aizoaceae* to the *Portulacaceae*. The confusing generic limits between *Trianthema* and *Sesuvium* in Africa are resolved by re-establishment of the genus *Zaleya*, containing *Z. decandra* (L.) Burm.f., *Z. pentandra* (L.) Jeffrey and *Z. sennii* (Chiov.) Jeffrey. *Z. decandra* is a widespread weed, and in Africa, India and the Philippines, the leaves are eaten in times of scarcity. The root is used against hepatitis and asthma, and as an aperient. In Australia, *Z. decandra* is suspected of poisoning sheep, due to the triterpenes or steroids it contains. *Trianthema* and *Sesuvium* species exhibit structural adaptations of the leaves to xerophytic conditions.

Ecology *T. portulacastrum* is a common weed in fields and in open, sunny localities such as roadsides, often found on clayey soils near the sea, up to 200 m altitude. It is an aggressive weed, especially in Thailand, Australia and South America, and can be controlled either by uprooting the plants before flowering, or by spraying the herbicide Fernoxone.

Propagation and planting Seeds of *T. portulacastrum* germinate between 20°C and 45°C, with an optimum at 35°C. More than 50% of fresh seeds germinate within 4–8 days of incubation. When stored under field conditions, germination increases during 7–8 months. Optimum sowing depth is 1 cm.

Diseases and pests *T. portulacastrum* is a host for aubergine mosaic virus, tobacco mosaic virus, rice tungro bacilliform virus, rice tungro spherical virus, cucumber mosaic virus and watermelon mosaic virus. It also has its own virus, Trianthema mosaic virus, which causes distinct necrotic lesions on the leaves, and also attacks several other weeds and tobacco. It is attacked by fungi such as *Macrophomina phaseoli*, causing dry root rot, and by *Colletotrichum capsici*, *Fusarium semitectum*, *Drechslera* sp. and *Stemphylium* sp., all of which cause leaf spot diseases.

Harvesting *T. portulacastrum* is collected from the wild whenever needed.

Genetic resources and breeding *T. portulacastrum* is extremely widespread and occurs in anthropogenic habitats, which means that there is little risk of genetic erosion. Much effort is made to eradicate it as a noxious weed, but it seems well able to survive since it is resistant to many herbicides.

Prospects The anti-hepatotoxic effects of *T. portulacastrum* extracts on the liver in jaundice and alcohol poisoning are interesting. These effects merit further research, as do those of the isolated ecdysterone as a chemosterilant in pest control.

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Other selected sources 74, 84, 111, 215, 312, 696, 788, 937, 1043, 1116.

N.O. Aguilar

Tribulus L.

Sp. pl. 1: 386 (1753).

ZYGOPHYLLACEAE

$x = 6$; *T. cistoides*: $2n = 12$, (18), *T. terrestris*: $2n = 12$, (22), 24, (32), 36, 48

Major species *Tribulus cistoides* L., *T. terrestris* L.

Vernacular names Caltrop, puncture vine (En). Croix de chevalier (Fr).

Origin and geographic distribution *Tribulus* consists of about 20–25 closely related species, distributed in tropical and warm regions of the world, especially in the dry regions of Africa (10 species) and Australia.

Uses *T. terrestris* has a reputation as a powerful medicine in South and North America, Europe and Africa. It has astringent, abortifacient, emmenagogue, galactagogue, aphrodisiac, diuretic, anthelmintic, tonic and haemostatic properties. The seeds or the fruits are used against abscesses and ulcers, nosebleed, dysentery, sore throat, painful urination, calculous affections and aphthae. In India, a decoction of the leafy stem is applied to scabies and other scaly skin diseases. It is also used as a tonic, diuretic and as an aphrodisiac. In Vietnam and Argentina, the fruits are used externally in ophthalmia, by exposing the eyes to the vapours of a hot infusion, and for ulcers of the mouth, by gargling the infusion. In Pakistan, the fruits are used for painful urination, impotence and haemorrhages. In China, the seeds are used to treat spermatorrhoea, anaemia, coughs, purulent expectorations and haemorrhoids.

In Thailand, the whole plant is considered diuretic, and used in the treatment of dysuria with bladder stones, leucorrhoea, kidney dysfunction and abnormal urination. It is not recommended for people with heart diseases. In China though, the plant is taken for coronary heart diseases, because it is said to dilate the coronary arteries and improve the blood circulation. It is also very popular for treating angina pectoris.

In India, the leaves and tender shoots are eaten by poor people as a pot herb, either alone or mixed with other herbs. They are rich in calcium, but poor in iron. The flour from the seeds is made into a bread which is eaten in times of scarcity. The plant at early post-flowering stage is also used as a fodder for horses, camels and sheep. Dried plants at pre-flowering stage were refused by sheep.

In Mexico, a decoction of the leaves and root of *T. cistoides* (often used indiscriminately with *T. terrestris*) is sweetened and taken as a diuretic and treatment for various kidney complaints. In Venezuela, a decoction of the whole plant is drunk in cases of gonorrhoea, chest congestions and also used as an eyewash and a bath for swollen legs. In El Salvador, the seeds serve as a vermifuge.

The spiny fruits of *T. cistoides* and *T. terrestris* cause injury to the feet, skin and stomach of animals, may cause punctures in vehicle tyres and are a nuisance in lawns and playgrounds. They also reduce hay and seed quality.

Production and international trade Many preparations containing *T. terrestris* powder are sold on the northern American and European market. The steroidal saponin content acts on testosterone levels in the body. These are sold as a food supplement, claiming to improve reproductive function, libido and ovulation and also performance of athletes, by increasing muscle cell growth and body strength. Prices in 2000 were around US$ 10–20 for 60 capsules containing 500–750 mg of *T. terrestris* powder, with varying saponin content. Bulgaria and the United States are known to cultivate *T. terrestris* but no statistics on production and trade are available.

Properties The whole plant of *T. terrestris* contains steroidal saponins, which on hydrolysis yield steroidal sapogenins: diosgenin, gitogenin, chlorogenin, ruscogenin, and 25 d-spirosta-3,5-diene. Sapogenins with a high haemolytic index are present in leaves and roots, but absent in stems or seeds. Leaves and fruits also contain kaempferol, kaempferol-3-glucoside, kaempferol-3-rutinoside and the flavonoid tribuloside. The fruits contain a fixed oil (3.5%) consisting mostly of glycerides of unsaturated acids, an essential oil, resin, nitrates and steroidal saponins with aglycones diosgenin, ruscogenin, gitogenin, furostanol, tigogenin, epismilagenin and yamogenin. The fruits also contain N-trans-feruloyltyramine, terrestriamide, N-trans-coumaroyltyramine, terrestrosin A–E, terrestribisamide, 25R-spirost-4-en-3,12-dione, tribulusterine, N-p-coumaroyltyramine, aurantiamide acetate, xanthosine, ferulic acid, vanillin, p-hydroxybenzoic acid and β-sitosterol. The lignanamides tribulusamide A and B were also isolated from the fruits and significantly prevented cell death of cultured mouse hepatocytes induced by D-galactosamine tumour necrosis factor α. Several indole alkaloids e.g. harmaline, harmalol, harman, nor-harman and harmine were isolated from the entire plants.

T. terrestris is known to cause photosensitivity in small livestock, and is responsible for the disease 'geeldikkop' (South Africa) or 'bighead' (Australia, United States) among sheep. It is also found to occur among sheep in East Africa, Colombia and Argentina. This condition is characterized by oedema of the head, fever and jaundice, finally leading to death. The plant causes liver damage followed by photosensitivity of the skin cells from phylloerythrine, a derivative of chlorophyll. Hepatogenous photosensitization occurs mainly when the animals are in short supply of pasture. The disease was found to occur only in white (unpigmented) sheep, not in black sheep. In South Africa, 'geeldikkop' was induced in sheep by oral administration of crude steroidal saponins from *T. terrestris*. The chemical composition of biliary crystals that are formed during the disease was shown to be a 6:1 mixture of the calcium salts of the β-D-glucuronides of the steroidal sapogenins epismilagenin and episarsasapogenin.

The ether extract, but not the aqueous extract, of the fruits caused diuresis and increased creatinine renal clearance in anaesthetized dogs. The diuretic effect is likely due to the abundance of nitrates. Another study reported prolonged diuretic activity of a 10% infusion of whole plants. An extract from the leaves showed hypotensive activity in anaesthetized dogs, which was probably due to γ-aminobutyric acid.

The effect of an aqueous extract of the whole plant on the metabolism of oxalate was tested in male rats fed sodium glycolate, resulting in hyperoxaluria and increased activities of oxalate synthesizing enzymes in the liver. The extract showed a significant decrease in urinary oxalate excretion, and a significant increase in urinary glyoxylate excretion. An aqueous or ethanolic extract of the fresh leaves and stems showed antispasmodic activity on guinea-pig ileum. In rabbits, it showed a positive effect on spontaneous pendulum movement and tone of the duodenum, but negative effect on rate, amplitude and rhythm of the isolated heart.

A preliminary study of the effects of lyophilized saponin mixture from the aerial parts on several smooth muscle preparations in vitro showed a significant decrease of peristaltic movements of isolated sheep ureter and rabbit jejunum preparations in a dose-dependent manner. No effect was observed on isolated rabbit aorta and its contractile response to KCl or noradrenaline. The saponin mixture might be of some use on some smooth muscle spasms or colic pains.

In China, the fruits of *T. terrestris* are traditionally used in the treatment of vitiligo. An aqueous extract of the fruits though showed significant stimulation of melanocyte proliferation of a mouse pigmented cell line.

The effects of a commercial herbal preparation of *T. terrestris* on body composition and exercise performance in resistance-trained males were tested. Body weight, body composition, maximal strength, dietary intake and mood states were determined before and after an 8-week training and supplementation period (3.2 mg/kg body weight daily) but failed to show any significant differences with a placebo group.

The pro-erectile pharmacological effects of an extract of *T. terrestris*, containing protodioscin (PTN), on the corpus cavernosum of white rabbits were investigated at different doses, 2.5, 5 and 10 mg/kg respectively. PTN was found to have no effect on the isolated corpus cavernosal strips; however, the relaxant responses to acetylcholine, nitroglycerin and electrical field stimulation increased by more than 10%, 24% and 10% respectively compared to their control values, and the lack of such effect on the contractile response to noradrenaline and histamine would indicate that PTN does have pro-erectile activity. The enhanced relaxant effect observed is probably due to increase in the release of nitric oxide from the endothelium and nitrergic nerve endings, which may account for its claims as an aphrodisiac. In another test, protodioscin was tested as a medicine to treat erectile dysfunction and was found to improve sexual desire and enhance erection via the conversion of protodioscine to de-hydro-epi-androsterone (DHEA). In Russia, China and Bulgaria, the medicinal preparation 'Tribestan', based on the total glycosides of *T. terrestris*, is used for treating impotence and female infertility. The preparation was found to stimulate blood testosterone and testicular maturation of ram lambs when given orally at 250 mg daily for 40 days. It is also claimed to enhance testosterone levels by increasing luteinizing hormone, follicle stimulating hormone levels and estradiol. Methanol extracts of whole plants, given at 560 mg/kg to nursing rats, increased milk yield significantly compared with control groups. In a second trial, an extract in 10% methanol, given at 450 mg/kg, increased milk yield of nursing rats compared with controls but a hexane extract had no effect. Another extract, given at 200 mg/kg for 6 days, was able to produce an oestrogenic response in ovariectomized, anoestrous rats as indicated by vaginal cornification (90%) and glycogen deposition (100%).

The root extract of *T. terrestris* significantly and strikingly inhibits the growth of *Pennisetum glaucum* R.Br. seedlings, in field experiments. In another test, at 200 ppm, an extract of *T. terrestris* plants was found to have 100% molluscicidal activity for *Bulinus truncatus*. An ethyl ether and ethanol extract were found to be significantly active against *Staphylococcus* aureus and *Candida albicans*.

The desert locust *Schistocerca gregaria* was found to prefer feeding on *T. terrestris* plants from populations in Mauritania that are rich in quercetin glycosides. An extract of the plant significantly increased the growth and development of silkworms (*Bombyx mori*), silk gland weight and silk thread length.

T. cistoides has been found to be poisonous to animals in Australia, Colombia and Venezuela. A methanol extract from the roots contains the cardioactive saponin-3, which also occurs in the leaves, and also tribulosin (a pregnane-type glycoside) and 8 cholestane-type glycosides. Three steroid sapogenins and 2 N-acyltyramines were isolated from a petrol extract of the leaves and stems, whereas the methanol extract gave 9 steroid sapogenins, among them the cardioactive cistocardin, saponin-3, saponin-4 and saponin-7. The extract also contained a furostanol diglycoside, 5'-(hydroxysulphonyloxy)-jasmonic acid, D-(+)-pinitol and sucrose. An aqueous seed extract was sprayed on 15-day-old rice seedlings, before inoculating them with viruliferous *Nephotettix virescens*, causing rice tungro virus. The seedlings showed a 45% infection reduction. The extract was also very effective against the larvae of the nematode *Meloidogyne incognita*.

Adulterations and substitutes *Dioscorea* L., *Brachiaria decumbens* Stapf and *Trigonella foenum-graecum* L. contain similar steroidal saponins to those found in *T. terrestris*. Also, pastures of *Brachiaria decumbens* in Java and Brazil were found to cause the same photosensitization disease in sheep as *T. terrestris* does in South Africa.

Description Annual or perennial herbs, branches prostrate to ascending, with silky white hairs; taproot long. Leaves opposite, paripinnate, anisophyllous; stipules present. Flowers actinomorphic, 5-merous, bisexual, solitary on pseudo-axillary peduncles, next to shorter leaves. Sepals 5, free, imbricate, persistent or caducous; petals 5, free, patent, imbricate, delicate, early caducous, white or yellow; disk annular, lobed or not; stamens 10, in 2 whorls, subequal or unequal, the inner whorl at base with an abaxial appendage and an adaxial scale (gland), scales free or laterally connate, anthers dorsifixed; ovary superior, sessile, 5–12-lobed, 5–12-celled, densely hairy, style short, thick, stigmas 5(–12), decurrent, ovules 3 or more per cell. Fruit composed of 5 mericarps (cocci), angled or 5–12-winged; cocci partly abortive, spinous or tuberculate, indehiscent with 3–5 superposed seeds, separated by septa; seeds obliquely pendulous. Seed ovoid, flattened, 2.5 m long, tip pointed, whitish, embryo exalbuminous. Seedling with hypogeal germination; cotyledons lanceolate; first leaves paripinnate.

Growth and development *T. terrestris* is able to reach water at depths of 1–2.5 m with its taproot, and also has an extensive lateral root system at the end of the growing season. It can become perennial when enough water is available throughout the year. After germination, the seedling grows very rapidly, producing its first flowers after 3–5 weeks, and its first fruits after 5–6 weeks. Fruits mature in 2 weeks, splitting into segments soon thereafter. Although they are normally prostrate plants, *T. terrestris* and *T. cistoides* can grow almost upright in dense crop stands with shading.

T. cistoides begins to flower and set seeds 3–4 weeks after germination and continues to flower throughout the year when enough water is available. It can form large pure patches near the coast. In Java it flowers during the rainy season, from March–July. Flowers open in the morning and close after sunset, lasting for 2 days.

Tribulus is pollinated mainly by honeybees, foraging for nectar and pollen, and by solitary bees, foraging for pollen.

The spiny fruit segments (cocci) of *Tribulus* have probably been transported over the world in the wool of sheep. They are often first reported near agricultural communities, railroad yards or coastal towns, in hay, straw or manure. The spines on the fruits are arranged at different angles, thus picked up easily by hoofs, shoes or tyres and transported over some distance.

Other botanical information *Zygophyllaceae* s.l. are a heterogeneous family of trees, shrubs and herbs, and the systematic status of some groups within the family has been disputed. *Balanites* and the group consisting of *Tribulus*, *Kallstroemia* and *Kelleronia* probably deserve to be distinguished at least at subfamily level. *Tribulus* is sometimes even put into a family of its own, *Tribulaceae*, but this view is not shared here. *Tribulus* is one of the few pantropical genera that thrives in (semi-)arid conditions. Several species are highly polymorphic, and many intermediate forms exist, sometimes distinguished at variety level. Especially the *T. terrestris* complex is in need of a world revision. The common name, caltrop, refers to the resemblance of the fruits to the medieval spiked weapon called tribolos.

Ecology *T. cistoides* and *T. terrestris* are well adapted to dry, loose, sandy soils, such as coastal or inland dunes or field margins, but also grow in heavier, moist and fertile soils, such as playgrounds or waste land.

Propagation and planting *T. cistoides* and *T. terrestris* both reproduce by seed. Without competition, one *T. terrestris* plant can produce thousands of seeds. In the field, germination starts 5–7 days after the first rains of the season and continues throughout the season. Germination is very erratic under laboratory conditions, ranging from 0–22%, and more research is needed to clarify the pattern. Some dormancy does exist in seeds buried in the soil for 3–4 years, but in general they do not show dormancy. The woody mesocarp will protect the seed for some time from the influence of water.

In vitro production of active compounds Steroidal sapogenins such as diosgenin and hecogenin, used in the synthesis of medicinal steroids, are known to occur in their glycosylated forms in *T. terrestris* but not in economic quantities. Callus cultures were induced from leaf and stem portions on Murashige and Skoog medium containing 2,4-D and kinetin. Lignin, saponins, flavonoids spirosta-3,5-dienes, and free and glycosylated steroidal sapogenins were detected in the cultures. Free sapogenins were not present in the explant sources.

Diseases and pests *Tribulus* is an alternate primary host for *Cuscuta hyalina* Roth in India. Biological control of *T. cistoides* and *T. terrestris* has been found to be very successful in India, Hawaii, Australia and the United States using a fruit-infesting weevil (*Microlarinus lareynii*) and a stem- and a crown-mining weevil (*M. lypriformis*). Other potential biological control agents against *T. terrestris* in southern Africa are a seed-sucking bug (*Deroplax* sp.), a noctuid defoliator (*Prodotis stolida*) and a downy mildew (*Peronospora tribulina*). In India and the Mediterranean region, leaf-feeding moths (*Ephysteris subdimintella* and *Tegostoma comparalis*) and a leaf mite (*Eriophyes tribuli*) have also been found to be promising for biological control. Other *Tribulus* can serve as a host for most of these agents.

Harvesting The fruits of *T. terrestris* are harvested in Vietnam from August to October.

Yield In *T. terrestris* from India, the maximum diosgenin content occurred in the seeds, being 6.2 mg/g dry weight, compared with 3.1% and 3.8% in the roots and leafy stems, respectively.
Preliminary observations suggest that *T. terrestris* grown on different soils does not consistently produce the active compound protodioscin.

Handling after harvest Leafy stems, roots or fruits of *T. terrestris* are used fresh or dried for storage.

Genetic resources and breeding Both *Tribulus* species treated here are weeds with a wide distribution, and are not likely to be threatened with genetic erosion. The steroidal saponin content apparently differs greatly in different populations, and breeding for medicinal purposes should concentrate on this aspect. A breeding programme is known to exist in Bulgaria.

Prospects Although *Tribulus* does not have a history of medicinal use in Malesia, it shows some potential because of the steroidal saponins present, especially in the fruits. The pharmacological effects shown in in vitro and in vivo tests are promising and merit further research. *T. terrestris* is not mentioned as a weed in South-East Asia, but it is most likely to occur here, especially in drier regions.

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Selection of species

Tribulus cistoides L.

Sp. pl. 1: 387 (1753).

Synonyms *Tribulus moluccanus* Decne. (1835), *Tribulus macranthus* Hassk. (1865).

Vernacular names Large-flowered caltrop (En), carpet weed (Hawaii), rock rose (Australia). Thailand: khokkrasun (central). Vietnam: gai ch[oos]ng.

Distribution Native of tropical America, now widespread along tropical coasts, from 22°S to 32°N. In Malesia not in Malaysia and Brunei, in Indonesia not in Sumatra and Kalimantan, rare in Papua New Guinea. It is a weed in Indonesia, Australia, Madagascar, Hawaii and Central America.

Uses In India and Central America *T. cistoides* is used to treat colds, malaria and infections of kidney and bladder. A decoction of the roots is given to children to relieve toothache. In South-East Asia, *T. cistoides* does not have a history as a medicinal plant.

Observations A perennial, decumbent, pubescent herb, branches 0.5–1.8 m long, tips ascending; longer leaves up to 7 cm long, with 6–9 pairs of leaflets, shorter leaves up to 6 cm long with 3–5 pairs of leaflets, midrib ending in a mucro, 0.5–2 mm long; leaflets 6–22 mm × 2.5–9 mm, base obliquely rounded, apex subacute, both surfaces silky, subsessile, stipules falcate, 3–6 mm long, acuminate; pedicel 2–4 cm long, sepals narrowly lanceolate, 7–11 mm long, apex acute, appressed hairy, caducous, petals obovate-cuneate, 1–2 cm × 1–1.5 cm, apex broadly rounded-truncate, bright yellow, stamens subequal, anthers 1 mm long; cocci 4–5, spines stout, sharp, 2 lateral ones largest, pericarp rather thick, corky, seeds 1–4 in each coccus. In Malaysia, *T. cistoides* is found along sandy beaches and coastal dunes, locally often gregarious.

Selected sources 9, 279, 302, 633, 903.

Tribulus terrestris L.

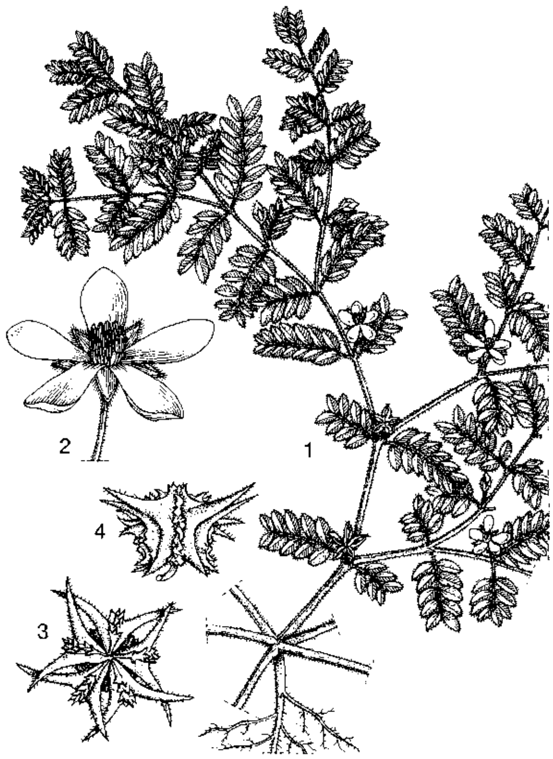
Sp. pl. 1: 387 (1753).

Vernacular names (Small) caltrop, puncture vine, burnut (En). Herbe terrestre, saligot terrestre, croix de chevalier (Fr). Thailand: khokkrasun (central), naam krasung, naam din (northern). Vietnam: t[aaj]t l[ee], b[aj]ch t[aaj]t l[ee], gai ma v[uw][ow]ng.

Distribution Native of the Mediterranean region, now widespread throughout the world from 35°S to 47°N, often as a noxious weed. It is not recorded as a weed in Central or South America, South-East Asia or western Africa.

Uses In Vietnam, the dried fruits are widely used as haemostatic, diuretic and galactagogue, and are considered beneficial for the kidneys and for regulating menses. They are prescribed as a decoction for backache, headache, red eyes, nosebleeds and spermatorrhoea. In Thailand, the aerial parts are used as a diuretic.

Observations An annual to biennial, much branched, mat-forming, pubescent herb, stems radiating from a central axis, up to 2.4 m long; longer leaves up to 6 cm long, with 6–8(–11) pairs of leaflets, smaller leaves up to 3.5 cm long, with 3–4 pairs of leaflets, leaflets oblong-lanceolate, up to 15 mm × 5 mm, base obliquely rounded, upper surface green, sparsely pubescent, lower surface whitish pubescent, stipules linear, up to 10 mm long; pedicel 2–4 cm long, sepals 3–5 mm long, petals 3–12 mm long, pale yellow, stamens about as long as the petals; cocci 4–5, spines stout, sharp, 2 lateral ones largest, 2 shorter ones near the base, directed downward, seeds 1–4 in each coccus. *T. terrestris* occurs in dry, sandy locations, at low altitudes.



Tribulus terrestris L. – 1, plant habit; 2, flower; 3, fruit, top view; 4, fruit, side view.

Selected sources 15, 61, 124, 201, 215, 279, 285, 343, 493, 621, 633, 673, 707, 786, 863, 884, 903, 929, 960, 1114.

Wongsatit Chuakul, Noppamas Soonthornchareonnon & Orawan Ruangsomboon

Triumfetta bartramia L.

Syst. nat. ed. 10: 1044 (1759).

TILIACEAE

$2n = 32, (48)$

Synonyms *Triumfetta rhomboidea* Jacq. (1760).

Vernacular names Chinese burr, burrbush, burrweed (En). Indonesia: sukupan (Javanese), pungpurutan (Sundanese), galopang (Minakasa). Malaysia: pulut-pulut, champadang. Papua New Guinea: gavana (Goldie river, Central Province), siponi (Killerton, Oro Province). Philippines: kulutkulutan (Tagalog, Pangasinan), bulagun (Sulu), kollo-kolot (Sambali, Iloko). Thailand: po yumyuu (northern), seng (peninsular). Vietnam: day k[es], gai d[aaf]u.

Origin and geographic distribution *T. bartramia* is distributed from tropical Africa to tropical Asia including South-East Asia, mainly as a weed.

Uses The leaves of *T. bartramia* are mucilaginous and emollient. In India, a decoction of the plant in rice water, or the root and bark, is used as an astringent or diuretic after diarrhoea, dysentery and gonorrhoea, but also as an antihypertensive. The fruit and pounded roots are believed to promote childbirth. The leaves and flowers are also used against leprosy. In Papua New Guinea, a decoction of the leaves is drunk to treat internal haemorrhage or dysentery. Patients with severe colds are treated by giving them a daily sauna with the boiling leaves. In the Philippines, a decoction of the root is a remedy for internal ulcerations. Crushed flowers may be applied to boils.

T. bartramia is also used as a fibre. The leaves serve as a famine food in India and Africa, and are widely used as fodder.

Production and international trade *T. bartramia* is used and traded at a local level only for medicinal purposes.

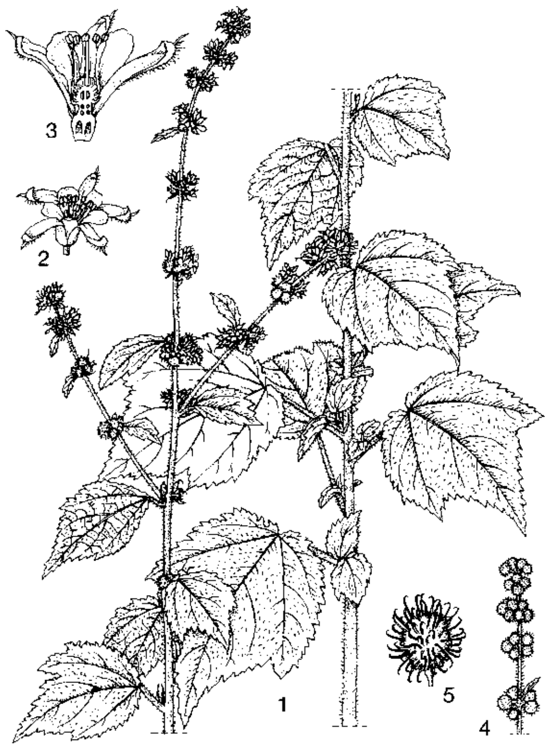
Properties Little is known about the phytochemistry and biological activities of *T. bartramia*. Triumferol (4-hydroxy-isoxazole) was isolated from the plant. Water and ethanol extracts, containing 4-hydroxy-isoxazole, were tested for their anti-implantation effects by oral administration to rats over a 10-day period after mating, and were found to interrupt pregnancy in a dose-dependent manner. The compound is also an effective seed-germination inhibitor.

The crude extract of the aerial parts significantly inhibit the activity of angiotensin converting enzyme (ACE) in vitro. This is one of the enzymes involved in blood pressure regulation.

Phytochemical analysis also revealed the presence of the flavone glycoside triumboidin (scutellarein-6-xyloside-7-rhamnoside), rosmarinic acid, friedelin and friedelinol from the leaves.

Adulterations and substitutes The roots and leaves of *Abutilon*, *Sida* and *Urena* in decoction are used as an emollient in the same way as for *T. bartramia*.

Description An erect, branched, more or less hairy annual, often sub-woody shrub, 0.5–1.5 m tall. Leaves alternate, variable, orbicular or rhomboid-ovate, 2.5–8 cm long, entire or 3-lobed, the upper ones smaller, oblong to ovate-lanceolate, not lobed, base obtuse to rounded, apex acuminate, margins serrate-dentate, upper surface covered with simple hairs, green, lower surface covered with stellate hairs, greyish; petiole 0.3–7 cm long, stellately pubescent; stipules 3 mm long, early caducous. Inflorescence composed of dense axillary or terminal clusters of cymes, peduncle 2 mm long, bracteoles narrowly ovate, 1.5–2.5 mm long. Flowers actinomorphous, 5-merous; pedicel 1 mm long; sepals valvate, free, linear, 4.5–5.5 mm long, hairy outside, with apical appendages, 1–2 mm long; petals free, imbricate, narrowly obovate, 3–4.5 mm long, yellow; staminal column 0.2 mm long, with 5 rounded glands, stamens 10; ovary superior, style filiform, stigma 2-dentate. Fruit a small, rounded, indehiscent, spinose capsule, 3–4 mm in diameter, spines 1–2 mm long, hooked at the apex, glabrous. Seeds (2–)4(–6), semi-ovoid, 2–2.5 mm long. Seedling with epigeal germination.



Triumfetta bartramia L. – 1, flowering branch; 2, flower; 3, flower in longitudinal section; 4, part of fruiting branch; 5, fruit.

Growth and development In Taiwan, *T. bar-*

tramia flowers from September to December, and in the Philippines from October to February.

Other botanical information *Triumfetta* comprises about 70 species with a tropical distribution, and some of them are pantropical weeds. In the vegetative state, *T. bartramia* can easily be confused with *Urena lobata* L., but the latter has a gland at the base of the midrib on the lower side of the leaf. Because of the nectar glands in the flower, *T. bartramia* is a popular bee plant.

Ecology *T. bartramia* is common along roadsides, in waste places and other ruderal locations, up to 1200 m altitude.

Propagation and planting *T. bartramia* is propagated by seed. The fruits cling to fur or clothes and are thus dispersed.

Diseases and pests No serious diseases and pests are recorded for *T. bartramia*. It is sometimes attacked by the fungus *Corynespora* spp. and powdery mildew causing fungi, and also by a geminivirus, causing yellow netting on the leaves.

Harvesting *T. bartramia* is collected from the wild whenever the need arises.

Genetic resources and breeding *T. bartramia* has a large area of distribution in anthropogenic habitats and does not seem to be at risk of genetic erosion. No breeding programmes are known to exist for medicinal purposes.

Prospects Preliminary investigations of *T. bartramia* show some interesting biological effects of extracts (ACE-inhibition) and isolated compounds (triumferol). More research is needed, however, to fully evaluate their potential.

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Other selected sources 135, 418.

N.O. Aguilar

Tylophora R.Br.

Prodr.: 460 (1810).

ASCLEPIADACEAE

$x = 11$; *T. indica*, *T. flexuosa*: $2n = 22$

Major species *Tylophora indica* (Burm.f.) Merr.

Origin and geographic distribution *Tylophora* is a large genus of 75–100 Old World species, centred in tropical Asia, and extending to Africa, China and Japan, Australia and Melanesia. Many species are endemic to a small region.

Uses The roots of many *Tylophora* have a sweetish taste turning acid, a pleasant odour, and are considered poisonous, emetic or tonic, depending on the dose. The roots of *T. indica* possess stimulant, cathartic, expectorant, stomachic and diaphoretic properties and are used in India and Burma (Myanmar), in the treatment of asthma, bronchitis, whooping cough, dysentery and diarrhoea, and also in rheumatic pains and gout. They are said to possess bacteriostatic properties and have been suggested to be a good preservative of food. In India, dried leaves are considered to have anti-allergic, anti-inflammatory and antifeedant properties, and are employed to destroy vermin. The roots and leaves are also used in hydrophobia. In the Philippines, a decoction of the fresh or dry roots of *T. brevipes* is considered to be emmenagogue and carminative, diaphoretic, expectorant, anti-allergic and said to cure indigestion and colic. In Peninsular Malaysia and India, the leaves of *T. flexuosa* R. Br. are used as an application to treat scabies. In India, the plant is used for the treatment of urticaria, excessive perspiration, bilious swellings and smallpox. A decoction or infusion of the roots is considered to be a potent antidote to arsenic poisoning. In Indonesia, the leaves of *T. cissoides* Blume are taken internally or applied externally to treat abdominal pain. The roots and leaves are used to treat thrush. The leaves of *T. perrottetiana* are an effective vulnerary. *T. fasciculata*, from Nepal, India and Indo-China, is employed in India to poison rats and other vermin. Juice of the roots mixed with milk is given as a tonic. A decoction of the roots is given in fevers and a poultice prepared from the leaves is applied to ulcers and sores.

Production and international trade *Tylophora* is only used on a local scale.

Properties *T. indica* contains a series of furoquinoline alkaloids, e.g. tyloindicine A–J, tylophorinicine, tyloindane, tylophorine, and tylophorinine and also (+)-septicine and (+)-isotylocrebrine, which are indolizidine alkaloids. The purified alkaloids isolated from the aerial parts, showed significant amoebicidal action against *Entamoeba histolytica* and the yeast *Candida albicans* in vitro. Out of the 14 alkaloids, tylophorine and tylophorinine were considerably more effective than standard drugs. Tylophorine proved to be very effective against caecal and hepatic infections in test animals; it is also a component with emetic and purgative properties. Tylophorinidine isolated from for example the roots is reported as a potential antitumour alkaloid.

In general the potential use of these compounds in humans is considered low because of their considerable toxicity. Pure alkaloids administered in a single dose (12–100 mg/kg) to male rats caused inactivity, respiratory distress, salivation, nasal discharge and diarrhoea. The oral LD_{50} value was 35.3 mg/kg, although small daily doses (1.25–2.5 mg/kg) produced no signs of poisoning or death of test animals. Tylophorine and tylophorinine are reported to cause dermatitis in humans, producing itching, redness, swelling and eruptions on the skin. Interestingly, toxicity for mice and guinea-pigs seems very low. There is no irritant action locally, or when injected subcutaneously or intramuscularly. Compounds have a marked stimulating effect on both the striped and unstriped muscles, and a distinct depressing effect on the musculature of the heart. The blood pressure is lowered at first, but is raised soon after and maintained at a higher level than the normal for a long time. Pharmacological effects of extracts include significant anticancer activity of leaf and stem extracts against 2 standard transplantable tumours, lymphoid leukemia L1210 and lymphocytic leukemia P388 in mice, and suppression of the histamine response. In India, preliminary clinical trials on patients with bronchial asthma and allergic rhinitis, with infusions of the leaves, gave a marked relief of the symptoms for a few weeks in 40–50% of the cases, but also serious side effects including a sore mouth, loss of taste, vomiting etc. In laboratory animals the LD_{50} was found to be 2 mg/kg. Several extracts of the aerial parts were furthermore tested for their effects on the pituitary-adrenal axis in albino rats. The extracts showed a stimulation of the adrenals, combined with antagonistic activity on the dexamethansone/hypophysectomy-induced suppression of the pituitary on activity of the adrenals. Therefore it was concluded that the extracts may act by direct stimulation of the adrenal cortex. The immuno-biological activity of the ethanol extract of the aerial parts was studied on delayed type hypersensitivity, humoral responses to sheep red blood cells, skin allograft rejection and phagocytic activity of the reticuloendothelial system in mice, and appeared to stimulate phagocytal function while inhibiting the humoral component of the immune system.

Tylophorine, isolated from a methanol extract of *T. indica* leaves, produces complete feeding inhibition of *Spilosoma obliqua*, under laboratory and greenhouse conditions. It was persistent for 2 days in field trials, and was shown to be non-systemic when tested with Hoagland culture media. An extract of the aerial parts, containing tylophorine, tylophorinine and pergularinine, also inhibited feeding of larvae of *Spodoptera litura* at 0.01%. Their EC_{50} values were found to be 2.9, 8.6 and 12 ppm, respectively. Powdered aerial parts, incorporated into a standardized culture medium, gave 100% inhibition of hatching of *Musca domestica* eggs, and 85–90% inhibition of development of third-instar larvae. Powdered leaves of *T. indica* reduced adult emergence of the rice moth (*Corcyra cephalonica*) by 78%–100%. The alkaloid fraction showed antiamoebic activity against *Entamoeba histolytica*.

Adulterations and substitutes In Asia, the leaves of *Tylophora* are used as a substitute for ipecacuanha (*Psychotria ipecacuanha* (Brot.) Stokes), from tropical America, as a cure for dysentery.

Description Perennial undershrubs or vines, often rhizomatous; stems twining, slender to woody, glabrous or hairy; latex white or yellow. Leaves opposite, elliptical to ovate; petioles present; stipules present; extrafloral nectaries present or absent. Inflorescence an axillary cyme, umbelliform to racemiform, with 1-many fascicles; peduncle present. Flowers with 5 distinct sepals, generally with glands at base of lobes; corolla deeply 5-lobed, rotate, valvate, greenish-yellow, often tinged with purple, or uniformly purplish-brown; staminal corona of gynostegium with 5 triangular lobes adnate to the staminal column below the anther wings and not overtopping them; stamens inserted at corolla-tube base, connate, anthers short, with incurved terminal appendages, pollinia 5, pollinium sacs 2, smooth, globose, brown, united by 2 pendulous translator arms; caudicles flattened, much longer than broad; style head obtuse or capitate, ovaries free or only the tip joined. Fruit a dry follicle, fusiform to fusiform-ovoid, tapering to the apex, smooth, normally single. Seed flat, ovate, brown; long white floss (coma) at apex.

Growth and development Most *Tylophora* flower throughout the year. The alkaloid content increases especially in the leaves during flowering. Under drier conditions in India, *T. indica* does not produce fruits and seeds unless treated with growth regulators. Best fruit set was recorded on plants sprayed with kinetin or gibberellic acid at 50 and 100 ppm. In 2-year studies with *T. indica* clone TC1 plants were sprayed with B, Cu, Zn or Mn or a mixture of B, Cu, Zn, Mn, Fe and Mo, all at 5 ppm, or with Fe at 10 ppm. The nutrients were applied to the foliage 4 times at 10-day intervals, starting when the plants had 5–10 leaves. Only B significantly increased herbage yield. Total leaf alkaloid content was highest (0.4%) in plants treated with Cu, Zn or the nutrient mixture.

Other botanical information *Tylophora* is in need of a general taxonomic revision; at present only partial revisions of Australia and Papuasia (Papua (Indonesia), Papua New Guinea and Solomon Islands) exist. The genus is well developed in Australia, where 12 species occur, all endemic but one, *T. flexuosa* R.Br., which is also common in Papuasia. In Papuasia, 6 other species occur, of which 5 are endemic to the region. The number of species occurring in South-East Asia is unknown.

Ecology *Tylophora* is found in a wide range of habitats, from river banks to forest, usually in lowland but also in sub-montane forest. *T. flexuosa* is also a common weed in Indian tea plantations.

Propagation and planting In India, a method for rapid multiplication of *T. indica*, grown for medicinal purposes, has been developed using single nodal stem segments on a Murashige and Skoog (MS) medium containing benzyladenine (BA) at 5 mg/l, naphthalene acetic acid (NAA) at 0.5 mg/l and ascorbic acid at 100 mg/l. Rooting of in-vitro produced shoots was readily achieved with indole acetic acid (IAA) alone at 1 mg/l in MS medium. In China, explants were cultured on MS medium supplemented with different concentrations and combinations of BA and adenine sulphate. A concentration of 5 mg/l BA and 0.5 mg/l adenine sulphate produced the greatest average number of shoot buds per explant.

In vitro production of active compounds Nodal explants of *T. indica* were grown in growth regulator free MS medium with 2% sucrose and NH_4NO_3 at 0.16, 0.2, 0.25, 0.3 or 0.4%. Maximum shoot formation was obtained with 0.3% NH_4NO_3, whereas root formation was maximum with 0.16% NH_4NO_3, and 0.4% proved lethal. The growth rate was highest with 0.3%, as was the alkaloid content. Stem, root and leaf tissues treated with the colorant 'Dragendorff reagent' showed that the highest alkaloid content was found in the leaves.

Diseases and pests In Australia, the lepidopteran *Pyrausta incoloralis* feeds on *Tylophora*, and other *Asclepiadaceae*. In India, the lepidopteran *Dichromia orosia* causes heavy defoliation in *T. indica*. Roots of *Tylophora* are often infested with nematodes.

Harvesting *Tylophora* plants are generally harvested from the wild whenever the need arises.

Handling after harvest The leaves or roots of *Tylophora* are used fresh or dried for later use.

Genetic resources and breeding As many *Tylophora* species are endemic or restricted to a rather small region, they might be threatened by habitat degradation and overcollection.

Prospects Extracts and isolated alkaloids from *Tylophora* show a broad range of interesting effects in pharmacology (e.g. antimicrobial, antitumour, anti-asthma, immunobiological, anti-allergic, and stimulation of the adrenal cortex) and pest control (e.g. antifeedant). More research is needed, however, to fully investigate the possibilities of the extracts. The potential of the purified alkaloids in medicine is considered low, due to their toxicity. They might be of interest to serve as lead compounds in the development of less toxic analogues.

Literature |1| Bera, T.K. & Roy, S.C., 1993. Micropropagation of Tylophora indica (Burm.f.) Merr. by multiple bud formation from mature leaf explants without callus intervention. Botanical Bulletin of Academia Sinica 34(1): 83–87. |2| Dikshith, T.S., Raizada, R.B. & Mulchandani, N.B., 1990. Toxicity of pure alkaloid of Tylophora asthmatica in male rat. Indian Journal of Experimental Biology 28(3): 208–212. |3| Forster, P.I., 1992. A taxonomic revision of Tylophora R. Br. (Asclepiadaceae: Marsdenieae) in Australia. Australian Systematic Botany 5: 29–51. |4| Forster, P.I., 1994. A taxonomic revision of Tylophora (Asclepiadaceae: Marsdenieae) in Papuasia. Australian Systematic Botany 7: 485–505. |5| Mulchandani, N.B., Iyer, S.S. & Badheka, L.P., 1971. Structure of tylophorinidine: a new potential antitumour alkaloid from Tylophora asthmatica plants. Chemical Industry (London) 19: 505–506. [6] Shivpuri, D.N., Menon, M.P. & Prakash, D., 1969. A cross-over double-blind study on Tylophora indica in the treatment of asthma and allergic rhinitis. Journal of Allergy 43(3): 145–150.

Selection of species

Tylophora brevipes (Turcz.) Fern.-Vill.

Fl. Filip. ed. 3, 4 (21a): 134 (1880).

Vernacular names Philippines: posuka (Tagalog), sarungkar (Iloko).

Distribution Endemic in the Philippines.

Uses A decoction of the fresh or dried roots is used as an emetic and as an emmenagogue, carminative, diaphoretic, and expectorant. The fresh roots are chewed and swallowed for indigestion.

Observations A slender, woody climber, stem terete; leaves oblong-ovate to ovate, 5–6.5 cm × 2.5–5 cm, base rounded, apex pointed, hairy, thin; inflorescence an umbel-like cyme, slender, few-flowered; corolla 7–8 mm in diameter, greenish, pedicel 1–2.5 cm long, slender; follicles fusiform, 4–7 cm long. *T. brevipes* is found in thickets at low altitudes.

Selected sources 786, 810.

Tylophora cissoides Blume

Bijdr. fl. Ned. Ind. 16: 1061 (1827).

Vernacular names Indonesia: areuy peujit hayam (general), buntali oyod (Javanese).

Distribution Borneo, Java, Moluccas, Papua, and Papua New Guinea.

Uses In Java, juice from the leaves and roots is used against thrush, and the leaves are applied for abdominal pain.

Observations A wiry climber, latex white, rhizome twisted; leaves ovate to elliptical to broadly lanceolate, 9–15 cm × 4–9 cm, base rounded to cordate, apex shortly acuminate, glabrous or with short hairs, petiole 3–5 cm long; inflorescence umbelliform, 3–4-branched and many-flowered, 7–20 cm long; calyx lobes narrow, 1 mm long, glabrous, corolla 3.5–7 mm long and 2–3 mm in diameter, yellow, green or red, pedicel 0.5–1 cm long, very slender; follicles fusiform to ovoid, 7–12 cm × 3–5 cm. *T. cissoides* occurs in lowland to sub-montane rainforest at altitudes of 300–2000 m.

Selected sources 407, 786.

Tylophora fasciculata Buch.-Ham. ex Wight

Contr. bot. India: 50 (1834).

Vernacular names Thailand: thao rong dam (northern).

Distribution From Nepal and India, rare in Sri Lanka, and further to Burma (Myanmar) and Thailand.

Uses In India and Indo-China, it is employed to poison rats and other vermin. The roots and leaves possess emetic and purgative properties.

Observations A small, slender, much-branched undershrub or twining pubescent herb, 30–90 cm tall, rhizome 2.5–5 cm in diameter, roots cord-like, with fissured, corky bark; leaves ovate to lanceolate, 2–4 cm × 0.8–1.5 cm, base and apex rounded to acute, petiole 0.5–0.7 cm long; inflorescence an umbel-like cyme or 2 superposed umbel-like cymes, flowers minute, calyx lobes 2–2.5 mm long, triangular, corolla 6 mm in diameter; follicles ovoid-lanceolate, 4–5 cm long, glabrous, thick. *T. fasciculata* occurs in thickets up to an altitude of 1250 m in India.

Selected sources 135, 215, 838.

Tylophora indica (Burm.f.) Merr.

Philip. Journ. Sci., Bot. 19: 373 (1921).

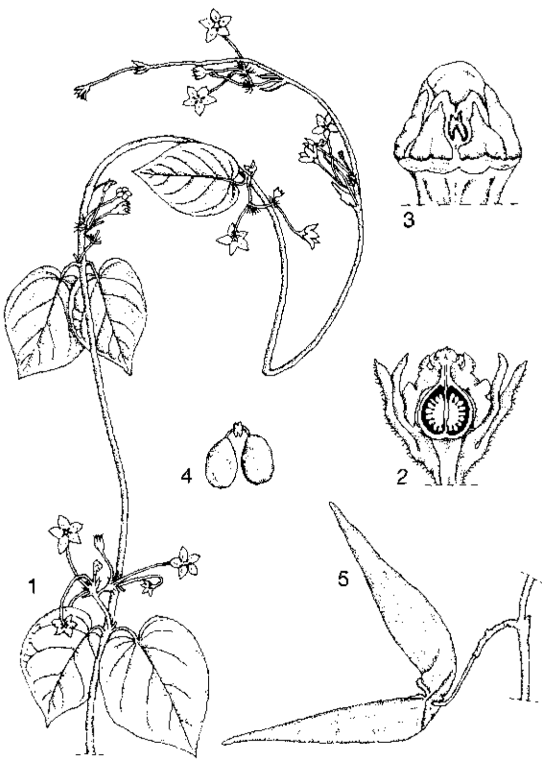
Synonyms *Tylophora asthmatica* (L.f.) Wight & Arnott ex Wight (1834).

Vernacular names Emetic swallow wort, Indian ipecacuanha (India) (En). Ipéca sauvage (Fr). Malaysia: simbukan. Thailand: khun phuum (north-eastern), khanthulee, thaao phan raak (peninsular). Vietnam: thu[oos]c hen, d[aaf]u d[af]i [aas]n d[ooj].

Distribution From the Seychelles through India and Sri Lanka, to South-East Asia including Malesia.

Uses The roots possess stimulant, emetic, cathartic, expectorant, stomachic and diaphoretic properties and are used in the treatment of asthma, bronchitis, dysentery and diarrhoea. *T. indica* stems yields a fine, silky and strong fibre.

Observations A slender, hairy or glabrous branching climber, up to 1.5 m tall; rhizomes short, 3–4 mm thick, knotty, roots numerous, fine; leaves ovate-oblong to orbicular, 3–10 cm × 1.5–7 cm, base cordate or rounded, apex acute or obtuse, petiole 0.5–2 cm long; flowers in few to many-flowered umbel-like cymes or sometimes 2 superposed umbellate cymes, shorter than or as long as the leaves, calyx lobes 1.5–2.5 mm long, lanceolate, corolla 1–1.5 cm in diameter, greenish-yellow outside, purplish within; follicles fusiform, 5–10 cm ×



Tylophora indica (Burm. f.) Merr. – 1, flowering twig; 2, flower in longitudinal section; 3, gynostegium; 4, pollinium; 5, follicles.

1 cm. *T. indica* is common along the coast on sandy soils, particularly on stabilized dunes and in sandy coconut plantations, up to 900 m altitude.

Selected sources 27, 74, 115, 130, 135, 172, 215, 378, 838, 900, 1011, 1019, 1020, 1040.

Tylophora perrottetiana Decne.

in DC., Prodr. 8: 609 (1844).

Vernacular names Philippines: kulangan (Tagalog), maraipos-ti-bakis (Iloko).

Distribution Endemic in the Philippines.

Uses The leaves are reported to be an effective dressing on wounds.

Observations A slender, twining, herbaceous vine, 2–5 m tall, glabrous; leaves oblong to oblong-ovate, 5–8 cm long, base broad, rounded or slightly cordate, apex pointed, blade shiny; inflorescence a simple or slightly branched fascicle, slender, 10–30 cm long, many-flowered; corolla 4–5 mm in diameter, dull-purple, pedicel short or absent; follicles fusiform, 5 cm × 5 mm. *T. perrottetiana* is found in thickets at low altitudes.

Selected sources 786, 810.

Tylophora tenuis Blume

Bijdr. fl. Ned. Ind. 16: 1062 (1827).

Synonyms *Tylophora tenuis* Blume (1827), *Tylophora tenuissima* (Roxb.) Wight & Arn. ex Wight (1834).

Vernacular names Malaysia: akar saput tunggal, akar selar mati, akar kankun janing. Vietnam: oa nhi d[awf]ng l[as] nh[or], d[aaf]u d[af]i m[ar]nh.

Distribution From India and Sri Lanka throughout South-East Asia to Australia.

Uses In Peninsular Malaysia, the leaves are crushed and applied to treat scabies. In Vietnam, the stem is used in the treatment of urticaria and smallpox. In India, a decoction or infusion of the roots is taken as an antidote to arsenic poisoning.

Observations A slender, glabrous or hairy, much-branched twining vine, up to 2.5 m tall; leaves very variable, lanceolate to ovate, 1.5–10 cm × 0.5–5.5 cm, base rounded to subcordate, apex acute, blade thin, petiole 2–18 mm long; inflorescence in slender, few-flowered, axillary paniculate cymes, branched and longer than leaves, up to 10 cm long; calyx lobes tiny, about 0.6 mm long, corolla 3–6 mm in diameter, white, yellow, pink, red purple or green, coronascales at the outer angle very small; follicles lanceolate-fusiform, 5–8 cm long. *T. tenuis* occurs in lowlands, most common on banks of tidal rivers, but also inland in open locations, brushwood and teakforest, up to 2100 m altitude.

Selected sources 74, 135, 215, 786, 838.

R. Kiew

Uncaria Schreb.

Gen. pl. 1: 125 (1789).

RUBIACEAE

$x = 11, 22$; *U. elliptica*: $2n = 44$

Major species *Uncaria lanosa* Wallich, *U. rhynchophylla* (Miq.) Miq. ex Havil.

Vernacular names Malaysia: akar ait. Vietnam: c[aa]u d[awf]ng.

Origin and geographic distribution *Uncaria* has a pantropical distribution, and comprises 34 species of which 2 species occur in tropical America, 3 species in Africa and Madagascar, and 29 species in Asia and Oceania.

Uses Most *Uncaria* species are morphologically very similar and have similar medicinal uses throughout the South-East Asia. They are mainly applied for their astringent properties. Fresh *Uncaria* leaves, or parts of the stem with hooks, are

employed for making astringent decoctions or preparations for application to wounds and burns, as a gargle for sore throats and for the treatment of intestinal problems, such as diarrhoea and dysentery.
The Chinese in Peninsular Malaysia import pieces of the stem and hooks of *U. sinensis* (Oliv.) Havil. (synonym *Nauclea sinensis* Oliv.) and of *U. rhynchophylla* for the treatment of children with fever or as a sedative and analgesic in nervous or cerebrovascular disorders and convulsions.
In China, *U. rhynchophylla* is used to treat headaches or dizziness caused by hypertension, cerebral arteriosclerosis, epileptic convulsions and for its spasmolytic, analgesic and sedative properties.
The fresh bark of *U. lanosa* var. *glabrata* (Blume) Ridsdale is taken in Sumatra for treating blood poisoning. *U. callophylla* Blume ex Korth. (synonym *Uncaria jasminiflora* Hook.f.) is used in Peninsular Malaysia for the treatment of hypertension. In China, the stem with hooks of *U. sessilifructus* Roxb., occurring from India to Indo-China and southern China, is used for fever and irritability in children, and also for abdominal pain and faintness. In Taiwan, it is used in the same way as the Chinese *U. hirsuta* Havil. *U. tomentosa* (Willd.) DC., 'cat's claw', from Central America and northern South America, is traditionally used as a medicinal for its anti-inflammatory, contraceptive, hypotensive and immunostimulant properties. *U. gambir* Roxb. is well known as a dye and tannin-producing species, because of the astringent substance gambier, but is also used medicinally in the same way as other *Uncaria*.
Some of the larger *Uncaria* species have stems which may be cut to draw potable water from them. *U. cordata* Merr. (synonym *Uncaria sclerophylla* Roxb.) can also be cut into thin, small planks, and used for hoops and sieves, as they are very tough and rather flexible. The young stems give a black dye. A decoction of the root is used in Sarawak as an antidiarrhoeal. Some *Uncaria* are used as astringent masticatories because of their tannin content e.g. *U. homomalla* of Indo-China, a stimulant, and also *U. gambir* and the Malesian *U. longiflora*. In India, a decoction of the bark of *U. sessilifructus* is used as a mordant.

Production and international trade Most *Uncaria* are only locally used, or cultivated for the local market. Different types of preparations of *U. tomentosa*, mainly collected in Peru, are sold in North America and Australia. Inner bark is used most often in the tablets or capsules, sometimes inner root bark (which is not better than the stem bark) or even whole ground bark, and the quantity of alkaloids present in the products varies widely.

Properties In general, *Uncaria* species contain a wide variety of alkaloids, belonging to the indole (hetero-indole) type and oxindole type. Furthermore, series of quinovic acid glycosides (triterpenes) and tannins are also present. The alkaloids and tannins together may form a complex that can reduce or eliminate bioavailability of extracts containing *Uncaria*. On the other hand, however, stomach acid is known to dissolve this complex again.
Alkaloidal extracts from several *Uncaria* species, i.e. *U. callophylla*, *U. canescens* Korth., *U. cordata*, *U. elliptica* R.Br. ex G. Don, *U. gambir*, *U. lanosa* and *U. longiflora*, collected from various locations in Peninsular Malaysia, showed in vivo anti-hypertensive effects in various animal models. Phytochemical investigations reported isolation of indole alkaloids (dihydrocorynantheine, yohimbine, pseudoyohimbine, gambirine, isocorynoxeine, corynoxeine and callophylline) and oxindole alkaloids (isopteropodine, pteropodine, isorynchophylline and rynchophylline).
The leaves of *U. callophylla* contain the alkaloids dihydrocorynantheine, gambirine, isogambirine, gambireine, pseudoyohimbine and callophylline A and B. These alkaloids were investigated for cardiovascular effects in Sprague-Dawley normotensive rats in order to study their hypertension effects. It was shown that isolated dihydrocorynantheine and gambirine at a dose of 5 mg/kg, and pseudoyohimbine at a dose of 10 mg/kg, caused similar reductions in the mean arterial blood pressure both in anaesthetized and conscious rats. However, callophylline did not appear to possess any cardiovascular activity. In addition, intravenous injections of gambirine, at a dose range of 0.2–10 mg/kg caused a dose-related fall in both systolic and diastolic blood pressures as well as heart rate of normotensive rats. At all doses gambirine showed a prompt onset of action and at the higher doses, marked persistence of hypotension accompanied by severe bradycardia were observed. It is suggested that the hypotensive effect of gambirine may be peripheral in origin and is associated, at least in part, with a cardiac action.
The stem and root of *U. rhynchophylla* contain the oxindole alkaloids isocorynoxeine, isorhynchophylline, corynoxeine and rhynchophylline. The hooks contain as much alkaloids as the stems. *U. rhynchophylla*, *U. sinensis*, *U. macrophylla* Wallich and their indole and oxindole alkaloid con-

stituents were studied for their effects on locomotor response in mice, assessed using the home cage activity apparatus. Water extracts of *U. macrophylla* and *U. sinensis* and 4 isolated alkaloids (corynoxine at 30 mg/kg, corynoxine B at 30 mg/kg, isorhynchophylline at 100 mg/kg and geissoschizine methyl ether at 100 mg/kg), significantly decreased locomotor activity after oral administration to mice. This effect appeared to be due to mediation of the central dopaminergic system. Furthermore, the anticonvulsant effect of the stem extract and the physiological mechanisms of its action were studied in male Sprague-Dawley rats, treated with kainic acid to induce epileptic seizures and different concentrations of the extract. The number of wet dog shakes, paw tremor and facial myoclonia were counted. The results indicated that both 1000 and 500 mg/kg of the extract decreased in a dose-dependent way the kainic acid-induced effects and also decreased the lipid peroxide level in the cerebral cortex, indicating a free radical scavenging action.

The effects of hirsutine and dihydrocorynantheine, an indole alkaloid and its structural epimer, from *U. rhynchophylla* on membrane potentials of rabbit sino-atrial node and guinea-pig right ventricle and left atrium were studied with microelectrode techniques. The results showed that hirsutine and dihydrocorynantheine have direct effects on the action potential of cardiac muscle through inhibition of multiple ion channels, which may explain their antihypertensive, negative chronotropic and antiarrhythmic activity. In addition, vasodilative effects of hirsutine (HS) and hirsuteine (HST) were tested in the hind-limb artery of anaesthetized dogs. Intra-arterial administration of HS and HST caused a vasodilatation, and the potency was somewhat stronger in HS than that of HST, while both were approximately equal to that of papaverine. Uncarinic acids A and B, isolated from the hooks of *U. rhynchophylla*, were found to inhibit phospholipase Cγ1 with IC_{50} values of 36 and 45 μM, respectively.

Oral administration of the chloroform soluble fraction of a MeOH extract of hooks of *U. sinensis* prolonged the thiopental-induced hypnotics and hypotension reaction in rats. Of the three major indole alkaloids from this fraction, geissoschizine methyl-ether, hirsuteine and hirsutine, the first 2 significantly prolonged the pentobarbital-induced hypnotics at 100 mg/kg, whereas hirsuteine and hirsutine enhanced the hypotension reaction at 100 mg/kg in spontaneous hypertensive rats. Effects of hirsuteine on nicotine- and high potassium-induced responses were investigated in rat pheochromocytoma PC12 cells. Hirsuteine inhibited dopamine release evoked by 100 μM nicotine in a concentration-dependent manner and was found to antagonize non-competitively nicotine-evoked dopamine release by blocking ion permeation through nicotinic receptor channel complexes. The hooks were also found to contain the indole alkaloid glycosides cadambine, 3α-dihydrocadambine and 3β-dihydrocadambine. Only the last compound exhibited strong and persistent hypotensive activity in rats. An ethanolic extract from the hooks and stems also contained several 16-carboxy derivatives of pentacyclic oxindole alkaloids and their glucopyranosyl esters: mitraphyllic acid, isomitraphyllic acid, pteropodic acid, isopteropodic acid, rhynchophyllic acid and isorhynchophyllic acid, (16-1)-β-D-glucopyranosyl ester and mitraphyllic acid (16-1)-β-D-glucopyranosyl ester.

The protective effect of a water extract of the hooks and stems of *U. sinensis* against glutamate-induced neuronal death was investigated by microscopic observation and the 3-(4,5-dimethylthiazol)-2-yl-2,5-diphenyl-tetrazolium bromide assay, and action on $^{45}Ca^{2+}$ influx using cultured cerebellar granule cells from 7–8-day-old rats. Glutamate-induced cell death was reduced by the extract in a dose-dependent manner, and increase of $^{45}Ca^{2+}$ influx into cells induced by glutamate was blocked by the extract in a dose-dependent manner. Two different studies on the efficacy of the extract of the hooks and stem on patients with vascular dementia, a non-double blind study (60 patients) and a double-blind controlled study (139 patients), were performed. The medicine tested was found to be superior in global improvement rating, utility rating and improvement of subjective symptoms, psychiatric symptoms and disturbance in daily living activities.

U. tomentosa has undergone intensive phytochemical analysis, which revealed the presence of 2 important groups of compounds, i.e. oxindole alkaloids and quinovic acid glycosides. HPLC analysis confirmed the presence of 6 pentacyclic alkaloids (pteropodine, isopteropodine, speciophylline, uncarine F, mitraphylline, isomitraphylline) and 2 tetracyclic alkaloids (rhynchophylline, isorhynchophylline) in the roots and bark. Extracts and pure alkaloids were tested using a granulocyte-smear test and a chemiluminescence model to evaluate the stimulatory effect on the phagocytic activity of granulocytes. Phagocytosis was enhanced by pteropodine, isomitraphylline and isorhynchopylline. The strongest stimulation was observed with isopteropodine, whereas mitraphylline and rhynchophylline had no effect. Furthermore, the mixture of the 6 pentacyclic oxindole alkaloids induced EA.hy926 human endothelial cells in culture to release some factors into the supernatant. These factors were subsequently shown to significantly enhance proliferation of normal human resting or weakly activated B- and T-lymphocytes. An extract containing approximately 6 mg/g oxindoles (mixture of pteropodine, isopteropodine, speciophylline, uncarine F, mitraphylline, isomitraphylline) also stimulated IL-1 and IL-6 production by rat macrophages in a dose-dependent manner. In the carbon-clearance test in mice, used to evaluate the stimulatory effect on the phagocytic activity of granulocytes, a water extract of the drug showed good activity at concentrations of 10 mg/kg. An isolated mixture of the tetra- and pentacyclic alkaloids was inactive in this test system; however, activity was restored after the admixture of catechin to it. Several extracts of *U. tomentosa* root bark were furthermore tested for anti-inflammatory activity using the carrageenan-induced rat paw oedema test. The quinovic acid glycoside reduced the inflammatory response by 33% at 20 mg/kg orally. It could not be ruled out, however, that the strong anti-inflammatory effect as seen by extracts could be due to a combination of compounds. Single dose toxicity (LD_{50}) in mice is over 16 g/kg orally. Repeated dose toxicity, daily doses for a month of up to 1 g/kg of a root extract containing 7.5 mg total oxindole alkaloids, to rats revealed no relevant differences between treated and non-treated groups, except for a slight increase of lymphocyte count, a slight decrease of neutrophil granulocyte count, and an increase of the relative weight of the kidneys in the treated group. In addition, *U. tomentosa* bark showed no mutagenic effects in several strains of *Salmonella typhimurium*, but rather a protective antimutagenic activity in vitro against photomutagenesis.

An aqueous extract from *U. tomentosa*, depleted of indole alkaloids, was tested with female W/Fu rats at doses between 5 and 80 mg/kg for a period of 8 weeks in order to evaluate its effects on enhanced DNA repair, immune function and toxicity. Phytohaemagglutinin stimulated lymphocyte proliferation was significantly increased in splenocytes of rats treated at the higher doses, and white blood cell numbers were significantly elevated, thus indicating its anti-inflammatory effect. These results were confirmed in a human volunteer study. No toxicity was observed, and no body weight, food consumption, organ weight, kidney, liver, spleen, or heart pathological changes were found to be associated with this particular extract. The extract was furthermore examined in vitro for antitumour properties using two human leukaemic cell lines (K562 and HL60) and one human EBV-transformed B lymphoma cell line (Raji). The proliferative capacities of HL60 and Raji cells were strongly suppressed in the presence of the extract while K562 was more resistant to the inhibition. The suppressive effect of *U. tomentosa* extracts on tumour cell growth appears to be mediated through induction of apoptosis which was demonstrated by characteristic morphological changes, internucleosomal DNA fragmentation after agarose gel electrophoresis and DNA fragmentation quantification.

The bark of *U. elliptica*, from continental Asia and Malesia, contains roxburghines A–E, formosanine, ajmalicine and mitraphylline. Sometimes the roxburghines are not detected however. Fresh leafy shoots revealed rutin (up to 20%) and (–)-epicatechin as the major flavonoids present. The leaves generally contain much more rutin than the woody tissues, the content in young leaves being particularly high. The leaves of *U. homomalla* contain 4 pentacyclic oxindole alkaloids, isopteropodine, pteropodine, speciophylline and uncarine F, and the bark contains catechutannic acid and catechin. The indole alkaloids uncarine C, D and E, and the glucindole alkaloids glabratine and deoxycordifoline were extracted from fresh bark of *U. glabrata*. *U. lanosa* f. *setiloba* (Benth.) Ridsdale (synonym *Uncaria florida* Vidal) contains uncarine C (pteropodine), uncarine D (speciophylline), uncarine E (isopteropodine) and uncarine F, while *U. lanosa* f. *philippinensis* (Elmer) Ridsdale (synonym *Uncaria kawakamii* Hayata) contains isomitraphylline, mitraphylline, uncarine A (isoformosanine) and uncarine B (formosanine). A methanolic extract of the stem bark and hooks of *U. attenuata* Korth. (synonym *Uncaria salaccensis* Bakh.f.), from Peninsular Malaysia, Sumatra, Java, Borneo and the Philippines, contains the oxindole alkaloids salacin, 3-oxo-7-hydroxy-3,7-secorhynchophylline as well as rhynchophylline, isorhynchophylline and corynoxine, and 3-isoajmalicine, 19-epi-3-isoajmalicine, mitraphylline and uncarine B. *U. perrottetii* (A.Rich.) Merr. from the Philippines contains the alkaloids pteropodine and isopteropodine. An extract of *U. gambir*, containing catechin and tannin, was tested for its fungicidal activity, and was found to control the growth of *Fusarium* sp. causing leaf spot on *Clausena anisata* (Willd.) Hook.f. ex Benth. The stem also contains the alkaloids gambirdine, isogambirdine and gambirine.

Adulterations and substitutes Monoterpenoid terpene alkaloids occur particularly in *Loganiaceae* (e.g. *Strychnos*), *Apocynaceae* (e.g. *Catharanthus*, *Rauvolfia*, *Voacanga*) and *Rubiaceae* (e.g. *Cinchona*). Several species of these genera have similar uses comparable to *Uncaria*. In Thailand, the leaves of *Uncaria* are used as a substitute for the leaves of *Mitragyna speciosa* (Korth.) Havil., known for its stimulant properties. Many species of *Uncaria* contain alkaloids similar to those in the closely related genus *Mitragyna*.

Description Woody lianas; young branchlets angular to rounded, glabrous or pubescent, branches differentiated into monopodial orthotropic and plagiotropic systems; vegetative lateral branches of the plagiotropic system modified into hooks. Leaves opposite, simple, domatia usually present in the axils of the lateral veins, tertiary veins usually impressed; petiole present; stipules interpetiolar, entire or bifid, inside with colleters at the base or over the whole surface. Inflorescence a terminal or axillary head on the plagiotropic shoot. Flowers bisexual, 5-merous, (sub)-sessile or pedicellate on the receptacle, pedicels free or fused into groups, sometime accrescent, with or without interfloral bracteoles; receptacle sparsely to densely hairy; calyx tube short, often bottle-shaped, lobes variable in shape, glabrous to hairy, epicalyx present or absent; corolla tube hypocrateriform to infundibular, outside glabrous to hairy, lobes ovate-oblong to elliptical, valvate in bud, inside and outside glabrous or pubescent; stamens 5, inserted high in the corolla tube, exserted and spreading, filaments short, glabrous; ovary inferior, 2-locular, ovules numerous, style exserted, stigma globose to elongate-clavate, papillate. Fruit a dry capsule, 2-celled, exocarp thick, splitting loculicidally but long remaining intact below the calyx remnants, endocarp thick, horny, splitting septicidally and then slightly loculicidally from apex to base; seeds numerous. Seed small, centre reticulate, long winged at both ends, lower wing deeply bifid. Seedling with epigeal germination.

Growth and development Many *Rubiaceae*, including *Uncaria*, have differentiated growth axes. Each node of the orthotropic axis bears 2 serial buds in every leaf axil, and a lateral, plagiotropic axis develops from the upper bud. These branches monopodially increase in length, either throughout their life span or for a limited period only. During the vegetative phase the lateral buds of the plagiotropic shoot develop into hooks, by which the liana supports itself passively. The lower serial bud, if developing, grows out to produce a new orthotropic shoot.
In Indo-China, *U. acida* starts flowering in March, and is found fruiting till December. In Java, *U. acida* flowers from October-December and *U. lanosa* flowers throughout the year.

Other botanical information *Uncaria* belongs to the tribe *Cinchoneae*, subtribe *Mitragynae*, to which also *Mitragyna* belongs. This subtribe is characterized mainly by the thick black placentas bearing upwardly-imbricate ovules, and also by the mode of dehiscence of the fruits. Fruiting material of *Uncaria*, especially in the absence of stipules, is difficult to identify. *U. lanosa* is a complex species, and many forms have been described as separate species, but these differ only in the degree of pubescence of the leaf and in the shape of the calyx lobes, and intermediates occur in some regions.

Ecology *Uncaria* is a genus of climbers in primary and secondary forest, or forest borders, at low to medium altitudes.

Propagation and planting *Uncaria* can be propagated by seed or cuttings. The highest seedling rate was obtained when the seed was sown on peat. In Japan, transplanting wild plants of *U. rhynchophylla* to fields was successful. Cuttings of two-year-old branches led to more vigorous root formation than using main stems.

In vitro production of active compounds In Japan, the effects of plant growth regulators and nutrients on growth and alkaloid production by callus cultures of *U. rhynchophylla*, initiated from leaves, were investigated. Gamborg B5 medium supplemented with indole acetic acid at 10^{-4} M and 6-benzylaminopurine at 3 x 10^{-5} M was best for both growth and alkaloid production. The best alkaloid production was observed on B5 medium supplemented with 2% sucrose, but the best growth was observed in the presence of 3% sucrose. Hirsuteine, hirsutine, 3α-dihydrocadambine and ursolic acid were isolated from the callus, and the 3α-dihydrocadambine concentration of callus was 50-fold higher than that of the hooks and stems.

Husbandry *U. rhynchophylla* plants grown with the application of fertilizers containing both P and K showed an increased crude drug yield but its oxindole alkaloid content was the lowest.

In Japan, *U. rhynchophylla* was cultivated experimentally under high (30/35°C, night/day), medium (20/25°C, night/day) and low (10/15°C, night/day) temperature conditions in a biotron growth cabinet. When the night temperature was lower, the oxindole alkaloid content tended to be higher. It was concluded that the 20/25–28°C (night/day) condition with a daily temperature difference of 5–8°C was the most suitable for the cultivation of *U. rhynchophylla*.

Diseases and pests There are no major diseases or pests known for *Uncaria*.

Harvesting In China, pieces of the stem of *U. rhynchophylla* are collected in August and September, when the hooks become red. In general, *Uncaria* stems are harvested after 1–2 years.

Yield In Japan, *U. rhynchophylla* was cultivated under various shade conditions (20, 40, 60 or 80% shade) for 3 years, during which time hooks were collected every year from newly regenerated shoots. The yield of hooks increased with plant age. Plant growth rate and hook yield were highest when the plants were cultivated under 40% shade, and alkaloid content in the hooks increased with the degree of shade up to 40%. Analysis of dried stem segments with hooks showed that the total oxindole alkaloid content of the stem was similar to that of the hook portion. The area closest to the hook showed a slightly higher alkaloid content than the hook, and the oxindole alkaloid content decreased as the distance from the hook increased. Therefore, the presence of the hook does not affect the quality of the crude drug as far as the oxindole alkaloid content is concerned. Oxindole alkaloids comprised about 97% of the total alkaloids in the hook, twig and leaf, whereas about 96% of the root bark alkaloids were indole alkaloids. The wood had a very low alkaloid content, mostly of rare types. The yield of the crude drug and the oxindole alkaloid content of the plants vegetatively propagated by stem or root cuttings and those grown from seeds were compared. Only the productivity of individual alkaloids (isocorynoxeine, isorhynchophylline, corynoxeine and rhynchophylline) seemed to have been passed on from a mother plant to the vegetatively propagated plants, the yield of oxindole alkaloids was lower in the cuttings and variable in the seedlings.

Handling after harvest In China, pieces of the stem of *U. rhynchophylla* are dried in the sun, or may be roasted before drying.

Genetic resources and breeding Most *Uncaria* species are widespread throughout South-East Asia, and do not seem to be at risk of genetic erosion.

Prospects Extracts of *Uncaria*, and the isolated constituents such as (ox-)indole alkaloids and triterpenes, display a range of interesting biological activities in several fields, including the vascular system, hypotension, cardiac activity and the immune system. It is possible that several of these compounds have potential as lead substances in future development, and therefore the genus merits further research. As a consequence, the potential for cultivation of *Uncaria* species from China or South America in South-East Asian countries needs further investigation.

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Selection of species

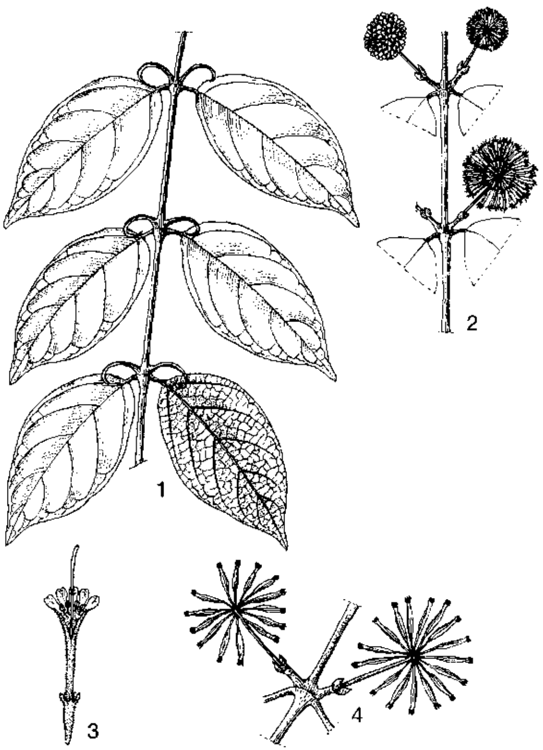
Uncaria acida (Hunt.) Roxb.

Hort. bengal.: 86 (1814).

Synonyms *Nauclea acida* Hunt. (1808), *Uncaria ovalifolia* Roxb. (1824), *Uncaria acida* var. *papuana* Valeton (1926).

Vernacular names Malaysia: kait-kait, gambir-gambir. Vietnam: vu[oos]t chua.

Distribution From Burma (Myanmar) to Thailand, southern Vietnam, Peninsular Malaysia, Sumatra, Java, Lesser Sunda Islands, Borneo, the Philippines and New Guinea.



Uncaria acida (Hunt.) Roxb. – 1, leafy branch; 2, inflorescences; 3, flower; 4, infructescences.

Uses In Peninsular Malaysia, the leaves are used for rubbing on the body to relieve pain. In Indo-China, the leaves are eaten.

Observations A rather slender climber, 4–6 m tall, hooks 2–3 cm long; leaves ovate to elliptical, 5–9 cm × 2.5–5 cm, chartaceous to subcoriaceous, glabrous, ultimate veins fine, frequently with domatia underneath, stomata present on upper surface, petiole 10–12 mm long, stipules deeply bifid, 4–7 mm long; flowering head up to 2 cm in diameter, over 5 cm in fruit, peduncle 1.5–2 cm long; flowers subsessile, white, interfloral bracteoles absent, calyx tube 2 mm long, lobes elliptical to suborbicular, 1 mm long, corolla tube 5 mm long, pubescent outside, lobes 1.5 mm long, hairy at both sides; capsule oblong, 13 mm × 2–2.5 mm, pointed at both ends, sparsely pubescent, pedicel 5–6 mm long, slender; seed 5 mm × 0.5 mm, wings long, white, slender, long acuminate. *U. acida* is locally abundant in humid primary and secondary forest, also along rivers, on swampy localities, at low altitudes.

Selected sources 74, 135, 841.

Uncaria homomalla Miq.

Fl. Ind. Bat. 2: 343 (1857).

Synonyms *Uncaria tonkinensis* Havil. (1897), *Uncaria parviflora* Ridley (1918), *Uncaria quadrangularis* Geddes (1928).

Vernacular names Cambodia: sângchoë, voë sângchoë. Thailand: khao khwai mai wong, khao khwai mai luup (northern), ee ngop (south-western). Vietnam: d[aa]y c[aa]u d[awf]ng, d[aa]y d[aws]ng qu[es]o, m[os]c [os].

Distribution From India to Indo-China, southern China, Thailand, Peninsular Malaysia and Sumatra.

Uses In Indo-China, an infusion from the stem is used as a depurative. The bitter bark is considered febrifuge, and is also applied for tetanus, headache, eye problems, and lumbago. It is a substitute for areca nut (*Areca catechu* L.) which is used for chewing.

Observations A large, woody liana, up to 25 m long; leaves elliptical-lanceolate to elliptical, 6–10 cm × 2.5–3.5 cm, hairy on both sides, with domatia in the axils of secondary veins below, stipules distinctly bifid, pubescent; flowering head terminal, globose, 1–2 cm in diameter, receptacle hairy, interfloral bracteoles present, flowers sessile, corolla salver-shaped, green to yellow, tube 5–7.5 mm long, pubescent outside, lobes short; capsule rounded, up to 4 mm × 2 mm. *U. homomalla* occurs in thickets, along rivers, at low altitudes.

Selected sources 786, 788, 841, 1024.

Uncaria lanosa Wallich

Roxb., Fl. ind. 2: 131 (1824).

Synonyms *Uncaria ferrea* DC. (1830), *Uncaria glabrata* DC. (1830), *Uncaria setiloba* Benth. (1843).

Vernacular names Indonesia: cantel wesi (Javanese), kait beusi (Sundanese). Malaysia: akar kait-kait bukit, kekait merah, tingangit (Sabah). Papua New Guinea: bebokai (North Solomons Province), zafengeng (Morobe Province). Thailand: ngop, naam chaochuu (peninsular).

Distribution Throughout Malesia and Micronesia.

Uses In Peninsular Malaysia, a decoction of the leaves is used for cleaning wounds and ulcers, and an infusion of the uninjured roots is taken as a drink for inflammation of the intestines. In Sabah, a decoction of leaves and roots is drunk to treat diarrhoea. The young leaves and flowers are used medicinally in western Java. In the North Solomons Province (Papua New Guinea), scraped bark is chewed to soothe a weak bladder. Root sap and root bark heated and squeezed is drunk for internal swellings. In Morobe Province (Papua New Guinea), stem sap is added to a vegetable soup to relieve fevers and stomach-ache.

Observations A relatively slender climber, glabrous to variably hairy, sometimes reddish-tomentose; leaves oblong to ovate, 5.5–9 cm × 2.4–5 cm, membranaceous, hairy or not, petioles 0.5–1 cm long, hairy, stipules entire or shallowly toothed; flowering head rather lax, 3.5–4 cm in diameter, 5–7 cm in fruit, peduncle 1–1.5 cm long, bracts 4, linear; flowers yellowish-white or pinkish, interfloral bracteoles absent, calyx up to 7 mm long, lobes filiform, corolla tube very slender, 1–2 cm long, lobes linear, glabrous or puberulous; capsule oblong, 8–12 mm long, glabrous. *U. lanosa* occurs in open, mixed forests, often near rivers, from 150–1000 m altitude. More than 10 varieties and forms have been distinguished in this very variable species.

Selected sources 74, 135, 407, 841.

Uncaria longiflora (Poir.) Merr.

Interpr. Herb. amboin.: 480 (1917).

Synonyms *Uncaria pteropoda* Miq. (1857).

Vernacular names Indonesia: daun getah gambir (Moluccas), kait-kait darat (Malay). Malaysia: kait-kait darat, kait besi. Thailand: kio cho (peninsular).

Distribution Peninsular Thailand, Malaysia, Indonesia, Papua New Guinea.

Uses The leaves are used for rubbing on the body to relieve pain. In the Moluccas, the juice of the leaves was used for thrush, and mixed with iron-rust for framboesia (yaws).

Observations A big climber, branches stout; leaves elliptical to broadly ovate, 12.5–16 cm × 9–12.5 cm, glabrous, coriaceous, petiole 9–20 mm long, strongly winged or not, stipules entire; flowering head up to 3 cm in diameter, 10 cm in fruit, peduncle up to 3 cm long, flowers short pedicellate, yellowish, calyx fusiform, lobes elliptical to oblong, pubescent, corolla up to 2.3 cm long, pubescent; capsule fusiform, 1.3–2.5 cm long, pubescent. *U. longiflora* is common in open areas in thickets and forest edges, also on stony soils.

Selected sources 135, 407, 841.

Uncaria rhynchophylla (Miq.) Miq. ex Havil.

Journ. Linn. Soc., Bot. 33: 890 (1897).

Synonyms *Nauclea rhynchophylla* Miq. (1868).

Vernacular names Vietnam: c[aa]u d[awf]ng, l[as] m[or].

Distribution China, Japan, Vietnam.

Uses In Vietnam and China, the stem with hooks is considered sedative and tranquillizing and is prescribed in nervous disorders and convulsions in children, and for dizziness caused by high blood pressure or for headache in adults. The infusion is sweet and cooling. In China and Korea, the dried hooks are considered a remedy for liver diseases. The Chinese *U. sinensis* is used similarly, has the same commercial name, and is imported into Peninsular Malaysia.

Observations A slender, glabrous climber; leaves oblong to ovate, 5–12 cm × 3–7 cm, coriaceous, glabrous, domatia sparsely hairy, petiole 5–15 mm long, stipules deeply bifid, of plagiotropic branches 6–10 mm long, of orthotropic shoot up to 30 mm long, inside hairy; flowering head up to 20–25(–35) mm in diameter, not subtended by foliaceous bracts, receptacle densely hairy, interfloral bracteoles numerous, filiform; flowers small, yellowish-white, subsessile, calyx 1 mm long, pubescent, lobes oblong, 0.5–1 mm long, corolla tube slender, 6–8(–10) mm long, lobes oblong, 1.5–2.5 mm long, outside glabrous or slightly pubescent; capsule oblong, 6–10 mm × 2–3 mm, pubescent. *U. rhynchophylla* occurs in forest areas, at 500–1000 m altitude.

Selected sources 474, 517, 518, 519, 551, 602, 651, 686, 739, 768, 786, 857, 858, 907.

Anas Subarnas

Urena lobata L.

Sp. pl. 2: 692 (1753).

MALVACEAE

$2n = 28, 56$

Vernacular names Congo jute, Aramina fibre (En). Indonesia: pangpulutan (Sundanese), pulutan (Javanese), pulut (Sumatra). Malaysia: pulut-pulut, pepulut, pulut lembu. Philippines: dalupang (Tagalog, Panay Bisaya, Pampangan), kulotan (Tagalog, Bisaya), saligut (Bontok). Papua New Guinea: haritapiraba (Uaripi, Gulf Province), kotokoto (Pokama, Central Province), Bitobito (Oroi, Central Province). Thailand: khamong dong (northern), po seng (peninsular), khee khrok (central). Vietnam: b[as]i l[uw][ow]ng, k[es] hoa d[af]o.

Origin and geographic distribution *U. lobata* is widely distributed as a weed in the tropics and subtropics of both hemispheres, including South-East Asia.

Uses The leaves and roots of *U. lobata* are mainly used. In Malaysia, Indo-China, the Philippines, Papua New Guinea, Fiji and Java, the juice of the leaves or roots is widely used for bowel complaints, especially colic, stomach-ache, diarrhoea and dysentery, and to treat gonorrhoea and persistent fever from malaria. The leaves are externally applied as a poultice on wounds and skin diseases as an emollient, a refrigerant and because of their styptic and healing properties. A decoction from the leaves and roots is drunk to relieve pains all over the body due to excessive exertion. An infusion of the roots is given to aid difficult childbirth. A lotion made from the plant is used to treat yaws and headache. In Burma (Myanmar), India and Malaysia, the roots are used to treat rheumatism and lumbago, while the twigs are chewed for toothache. In India, the root is popular as a diuretic, while the leaves are prescribed for inflammation of the intestines and bladder. In China and Fiji, the whole plant is macerated and used externally for treating fractures, wounds, mastitis and snake bites. A decoction of the root is used to treat colds, dysentery, enteritis, goitre, indigestion, leucorrhoea, malaria, rheumatism and tonsilitis. A decoction of a very old plant, boiled with eggs, is said to induce abortion. In Fiji, the roots are also chewed and applied to swellings caused by filariasis, while the bark is used to heal cuts. In Thailand, the leaves and stems are used as a diuretic, while the roots are taken for stomach-ache.

In India and Indo-China, the flowers are considered maturative and are taken in decoction as a pectoral and expectorant in dry coughs. An infusion of the flowers is used as a gargle for aphthae and a sore throat. In Malaysia, a decoction of the seeds is taken as a vermifuge.

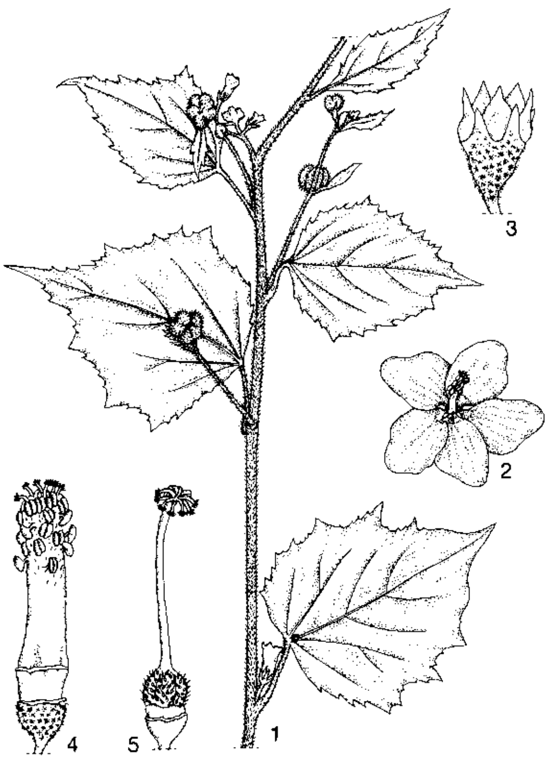
U. lobata is also widely used as a fibre, in tropical Africa, Madagascar, Cuba and Brazil. The seeds are used in Africa in stews, and in India for making soap, while the charcoal of the whole plant is used for blackening teeth. Like *Sida rhombifolia* L., *U. lobata* is considered a magic plant, and is used in similar ways in healing rites, for protection and in wedding and rice ceremonies.

Production and international trade *U. lobata* is used for medicinal purposes and traded at a local level only. In Peninsular Malaysia, the Chinese herbalists keep the plant in stock.

Properties Very little is known about the phytochemistry and biological activities of extracts and isolated compounds of *U. lobata*. The seeds contain about 7% of a fatty oil, which contains the fatty acids malvalic acid (2.4%), sterculic acid (42%), dihydromalvalic acid (0.5%) and dihydrosterculic acid (1.2%). The aerial parts contain the flavonol quercetin. Quercetin isolates also occur in *Phyllanthus emblica* L. (*Euphorbiaceae*) and have shown in vivo hepatoprotective activity in rats and mice. *U. lobata* has also been reported as antipyretic, anti-inflammatory and antirheumatic.

Adulterations and substitutes The leaves of patchouli (*Pogostemon cablin* (Blanco) Benth.) have been used as a substitute for *U. lobata*. The roots and leaves of *Abutilon*, *Sida* and *Triumfetta* in decoction are used as an emollient in the same way as those of *U. lobata*.

Description An annual, variable, erect, rarely ascendent undershrub, 0.5–2.5 m tall, stems covered with minute stellate hairs and scattered simple hairs, often tinged purple. Leaves alternate, simple, extremely variable in size and shape, suborbicular, ovate, oblong to lanceolate, 1–12 cm × 0.5–13 cm, more or less 3–5-lobed, base cordate to cuneate, apex acuminate, margins serrate to crenate, 3–9-veined, surfaces hairy, with a nectary on base of midrib beneath; petiole 0.5–12 cm long; stipules lanceolate to obovate, 2–4 mm long, acute,



Urena lobata L. – *1, flowering and fruiting branch; 2, flower; 3, epicalyx with calyx; 4, staminal column with pistil; 5, pistil.*

caducous. Inflorescence composed of axillary flowers, solitary or in clusters of 2–3, in the upper part seemingly in spikes. Flowers 5-merous, campanulate, 2–3 cm in diameter, pink with a purple centre, epicalyx 7–8 mm long, enveloping the calyx, segments 5, lanceolate, hairy; calyx tubular to campanulate, 5–6 mm × 1.5–2 mm, at 1/3 from the base of the ribs, thickened or with a nectary; petals obovate, apex rounded; staminal column 10–14 mm long, usually curved, anthers purple, pollen white; style arms 10, each 1 mm long, stigmas dark purple. Fruit a subglobular schizocarp, composed of 5 mericarps, 4–5 mm long, covered with barbed bristles. Seed reniform, 2.5–3.5 mm long, minutely hairy to glabrous, brown. Seedling with epigeal germination.

Growth and development *U. lobata* is a fast grower, and does not branch much when planted close together. It is a short-day plant, flowering starts 4–6 months after sowing, depending on the sowing time, while most viable seed is produced 1–2 months after flowering. The flowers open early in the morning and wither about noon. The nectaries are visited frequently by ants, aphids and various *Hymenoptera*.

Other botanical information The taxonomy of *Urena* has not yet been settled. Some authors consider it a genus with 1 polymorphic species only, *U. lobata*; others recognize 3 more species. *Urena* is morphologically very close to *Pavonia*, which has mericarp bristles that are not barbed, or with 3 hairy awns, and leaves normally without nectaries. It is argued by several authors that the two genera should be merged. Two subspecies have been distinguished in *Urena*, subsp. *lobata*, a stout plant with many ovate leaves, lower leaves shallowly lobed, and with a stiff, cupular epicalyx in fruit, segments long-triangular, 4.5 mm long, especially occurring above 400 m altitude, and subsp. *sinuata* (L.) Borss. Waalk., with lower leaves angular to palmately lobed or deeper incised, and a spreading, flexible epicalyx in fruit, segments linear, 3 mm long, especially occurring below 400 m altitude.

Ecology *U. lobata* is common on roadsides, in waste places, fallow fields, plantations, secondary growths, teak-forests, from sea-level up to 2000 m altitude, in many locations naturalized as a noxious weed.

Propagation and planting *U. lobata* is propagated by seed. Germination can be considerably improved by scarifying the seeds with concentrated sulphuric acid and then washing in running water. It is sown for fibre production at the beginning of the rainy season, up to 2 cm deep. In India, the crop requires 120–150 days to attain maturity.

Diseases and pests *U. lobata* is a host for cotton stainer bugs (*Dysdercus superstitious* and *D. voelkeri*), cotton spotted bollworm (*Earias fabia*) and in Thailand it is also attacked by the leaf-sucker *Haedus vicarius*. *U. lobata* is also a host for the okra mosaic virus.

Harvesting *U. lobata* plants, including the roots, can be harvested all year round.

Handling after harvest The plants of *U. lobata* are washed and then used fresh or dried. They are cut into smaller pieces before being used. Proper drying is necessary before being kept in stock.

Genetic resources and breeding *U. lobata* is widespread in anthropogenic habitats, and especially the size and shape of the leaves is very variable, suggesting a broad genetic variability. Breeding programmes, in India and Brazil, focus on fibre production. Some small germplasm collections exist in Bangladesh and the United States.

Prospects *U. lobata* will remain of local importance only. Far more research is needed in order to evaluate its possible medicinal prospects.

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Other selected sources 143, 215, 739, 786, 810, 1071.

H.C. Ong

Viola L.

Sp. pl. 2: 933 (1753); Gen. pl. ed. 5: 402 (1754).

VIOLACEAE

x = (5), 10, 12, 13; *V. odorata*: $2n$ = 20, *V. pilosa*: $2n$ = 20, *V. tricolor*: $2n$ = 26

Major species *Viola odorata* L., *V. pilosa* Blume.

Vernacular names Violet, pansy (En). Violette (Fr).

Origin and geographic distribution *Viola* is a large genus of about 400 species, mainly from the northern temperate zone, but also in mountainous regions in the tropics. In Malesia, about 18 species occur, some of them introduced as ornamentals.

Uses Many *Viola* species are used medicinally in South-East Asia and China for purifying the blood; the crushed aerial parts are applied to ulcers, sores, swellings and cuts and are also used for rheumatism. The flowers of *V. betonicifolia* J.E. Smith, *V. odorata*, *V. pilosa* and other species are generally taken as a diuretic and expectorant, and the syrup is a favourite medicine for cough, colds, asthma and hoarseness in local medicine throughout the world.

Many *Viola* species, especially *V. odorata*, are official in several pharmacopoeias throughout the world.

In large doses, the rhizomes, roots and seeds of *V. odorata* are poisonous, causing vomiting and affecting circulation and respiration. The rhizome in decoction is a powerful emetic and used in dysentery. An infusion of the fresh leaves or a syrup from the petals is used to reduce pain from cancerous growths, especially in the throat, and as a cure for cancer of the tongue. The fresh leaves are also prepared as a compress for local application, as they are emollient.

In India, *V. odorata* is found on the market in three forms: the dried flowers, the dried aerial parts including flowers and the dried aerial parts without flowers. The flowers are valued as a diuretic, expectorant, and as a purgative in bilious affections. They are also diaphoretic, and very useful in relieving febrile symptoms and excitement in all forms of fever, particularly in mixtures with other herbs. The seeds are also purgative and diuretic. The fresh flowering herb is applied in the treatment of skin diseases, as well as to infected eyes and ears, because of its antifungal and antibacterial activity. The rhizomes of several other *Viola* are also considered emetic, the leaves emollient and laxative, and the flowers pectoral, diaphoretic and antiseptic. The commonly cultivated, large-flowered *Viola* (*Viola* x*Wittrockiana* Gams) is a hybrid from unknown parentage, possibly between *V. tricolor* L., *V. lutea* Huds. and *V. altaica* Ker Gawl. In India it is used in the same way as the other *Viola* species. In China, *V. patrinii* DC. is especially used in the treatment of cancer. Chinese pharmacies import dried preparations of the leaves and fruit into Peninsular Malaysia. The dried flowers are used as a purgative. In India, the herb is also prescribed for syphilis, scrofula and biliousness.

The juice of *V. papuana* Becker & Pulle (synonym *V. klossii* Ridl.) is used in Papua New Guinea for toothache. In Vietnam, *V. inconspicua* Blume is used for conjunctivitis, pimples, inflammation of the breast, a sore throat, yellow fever and diarrhoea with vomiting. Young parts are eaten as a vegetable.

Some *Viola*, including *V. odorata* and *V. tricolor*, are widely cultivated as ornamentals or for their essential oil (flowers or leaves) which is used in perfumes, while their medicinal value is of secondary importance in some regions. *V. odorata* has been planted in the hills of Java to check erosion of borders of terraces. The flowers are often candied, and are used to decorate cakes, puddings, and ice cream, while the fresh flowers are put in salads. The flowers may also be processed into syrup, jellies and marmalade, and can be added to gelatins, ice, vinegar, honey, wine and salad dressing. They can have a slight laxative effect.

V. betonicifolia is sometimes cultivated as a pot herb, while a decoction of the flowers of *V. pilosa* is taken to improve the complexion.

Production and international trade In India, annual production of fresh *V. odorata* herb varied between 2.7–6.5 t in the 1950s, but no recent statistics are available.

Properties The leaves of *V. odorata* contain a highly fragrant essential oil. This steam-volatile oil consists for 30–50% of 2,6-nonadien-1-al (the violet-leaf aldehyde), 2,6-nonadien-1-ol, n-hexanol, n-hexenol, n-heptenol, n-octenol, traces of eugenol, as well as several acids. Volatile components of *V. odorata* leaves can also be extracted with 1,1,2-trichloro-1,2,2-trifluoroethane as well as hexane. More than 100 compounds were separated, of which 23 were identified, representing 95% of the total: 1-dodecanol, pentadeca-5,10-dien-1-ol, pentadec-5-en-1-ol, 1-octadecene, 1-eicosene and octadeca-9,12-dienoic acid, whereas the terpene friedelin has been recorded as well.

The flowers of *V. odorata* contain traces of an essential oil, and compounds were identified as linalool, terpineol, benzyl acetate, methyl salicylate, eugenol, pentadecanoic acid ethyl ester, pentaoxahexadecan-1-ol, tetraoxahexadecan-1-ol, octadecadienal, octadecatrienoic acid ethyl ester, pentaoxanonadecan-1-ol and hexadecanoic acid. In general, ketones are responsible for the characteristic odour of the flowers. Besides volatiles, the flowers contain an emetic compound called violin, and several flavonoids such as viola-quercetrin and rutin. The roots and rhizomes contain saponins, which are active as an emetic and expectorant, and also salicylic acid, methyl-salicylic ester and gaultherin, a glycoside of methyl salicylic acid. In addition they contain an essential oil closely resembling that of the flowers, and an alkaloid, odoratine, which has a marked hypotensive activity.

The chemopreventive potential of *V. odorata* on 7,12-dimethyl benz[*a*]anthracene-induced skin papillomagenesis was assessed with Swiss albino mice. Application of an acetone extract of *V. odorata* at 2 mg and 5 mg/kg, significantly reduced the papilloma incidence to 75% and 65% respectively in the anti-initiational experiment, but in the case of anti-promotional phase the papilloma incidence was reduced to 75% and 50% respectively. Continuous treatment of 5 mg/kg of the acetone extract after a period of 20 weeks showed complete tumour regression in mice. The modulatory effects were assessed by the significant increase in the level of sulphhydryl groups, activity of glutathione-S-transferase, glutathione reductase, glutathione peroxidase and glucose-6-phosphate dehydrogenase activity followed by a significant decrease in the activity of cytochrome P-450 and a decrease in the malonaldehyde level (lipid peroxidation).

Significant oral antipyretic activity in rabbits was exhibited by hexane-, chloroform- and water-soluble extracts of *V. odorata*, which were comparable in potency to aspirin. Pyresis was induced by subcutaneous yeast injections. Antipyretic activity was more prominent in the hexane-soluble portions of these plants. No obvious toxic effects were noted for plant extracts up to doses of 1.6 g/kg. An infusion of the leaves is reported to have diuretic activity when administered to rabbits by gastric intubation at a dose of 2 g/animal.

From the green parts of *V. tricolor* during flowering, caffeic-, protocatechuic-, genistic-, p-hydroxybenzoic-, 4-hydroxyphenylacetic-, p-coumaric- (trans and cis forms), vanillic- and salicylic acids were extracted. An extract was tested for 9 plant pathogenic fungi, but was found to be effective only against *Trichophyton mentagrophytes*. The content of the flavonoid rutin was found to be highest in petals of yellow-flowered *V. tricolor*, compared to their aerial parts. Rutin and its semi-synthetic derivatives have a wide application in the treatment of some venous diseases.

Adulterations and substitutes Ipecac (*Psychotria ipecacuanha* (Brot.) Stokes) can be used as a substitute for the rhizome of *V. odorata*, as an emetic. In India, dried *V. odorata* is commonly adulterated with other *Viola* species.

Description Perennial herbs (in Malesia), rhizomes and stolons absent or present. Leaves simple, alternate, suborbicular to linear-lanceolate, margin serrate or subentire, often glandular in indentations; petiole present; stipules free or adnate to the petiole, persistent, often conspicuous, usually serrate or fimbriate. Flowers bisexual, 5-merous, often fragrant, axillary, solitary, peduncle with a pair of bracteoles; sepals equal, entire to dentate, prolonged into appendages below the point of insertion; corolla zygomorphic, petals unequal, the lower saccate or spurred, usually broader than the others, the lateral pair smaller than the upper pair, often bearded inside; androecium shorter than the petals, filaments connivent around gynoecium, anthers 5, 2-celled, subsessile, the 2 lower ones with appendages projecting into the spur, connective produced into an apical appendage; ovary superior, glabrous or pubescent, with 3 placentas, ovules numerous, style straight, curved or geniculate, filiform to clavate, often lobed at apex. Fruit a 3-valved loculicidal capsule, globose to cylindrical, subtended by the dried calyx, 4–16 mm long; valves glabrous or hairy, boat-shaped, usually with rigid keels and thin sides, so that on drying they contract and forcibly discharge the seeds; seeds numerous. Seed ellipsoidal, glabrous, testa leathery, usually with terminal elaiosome. Seedling with epigeal germination; cotyledons ovate, leafy; first leaves alternate, margin serrate.

Growth and development Many *Viola* species produce both normal, open flowers and closed (cleistogamous), reduced flowers in individual plants; the normal ones are cross-pollinators, attracting insects, and the closed flowers are self-pollinated. In the tropics, *V. odorata* flowers from May–October, while *V. pilosa* can be found flowering throughout the year. The seeds of *Viola* are often dispersed by ants (myrmecochorous), which are attracted by the odorous elaiosome attached to the seed.

Other botanical information Most *Viola* species occurring in Malesia, except *V. biflora* L. and *V. tricolor*, belong to section *Viola*. Subsections can be distinguished on the basis of plant habit (stem and stolons present or absent) and method of seed dispersal (seeds dispersed by ants and/or by an explosive dispersal mechanism), but characteristics overlap sometimes and conclusions are not yet final.
The widespread references to *V. patrinii* DC. in South-East Asian literature probably concern *V. betonicifolia* and *V. inconspicua*, while *V. patrinii* should be restricted to northern East Asia. *V. betonicifolia* and *V. inconspicua* differ mainly in the length of the calyx appendages.

Ecology In tropical regions, *Viola* occurs generally in open or slightly shaded localities, usually above 1000 m altitude, occasionally descending to 250 m altitude. *Viola* grows well in cool, moist climates, but exposure to heavy rain hampers flowering. *V. odorata* grows well in rich, well-drained but moisture-retentive soils.

Propagation and planting Propagation of *V. odorata* is by division, cuttings from well-developed runners or seeds. The plants are repotted once or twice a year, and flower profusely in the second year. The old plants are removed after 4–5 years.
In vitro culture of *Viola* is widely practised and several protocols have been developed. A scheme for obtaining virus free *V. odorata* plants from meristem tip culture has also been developed: a medium containing kinetin, gibberellic acid and indolylacetic acid for the isolation of the meristem tips, the subsequent propagation through axillary budding by using agar solidified medium containing N-6-benzylaminopurine, the final rooting of plantlets with a low auxin level. Biological and serological tests allowed the identification of two virus-free clones which are intensively multiplied. Subsequently they are transferred to a greenhouse protected against the aphid vectors, to avoid new virus infections.

Diseases and pests Cultivated *Viola* is frequently attacked by a complex of three viruses: cucumber mosaic virus, bean yellow mosaic virus and viola mottle virus, with aphids acting as main vectors, but also mealy-bugs. Nematodes are known to attack the roots of several *Viola* species.

Harvesting In India *Viola* is harvested annually, in February–March.

Handling after harvest The flowers of *V. odorata* are washed and dried in the shade, or between cloth, in order to retain the fragrance and colour. When crumbly to the touch, the dried petals are placed in airtight containers and stored in a dark place. Other plant parts are simply dried in the shade.

Genetic resources and breeding In India, natural populations of *Viola* have been too heavily exploited and have become rather rare. Therefore, there is some danger of genetic erosion. There are no known breeding programmes of *Viola* for medicinal purposes.

Prospects *Viola* is well known in several systems of traditional medicine throughout the world, and different plant parts are commonly applied for a vast array of complaints. However, surprisingly little is known about the phytochemistry (with the exception of the volatile oil) and phytopharmacology of these species. More research will therefore be needed to find evidence for the pharmacological effects reported.

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Selection of species

Viola odorata L.

Sp. pl. 2: 934 (1753).

Vernacular names Sweet violet, purple violet, March violet (En). Violette odorante, violette de mars (Fr). Indonesia: atanan (Sundanese). Philippines: violeta (Tagalog). Thailand: waiolet (Bangkok). Vietnam: hoa t[is]m th[on]m.

Distribution Native to Europe, North Africa and western Asia. Widely cultivated in gardens in the temperate zone, in the tropics (including Java and the Philippines) cultivated at higher altitudes.

Uses The crushed aerial parts are applied for rheumatism and to ulcers, sores, swellings and cuts. The leaves are emollient and preparations are used internally and externally in the treatment of cancer. The flowers enter many pharmacopoeias throughout the world, especially for their diuretic and expectorant properties. The syrup made from the flowers is a well-known medicine for cough, colds, asthma and hoarseness. In large doses, the rhizomes and seeds are poisonous.

Observations A perennial herb, up to 30 cm tall, rhizome stout, vertical, bearing a rosette of leaves and long, procumbent rooting stems at apex; leaves orbicular-reniform to orbicular-ovate, 2.5–6 cm × 2.5–6.5 cm, base deeply cordate, rounded or obtuse, apex rounded, margins shallowly crenate, glabrous or sparsely pubescent on veins and margins, petiole up to 20 cm long, stipules ovate to ovate-lanceolate, 8–12 mm × 3–5 mm, usually glandular-fimbriate, glabrous, free; flowers 10–15 mm in diameter, purple or white, peduncle 5–14 cm long, slender, sepals ovate, 5 mm long, margins ciliate, appendage 1–2 mm long, dentate, petals broadly obovate, lateral ones bearded or not, spur 4 mm long, usually straight; style 2 mm long, curved at apex; capsule globose, pubescent, with mechanism for explosive seed dispersal; seed with small elaiosome. *V. odorata* is commonly planted in Java, from sea-level to the hills. In *V. odorata* several single- and double-flowered cultivars are known.

Selected sources 135, 221, 668, 1006, 1051.

Viola pilosa Blume

Cat. Gew. Buitenzorg: 57 (1823).

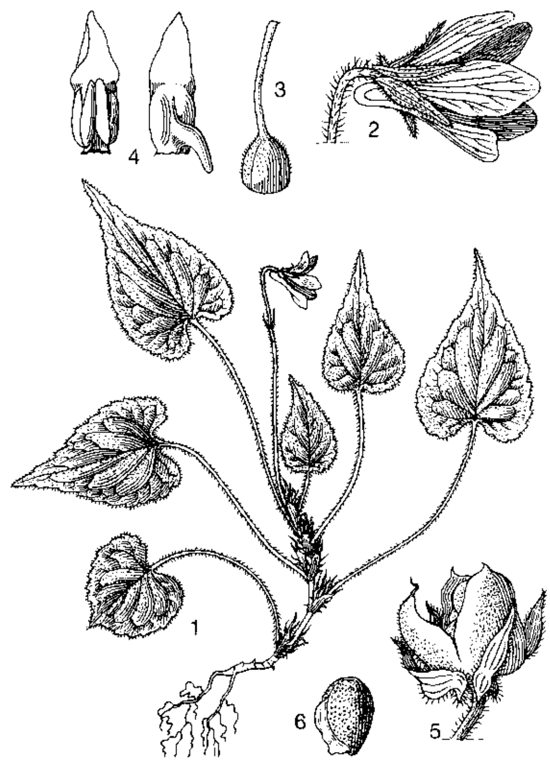
Synonyms *Viola serpens* Wallich ex Ging. (1824), pro parte, *Viola canescens* (non Wallich) Boissieu & Capitaine (1916), *Viola celebica* Becker (1916).

Vernacular names Thailand: vaasukree (Bangkok). Vietnam: hoa t[is]m l[oo]ng.

Distribution From India to Burma (Myanmar), Thailand, China, Sumatra, Java, Lesser Sunda Islands (Bali, Timor), Sulawesi and the Moluccas.

Uses The aerial parts, especially the flowers, are generally taken as a diuretic and expectorant. Most uses are identical to those of *V. odorata*.

Observations A variable perennial, hairy, rarely glabrous herb, rhizome vertical to diagonal, 1.5–4 mm in diameter, with leaves and rooting stems at apex, stems horizontal, up to 1 m long, slender; leaves ovate, 1–10 cm × 1–6.5 cm, 1–2 times longer than broad, base deeply cordate, apex acute to acuminate, margins serrate to serrate-crenate, pubescent to hirsute, especially on veins, pale green, petiole 1–17 cm long, pilose especially distally, stipules lanceolate, 7–30 mm long, long-fimbriate, pubescent; flowers (5–)8–14 mm in diameter, purple to white with darker veins, peduncle 4–12 cm long, pilose, especially distally, sepals linear-lanceolate, 3.5–9 mm long, apex acute, entire to denticulate, pilose, appendage 0.8–2.5 mm long, pointed or denticulate, pilose, petals 1.5–4 times longer than broad, basal petal obovate, lateral petals oblanceolate, bearded, upper pair usually slightly bearded, spur cylindrical, 1–2.5 mm long, obtuse, style 1.5–3 mm long, filiform, apex slightly to strongly curved, stigma emarginate; capsule ellipsoid, 5–10 mm long, glabrous or pubescent in centre of valves, without mechanism for explosive seed dispersal; seed with large elaiosome. *V. pilosa* occurs in grasslands, alpine woods and along paths, from 1100–3300 m altitude.



Viola pilosa Blume – 1, plant habit; 2, flower; 3, pistil; 4, stamens (2 types); 5, ripe fruit; 6, seed.

Selected sources 135, 754.

G.H. Schmelzer & S.F.A.J. Horsten

Voacanga Thou.

Gen. Nov. Madag.: 10 (1806).
APOCYNACEAE
$x = 11$; *V. africana*: $2n = 22$, *V. grandifolia*: $2n = 22$

Major species *Voacanga foetida* (Blume) Rolfe, *V. globosa* (Blanco) Merr., *V. grandifolia* (Miq.) Rolfe.

Origin and geographic distribution *Voacanga* is an Old World genus comprising 12 species of which 5 occur in Malesia. *V. grandifolia* has the widest distribution in Malesia. The natural distribution of *V. havilandii* Ridley is limited to northwestern Borneo and *V. megacarpa* Merr. is confined to the Philippines.

Uses The various *Voacanga* species have only rather limited local use. A few of the medical applications appear to reflect the activity of the alkaloids present in the plant.

Production and international trade Since the 1980s there has been a steady market for *Voacanga* seeds in Europe. From Cameroon, for example, 400 tonnes of seeds are collected and exported annually for processing in Europe.

Properties Indole alkaloids are by far the medicinally most important compounds of *Voacanga*. Comparison of the alkaloid composition of the individual species is hampered by the varying detail of investigations. The various *Voacanga* species have many of the alkaloids in common. *V. africana* Stapf is of local importance in traditional medicine in Africa and has been studied most extensively. The main alkaloids of the root bark are usually corynanthean-ibogan dimers, chiefly voacamine, with voacamidine and voacorine; vobtusine (a plumeran-plumeran dimer) may also be present. Among the monomers found, voacangine (an ibogan-type compound) is the most important; tabersonine (a plumeran base) has also been found. In the trunk bark, voacamine and congeners predominate; vobtusine may also be present. Voacangine and voacristine are also major constituents. The leaves contain mainly dimeric alkaloids of both the voacamine and vobtusine groups; nevertheless the monomeric plumeran base voaphylline is the main alkaloid. The alkaloid composition of the seeds is very different, and consists almost exclusively of the plumeran base (–)-tabersonine. *V. globosa* has an alkaloid composition recognizable as that of a *Voacanga*. The dimer voacamine is the principal alkaloid of the root and trunk bark; plumeran-plumeran dimers related to vobtusine have also been isolated, as well as the ibogan monomer voacangine. From the root bark of *V. grandifolia*, the plumeran-plumeran dimer voacamine has been isolated as the major alkaloid, together with voacamine and voacangine. From the leaves chiefly vobtusine has been isolated with only traces of voacamine. Yield of alkaloids from the fruits is low, with vobtusine as the principal base and small amounts of akuammidine and tabersonine. From the bark of *V. megacarpa*, vobtusine and voacamine have been isolated.

The alkaloids remaining after crystallization of the tabernaemontanine fraction obtained from the stem bark of *V. globosa* show activity against L-1210 lymphoid leukaemia and Ehrlich ascites tumour cells; tabernaemontanine itself is inactive. Tabernaemontanine causes peripheral vasodilation in chloralozed dogs; it is claimed to be of use when given orally in certain geriatric conditions (arteriosclerosis, cerebral trauma, peripheral circulatory irregularities). Tabersonine is only slightly toxic. It has about a quarter of the hypotensive activity of reserpine, 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. Voacangine exhibits some cataleptic activity. In regular doses, voacangine has anticonvulsant activity, increases hexobarbital sleeping time in mice and decreases body temperature. In addition, it has hypotensive properties, causes bradycardia and has local analgesic activity. The hydrochloride salt of voacangine has significant diuretic activity.

Most of the pharmacological work on voacorine, voacamine and its sulphate has focused on their cardiotonic properties. Voacamine and its sulphate show little tendency to accumulate. The camphorsulphonate salt of voacamine is 1.5–2 times less toxic than the sulphate and its cardiotonic effect on the rabbit auricle 4 times stronger. Like the base, the camphorsulphonate has a direct effect on the myocardium, which is also found in situ. The cardiotonic effects of voacamine sulphate are greatly reinforced in the presence of theophylline; in the same way, simultaneous administration of strophanthin enables the dose of voacamine to be much reduced. Voacamine sulphate resembles ouabain and other cardiac glycosides in its actions on the fatigued frog heart, and there is a progressive increase in the heartbeat back to normal. When tried clinically on several patients with chronic cardiac insufficiencies of various origins, there was considerable improvement in clinical status and in haemodynamic parameters; again 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. The compounds also have parasympatholytic and sympatholytic properties, bringing about contraction of smooth muscle fibres, and they are also central nervous system (CNS) depressants. Finally, voacamine sulphate has very weak analgesic properties.

Voacamine, voacorine and voacamidine are all cytotoxic in the P-388 cell-culture system. In experiments with rats and mice parenteral and oral administration of voacamine, voacorine and voacamidine slows the growth of transplanted and primary induced neoplasms. Vobtusine is a cardiac depressant, and it causes hypotension as a result of peripheral vasodilation and a direct action on the heart. In moderate doses initial agitation is followed by a sedative effect; high doses may bring about convulsions and death. Therefore it is of no clinical interest.

Tabersonine, the major alkaloid from the seeds is readily converted to vincamine and vincamine derivatives. This is one of the principal reasons for the interest in the alkaloids from *Voacanga*, since vincamine has some protective action in brain ischaemia. The compounds have been shown to improve performance in animal models of cognitive dysfunction produced experimentally by hypoxia, cerebral ischaemia, and amnesia producing agents.

Finally, aqueous extract of the root bark of *V. africana* shows 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.

Adulterations and substitutes Plants producing alkaloids of the ibogan and bis-indole type are mostly confined to closely related genera of the tribe *Tabernaemontaneae* (e.g. *Tabernaemontana*), with the exception of e.g *Catharanthus roseus* (L.) G. Don.

Description Shrubs or trees, repeatedly dichotomously branched and with 2 inflorescences in the forks when flowering, bark usually with some latex. Leaves opposite, simple, those of a pair equal or unequal, elliptical or obovate, base cuneate or decurrent; usually petiolate, base of petioles connate into a short ocrea, with a single row of colleters in the axils. Inflorescence usually long-pedunculate, cymose, usually fairly lax. Flowers actinomorphic, 5-merous, often fragrant, calyx campanulate to cylindrical, lobes subequal, corolla twisted, tube usually shorter or only slightly longer than calyx, usually creamy or yellow, lobes in bud overlapping to the left, spreading or recurved; stamens 5, exserted or included; ovary superior, usually broadly ovoid, pistil glabrous. Fruit consisting of 2 free or less often partly or completely united carpels, usually many-seeded. Seed surrounded by a yellow or orange pulpy aril, endosperm copious, starchy, creamy to white, ruminate, surrounding the spathulate creamy to white embryo.

Growth and development The South-East Asian *Voacanga* species appear to flower and fruit throughout the year.

Other botanical information *Voacanga* belongs to the tribe *Tabernaemontaneae* of the subfamily *Plumerioideae*. It is closely related to *Tabernaemontana*. In Malesia, *Voacanga* can easily be distinguished by the pistil head, style and calyx being shed with the corolla, whereas the calyx is persistent in *Tabernaemontana*, even in fruit.

V. africana is of local importance in traditional medicine in West, Central and East Africa. Various parts of the plants are used in numerous kinds of preparations, applied externally and internally, for skin afflictions, ophthalmia, diarrhoea, oedema, afflictions of the urogenital system, rheumatism, and also as a vermifuge and general tonic.

Ecology The Malesian *Voacanga* species occur in light forest or secondary vegetation, often along rivers.

In vitro production of active compounds Leaf-cell suspension cultures of *V. africana*, grown for 20 days under standard conditions, yielded 6 alkaloids. (–)-Tabersonine, lochnericine and (–)-minovincinine were the major alkaloids. Voafrine A and B, plumeran-plumeran dimers not previously detected from nature were also produced. Voafrine A and B are of pharmacological interest due to the activity of the related compound vincaleucoblastine. This alkaloid composition approaches most nearly that of the seeds.

Harvesting Fruits of *Voacanga* are collected when mature. Bark should preferably be collected at the end of the growing season in view of the higher alkaloid content. Roots are simply unearthed to obtain the root bark.

Yield The content and composition of alkaloids in leaves and bark of *Voacanga* varies seasonally. In seasonal climates contents are highest at the end of the growing season, e.g. November in India. With respect to alkaloid concentration in the leaves in November, an increase from 1% for those at the first to 2.2% at the 6th node (25 days old) and a steady decline at older nodes was observed.

Handling after harvest Fruits of *Voacanga* are dried and seeds subsequently removed, or seeds are removed prior to drying. Dried seeds are pulverized and the powdered material is usually subjected to extraction by standard methods for alkaloids. Other more sophisticated methods have also been patented. Trunk bark, after being removed in strips, is dried. Patented extraction procedures have been developed to obtain cardioactive components from the bark.

Genetic resources and breeding The apparent tolerance of *Voacanga* for disturbed habitats 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* display very distinct and interesting pharmacological activities. Some of them have the potential to be excellent candidates for lead compounds in the development of future medicines. Much research has been done already, however, much more will be needed in future to fully exploit their possibilities.

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Selection of species

Voacanga foetida (Blume) Rolfe

Journ. Bot. London 21: 202 (1883).

Synonyms *Orchipeda foetida* Blume (1826).

Vernacular names Indonesia: rango-rango (Malay), hamperu (Sundanese), puding-hitam (Riau, Sumatra).

Distribution Sumatra, West and Central Java, southern Kalimantan.

Uses In Indonesia, the latex is applied externally against various skin diseases. In Madura, the leaves are heated over a fire and placed on chronic leg sores. In South Sumatra, the leaves are moistened with coconut oil and used externally against headache and stomach-ache. The wood is used for making sheaths for knives and other weapons.

Observations A shrub or small tree with a wide crown, 3–20 m tall, trunk up to 20–40 cm in diameter; leaves elliptical, narrowly elliptical or narrowly ovate, 7–34 cm × 3–11 cm, 1.9–3.5 times longer than wide, petiole 5–15 mm long; inflorescence pedunculate, cymose, lax, 12–21 cm × 5–10 cm, few-flowered; flowers a little foul-smelling, calyx campanulate, clasping the corolla tube, 2.0–3.7 cm long from the abscission layer, corolla 6.5–10.0 cm long, corolla tube infundibuliform, not twisted, white, creamy or sometimes pale yellow, stamens deeply included; fruit consisting of 2 free subglobose mericarps, 6–11 cm in diameter, green with small grey warts, fruit wall 10–15 mm thick, aril orange. *V. foetida* is found in light forest from sea-level up to 600 m altitude.

Selected sources 372, 407, 786.

Voacanga globosa (Blanco) Merr.

Philipp. Journ. Sci. 4, Bot.: 319 (1909).

Synonyms *Voacanga cummingiana* Rolfe (1884), *Voacanga dolichocalyx* Quisumb. & Merr. (1928), *Voacanga latifolia* Quisumb. & Merr. (1928).

Vernacular names Philippines: bayag-usa (Tagalog, Bikol), bayag-kambing (Tagalog), alibutbut-nga-bai (Panay Bisaya).

Distribution The Philippines.

Uses In the Philippines, the pounded roots are used for stupefying fish. On Bilirian Island, a decoction of the leaves is applied for cleaning skin affections.

Observations A shrub or small tree up to 15 m tall, trunk up to 20 cm in diameter; leaves narrowly elliptical or narrowly ovate, 4–25 cm × 1–9 cm, 2–4 times longer than wide, petiole 5–30 mm long; inflorescence pedunculate, cymose, lax, 6–17 cm × 5–10 cm, few-flowered; flowers very variable in size, sweet-scented, calyx cylindrical or nearly so, clasping the corolla tube, 0.8–5.0 cm long from the abscission layer, corolla 3.0–6.5 cm long, corolla tube almost cylindrical, not twisted, white or creamy, stamens included for 2–10 mm; fruit con-

Voacanga globosa (Blanco) Merr. – 1, flowering branch; 2, fruit.

sisting of 2 free subglobose mericarps, 4–6 cm in diameter, green, plain with a granular skin, fruit wall 3–5 mm thick, aril pale orange. *V. globosa* is found in forest or bush vegetation from sea-level up to 300 m altitude.

Selected sources 128.

Voacanga grandifolia (Miq.) Rolfe

Journ. Bot. 21: 202 (1883).

Synonyms *Tabernaemontana celebica* Miq. (1869), *Voacanga papuana* (F. Muell.) K. Schum. (1895), *Voacanga versteegii* Markgr. (1927).

Vernacular names Indonesia: kalak kambin (Javanese), lambuto (Makassarese). Papua New Guinea: bahira (Orokaiva, Mumuni).

Distribution From the Philippines (Mindanao) southward to Sulawesi, East and Central Java, the Lesser Sunda Islands and eastward to the Moluccas (Halmahera) and New Guinea.

Uses In Central Java the young leaves are mashed and rubbed on the stomach against illness from worms and diarrhoea. In Papua New Guinea, the plant is used as a medicine for malaria.

Observations A shrub or small tree up to 15 m tall, trunk up to 20 cm in diameter; leaves elliptical, narrowly elliptical or narrowly ovate, 8–40 cm × 2–14 cm, 2–4 times longer than wide, petiole 0–5 cm long; inflorescence long-pedunculate, dichotomous in first branchings and further variably monochasial, 8–30 cm × 5–20 cm, few- to many-flowered; flowers foul-smelling or sweet-scented, calyx nearly cylindrical, not clasping the corolla tube, 1–2 cm long from the abscission layer, corolla 2–4.5 cm long, corolla tube almost cylindrical to bottle-shaped, twisted or sometimes not, white, creamy, or sometimes yellow, stamens slightly exserted to barely included; fruit consisting of 2 free, partly or completely united carpels, separate carpels subglobose, 3–6 cm in diameter, fused carpels shaping a laterally compressed, transversely elliptical fruit up to 12 cm × 15 cm × 10 cm, pale yellow or dark green with many small pale grey-brown warts, fruit wall 5–25 mm thick, aril orange. Dried specimens from New Guinea are often confused with those of *Tabernaemontana aurantiaca* Gaud. However, they differ considerably in flowers and fruits. *V. grandifolia* is found in bush vegetation or light forest, often on heavy clay on stream banks, from sea-level to 1000 m altitude.

R. Hendrian

Waltheria indica L.

Sp. pl. 1: 673 (1753).

STERCULIACEAE

$2n = 24$

Synonyms *Waltheria americana* L. (1753).

Vernacular names Philippines: barulad (Iloko), kanding-kanding (Cebu Bisaya). Thailand: taan saai (south-western), yaa hua nok khao (northern). Vietnam: ho[af]ng ti[ee]n, ho[af]n ti[ee]n.

Origin and geographic distribution The area of origin of *W. indica* is uncertain, but it is at present widely distributed throughout the tropics and the subtropics.

Uses In the Philippines, *W. indica* is considered a febrifuge and an antisyphilitic.

In Central America a decoction of various plant parts is taken as a treatment for fever and syphilis, and is applied externally on skin eruptions and wounds. In Cuba, a decoction of the leafy stems is taken to relieve bladder ailments. In Panama, it is considered a remedy for haemoptysis. In northern Nigeria and Togo a decoction of the root is given as a general tonic to children. In

Burkina Faso it is given as an antidiarrhoeal to children. The root is also used as a cough medicine in Togo and in Senegal for healing wounds. Various parts are also employed in veterinary medicine in North and West Africa.

The bark yields a fibre similar to jute, but is of no commercial interest.

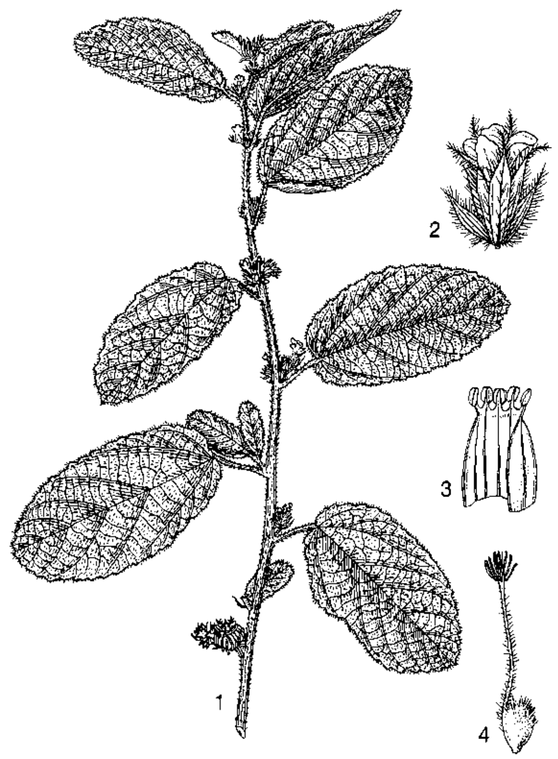
Production and international trade *W. indica* is only used on a local scale.

Properties A general screening of *W. indica* revealed the presence of some general flavonoids and caffeic acid. In addition, 3 alkaloids have been isolated: adouétine X, Y and Z. These are characterized by only one of the four nitrogen molecules being basic. The adouétine Z (in the form of its amidosulphonate) has an LD_{50} in mice of 52.5 mg/kg. It acts as a sedative of the central nervous system and as a stimulant of the medulla. In dogs it produces hypertension, slows down the heartbeat, and has a relaxing action on the smooth muscle fibres of the intestine.

Two antifungal flavonoids have been isolated from the chloroform extract of *W. indica*, collected in the Philippines: 5,2′,5′-trihydroxy-3,7,4′-trimethoxyflavone and 5,2′-dihydroxy-3,7,4′,5′-tetramethoxyflavone. The first showed high antifungal activity against *Candida albicans* and low activity against *Trichophyton mentagrophytes*, while the second showed moderate antifungal activity against *Aspergillus niger* and *Trichophyton mentagrophytes*. Furthermore, a total aqueous extract of *W. indica* collected in Burkina Faso showed in-vitro antibacterial activity against 3 entero-bacteria: *Escherichia coli*, *Salmonella typhi* and *Shigella dysenteriae* at a minimum inhibitory concentration of 5, 2.5 and 2.5 mg/ml, respectively.

Using an in vivo (mice) model, hexane, chloroform, methanol or water extracts of *W. indica* showed no significant effects on castor oil induced diarrhoea.

Description A subshrub, 0.5–2 m tall, with ascending branches, sparsely to densely stellate-pubescent or stellate-tomentose. Leaves alternate, simple, ovate-oblong to oblong, 2.5–9 cm × 1.5–4 cm, base rounded, apex obtuse or subacute, margin serrate, basally 3–5-nerved; petiole 0.5–3.3 cm long; stipules narrow. Inflorescence an axillary, dense globose cluster, subsessile or pedunculate, those in the upper axils often forming an interrupted or continuous spike-like or corymb-like inflorescence; bracts and bracteoles linear to linear-lanceolate. Flowers bisexual, 5 mm across, 5-merous; calyx tube campanulate, 2–3 mm long, lobes 5, triangular, 1 mm long; petals 5, obovate oblong, yellow, 2–5 mm long, shortly clawed; stamens 5, opposite the petals, filaments united into a tube; ovary superior, globose, 1-loculed, ovules 2, style excentric, stigma fimbriate. Fruit an obconical capsule, 3 mm × 2 mm, enclosed in the calyx, 2-valved, 1-seeded. Seed obovoid, 2 mm × 1.4 mm, dark brown. Seedling with epigeal germination; cotyledons obovate to orbicular, 7 mm long, petiole up to 1 cm long; first leaves alternate, ovate, 1–2 cm long, densely stellate pubescent, margin serrate, petiole 1–2 cm long.



Waltheria indica L. – *1, flowering twig; 2, flower; 3, staminal column; 4, pistil.*

Growth and development *W. indica* flowers and fruits throughout the year.

Other botanical information *Waltheria* comprises about 50 species, almost all from the tropics of Central and South America, one of which is a weed in the Old World tropics and subtropics. Whereas *W. indica* plants from Central America are homostylous, plants in India are reported as heterostylous.

Ecology *W. indica* is an ubiquitous weed and early colonizer in disturbed ground, tolerant of a wide spectrum of habitats and altitudes, from coastal plains, open scrub, roadsides and weedy fields to steep rocky slopes, from sea-level to 125 m altitude in Java.

Propagation and planting *W. indica* is propagated by seed.

Harvesting Plant parts of *W. indica* are collected whenever the need arises.

Handling after harvest Plant parts of *W. indica* are used fresh or dried and stored for future use.

Genetic resources and breeding *W. indica* is widespread and common in dry open, often disturbed habitats throughout South-East Asia, and therefore not endangered.

Prospects Limited information is available on the phytochemistry and phytopharmacology of *W. indica*. More research is needed to fully evaluate its future potential.

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Other selected sources 74, 76, 143, 215, 662, 760, 810.

N.O. Aguilar & J.L.C.H. van Valkenburg

Wedelia Jacq.

Enum. syst. pl. Carib. 8: 28 (1760).

COMPOSITAE

x = unknown; *W. biflora*: $2n = 30$; *W. chinensis*: $2n = 50$

Major species *Wedelia biflora* (L.) DC., *Wedelia chinensis* (Osbeck) Merr.

Origin and geographic distribution *Wedelia* is a large tropical and subtropical genus of 50–70 species, with probably about 15 species in South-East Asia.

Uses In South-East Asia and India, *Wedelia* is commonly used for medicinal purposes, e.g. as a diuretic and anti-inflammatory. When prepared as a tea, the fresh roots and leaves of *W. biflora* are especially known for their diuretic qualities, but the flower heads are a violent purgative, and old stems and leaves are toxic and can cause horses and goats to vomit and even die. Furthermore, the fresh or cooked roots of *W. biflora* are used as a stomachic, a febrifuge, an emmenagogue, for checking vaginal discharges and as a cure against a tight chest and dizziness caused by eating poisonous fish and crab. The leaves, prepared as a tea, are an antiperiodic in malaria, and a cure for haematuria, stomach-ache, and in Thailand for headaches. Fresh leaves are used for dressing ulcers and abscesses, and in Malaysia also as a poultice for varicose veins and insect bites. The juice of the leaves mixed with cow's milk is given as a tonic after childbirth. Mixed with ginger, it is used against flatulence.

W. chinensis has analgesic, antipyretic, anti-inflammatory and antimicrobial properties and is commonly used in the treatment of abscesses, arthritis, mammary infections and odontitis. The leaves are considered tonic, alterative, and useful in coughs, headaches and skin diseases. The fruit and flower heads, as well as the leaves, are used in decoction as a purgative and emetic, and in uterine haemorrhage. In Indo-China, the herb is applied as a decoction against abdominal swellings and against hepatitis. In China, the plant is also used to treat diphtheria and haemorrhoids. In Fiji, the leaves are soaked in coconut oil and the oil is used to massage sprained or bruised limbs. A decoction of the leaves is applied to treat bacillary dysentery, infective hepatitis, haemorrhoids, bladder infections, swollen testicles and diarrhoea. The bark is used with coconut milk to treat fish poisoning.

In India, the juice of *W. chinensis* is also used for tattooing, the colour produced being a deep indelible blue-black. The root is pounded and used as a black dye with salts of iron. In the Philippines and in India, the leaves are used for dyeing grey hair and against baldness.

Two *Wedelia* species are cultivated as ornamentals: *W. trilobata* Hitchc. (introduced from South Africa) under lane trees in Singapore, and *W. urticifolia* (Blume) DC. var. *scaberrima* DC. is known as a garden plant in Thailand. According to Rumphius, *W. moluccana* (Blume) DC. has the same medicinal uses as *W. biflora*.

Production and international trade In Indo-China, *W. chinensis* is sold dry at markets by herbalists.

Properties The methylene chloride extract of the dried leaves of *W. biflora* contains, in addition to protein and a high fibre content, the flavonoids 3,3′-di-O-methylquercetin, 3′,7-di-O-methylquercetin and 2,7-dihydroxy-3(3′-methoxy-4′-hydroxy)-5-methoxy-isoflavone and also veratrylidenehydrazide and rhamnazine. The first two compounds exhibit antifungal activity against *Rhizoctonia grandis*, and the second compound also possesses antifeedant activity against the cotton boll-weevil (*Anthonomus grandis*). 24-Ethylcoprostanone and ent-kauradienoic acid (a diterpene) are present in all above-ground parts of *W. biflora* and also show antifeedant activity against the cotton boll-weevil, while the kaurane-type diterpene 16-methylkaur-15-en-19-oic acid and grandifloric acid show antifungal activity against *Pythium ultimum* and *Rhizoctonia solani*. An aqueous extract of the plant is toxic to American cockroaches. *W. chinensis* leaves are known to contain around 0.05% wedelolactone (5,6-dihydroxy-2(2,6-dihydroxy-4-methoxyphenyl) benzofuran-3-carboxylic acid lactone), which is analogous in structure to coumestrol, a well-known phyto-oestrogen found in many *Leguminosae* (e.g. *Medicago sativa* L., *Melilotus* spp. or *Trifolium* spp.). Wedelolactone shows marked and selective inhibitory activity against 5-lipoxygenase, a key enzyme system involved in inflammatory reactions. The leaves also contain isoflavonoids, and melissic- and lignoceric acid, stigmasterol, stigmasteryl glucoside, (–)-kaur-16-en-19-oic acid and a mixture of three kaurenoid esters have been isolated from the whole dried plants.

The crude aqueous extract shows significant protection of the liver against the hepatotoxins CCl_4 and acetaminophen in mice, and D-(+)-galactosamine in rats. An alcoholic extract of the whole plant has a protective activity against CCl_4-induced liver injury in vivo. More detailed investigations in vitro reveal very marked antihepatotoxic activity of (–)-kaur-16-en-19-oic acid and the esters in assays with liver cells damaged by CCl_4 and D-(+)-galactosamine. Lignoceric acid shows activity against CCl_4-induced damage, and stigmasterol and its glucoside give some protection against both types of damage.

Further pharmacological effects include a significant healing effect of an aqueous extract of the leaves on open or sutured wounds in rats. An alcoholic extract increases bile flow in rats, which suggests a stimulation of liver secretory capacity. It has been observerd that growth of Ehrlich's ascites carcinoma is inhibited by a 5% ethanolic extract of the plant. The minimum lethal dose of the alcoholic extract was > 200 mg/kg orally in mice.

The aqueous extract of the leaves of *W. chinensis* has an allelopathic effect on seedling growth of radish, mung bean, cucumber and rice, on the germination of rice, and on the germination and seedling growth of *Althernanthera philoxeroides* Griseb. and *Eragrostis cilianensis* Vignolo.

Adulterations and substitutes *Eclipta prostrata* (L.) L. is said to possess properties similar to those of *W. chinensis*, because of the presence of the coumestans wedelolactone and demethylwedelolactone, which are liver drugs. In India, *W. chinensis* is supposed to be more active than *Taraxacum officinale* Weber ex F.H. Wigg. for diseases of the digestive tract and for liver obstructions.

Description Perennial herbs or subshrubs, scabrous to hirsute, with a camphor-like odour; stems creeping or climbing. Leaves opposite, simple, blade elliptical to ovate, entire or toothed, often with 3 pronounced basal veins; petiole present or leaf subsessile; stipules absent. Inflorescence consisting of 1–5 or more long-pedunculate heads, terminal and axillary; involucre 1-whorled, with a few smaller outer bracts, receptacle bracts strongly veined, obtuse, enfolding the achenes. Ligulate flowers 6–10, apex of corolla usually 2–3-toothed, yellow, corolla of tubular flowers 5-lobed, (greenish) yellow; anthers 5; style bifid. Fruit a thick, cuneiform achene, those of ligulate flowers 3-angled, of tubular flowers 4-angled; pappus consisting of 1–2 short hairs or absent, or crown-like, toothed or ringed, lower part glabrous.

Growth and development *Wedelia* can be found flowering throughout the year, when sufficient water is available.

Other botanical information *Wedelia* belongs to the tribe *Heliantheae*, and is a large genus, in which only some partial revisions exist. *W. biflora* has recently been renamed as *Wollastonia biflora*

(L.) DC. but the status of other *Wedelia* species in Malesia is still unclear. It seems therefore appropriate to conserve the old name, until a revision of *Wedelia* and closely related genera is completed. The status of *W. moluccana* (Blume) DC. and *W. prostrata* Hemsl., for which medicinal uses are mentioned, will then hopefully be elucidated.

Ecology South-East Asian *Wedelia* species are common near the coast, also on sandy beaches, in plantations and waste places. They prefer sunny to lightly shaded localities.

Propagation and planting *Wedelia* is propagated mainly by seed, but shoots can root quite easily as well.

Harvesting *Wedelia* is very common near the seaside and can be picked whenever the need arises.

Handling after harvest *Wedelia* can be used fresh or dried.

Genetic resources and breeding Both *Wedelia* species have a large area of distribution and do not seem to be at risk of genetic erosion. No germplasm collections are known to exist, except in botanical gardens.

Prospects *Wedelia* contains several compounds, e.g. flavonoids, diterpenes and wedelolactone, which have interesting pharmacological activities (antifungal, antifeedant, antihepatotoxic and anti-inflammatory), and therefore merits further research.

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Selection of species

Wedelia biflora (L.) DC.

in Wight, Contr. bot. India: 18 (1834).

Synonyms *Wollastonia biflora* (L.) DC. (1836).

Vernacular names: Indonesia: saruni laut (Sundanese), cinga-cinga (Ternate). Papua New Guinea: betet (Kamba, Madang Province), gasauk (Keriga, Morobe Province), bari (Sasembata, Northern Province). Philippines: hagonoi (Tagalog, Bisaya). Thailand: phak khraat thale (central). Vietnam: h[ar]i c[us]c, s[af]i d[aas]t hai hoa.

Distribution From tropical Africa eastward to India and Indo-China to Japan, and southwards from Malesia to tropical Australia and western Polynesia.

Uses Apart from its medicinal use throughout the region as a diuretic, *W. biflora* is used in small quantities for seasoning fish and turtle meat. In Papua New Guinea, crushed leaves are rubbed on the forehead to relieve headache, and drunk with water for a bad cough or malaria. The pounded stem or leaves are taken in water for diarrhoea and stomach-ache. The sap of the leaves is used to stop bleeding cuts and wounds.

Observations A straggling herb or vine, 1.5–2(–6) m tall; leaves ovate, 6–15 cm × 5–10 cm, base rounded, apex pointed, margins rather coarsely toothed, appressed-strigose on both surfaces, petiole 2–6 cm long; inflorescence consisting of 1–3 heads, peduncle 2–8 cm long, heads up to 3 cm in diameter, involucral bracts narrowly oblong, somewhat recurved, 10–13 mm long, hairy, equalling or exceeding the disk; ligulate flowers 6–12 mm long, tubular flowers 5 mm long; achene cylindrical-cuneate, 3.5 mm long, 3–4-angled, pappus bristles 1–2, 2.5 mm long. *W. biflora* is usually abundant at the back of beaches and along tidal streams and mangrove-borders, where it can form impenetrable thickets. It is also common in secondary forest, abandoned gardens, coconut plantations and fallowed rice fields.

Selected sources 74, 143, 407, 418, 565, 604, 674, 750, 779, 786, 788.

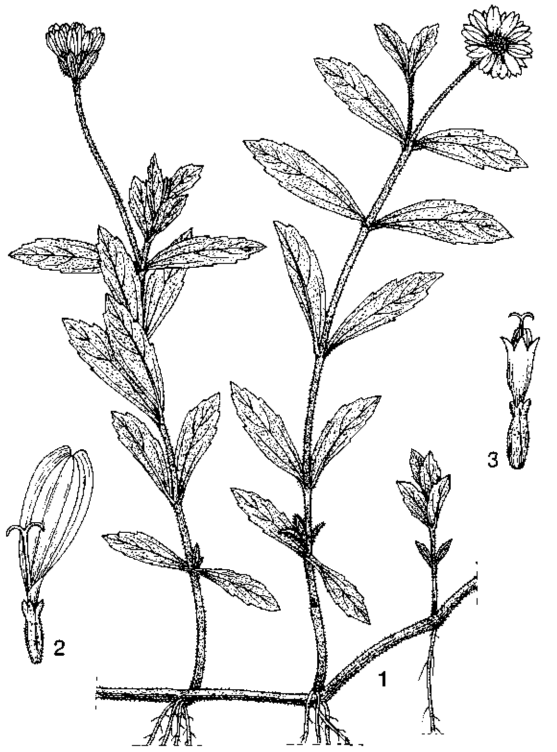
Wedelia chinensis (Osbeck) Merr.

Philipp. Journ. Sci., Bot. 12: 111 (1917).

Synonyms *Wedelia calendulacea* Less. (1832).

Vernacular names Philippines: hagonoi-tsina (Tagalog). Thailand: ka meng tua phuu (central), hom kieo kham (northern). Vietnam: s[af]i d[aas]t, ng[oor] n[us]i, hoa m[us]c.

Distribution From India and Indo-China to Japan, and southwards to Malaysia and the Phi-



Wedelia chinensis (Osbeck) Merr. – 1, plant habit; 2, ligulate flower; 3, tubular flower.

lippines, where it was introduced.

Uses *W. chinensis* is primarily known as a medicinal plant for the treatment of inflammations, including abscesses and sore throat, but also for cough. In India, the fresh plant mixed with sesame oil, is also used to treat elephantiasis. In Vietnam, the leaves are employed for purifying water.

Observations A slender, spreading herb, 50–80 cm tall, rooting at the lower nodes; leaves oblong to oblong-lanceolate, 2–5 cm × 1–2 cm, base cuneate, apex acute, margins entire or obscurely serrulate, both surfaces with appressed stiff hairs, petiole almost absent; inflorescence a solitary head, peduncle 6–12 cm long, heads about 1 cm in diameter, involucral bracts 5, oblong, 8 mm long, puberulent; ligulate flowers 9–11 mm long, about equal to the bracts, spreading, tubular flowers 4 mm long; achene obovoid, 3.5 mm long and upper half coarsely hairy, pappus cup-shaped. *W. chinensis* is found on open waste places at sea-level.

Selected sources 74, 400, 407, 418, 565, 604, 739, 750, 786, 788, 901, 1050, 1122.

G.H. Schmelzer

Xanthium strumarium L.

Sp. pl. 2: 987 (1753).
COMPOSITAE
$2n = 36$

Vernacular names (Common) cocklebur (En). Glouteron, grateron, lampourde (Fr). Malaysia: buah anjang. Thailand: kachab. Vietnam: k[es] d[aaf]u ng[uwj]a, th[uw][ow]ng nh[ix].

Origin and geographic distribution *X. strumarium* is found from about 53°N to 33°S, most frequently in the temperate zone. It possibly originated in the Mediterranean region. However, it is also a widespread, often rather localized pantropical weed, found here and there in Malaysia.

Uses All parts of *X. strumarium* seem to be used in South-East Asia and India. Sometimes the whole plant is used, but the roots are used least and the fruits most. In general, it is taken as a tonic, diuretic, diaphoretic and sedative, and also to treat allergic rhinitis, muscular paralysis or numbness, oedema, arthritis, rheumatism, malarial fever, herpes, erysipelas, bladder infections, ulcers and hives. It is also used for a swollen stomach, muscular pain, and as an astringent and a haemostatic. The burs are found in Chinese pharmacies in Peninsular Malaysia.

In Indo-China, a poultice of macerated fruits of *X. strumarium* is used for itching, furuncles, abscesses, and red spots of the face. The fruits are also used in the treatment of goitre, on account of its richness in iodine.

The crushed stem and leaves are applied to scabies, chicken pox, leprosy, and insect bites, as poultices for abscesses, as a wash for open sores, to cure colds, headache, toothache, earache and ringing in the ear. The roots are used to disinfect wounds, furuncles and mouth sores. In Peninsular Malaysia, the aerial parts are used as an antiseptic wash after childbirth.

In Cuba, *X. strumarium* is a popular medicinal plant, and is sold by herbalists. The bitter, astringent root decoction is used in kidney troubles, for expelling gravel and stones, and is also beneficial for the liver. The burs are considered to be cooling and soothing. The ashes are applied to sores on the lips and in the mouth.

X. strumarium is also poisonous, acting on the heart, inducing a comatose condition and death in cattle. The poison is concentrated in the achenes, in particular in the cotyledons. The burs injure mechanically as well. Despite being poisonous, the herb is used as a leafy vegetable in China, and in North-East India the floral tops and the 2 leaves below are boiled in water and eaten. The toxic substances are removed by washing and cooking. The achenes yield a pale yellow oil which can be used for cooking and industrial purposes. In India, the dry stems are used as fuel.

Production and international trade In India, *X. strumarium* has been cultivated as an oil plant for the local market, but no statistics are available.

Properties Important compounds isolated from *X. strumarium* are the xantholides and xanthane epoxide derivatives (sesquiterpene lactones), e.g. xanthumin, xanthinin, xanthatin, xanthinosin, xanthanol, isoxanthanol, 1α,5α-epoxyxanthatin, 1β,5β-epoxyxanthatin, 4-epixanthanol, 4-epi-isoxanthanol, 11α,13-dihydroxanthatin, 4β,5β-epoxyxanthatin-1α,4α-endoperoxide, and 1β,4β,4α,5α-diepoxyxanth-11(13)-en-12-oic acid, tomentosin, 8-epi-xanthatin and 8-epi-xanthatin-1β,5β-epoxide. In general, the quantity of these phytochemical components differ for the different subspecies. In addition, the fruit contains vitamin C, a glycoside called xanthostrumarine (carboxyatractyloside), and consists for about 30% of a drying oil, containing oleic and linoleic acids and phosphatides. The plant itself is also known to be a rich source of iodine, and the leaves contain volatile oil components (terpenes) including δ-limonene and δ-carveol, which have potent antifungal activity.

The air-dried young burs contain glucose and fructose (7%), sucrose (5%), phytosterols such as sitosterol and its glycosides, a thiazinedione and the phenolics caffeic acid, potassium 3-O-caffeoylquinate, 1,5-di-O-caffeoylquinic acid and 1,3,5-tri-O-caffeoylquinic acid.

Several of the xantholides and xanthane epoxide derivatives display pharmacological activities. Xanthumin is useful as a central nervous system depressant and the extraction of this lactone has been patented in Japan. Xanthinin acts as a growth regulator for plants, and the alcoholic solution (95%) shows strong antibacterial activity against gram negative bacteria and fungi, for example the pineapple fruit-rotting fungus (*Ceratocystis paradoxa*). Xanthatin also shows potent antibacterial activity, against *Streptococcus aureus*, including the methicillin resistant type, *S. epidermidis*, *Klebsiella pneumoniae*, *Bacillus cereus*, *Pseudomonas aeruginosa*, *Vibrio cholerae* and *Salmonella typhi*, but not against some other bacteria, including *Escherichia coli*. Furthermore, xanthumin, tomentosin, 8-epi-xanthatin and 8-epi-xanthatin-1β,5β-epoxide, isolated from an acetone extract of the aerial parts, show antimalarial activity against chloroquine-resistant *Plasmodium falciparum* strain K1.

Xanthostrumarine occurs in high concentrations in germinating seeds and very young seedlings, causing death in animals that feed on them, such as cattle, sheep, pigs and rats, but not in chickens. Clinical signs of this toxicity, which is also known as cocklebur toxicosis, range from acute death to hyperexitability, blindness, tense musculature, and spastic gait with heads and ears erect. Male rats, when given xanthostrumarine intraperitoneally at a calculated LD_{50} dosage, and treated with enzyme inducers and inhibitors or glutathione precursors and depletors, showed different levels of recovery.

Pharmacological effects of *X. strumarium* parts and preparations include antitrypanosomal activity of a crude 50% ethanol extract of the leaves. The extract exhibits trypanocidal (*Trypanosoma evansi*) activity in vitro and also in vivo, when administered intraperitoneally to *Trypanosoma evansi* infected mice. However, it was toxic to the animals at 1000 mg/kg dose.

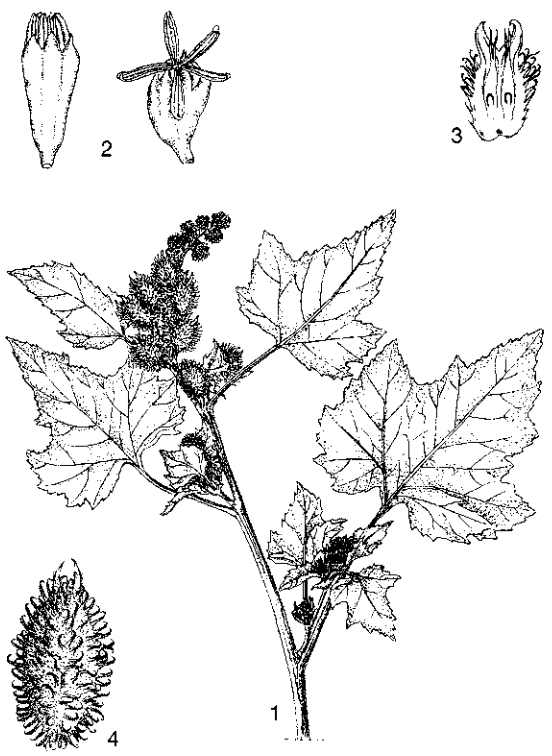
The stem distillate of the leaves, which contains oleic acid and phenolics such as 3,4-dihydroxycinnamic acid, shows nematicidal activity against *Meloidogyne incognita* in in vitro and in vivo tests. All the plant parts also cause significant larval mortality in *Tylenchus semipenetrans* and *Heterodera cajani*.

Water extracts of the inflorescences completely inhibit germination of *Parthenium hysterophorus* L. (*Compositae*), a noxious weed.

Standardized water extracts of *X. strumarium* leaves and stems are a known cause of contact dermatitis, while pollen can cause airborne contact dermatitis.

Adulterations and substitutes The oil from the achenes of *X. strumarium* yields a fatty oil, resembling that of sunflower (*Helianthus annuus* L.) or linseed (*Linum usitatissimum* L.).

Description A coarse, erect, branching, monoecious, annual herb, 30–150 cm tall, stems tough, with short dark streaks or spots and covered with short hairs. Leaves alternate, triangular-ovate to broadly ovate, 2–12 cm long, base often cordate, apex pointed, margins irregularly toothed or lobed, short stiff hairs on both sides; petiole 2–8 cm long; stipules absent. Inflorescence a 2–many-flowered head, in axillary and terminal clusters or halfway along the branches. Flowers unisexual; male flowers in inconspicuous, many flowered heads, 5–8 mm across, often clustered at the tips of branches or above the female flowers, involu-



Xanthium strumarium L. – 1, flowering branch; 2, male flowers, before and after anthesis; 3, female flowers, vertical section through inflorescence; 4, bur.

cral bracts in 1 row, receptacle cylindrical, with scales, corolla campanulate, 1 mm across, with 6 lanceolate lobes; stamens 5, anthers free and hooked at apex, filaments connate, style and ovary rudimentary; female flowers in 2-flowered ovoid heads, 1.5–2.5 cm long, involucral bracts in 2 rows, the outer small, free, the inner connate, coriaceous, covered with hooked spines, 2–4 mm long, ending in 2 beaks and forming a 2-locular structure (a bur), greenish, corolla absent; styles exserted through a hole on the inside of the beak near its base. Fruit an ovoid achene, 2 in each bur, black; pappus absent. Seedling with epigeal germination; hypocotyl 2–3 cm long, glabrous; cotyledons lanceolate, base attenuate, apex rounded apex, basal veins 3, epicotyl very short, first leaves 2, almost equal, base cordate, apex pointed, margins toothed, rough hairy.

Growth and development The spiny infructescences of *X. strumarium* are dispersed by animals and water. It is a short-day plant and usually will not flower if the day length exceeds 14 hours. Therefore it does not flower in the temperate zone until late summer, and seeds also ripen late. *X. strumarium* is wind pollinated.

Other botanical information The many forms of *X. strumarium* vary widely in plant size, fruit shape and size, and in their response to environmental factors. Linnaeus described 2 species in *Xanthium*, belonging to the tribe *Heliantheae*, *X. strumarium* and *X. spinosum* L. (cotweed). Since then many other species have been published, but most of these have now been regrouped into 8 morpho-physiological 'complexes', or into subspecies, belonging to *X. strumarium*. In South-East Asia, subsp. *strumarium* occurs most frequently, but in Vietnam subsp. *inaequilaterum* DC. is locally common. *X. spinosum*, a species from the Americas but naturalized in Europe, is easily recognized by its 3-fid axillary spines and deeply lobed leaves.

Ecology *X. strumarium* is a weed of wastelands or disturbed lands, often associated with open grounds, as it does not tolerate shade. It is frequently found along roadsides, edges of small streams and ponds, and grows on a wide range of soils and moisture regimes, from sands to heavy clays. Under optimal growing conditions it becomes tall and luxurious, while in dry, poor soils it stays small, a few cm tall, but still flowers and fruits. *X. strumarium* is a weed in crops in many countries, but rarely a major one. It becomes a serious weed in degenerated pastures, where it can form pure stands, and may then cause poisoning in cattle.

Propagation and planting *X. strumarium* has been cultured in vitro, not for its medicinal compounds, but for the determination of effective herbicides for specific crops, such as cotton. The 2 achenes in the bur germinate at a different rate. The slow-germinating achene has a seed coat with low permeability to oxygen, and a longer dormancy. Water requirements for germination are high. In Vietnam, the fruits are sown after the beginning of the rains, and seedlings are transplanted when they are 6–7 cm tall.

Husbandry *X. strumarium* is rarely cultivated, and not for medicinal purposes, but for its oil. In fact, many tests have been done to find herbicides to get rid of this weed. The herb is suitable as an organic manure, rich in nitrogen, which is mineralized within 30 days after incorporation of the weed into the soil. The oilcake is also valued as a manure, as it contains 8–10% nitrogen and 3–3.5% phosphoric acid.

Diseases and pests *X. strumarium* is a host for numerous important diseases and pests, including the fungi *Alternaria helianthi* (blight disease), *Colletotrichum orbiculare* and *Rhizoctonia solani*, and the leafminer *Liriomyza helianthi*.

In North America and Australia, some insects are being screened as candidates for biological control of *X. strumarium*. For instance, the Argentine stem borer (*Apagomerella versicolor*) reduced fruit production by about 65% under laboratory conditions when 45-day-old plants were infested. When the infection occured later, there was less damage. In Australia, the stem-galling moth *Epiblema strenuata* is used for biological control of *Parthenium hysterophorus*, but it also attacks *X. strumarium*, thus substantial control may be achieved. In the 1970s numerous tests were carried out with specific fungi to be used as biological control for *X. strumarium*, but none of them were successful.

Harvesting Whole *X. strumarium* plants are harvested when the fruits are ripe.

Yield In India, the yield of the achenes from cultivated *X. strumarium* is 550–660 kg/ha. The yield of the oil is about 175 kg/ha.

Handling after harvest Whole plants of *X. strumarium* are dried in the shade for medicinal or culinary use. For oil production, the burs require pre-treatment with sulphuric acid for 12 hours and are then dried in the sun. The achenes can then easily be obtained by slightly pressing the burs between rollers and winnowing. The achenes can also be obtained by passing the burs through a special decorticator which cuts the burs. Broken burs and achenes are subsequently separated by passing through shaking sieves, which retain the burs and allow the achenes to fall through. The achenes are fairly soft and can then be pressed. The oil is pale yellow, odourless, and quite stable if kept in airtight containers.

Genetic resources and breeding Small germplasm collections of *X. strumarium* are maintained in Germany and the United Kingdom. As the different 'complexes' of *X. strumarium* differ in the amounts of biologically active compounds that they contain, careful selection is required in breeding programmes. Subsp. *inaequilaterum* is locally overcollected in Vietnam, threatening its genetic diversity.

Prospects Both *X. strumarium* extracts, the xantholides and xanthane epoxide derivatives show some interesting antimicrobial, antimalarial and antitrypanosomal activities, although their direct use will be very limited due to their sensitizing potential (contact dermatitis). However, they might serve as templates in further research. The oil can be used for industrial purposes as it contains about 94% phosphatides, useful for the production of lecithin. The rather large quantities of linoleic and oleic acids can be used for the production of soft soaps and sulphonated oils. After hydrogenation it can be used in hard soaps and for the manufacture of stearin. The oil can also be used for paints. A homogenous paste of the boiled oil, zinc oxide and guar gum, makes a good varnish, but requires quite a long drying period. As the collection and shelling of the fruits is laborious, the production costs of the oil are likely to be higher than those of common vegetable oils. However, it can be employed where imported oils are used. The powdered burs can be used for making activated carbon. They contain 16% pentosans and can be applied as raw material for the synthesis of furfural.

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Other selected sources 1, 119, 135, 254, 261, 281, 347, 354, 394, 494, 721, 734, 737, 739, 786, 788, 983, 1100.

Nguyen Nghia Thin & G.H. Schmelzer

Zanthoxylum L.

Sp. pl. 1: 270 (1753); Gen. pl. ed. 5: 130 (1754).
RUTACEAE
x = 16, 17, 18; *Z. armatum*: $2n$ = 66, *Z. nitidum*, *Z. rhetsa*: $2n$ = 68

Major species *Zanthoxylum armatum* DC., *Z. nitidum* (Roxb.) DC., *Z. rhetsa* (Roxb.) DC.

Vernacular names Ivy-rue, thorny yellow-wood (En). Malaysia: chenkring, hantu duri (Peninsular). Vietnam: s[er]n.

Origin and geographic distribution *Zanthoxylum* comprises about 200 species and has a pantropical distribution with a few representatives in temperate eastern Asia and North America. Most species occur in South America. The genus is found throughout South-East Asia and in northern Australia and the Pacific; there are 20 species within Malesia.

Uses Throughout Asia numerous *Zanthoxylum* are widely used in folk medicine. The fruits are widely used, but also the leaves, bark and roots are employed, and the essential oil from the fruits is well known. Apparently plant parts as well as the various species are to some extent mutually exchangeable. The fruits are applied for a variety of gastro-intestinal complaints, and credited with many more virtues. The bitterness of the bark has contributed to its use as a tonic. The bark of *Zanthoxylum* (e.g. *Z. integrifoliolum* (Merr.) Merr. from Taiwan and the Philippines) is also widely used as a remedy for snakebites. The bark but also other plant parts of various *Zanthoxylum* are used to stupefy fish. The roots are considered sudorific and antipyretic, and are used for gastro-intestinal affections and as an emmenagogue.

The dried fruits or the fruits with the seed removed of several *Zanthoxylum* are used as a condiment. In India, also young leaves of *Z. rhetsa* are eaten as a spice and condiment. The wood of *Zanthoxylum* is used for house building, furniture and various small articles such as jewelry boxes, tool handles, walking-sticks, carving and novelties.

Production and international trade In South-East Asia *Zanthoxylum* is only used and traded at a local level. In more temperate continental Asia, however, the dried fruits of *Zanthoxylum* are widely used and traded.

Properties *Zanthoxylum* species are known for their essential oils, which have a complex terpenoid composition. For instance, in the seed essential oil of *Z. armatum* (collected from India), linalol (87.7%) was the main constituent identified. The essential oil from aerial parts of *Z. armatum* collected in north-west India contained 33% monoterpene hydrocarbons. The predominant constituents included 1,8-cineole (= eucalyptol) (15.7%), linalol (18.8%) and undecan-2-one (17.0%).

The essential oil of the seeds of *Z. rhetsa* was analyzed by GC-MS. The monoterpenes sabinene, limonene, α- and β-pinene, p-cymene, as well as the monoterpene alcohols terpinen 4-ol and α-terpineol, were the dominant constituents that were responsible for the characteristic odour of seeds.

The seed essential oil showed anti-inflammatory activity against the exudative phase of inflammation in formalin- and carragenin-induced rat's hind-paw oedema models. Local anti-inflammatory activity was furthermore confirmed in clinical trials by topical application in cases of inflammatory dermatosis. The oil also showed local anaestethic activity by infiltration and corneal application in guinea-pigs, its maximum potency at a concentration of 0.2%; however, it lacked surface anaesthetic activity. In addition it produced a transient fall in blood pressure in cats an dogs.

The essential oil from the fruits of *Z. rhetsa* showed stronger in vitro anthelmintic activity than piperazine against *Taenia solium*, *Ascaridia galli* and *Pheretima postuma*.

In tests with 15 compounds isolated from the essential oil of *Z. avicennae*, using 8 moulds (*Aspergillus niger*, *A. sydowi*, *A. terreus*, *Penicillium chrysogenum*, *Paecilomyces varioti*, *Chaetomium globosum*, *Cladosporium herbarum* and *Trichoderma* sp.), citral, 1-octanol, 4-methyl-6-acetoxyhexanal and linolool showed strong antimildew activities.

The essential oil obtained by steam distillation of the seeds of *Z. armatum* exhibited strong antibacterial activity against *Escherichia coli*, *Vibrio cholerae*, *Micrococcus pyogenes* var. *aureus*, *Shigella dysenteriae* and *Salmonella typhi*. Furthermore, the essential oil of the fruits of *Z. armatum* proved to be insect repellent to *Aulacophora foveicollis* and fungistatic against aflatoxin-producing strains of *Aspergillus flavus* and *A. parasiticus* at a minimum dose of 2 ml/l. The fungistatic properties of the oil were not affected by high temperature, prolonged storage or increased inoculum. Additionally, in field trials on persistence of leech repellent properties, the essential oil of *Z. armatum* was compared with the following chemicals: N,N-diethyl phenyl acetamide (DEPA), N,N-diethyl-m-toluamide (DEET), 3-acetyl-2-(2,6-dimethyl-5-heptenyl)oxazolidine (Citronyl), dimethyl phthalate (DMP) and N-benzoyl piperidine (NBP). DEPA and DEET were found to be the best. However, *Z. armatum* oil was comparable with Citronyl and exhibited far better results than DMP and NBP.

The accumulation of alkaloids is also characteristic for several members of this genus. *Z. nitidum* DC. is a source of nitidine, a benzo[c]phenanthrine alkaloid reported to have antitumour activity. Other alkaloids isolated include chelerythrine, oxynitidine, oxychelerythrine, skimianine, magnoflorine, (+)-tembetarine and (+)-isotembetarine. A methanol extract of *Z. nitidum* was furthermore found to inhibit topoisomerase I-mediated DNA relaxation and stabilize the covalent binary complex between the enzyme and DNA. The extract was subjected to bioassay-guided fractionation; three strongly inhibitory principles were identified as the alkaloids nitidine, chelerythrine and isofagaridine.

Avicine pseudocyanine is a semisynthetic derivative of avicine, a benzo[*c*]phenanthrine alkaloid isolated form *Z. integrifoliolum*. The compound concentration-dependently inhibits platelet aggregation and release reaction induced by a variety of reagents: collagen, trimucytin (a collagen-like snake venom protein isolated from *Trimeresurus mucrosquamatus*). Additional phytochemical investigations of this species led to the isolation and identification of several other compounds. These include alkaloids such as (–)-tetraberberine, skimmianine, canthin-6-one, rutaecarpine, atanine, lignans (e.g. sesamin, pinoresinol-di-3,3-dimethylallyl ether, pinoresinol-3,3-dimethylallyl ether), flavonoids (tambulin, prudomestin) and several isobutylamides. Evaluation of the biological activity revealed that rutaecarpine, tetrahydroberberine, canthin-6-one, tambulin, prudomestin and the isobuthylamides lanyuamide-I and -II, tetrahydrobungeanool, 2E,4E,8Z,11Z- and 2E,4E,8Z,11E-2′-hydroxy-N-isobutyl-2,4,8,11-tetradecatetraenamide, γ-sanshoöl and hydroxy-γ-sanshoöl displayed strong antiplatelet aggregation activity in vitro.

Biological effects of crude extracts of *Zanthoxylum* include 2.5% and 5% petroleum ether extracts of *Z. rhetsa* and *Z. armatum* which possessed antifeedant properties against 5th-instar larvae of *Diacrisia obliqua* (*Spilosoma obliqua*) and adults of *Sitophilus oryzae*.

Finally, a methanol extract from *Z. armatum* bark from Nepal was investigated for its antiproliferative activity against the growth of human keratinocytes (HaCaT cells). The extract was highly active with an IC_{50} value of 11 μg/ml. The antiproliferative activity was not due to cytotoxic effects on cell membranes, as documented by the activity of lactate dehydrogenase released from the cytoplasm of keratinocytes, which did not exceed that of the control value. Furthermore, the extract also protected against radical-induced damage to model membranes stimulated with 2,2′-azo-bis (2-amidinopropane)-dihydrochloride.

Adulterations and substitutes Alkaloids of the types present in *Zanthoxylum* have also been found in several other genera belonging to the *Rutaceae*. Examples include skimmianine, which is also reported for *Glycosmis*, *Orixa* and *Ruta* species. Also canthin-6-one is found in the wood of *Ailanthus altissima* (Miller) Swingle (*Simaroubaceae*).

Description Evergreen or deciduous, dioecious or rarely monoecious, scandent or erect shrubs or small to medium-sized trees up to 35 m tall; bole up to 60 cm in diameter, occasionally larger, without buttresses; bark surface often studded with spines or prickles, grey or brownish, inner bark fibrous, aromatic. Leaves alternate, paripinnate or imparipinnate; petiolate; stipules absent; leaflets opposite to alternate, 1–15 pairs, entire or glandular-dentate, with pellucid dots; stipellae absent. Inflorescence axillary or terminal, a panicle, raceme or cyme or rarely flowers solitary. Flowers unisexual or bisexual; perianth with 6–8 tepals or differentiated into 4–5 sepals and petals; stamens 4–6, rudimentary in female flowers; disk flat to cushion-like; ovary superior, 1–5-carpellate, rudimentary in male flowers, carpels free or fused at base, each with 2 ovules, styles fused to divergent, stigma capitate. Fruit composed of 1–5 free or basally fused follicles; exocarp glandular, red to black. Seed ovoid to globose, 1 per follicle, often hanging from a funiculus; testa black or reddish, glossy; endosperm present. Seedling with epigeal germination; cotyledons emergent; hypocotyl elongated.

Growth and development Several *Zanthoxylum* are myrmecophytes, with hollow branches showing slit-like openings in which ants of the genera *Camponotus* and *Crematogaster* live. In Peninsular Malaysia *Z. rhetsa* is deciduous around March or April and flowers just after or just before the new leaves. In Java it flowers in December. The fragrant flowers are probably pollinated by insects. In Java ripe fruits of *Z. rhetsa* are available in February and March.

Other botanical information *Zanthoxylum* belongs to the subfamily *Rutioideae* and includes the genus *Fagara*. It is often misspelled as *Xanthoxylum*. The variation as observed in *Z. nitidum* appears to correspond with ecological differences within its range. Large-leaved plants in general are found in rain forest and small-leaved ones in drier situations. Plants of the first group are high climbing lianas with leaves over 25(–40) cm long, leaflets chartaceous or subcoriaceous, dull above, pubescent below. This form predominates in Malesia. Plants of the second group are climbing or semi-erect shrubs with leaves less than (5–)25 cm long, leaflets coriaceous, shiny above, glabrous below. This form predominates in mainland Asia with some outliers at higher elevations in Malesia. However, intergradation is so complete, that no taxonomic rank is given.

Ecology *Zanthoxylum* is found in primary and secondary forest and thickets, up to 2100 m altitude. It thrives in deep fertile soils that are moisture retentive but welldrained, with a position in full sun or semi-shade. *Z. myriacanthum* is locally common in secondary forest and thickets on hills and mountains. *Z. rhetsa* is generally found in rather dry, often monsoonal forest and thickets, up to 500 m altitude. It can be planted in the open provided it is above 400 m altitude. At lower altitudes it will benefit from some shade. It is not resistant to fire.

Propagation and planting In general *Zanthoxylum* is propagated by seed. Assuming similarity between temperate and tropical species it may well be propagated by semi-ripe cuttings at the height of the growing season, root cuttings during the resting period or simply by removal of rooted suckers. Multiple shoots were induced from nodal explants of mature tree (MTN) origin and from cotyledonary nodes (CN) of *Z. rhetsa*. Both types of explants formed the maximum number of shoots on Murashige & Skoog's (MS) medium supplemented with 2% sucrose and 10 mg/l TDZ (thidiazuron). The shoots from MTN developed very slowly and could not be rooted in vitro. The shoots obtained from CN were 2–3 cm longer and were rooted ex vitro by pre-treatment with 1 mg/ml catechol for 0. 5 h. Plantlets were successfully established in soil.

Husbandry At the beginning of the growing season *Zanthoxylum* may be pruned to remove dead or damaged wood.

Harvesting Bark, leaves and roots of *Zanthoxylum* are collected whenever the need arises. Fruits are collected when ripe or just before when still green. In Vietnam roots of *Z. nitidum* are collected throughout the year and fruits are collected green.

Handling after harvest In Vietnam both roots and fruits of *Z. nitidum* are dried in the sun or shade for storage and future use.

Genetic resources and breeding *Zanthoxylum* species treated here are in general widespread and common throughout South-East Asia, and therefore are not endangered. The availability of *Z. rhetsa* in Bali (Indonesia) is seriously reduced due to exploitation for the handicraft industry.
There are no known breeding programmes of *Zanthoxylum*.

Prospects Compounds with anti-platelet activity are of interest in medicinal reaserch. Therefore, alkaloids and other constituents of *Zanthoxylum* merit further research in order to evaluate their possibilites for future developments. Also its essential oils may become of interest as a local source of insect repellents.

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Selection of species

Zanthoxylum armatum DC.

Prodr. 1: 727 (1824).

Synonyms *Zanthoxylum alatum* Roxb. (1832), *Zanthoxylum planispinum* Siebold & Zucc. (1846).

Vernacular names Wild Chinese pepper (En). Philippines: chi-it, sibit-paklauit (Igorot). Laos: ma:d. Thailand: mak kaak (northern). Vietnam: d[aws]ng cay, s[er]n gai.

Distribution From Pakistan and northern India eastward to China, Korea, Japan, the Ryukyu Islands and Taiwan; in Malesia of limited distribution in the Philippines (Luzon) and Indonesia

(Lesser Sunda Islands). Occasionally cultivated there and also outside its natural area of distribution.

Uses In India, the pungent bark is used to clean teeth and as an insect repellent. Leaves, bark and fruits are employed in India to cure fever, dyspepsia, diarrhoea, smallpox, diabetes and cholera, and as an anthelmintic. Since ancient times, the fruits have been used in Chinese medicine as a stimulant and emmenagogue, against toothache and as an anthelmintic. The bark but also other plant parts are used to stupefy fish. Various parts of the plant are used to season food, especially in Thailand, China and India.

Observations A dioecious, deciduous or evergreen, scandent or erect shrub or small tree up to 6 m tall; leaves alternate, trifoliolate or imparipinnate, rachis winged, 5–23 cm long, leaflets opposite, 3–11, ovate to lanceolate, 1.5–13 cm × 0.5–5 cm, margin entire to glandular crenate; panicle axillary or terminal, 1–7 cm long; flowers about 2 mm long, perianth segments 6–7, green-yellow; male flower with 4–6 stamens, rudimentary carpels none; female flower with, ovary 1–3-carpellate, stigmas 1–3; follicle subglobose, 4–5 mm in diameter, single or 2–3 together, reddish; seed shiny black. *Z. armatum* occurs in rain forest, thickets and, at higher elevations, often on open slopes and rock ledges; in Malesia up to 1750 m, in continental Asia up to 2400 m altitude.

Selected sources 215, 237, 271, 488, 786, 788, 810, 824, 1063.

Zanthoxylum avicennae (Lamk) DC.

Prodr. 1: 726 (1824).

Synonyms *Fagara avicennae* Lamk (1788), *Zanthoxylum tidorense* Miq. (1867), *Zanthoxylum diversifolium* Warb. (1891).

Vernacular names Indonesia: karangeang (Javanese), adas kastela, samirin (Moluccas). Philippines: bagatambal (Bisaya), bungi (Tagalog), kangai (Pampango). Vietnam: mu[oof]ng tru[oor]ng, bu[oof]n chu[oof]n, s[er]n lai.

Distribution From Thailand east to Vietnam and south-eastern China and south to the Philippines, Malaysia (Sabah) and Indonesia (Java, Lesser Sunda Islands, Sulawesi, Moluccas).

Uses In the Philippines and Indo-China the stem and bark are used medicinally as a tonic and to treat snakebites. In Vietnamese folk medicine a decoction of the roots is drunk or employed as a wash for allergic dermatitis. In Java, the leaves and fruits are used to flavour food; the leaves smell like coriander, the seeds like anise. The hard, dense, heavy reddish wood is used to make small tool handles.

Observations A dioecious, erect or scandent, evergreen shrub or small tree, up to 15 m tall, with pseudostipulae, straight or recurved prickles on the branches; leaves alternate, imparipinnate, rachis narrowly winged, 5–30 cm long, leaflets subopposite, 3–23, ovate to elliptical-lanceolate, 1–8 cm × 1–3 cm, pellucid dotted, margin subentire to glandular crenate; cyme terminal or axillary, 5–21 cm long, upper branches usually whorled; flowers up to 3 mm long, 5-merous, sepals 5, petals 5, white to green-yellow; male flowers with 5 stamens, rudimentary carpels 2; female flowers with ovary 2-carpellate; follicle subglobose, 4.5 mm in diameter, single or more usually in pairs. *Z. avicennae* occurs in dry forest, thickets and on open slopes at altitudes up to 1650 m. Plants from dry, open and mountainous locations tend to become dwarfed or scandent with much reduced leaves and inflorescences.

Selected sources 74, 187, 237, 391, 407, 739, 810, 949.

Zanthoxylum myriacanthum Wallich ex Hook.f.

Fl. Brit. Ind. 1: 496 (1875).

Synonyms *Fagara myriacantha* (Wallich ex Hook.f.) Engl. (1896), *Zanthoxylum diabolicum* Elmer (1908), *Zanthoxylum rhetsoides* Drake (1892).

Vernacular names Thorny ivy-rue (En). Malaysia: chengkring, kabu-kabu utan (Peninsular). Philippines: madbad (Samar-Leyte Bisaya). Vietnam: s[er]n l[as] to, ho[af]ng m[ooj]c nhi[eef]u gai.

Distribution India (Assam), northern Vietnam, southern China, Peninsular Malaysia, Sumatra, Borneo (Sabah, Sarawak) and the Philippines.

Uses In Peninsular Malaysia, the smoke from burning seeds is inhaled for the treatment of an ulcerated, syphilitic nose. In Vietnam the plant is recorded as a fish poison, and the fruits as being used as a condiment.

Observations A dioecious, evergreen, small to medium-sized tree, up to 25 m tall, branches with straight prickles, generally swollen and hollow; leaves alternate, imparipinnate, 25–45(–60) cm long, leaflets opposite to subopposite, 9–19(–23), elliptical, 8–18 cm × 2.5–8 cm, pellucid dotted, margin finely glandular crenate; panicle terminal or axillary, 15–25 cm long; flowers about 3 mm long, 5-merous, sepals 5, petals 5, white, pale yellow to violet; male flowers with 5 stamens, rudimentary carpels 3; female flowers with ovary

Zanthoxylum myriacanthum Wallich ex Hook.f. – 1, flowering twig; 2, dehisced fruit.

3(–4)-carpellate; follicle subglobose, 3–6 mm in diameter, single or up to 3 together. *Z. myriacanthum* is found in forest and thickets at 100–1230 m altitude in Malesia, in continental Asia at 200–2150 m altitude.

Selected sources 135, 207, 788, 949, 954, 1063.

Zanthoxylum nitidum (Roxb.) DC.

Prodr. 1: 727 (1824).

Synonyms *Fagara torva* (F. Muell.) Engl. (1896), *Zanthoxylum hirtellum* Ridley (1920).

Vernacular names Prickly ash (En). Indonesia: areuy beulit gede (Sundanese), daun seriawan (drug, leaves), kembang seriawan (drug, fruits). Malaysia: pokok kuku lang, kayu sekatok (Peninsular). Laos: mak khen. Thailand: kamchat nuai (peninsular), nguu hao (north-eastern). Vietnam: h[aj]t s[er]n, xuy[ee]n ti[ee]u, ho[af]ng l[uj]c.

Distribution From north-eastern India eastward to Taiwan and the Ryukyu Islands, throughout South-East Asia, to the Solomon Islands and northern Australia.

Uses In the Philippines, Indo-China and China the pounded bark is used to stupefy fish. In Peninsular Malaysia, the bark is employed for treating toothache by inserting it into a hollow tooth, most likely as a counter-irritant. In Vietnamese folk medicine a decoction of the fruits is used as a stomachic and for toothache. The fruits are further credited as an astringent, anthelmintic, carminative, diaphoretic, stimulant and antipyretic. They are prescribed to treat catarrh, uterine haemorrhage, rheumatism and lumbago. The fruits are taken in decoction or as a powder. The roots are indicated as sudorific, febrifuge and emmenagogue. They are prescribed as a decoction or alcoholic maceration for fevers and rheumatism. In Java, leaves and fruits are merely mentioned as being traded medicinally. In India, the root is used in toothache, stomach-ache and against boils. It is also used as an insecticide and fish poison. The fruit is considered to be an aromatic stimulant and prescribed in stomach-ache. In Taiwan, a decoction of the leafy branches is considered cooling, disinfectant, and bechic; it is gargled for inflammation of the throat. Occasionally cultivated as a hedge plant in China.

Observations A scandent and generally climbing or occasionally suberect or erect, dioecious or rarely monoecious, evergreen shrub, branchlets, leaf rachises and midribs generally with scattered and retrorse prickles; leaves alternate, imparipinnate, 5–40 cm long, leaflets opposite, (3–)5–9, ovate to elliptical, (1.3–)5–12(–16) cm × (0.7–) 2.5–6(–8) cm, with or without pellucid dots, margin entire to glandular crenate; inflorescence axillary or axillary and terminal, racemose to paniculate, up to 15 cm × 7 cm; flowers up to 5 mm long, 4-merous, sepals 4, petals 4, white to pale yellow or rarely reddish; male flowers with 4 stamens, rudimentary carpels 2 or 4; female flowers with ovary 4-carpellate; follicle subglobose, 5–7 mm in diameter, single or up to 4 together. *Z. nitidum* occurs in rain forest and thickets up to 1100 m altitude in Malesia, in continental Asia up to 1400 m altitude.

Selected sources 74, 135, 189, 215, 263, 391, 407, 739, 786, 788.

Zanthoxylum rhetsa (Roxb.) DC.

Prodr. 1: 728 (1824).

Synonyms *Fagara rhetsa* Roxb. (1820), *Zanthoxylum budrunga* (Roxb.) DC. (1824), *Zanthoxylum limonella* (Dennst.) Alston (1931).

Vernacular names Indian ivy-rue (En). Indonesia: kayu lemah (Javanese), kayu tana (Madurese), ki tanah (Sundanese). Malaysia: hantu duri (Peninsular). Philippines: kayetana (Tagalog), salai (Bisaya), kasabang (Iloko). Burma (Myanmar): kathit-pyu. Laos: khênl, khouang. Thailand: kamchat ton, luuk ra maat (central), ma khuang (northern). Vietnam: ho[af]ng m[ooj]c h[oo]i, c[os]c h[oo]i, s[er]n h[oo]i.

Distribution From India and Sri Lanka to Burma (Myanmar), Indo-China, Thailand, Peninsular Malaysia, Java, the Lesser Sunda Islands, Moluccas (Wetar), Sulawesi, the Philippines and southern Papua New Guinea.

Uses In the Philippines, the bark pounded and mixed with oil is used externally as a remedy for stomach pains. A decoction of the bark is taken internally as a cure for pains in the chest. When chewed it is applied to snakebites. In India, the fruits are used in dyspepsia, asthma and bronchitis, heart troubles, toothache and rheumatism. The pericarps are credited with astringent, stimulant and digestive properties. The oil obtained by steam distillation is used as a traditional remedy for cholera. It is further applied as an antiseptic and disinfectant. In Java, the young fruits are eaten as a spice. In Burma (Myanmar), the young leaves are used as a seasoning.

Observations A dioecious, deciduous, medium-sized tree, up to 35 m tall, branches sparsely armed with straight or ascending prickles, generally swollen and hollow; leaves alternate, paripinnate or imparipinnate, 30–40 cm long, leaflets opposite to subopposite, 10–17, ovate to elliptical, 7–13 cm × 3–5 cm, occasionally pellucid dotted, margin entire to glandular crenate; panicle terminal or axillary, 8–14 cm long; flowers up to 2.5 mm long, 4-merous, sepals 4, petals 4, white or pale yellow; male flowers with 4 stamens, rudimentary carpel 1; female flowers with ovary 1-carpellate; follicle subglobose, 6–7 mm in diameter, single. *Z. rhetsa* occurs in rather dry, often monsoonal forest and thickets from sea-level up to 500 m altitude.

Selected sources 30, 74, 207, 215, 391, 407, 488, 492, 502, 838, 954.

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Acronyms of organizations

- ASEAN: Association of South-East Asian Nations (Jakarta, Indonesia).
- CITES: Convention on International Trade in Endangered Species of Wild Fauna and Flora (Lausanne, Switzerland).
- DGIS: Directorate-General for International Cooperation of the Netherlands Ministry of Foreign Affairs (Den Haag, the Netherlands).
- FAO: Food and Agriculture Organization of the United Nations (Rome, Italy).
- FRIM: Forest Research Institute Malaysia (Kepong, Malaysia).
- IEBR: Institute of Ecology and Biological Resources (Hanoi, Vietnam).
- LIPI: Indonesian Institute of Sciences (Jakarta, Indonesia).
- PCARRD: Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (Los Baños, the Philippines).
- PROSEA: Plant Resources of South-East Asia (Bogor, Indonesia).
- RDCB: Research and Development Centre for Biology (Bogor, Indonesia).
- TISTR: Thailand Institute of Scientific and Technological Research (Bangkok, Thailand).
- UNDP: United Nations Development Programme.
- UNITECH: Papua New Guinea University of Technology (Lae, Papua New Guinea).
- UPLB: University of the Philippines at Los Baños (Los Baños, the Philippines).
- WU (formerly WAU): Wageningen University (Wageningen, the Netherlands)

Glossary

abaxial: on the side facing away from the axis or stem (dorsal)
abortifacient: causing abortion; an agent that causes abortion
abortive: imperfectly developed; effecting an abortion (abortifacient)
abscission: the natural detachment of leaves, branches, flowers or fruits
acaricidal: destroying or controlling mites
accrescent: increasing in size with age
acetates: a large group of secondary metabolites, in which acetylcoenzyme A ('acetate') is the building block; acetate itself is derived from primary metabolism carbohydrates via pyruvic acid
acetogenins: a group of long-chain aliphatic compounds, ending with a 'gamma' lactone, most often unsaturated and cyclized into one or two tetrahydrofuran rings that may or may not be adjacent
achene: a small dry indehiscent one-seeded fruit
acne: inflammatory disease affecting hair follicles and glands of the skin; frequently used to designate acne vulgaris, with lesions on the face, chest and back
actinomorphic: radially symmetrical; applied to flowers which can be bisected in more than one vertical plane
acumen: the point of an acuminate leaf; the drip-tip
acuminate: ending in a narrowed, tapering point with concave sides
acute: in botany: sharp; ending in a point with straight or slightly convex sides; in medicine: with a short and relatively severe course
acute toxicity: toxicity characterized by a sudden onset, sharp rise and short course
adaxial: on the side facing the axis (ventral)
adenocarcinoma: carcinoma derived from glandular tissue or in which the tumour cells form recognizable glandular structures
adenovirus (AV): a virus belonging to the Adenoviridae, a family of DNA viruses
adherent: the union of parts usually separate
adnate: united with another part; with unlike parts fused, e.g. ovary and calyx tube
adpressed (appressed): lying flat for the whole length of the organ
adrenergic: activated by, characteristic of, or secreting epinephrine or related substances, particularly referring to the sympathetic nerve fibres that release norepinephrine when a nerve impulse passes
adrenoceptor, adrenoreceptor: adrenergic receptor, i.e. postulated site on effector organs innervated by adrenergic fibres of the sympathetic nervous system
adventitious: not in the usual place, e.g. roots on stems, or buds produced in other than terminal or axillary positions on stems
aerophore: a localized outgrowth associated with ventilation (in plants)
aestivation: the arrangement of sepals and petals in the bud
aflatoxin: a toxic factor produced by *Aspergillus flavus* and *A. parasiticus* and implicated as a cause of human hepatic carcinoma
aglycones: the non-sugar part of glycosides is called the aglycone part or simply the aglycone; aglycones and their glycosides may be present in the same plant; furthermore, the combination of aglycone and sugar will alter the properties of the molecule
agonist: a drug that has affinity for and stimulates physiological activity at cell receptors normally stimulated by naturally occurring substances (see also antagonist)
agroforestry: land-use systems in which trees or shrubs are grown in association with crops (agricultural crops or pastures) in a spatial arrangement or a rotation and in which there are both ecological and economic interactions between the trees and the other components of the system
ague: a fever of malarial character marked by paroxysms of chills, fever, and sweating that recur at regular intervals
AIDS: acquired immune deficiency syndrome, an epidemic, transmissible retroviral disease due

to infection with HIV (human immunodeficiency virus), in severe cases manifested as a profound depression of cell-mediated immunity

albino: a person, animal or plant lacking normal pigmentation

albumen: the nutritive material stored within the seed, and in many cases surrounding the embryo (endosperm)

albuminuria: presence in the urine of serum albumin

algicidal: kills algae

alkaloid: large group of organic bases containing nitrogen and usually oxygen that occur for the most part in the form of salts; usually optically and biologically active

alkaloids, pseudo-alkaloids: compounds, derived from plant sources, with basic properties, containing one or more nitrogen atoms (usually in a heterocyclic ring), they usually have a marked physiological action on man or animals

allergenic: acting as an allergen; inducing allergy

allergic: pertaining to, caused by, affected with, or of the nature of allergy

allergy: a state of hypersensitivity induced by exposure to a particular antigen (allergen) resulting in harmful immunological reactions on subsequent exposures

alluvium: soil material deposited by running water in recent geological time

alopecia: baldness; absence of the hair from skin areas where it is normally present

alterative: tending to change gradually the condition of the body to a normal state; a drug having this effect

alternate: leaves, etc., inserted at different levels along the stem, as distinct from opposite or whorled

amenorrhoea: abnormal absence or suppression of the menses

amoebicidal: destroying amoebae

amplexicaul: stem-clasping, when the base of a sessile leaf or a stipule is dilated at the base, and embraces the stem

anaemia: a condition in which the blood is deficient in red blood cells, in haemoglobin, or in total volume

anaesthesia: loss of the ability to feel pain, caused by administration of a drug or by other medical interventions

anaesthetic: producing loss of sensation; producing loss of the ability to feel pain; an agent used to abolish the sensation of pain

analgesia: absence of sensibility to pain; the relief of pain without loss of consciousness

analgesic: relieving pain; not sensitive to pain; an agent alleviating pain without causing loss of consciousness

anaphylaxis: a general term, originally applied to the situation in which exposure to a toxin resulted not in immunity (prophylaxis), but in hypersensitivity; extended to include all cases of systemic anaphylaxis in response to foreign antigens and to include a range of experimental models

androecium: the male element; the stamens as a unit of the flower

androgen: any substance that promotes masculinization

androgynophore: a column on which stamens and carpels are borne

andromonoecious: having bisexual and male flowers, but no female flowers, on the same plant

androphore: a stalk supporting the androecium or stamens

aneuploid: with other than the exact multiple of the haploid chromosome complement

angina pectoris: a paroxysmal thoracic pain, often radiating to the arms. It is most often due to deficiency of blood in the myocardium and precipitated by effort or excitement

angiotensin: any of a family of polypeptide hormones formed by the catalytic action of renin on renin substrate and stimulating contraction of the muscular tissue of the capillaries and arteries

aniline: an oily liquid poisonous amine, colourless when pure

anisophyllous: the 2 leaves of a pair being different in size or shape

annual: a plant which completes its life cycle in one year

annular: used of any organs disposed in a circle

annulate: ring-shaped

anodyne: relieving pain; a medicine that relieves pain

anorexia: lack or loss of the appetite for food

antagonist: a substance that tends to nullify the action of another, as a drug that binds to a cell receptor without eliciting a biological response (see also agonist)

anterior: of time, previous; of place, position in front, or turned away from the axis

anthelmintic: destructive to worms: a drug or agent that destroys worms

anther: the part of the stamen containing the pollen

antheriferous: bearing anthers

anthesis: the time the flower is expanded, or, more strictly, the time when pollination may take place

anthocarp: a fruit formed by the union of floral organs or parts of them with the fruit itself as in *Nyctaginaceae*

anthocyanidins: the aglycone part of anthocyanins, compounds closely related to the flavonoids but derived from the 2-phenyl benzopyrylium cation, see also Introduction anthocyanins

anthocyanin: the blue, sometimes red, colouring of plant parts

anthocyanins: glycosides of the anthocyanidins

anthraquinones: a subgroup of the quinones, in which the dione is conjugated to the condensed polycyclic aromatic system of anthracene

anti-inflammatory: suppressing or counteracting inflammation; an agent that suppresses or counteracts the inflammatory process

antiarrhythmic: preventing or alleviating arrhythmia; an agent that prevents or alleviates arrhythmia

antibiotic: any of a large class of substances produced by various micro-organisms and fungi and having the power of arresting the growth of other micro-organisms or destroying them; a chemical, produced by plants, animals or synthetically, having similar properties

antibody: an immunoglobulin molecule formed in the body in response to a foreign substance (antigen) and serving to neutralize that substance

anticholinergic: blocking the passage of impulses through the parasympathetic nerves; an agent that blocks the parasympathetic nerves

anticomplementary: reducing or destroying the power of a complement (a complex system of heat-sensitive proteins present in serum and reacting with antibodies to destroy antigens)

antidote: anything counteracting the effects of a poison

antifeedant: preventing something from being eaten

antihepatotoxic: counteracting injuries to the liver

antiherpetic: combats virus diseases which are characterized by the formation of blisters on the skin or mucous membranes

antimicrobial: killing micro-organisms, or suppressing their growth or multiplication; an agent acting so

antioxidant: a substance that opposes oxidation or inhibits reactions promoted by oxygen or peroxides; many of these substances are used as preservatives in various products

antiperiodic: remedial of periodic diseases, as quinine for malaria; a remedy for such diseases

antiphlogistic: counteracting inflammation and fever; an agent counteracting inflammation and fever

antiplasmodial: destroying plasmodia

antipyretic: relieving or reducing fever; an agent that relieves or reduces fever

antiscorbutic: relieving or preventing scurvy; a remedy for scurvy

antiseptic: pertaining to asepsis (prevention of contact with micro-organisms); preventing decay or putrefaction; a substance inhibiting the growth and development of micro-organisms without necessarily killing them

antispasmodic: relieving spasm; an agent that relieves spasm

antitoxic: counteracting poison

antitussive: preventing or relieving cough; an agent that prevents or relieves cough

anxiolytic: reducing anxiety

aperient: a mild or gentle purgative; also called laxative

aperture: gap or mouth

apetalous: without petals

apex (plural: apices): the tip or summit of an organ

aphrodisiac: stimulating sexual desire; a drug arousing the sexual instinct

aphthae: plural of aphtha; recurrent inflammation of the oral mucous membranes, characterized by the presence of small ulcers

apical: at the apex of any structure

apiculate: ending abruptly in a short point

apocarpous: with the carpels free from each other

apoptosis: fragmentation of a cell into membrane-bound particles, which are eliminated by phagocytosis

aporphine alkaloids: a subgroup of the alkaloids; see also alkaloids

appendage: a part added to another; attached secondary or subsidiary part, sometimes projecting or hanging

arboreal: of, relating to, or resembling a tree; inhabiting or frequenting trees

arborescent: attaining the size or character of a tree

arbuscular: shrubby, and branched like a tree

arcuate: curved

areole: an irregular square or angular space marked out on a surface, e.g. of a fruit; a small cell or cavity

aril: an expansion of the funicle enveloping the seed, arising from the placenta; sometimes occurring as a pulpy cover (arillus)

arillate: possessing an aril
arilloid: like an aril
aristate: awned
armed: bearing some form of spines
arrhythmia: any variation from the normal rhythm of the heartbeat
arteriosclerosis: a group of diseases characterized by thickening and loss of elasticity of arterial walls
arthritis: inflammation of a joint or joints
article: a segment of a constricted pod or fruit, as in *Desmodium*
articulate: jointed, or with places where separation takes place naturally
ascendent, ascending: curving or sloping upwards
ascites: effusion and accumulation of serous fluid in the abdominal cavity
ascitic: pertaining to or characterized by ascites
asphyxia: pathological changes caused by lack of oxygen in respired air, resulting in hypoxia and hypercapnia
asthma: a chronic disorder characterized by paroxysms of the bronchi, shortness of breath, wheezing, a suffocating feeling, and laboured coughing to remove tenacious mucus from the air passages
astringent: an agent or substance causing constriction of the skin, mucous membranes or raw or exposed tissues; as such, ethanol is used in skin-toning lotions and aluminium chlorohydrate in anti-perspirants
ataxia: failure of muscular coordination; irregularity of muscular action
atony: lack of normal tone or strength
attenuate: gradually tapering
auct.: auctorum (Latin); of authors
auricle: a small lobe or ear
auriculate: eared, having auricles
autotriploid: an autopolyploid with three similar sets of chromosomes
auxin: an organic substance characterized by its ability in low concentrations to promote growth of plant shoots and to produce other effects such as root formation and bud inhibition
awn: a bristle-like appendage, especially occurring on the glumes of grasses
axil: the upper angle between the leaf and the stem
axile: (placenta) belonging to or situated in an axis
axillary: arising from the axil
axis: the main or central line of development of a plant or organ
Ayurvedic: traditional Hindu system of medicine based largely on homeopathy and naturopathy
baccate: berrylike; pulpy or fleshy
bacillary dysentery: infectious disease caused by bacteria of the genus *Shigella*, and marked by intestinal pain, tenesmus, diarrhoea with mucus and blood in the stools, and variable toxaemia
bactericidal: destroying bacteria
bacteriostatic: inhibiting the growth or multiplication of bacteria
barbiturate: any of a group of sedative-hypnotic agents derived from barbituric acid or thiobarbituric acid
bark: the tissue external to the vascular cambium collectively, being the secondary phloem, cortex and periderm
basifixed: attached or fixed by the base
batik: an Indonesian method of hand-printing textiles by coating parts of the fabric with wax to resist dye, dipping in a cold dye solution, boiling off the wax, and repeating the process for each colour used
beak: a long, prominent and substantial point, applied particularly to prolongations of fruits
beaked: used of fruits which end in a long point
bearded: awned; having tufts of hairs
bechic: a remedy or treatment of cough
benzene derivatives (benzenoids): chemical compounds containing a characteristic benzene ring, often represented as a C_6 ring with 3 double bonds alternating with single bonds between the C-atoms
beri-beri: a disease caused by a deficiency of thiamine (vitamin B1), marked by inflammatory or degenerative changes of the nerves and heart, and edema
berry: a juicy indehiscent fruit with the seeds immersed in pulp; usually several-seeded without a stony layer surrounding the seeds
biconvex: convex on both sides
biennial: a plant which flowers, fruits and dies in its second year or season
bifid: forked, divided in two but not to the base
bilabiate: two-lipped
bilateral (botany): having 2, often opposite, sides
bilharzia: schistosomiasis
biliousness: a symptom complex with nausea, abdominal discomfort, headache and constipation, formerly attributed to excessive secretion of bile
bilocular: with two compartments or cells
biogenic: having origins in biological processes
bipinnate: when the primary divisions (pinnae) of a pinnate leaf are themselves pinnate
bisbenzylisoquinoline alkaloids: a subgroup of the isoquinoline alkaloids; see also alkaloids

biseriate: arranged in two rows
bisexual: having both sexes present and functional in the same flower
blade: the expanded part, e.g. of a leaf or petal
blastogenic: pertaining to or characterized by blastogenesis, i.e. the transformation of small lymphocytes into larger cells resembling blast cells
blennorrhoea: an excessive discharge of mucus; former name for gonorrhoea
blight: a general term applied to any of a wide range of unrelated plant diseases
blister: a small swelling of the skin, filled with watery matter and caused by burning or rubbing
bole: the main trunk of a tree, generally from the base up to the first main branch
bollworm: any of several genera of moths belonging to the *Noctuidae*
bract: a reduced leaf subtending a flower, flower stalk or the whole or part of an inflorescence
bracteole: a secondary bract on the pedicel or close under the flower
bradycardia: slowness of the heartbeat, as evidenced by a slowing of the pulse rate to less than 60 in an adult
bradykinin: a nonapeptide which is produced by activation of the kinin system in a range of inflammatory conditions; it is an extremely powerful vasodilator, which also increases vascular permeability, stimulates pain receptors and causes contraction of extravascular smooth muscles
bradypnea: abnormal slowness of breathing
breeding: the propagation of plants or animals to improve certain characteristics
bristle: a stiff hair or a hair-like stiff slender body
broadcast: to sow seed scattered, not in lines or pockets
bronchitis: inflammation of one or more bronchi
bud: the nascent state of a flower or branch; often applied to those primordial vegetative or reproductive branches that are enclosed in a prophyllum and have a resting stage
budding: the process of inserting a scion, which consists of the bud in a leaf axil on a shield of rind, with or without a small piece of wood attached, into a plant (rootstock) with the intention that it will unite and grow there, usually in order to propagate a desired cultivar
bulb: an underground storage organ with a much-shortened stem bearing fleshy leaf bases or scale leaves enclosing the next year's bud
bulbil: an aerial bulb or bud produced in a leaf axil or replacing the flower, which, on separation, is capable of propagating the plant
bulbous: having bulbs or having the form or function of a bulb
bullate: surface much blistered or puckered
bush: a low thick shrub without a distinct trunk
buttress: the enlargement of the base of trunks of tropical trees that ranges from a small spur or swelling to massive structures, partly root, partly stem, reaching as high as 10 m up the stem, thin and flat to thick, twisted or anastomose
caducous: falling off
calcareous: consisting of or containing chalk (calcium carbonate)
calculus: an abnormal concretion within the body and usually consisting of mineral salts; also called stone
callus: in plants, small hard outgrowth at the base of spikelets in some grasses, or tissue that forms over cut or damaged plant surface; in humans, localized hyperplasia of the horny layer of the epidermis due to pressure or friction, or an unorganized meshwork of woven bone which is formed after a fracture of a bone
calyx: the outer envelope of the flower, consisting of sepals, free or united
campanulate: bell-shaped
cancer: a malignant neoplasm or tumour, characterized by a morbid proliferation of epithelial cells in different parts of the body, resulting in progressive degeneration and often ending fatally
cancerous: of the nature of or pertaining to cancer
canopy: the uppermost leafy layer of a tree, forest or crop
capitate: headed, like the head of a pin in some stigmas, or collected into compact headlike clusters as in some inflorescences
capitellate: diminutive of capitate
capsule: in botany: a dry dehiscent fruit composed of two or more carpels and either splitting when ripe into valves, or opening by slits or pores; in medicine: a structure in which something is enclosed, e.g. a hard or soft, soluble container enclosing a dose of medicine
carbohydrates: compounds formed from water and carbondioxide; they can be grouped into sugars and polysaccharides
carcinogenesis: the production of carcinoma
carcinogenic: producing carcinoma
carcinoma: a malignant new growth consisting of epithelial cells, which tends to infiltrate surrounding tissues and give rise to metastases
cardenolides: cardiac glycosides in which the side chain of the steroid aglycone is a 5-membered lactone ring; see also cardiac glycosides

cardiac: pertaining to, situated near, or affecting the heart; pertaining to the opening between the oesophagus and the stomach

cardiac glycosides: natural products characterized by a specific effect on myocardial contraction and atrioventricular conduction

cardioactive: having an effect on the heart

cardiotonic: having a tonic effect on the heart; an agent that has a tonic effect on the heart

cardiovascular: pertaining to the heart and blood vessels

carminative: relieving flatulence; an agent relieving flatulence and assuaging pain

carpel: one of the foliar units of a compound pistil or ovary; a simple pistil has only one carpel

carpophore: the part of the receptacle which is prolonged between the carpels as a central axis

cartilaginous: hard and tough

caruncle: an outgrowth of a seed near the hilum

cataplasm: poultice or soft external application

catarrh: inflammation of the lining tissue of various organs, particularly of the nose, throat, and air passages, and characterized by an outpouring of mucus

cathartic: causing evacuation of the bowels; an agent that causes evacuation of the bowels by increasing bulk, stimulating peristaltic action etc.; also called purgative

catkin: a close bracteate, often pendulous spike, usually with unisexual flowers

caudate: with a tail-like appendage

cauliflorous: with the flowers borne on the trunk

cauline: belonging to the stem or arising from it

cellulose: a carbohydrate, being the material base of the cell wall; the residue when hemicellulose is extracted from the holocellulose; often referred to as α-cellulose

cephalalgia: headache

cerebrovascular: pertaining to the blood vessels of the cerebrum or brain

Chagas' disease: a form of trypanosomiasis, occurring widely in Central and South America and caused by *Trypanosoma cruzi*

chalcones: a subgroup of the flavonoids; see also flavonoids

chartaceous: papery

check: in wood, a small separation of the wood fibres along the grain forming a crack or fissure not penetrating as far as the opposite or adjoining side of a piece of sawn timber

chemiluminescence: luminescence resulting from the direct transformation of chemical energy into light energy

chlorophyll: green pigment in plants which absorbs light for photosynthesis

chlorosis (in medicine): a disorder characterized by greenish-yellow discoloration of the skin and generally affecting adolescent females in the nineteenth century; believed to be associated with iron deficiency anaemia

cholagogue: an agent that promotes an increased flow of bile

cholera: acute, infectious inflammation of the intestine, caused by an enterotoxin elaborated by *Vibrio cholerae*, and characterized by severe, watery diarrhoea

cholinergic: stimulated, activated or transmitted by acetylcholine; applied to the sympathetic and parasympathetic nerve fibres that liberate acetylcholine at a synapse when a nerve impulse passes (see also: anticholinergic)

cholinesterase: enzyme that catalyses the cleavage of the acyl group from various esters of choline, including acetylcholine, and several related compounds, and which occurs primarily in the serum, liver and pancreas

chromosome: a structural unit in the nucleus which carries the genes in a linear constant order; the number is typically constant in any species

chronic: persisting over a long period of time

ciliate: with a fringe of hairs along the edge

ciliolate: fringed with small hairs

cincinnus: a monochasial cymose inflorescence with branches alternating from one side of the vertical axis to the other and normally curved to one side

circumscissile: dehiscing or falling off along a circular line

clavate: club-shaped or thickened towards the end

claw: the basal, narrow part of a petal or sepal

clawed: furnished with a basal, narrow part (the claw)

cleft: cut halfway down

cleft grafting: grafting a decapitated rootstock by inserting a scion with a wedge-shaped base in a cleft cut into the cut surface of the rootstock

cleistogamous: pollination and fertilization taking place within the unopened flower

clone: a group of plants originating by vegetative propagation from a single plant and therefore of the same genotype

clustered: compactly gathered together; with several stems

coherent: the incorporation of one part with another, as the petals to form a tubular corolla

colic: acute, spasmodic pain in the bowels; pertaining to the bowels

collagen: an insoluble fibrous protein that occurs in vertebrates as the chief constituent of the connective tissues, as in skin, cartilage, bone and hair
collar: the boundary between the above- and underground portions of the axis of a plant
columella: a persistent central axis round which the carpels of some fruits are arranged
column (botany): a cylindrical body, e.g. a tube of connate stamen filaments or the central axis of a fruit
coma: in medicine: a state of unconsciousness from which the patient cannot be aroused; in botany: the hairs at the end of some seeds; a tuft of leafy bracts or leaves at the top of an inflorescence (e.g. pineapple)
compound: in botany: of two or more similar parts in one organ, as in a compound leaf or compound fruit; in chemistry: a substance consisting of 2 or more elements combined chemically in fixed proportions; in perfumery, a perfume concentrate in which the ingredients of a perfume formula are mixed together
concave: hollow
condensed tannins: see tannins
conduplicate: folded lengthwise
cone: the fruit of a pine or fir tree (gymnosperms), largely made up of imbricated scales
confluent: blended into one, passing by degrees from one into the other
conical: having the shape of a cone (cone-shaped)
conjunctivitis: inflammation of the conjunctiva
connate: united or joined
connective (botany): tissue between the pollen sacs of an anther
connivent: having a gradually inward direction, as in many petals (convergent)
conspecific: belonging to the same species
constipation: a condition of the bowels in which the expulsion of waste matter is infrequent and difficult
contiguous: touching but not united, directly bordering
contorted: twisted or bent
contraceptive: reducing the likelihood of or preventing conception; an agent that reduces the likelihood of or prevents conception
convex: having a more or less rounded surface
convulsion: a violent and involuntary contraction of the voluntary muscles
coppice: a small wood which is regularly cut at stated intervals; the new growth arising from the stools
cordate: heart-shaped, as seen at the base of a leaf, etc., which is deeply notched
core: central part; the seeds and integuments of a pome, such as an apple; pith in dicotyledonous plants
coriaceous: of leathery texture
corolla: the inner envelope of the flower consisting of free or united petals
corona: any appendage or extrusion that stands between the corolla and stamens; crown; the remains of the calyx limb on e.g. apples or pears
cortex: the bark or rind
cortical: relating to the cortex
corymb: a flat-topped indeterminate inflorescence in which the branches or pedicels sprout from different points, but attain approximately the same level, with the outer flowers opening first
corymbose: flowers arranged to resemble a corymb
costa: a rib, when single, the midrib or vein
cotyledon: seed-leaf, the primary leaf; dicotylous embryos have two cotyledons and monocotylous embryos have one
coumarins: benzo-α-pyrone (α-chromone) derivatives
counterirritant: producing a counterirritation, i.e. a superficial irritation in one part of the body, intended to relieve an irritation in another part; an agent which causes counterirritation
cover crop: a close-growing crop primarily grown for the purpose of protecting and improving soil between periods of regular crop production or between trees or vines in orchards and plantations
crenate: the margin notched with blunt or rounded teeth
crenulate: slightly crenate, with small teeth
crest: an elevation or ridge upon the summit of an organ
crisped: curled
cross-pollination: the transfer of pollen from one flower to the stigma of a flower of another plant which is not of the same clone
crown: the aerial expanse of a tree, not including the trunk; corona; a short rootstock with leaves; the base of a tufted, herbaceous, perennial grass
crustaceous: of hard but brittle texture
crystalline: of the nature of or relating to a crystal or crystals
cucullate: hooded; hood-shaped
cultivar (cv., plural: cvs): an agricultural or horticultural variety that has originated and persisted under cultivation, as distinct from a botanical variety; a cultivar name should be written with an initial capital letter and given single quotation marks (e.g. banana 'Gros Michel') unless preceded by 'cv.' (e.g. cv. Gros Michel)

cuneate: wedge-shaped; triangular, with the narrow end at the point of attachment, as the bases of leaves or petals
cupular: furnished with or subtended by a cupule
cupuliform: cupule-shaped
cuspidate: abruptly tipped with a sharp rigid point
cuticle: the outermost skin of plants, consisting of a thin continuous fatty film
cutting: a portion of a plant, used for vegetative propagation
cyanogenic glycosides: a group of secondary metabolites that form hydrocyanic acid on hydrolysis
cyme: a determinate inflorescence, often flat-topped, in which each growing point ends in a flower and the central flowers open first
cymose: bearing cymes or inflorescences related to cymes
cyst: a stage in the life cycle of certain parasites, during which they have a protective wall
cystitis: inflammation of the urinary bladder
cytokine: generic term for nonantibody proteins released by a cell population on contact with a specific antigen and acting as intercellular mediators
cytokinin: any of a class of phytohormones having as main functions the induction of cell division and the regulation of tissue differentiation
cytoplasm: the protoplasm of a cell, excluding the nucleus
cytosolic: pertaining to or contained in the cytosol
cytotoxic: pertaining to or exhibiting a destructive effect on certain cells
deciduous: shedding, applied to leaves, petals, etc.
declinate: bent or curved downward or forward
decoction: a medicinal preparation or other substance made by boiling, especially in water
decumbent: reclining or lying on the ground, but with the summit ascending
decurrent: extending down and adnate to the petiole or stem, as occurs in some leaves
decussate: of leaves, arranged in opposite pairs on the stem, with each pair perpendicular to the preceding pair
deflexed (reflexed): abruptly recurved; bent downwards or backwards
dehiscent: opening spontaneously when ripe, e.g. of capsules, anthers
deltoid: shaped like an equilateral triangle
demulcent: allaying the irritation of abraded or inflamed body surfaces, soothing; a soothing, mucilaginous or oily medicine or application
density: the ratio of mass to volume of a substance at a certain moisture content
dentate: margin prominently toothed with the pointed teeth directed outwards
denticulate: minutely toothed
depressant: diminishing functional activity; a medicine or drug which lowers functional activity and vital energy in general
depressed: sunk down, as if flattened from above
depurative: tending to purify or cleanse
dermatitis: inflammation of the skin
dermatosis: any skin disease, especially one without inflammation
determinate: of inflorescences, when the terminal or central flower of an inflorescence opens first and the prolongation of the axis is arrested; of shoot growth, when extension growth takes the form of a flush, i.e. only the previously formed leaf primordia unfold; for pulses also used to indicate bush-shaped plants with short duration flowering in one plane
diabetes: a general term referring to disorders characterized by the excretion of excessive amounts of urine. When used alone, usually referring to diabetes mellitus, i.e. a chronic syndrome of impaired carbohydrate, protein and fat metabolism owing to insufficient secretion of insulin or tissue insulin resistance
diadelphous: in two bundles
diapause: a state of inactivity and arrested development, accompanied by greatly reduced metabolism
diaphoretic: pertaining to, characterized by, or promoting (profuse) perspiration; an agent inducing sweating, having the power to increase perspiration
diarrhoea: a profuse, frequent, and loose discharge from the bowels
dichasium (plural: dichasia): a cymose inflorescence with 2 equal or nearly equal lateral branches arising below the terminal flower, this pattern being repeated or not (compound and simple dichasium respectively)
dichotomous: forked, parted by pairs
didynamous: with the stamens in two pairs, two long and two short ones
digestibility: the percentage of a foodstuff taken into the digestive tract that is absorbed into the body
dilated (botany): expanded into a flat structure
dimer: a compound formed by combination of two identical simpler molecules
dimeric: showing the characteristics of a dimer
dimorphic: of two forms, as may occur with branches, etc.
dimorphous: dimorphic

dioecious: with unisexual flowers and with the staminate and pistillate flowers on different plants (dioecy)
diosgenin: a complex steroid obtained from certain species of yam and which can be converted into 16-dehydropregnenolone, one of the main active ingredients in oral contraceptives
dipterocarp forest: woodland dominated by trees belonging to the family *Dipterocarpaceae*
discoid: resembling a disk or discus, being flat and circular, e.g. of a leaf with a round thickened lamina and rounded margins
disjunct: separated
disk (botany): a fleshy or elevated development of the receptacle within the calyx, corolla or stamens, often lobed and nectariferous
dispersal: the various ways by which seeds are scattered, e.g. by wind, water or animals
dissected: divided into many slender segments
distal: situated farthest from the place of attachment
distichous: regularly arranged in two opposite rows on either side of an axis
distillation: the process of transforming (fractions of) a liquid or solid into the vapour state, and condensing the vapour back to liquid or solid, named the distillate
distylous: referring to flowers of a species which possess one of two style types
diterpenes: a subgroup of the isoprenoids, formed by coupling of 4 C_5 units; see also isoprenoids
diuresis: increased discharge of urine
diuretic: tending to increase the flow of urine; an agent that promotes the excretion of urine
divaricate: extremely divergent
domatium (plural: domatia): a modified projection that provides shelter for other organisms
dormancy: a term used to denote the inability of a resting plant or plant part (e.g. the seed, bulb, tuber, or in tree crops usually the buds) to grow or to leaf out, even under favourable environmental conditions
dorsal: back; referring to the back or outer surface of a part or organ (abaxial)
dorsifixed: attached by the back, as in the case of the attachment of a filament to an anther
double blind: pertaining to a clinical trial or other experiment in which neither the subject nor the person administering treatment knows which treatment any particular subject is receiving
downy: covered with very short and weak soft hairs
dropsy: oedema
drupaceous: resembling a drupe, whether actually a drupe or not
drupe: a fleshy one-seeded indehiscent fruit with the seed enclosed in a strong endocarp
dysentery: any of various diseases characterized by inflammation of the intestines, abdominal pain and frequent bloody, mucous faeces
dysmenorrhoea: painful menstruation
dyspepsia: a condition of disturbed digestion
dyspnoea (dyspnea): laboured or difficult breathing
dysuria: difficult or painful urination
EC_{50}: median effective concentration, i.e. the concentration that produces the desired effect in fifty percent of a test population
eczema: a disease of the skin characterized by inflammation, redness, itching, and the formation of vesicles which exude a watery substance that evaporates and leaves the skin covered with crusts
ED_{50}: median effective dose, i.e. the dose that produces the desired effect in fifty percent of a population
egg: the female gamete or germ cell
eglandular: without glands
elaiosome: a seed or fruit outgrowth in which oil is stored; serves as food for ants
ellipsoid: a solid which is elliptical in outline
ellipsoidal: of a solid which is elliptical in outline
elliptical: oval in outline but widest about the middle
emarginate: notched at the extremity
embrocation: a liquid ointment
embryo: in plants, the rudimentary plant within a seed, developed from a zygote (sexual) or from other nuclei in the embryo sac or cells of the nucellus or integuments (apomictic); in animals, those derivatives of the fertilized ovum that will become the offspring, during their period of most rapid development; in humans, the developing organism from the end of the 2nd week after fertilization to the end of the 8th week
emergent: of a tree, one of which the crown reaches distinctly above the forest canopy; of cotyledons, becoming free from the seed coat and other external tissues
emesis: vomiting
emetic: tending to induce or cause vomiting; an agent that induces or causes vomiting
emmenagogue: a substance or measure that induces menstruation
emollient: soothening and softening; an agent that soothes or softens the skin or soothes an irritated internal surface
encephalitis: inflammation of the brain
endemic: exclusively native to a specified or com-

paratively small region; also used as a noun for a taxon thus distributed

endocarp: the innermost layer of the pericarp or fruit wall

endogenous: originating from within the organism

endosperm: the starchy or oily nutritive material stored within some seeds, sometimes referred to as albumen; it is triploid, having arisen from the triple fusion of a sperm nucleus and the two polar nuclei of the embryo sac

enema: a liquid injected into the rectum

energy value: the heat produced by the combustion of a unit weight of a fuel or food (= calorific value)

enteritis: inflammation of the small intestine

enterocolitis: enteritis (inflammation of the intestines) affecting both the large and small intestine

entire (botany): with an even margin without teeth, lobes, etc.

entomophilous: applied to flowers which are pollinated by insects

ephemeral: lasting for a day or less, e.g. the staminate inflorescences in *Pandanus*

epicalyx: an involucre of bracts below the flower, resembling an extra calyx

epicotyl: the young stem above the cotyledons

epidermis: in plants, the true cellular skin or covering of a plant below the cuticle; in humans, the outermost and nonvascular layer of the skin

epidermoid: belonging to or resembling the epidermis

epididymal: pertaining to the epididymis

epididymis: the cordlike structure at the posterior part of the testis, whose coiled duct provides for storage, transit and maturation of spermatozoa

epigeal: above the ground; in epigeal germination the cotyledons are raised above the ground

epilepsy: any of a group of syndromes characterized by recurrent, transient disturbances of the brain function, with manifestations including unconsciousness and uncontrolled motion

epileptic: pertaining to epilepsy

epimer: either of two diastereomers that differ in the configuration around one asymmetrical carbon atom

epipetalous: borne upon or placed before the petals

epistaxis: nosebleed

erect: directed towards summit, not decumbent

erysipelas: an acute, superficial form of dermatitis, usually caused by group A streptococci and characterized by a spreading, red, hot plaque

erythema: name applied to skin redness produced by congestion of the capillaries

essential oil: a volatile product, obtained from a natural source, which agrees with that source in odour and name; in a narrow sense, only volatile products obtained by steam or water distillation are called essential oils

evergreen: bearing foliage all year long; a plant that changes its leaves gradually

ex situ: in an artificial environment or unnatural habitat

exalbuminous: lacking albumen

excentric: one-sided, out of the centre

excitant: any agent that produces excitation of the vital functions, or those of the brains

exocarp: the outer layer of the pericarp or fruit wall

expectorant: promoting the ejection of mucus or other fluids from the respiratory tract; an agent tending to promote discharge of mucus or other fluids from the respiratory tract

expression: any process for the removal of essential oil from the outer rind of a citrus fruit, involving scarification and compression of the peel

exstipulate: without stipules

extract: a concentrated preparation of a vegetal or animal drug obtained by removing the active constituents with a suitable solvent

extraction: any process for separating aroma compounds from animal or plant matter using a volatile solvent; the product is called a concrete; the composition, and hence odour quality, of an aromatic extract depends strongly on the nature of the solvent used

extrafloral: of nectaries, beyond the flower

extrorse: directed outward, as the dehiscence of an anther

exudate: the secreted substance

F_1, F_2, *etc.*: symbols used to designate the first generation, second generation, etc., after a cross

falcate: sickle-shaped

fallow: land resting from cropping, often covered by natural vegetation or planted with fast growing herbs, shrubs or trees (fallow crop)

fascicle: a cluster of flowers, leaves, etc., arising from the same point

fasciculate: connected or drawn into a fascicle

febrifuge: an agent serving to reduce fever

fermentation: a chemical change accompanied by effervescence and suggestive of changes produced in organic materials by yeasts

ferruginous: rust-coloured

fertile: in plants: capable of completing fertilization and producing seed; producing seed capable of germination; having functional sexual organs; in humans: having the capacity to repro-

duce; capable of developing into a new individual (said of ova)
fertilization (biology): union of the gametes (egg and sperm) to form a zygote
fibre: in plants: any long, narrow cell of wood or bark other than vessel or parenchyma elements; in humans: an elongated, threadlike structure
fibreboard: sheet material manufactured under pressure and heat from fibres of any wood substances (see also hardboard)
fibrinolytic: pertaining to, characterized by or causing fibrinolysis, i.e. the dissolution of fibrin by enzymatic action
fibroblast: connective tissue cell
fibrosarcoma: a malignant tumour consisting of cells and fibres derived from fibroblasts
fibrous: composed of or containing fibres
fig: the fleshy multiple fruit, derived from the inflorescence of *Ficus* spp.(syconium)
filament: thread; the stalk supporting the anther
filariasis: a diseased state due to the presence of nematode worms of the superfamily *Filarioideae* in the body
filiform: slender; threadlike
fimbriate: fringed
fissured: provided with fissures (cracks of considerable length and depth), e.g. in the bark of some trees
fixed oil: a non-volatile oil, chemically a triglyceride of fatty acids; many fixed oils from plants have faint odours, even when purified, showing that they contain traces of volatile compounds
flabellate: fan-shaped, dilated in a wedge-shape, sometimes plaited (folded)
flaky: lamelliform, in the shape of a plate or scale
flatulence: the presence of excessive amounts of air or gases in the intestine
flavanones: a subgroup of the flavonoids; see also flavonoids
flavones: a subgroup of the flavonoids; see also flavonoids
flavonoid: water-soluble phenolic compound, consisting of 2 aromatic rings joint together with a 3-carbon unit
flavonoids: a group of natural products in which the basic structure is the 2-phenyl-chromane skeleton
fleshy: succulent
flexuous, flexuose: zigzag; bent alternately in opposite directions
floccose: covered with dense hairs that fall away in tufts, locks or flocci
floss: fluffy fibrous material
flush: a brief period of rapid shoot growth, with unfolding of the leaf primordia which had accumulated during the previous quiescent period
fluted: of a bole, with rounded grooves and folds
fodder: something fed to domesticated animals, especially coarse, dried food from plants (hay, straw, leaves)
foliaceous: leaf-like
foliolate: 2-, 3-, 4- etc., with 2-, 3-, 4- leaflets
follicetum: a whorl of follicles
follicle: in plants: a dry, unicarpellate fruit, dehiscing by the ventral suture to which the seeds are attached; in humans: a sac or pouchlike depression or cavity, e.g. hair follicle
fomentation: treatment by the application of warm, moist substances; the substance thus applied
forage: grassland and fodder plants suitable as feed for herbivores, usually with lower nutrient concentration and digestibility than concentrates such as grain
foveolate: with small pits
fractionation, fractional distillation: a distillation process in which a fractionating column is interposed between the distillation vessel and the condenser; during fractionation of a homogeneous mixture of volatile components of different boiling point, components with a lower boiling point move up the column faster than components with a higher boiling point and the components distil over in sequence
framboesia: see yaws
free: neither adhering nor united
free radical: a radical (a group of atoms which enters into and goes out of chemical combination without change and forms one of the fundamental constituents of a molecule) which is extremely reactive, has a very short half-life, and carries an unpaired electron
fringed: fimbriate; with hair-like appendages along the margin
frugivorous: feeding on fruit
fruit: the ripened ovary with adnate parts
fulvous: yellow, tawny
fungicidal: destroying fungi
fungicide: an agent that destroys fungi or inhibits their growth
fungistatic: inhibiting the growth of fungi
funicle (funiculus): the little cord which attaches the ovule or seed to the placenta
fusiform: spindle-shaped; tapering towards each end from a swollen centre
galactagogue, galactogogue: promoting the flow of milk; an agent that promotes the flow of milk
gallery forest: fringing forest, forest growing along a watercourse in an otherwise non-forested area

gamopetalous: with united petals either throughout their length or at the base
gamophyllous: with leaves which are united by their edges
gangrenous: having or developing gangrene, decay
gargle: to rinse or medicate the throat and mouth with a liquid kept in motion by the slow expulsion of air from the lungs; a solution used for rinsing or medicating the throat and mouth
gas-liquid chromatography (GLC): a technique for the separation of the constituents of liquid or gaseous mixtures; in combination with mass spectroscopy it is a powerful tool for the qualitative and quantitative analysis of complex mixtures of chemical compounds such as essential oils or perfumery products
gastralgia: gastric colic
gastric: pertaining to, originating in, or affecting the stomach
gastritis: inflammation of the stomach
gene: the unit of inheritance located on the chromosome
genetic erosion: the decline or loss of genetic variability
geniculate: abruptly bent so as to resemble the knee-joint
genome: a set of chromosomes as contained within the gamete and corresponding to the haploid chromosome number of the species
genus (plural: genera): the smallest natural group containing distinct species
germ: a bud or growing point; an ovary or young fruit; a reproductive cell, especially in bacteria
germplasm: the genetic material that provides the physical basis of heredity
gibbous: more convex in one place than another
girdle: a conspicuous horizontal band of tissue inserted circumaxially at the nodes of some bamboos
girth: a measure around a body
glabrate: destitute of pubescence and of any roughness
glabrescent: becoming glabrous or nearly so
glabrous: devoid of hairs
glandular: in botany: having or bearing secreting organs or glands; in medicine: pertaining to or of the nature of a gland
glaucoma: a group of eye diseases characterized by an increased intraocular pressure which causes pathological changes in the eye and impaired vision, and which may lead to blindness
glaucous: pale bluish-green, or with a whitish bloom which rubs off
gley: a sticky clay layer formed below the surface of some waterlogged soils
glioma: a tumour composed of tissue representing neuroglia (the supporting tissue of the nervous system); sometimes extended to include all primary, intrinsic neoplasms of the central nervous system
globose: spherical or nearly so
glomerule: a condensed head of almost sessile flowers; a cluster of heads in a common involucre
glucosidase: an enzyme that hydrolyses a glucoside
glucoside: compound that is an acetal derivative of sugars and that on hydrolysis yields glucose
glutinous: sticky
glycoside: compound that is an acetal derivative of sugars and that on hydrolysis yields one or more molecules of a sugar and often a noncarbohydrate
glycosides: see aglycones
goitre: an enlargement of the thyroid gland, resulting in a swelling in the front part of the neck
goitrogenic: producing goitre
gonorrhoea: a venereal disease characterized by inflammation of the mucous membrane of the genitourinary tract and a discharge of mucus and pus
gout: a group of disorders of (purine) metabolism, characterized by inflammation of a joint, paroxysmal recurrent pain and an excess of uric acid in the blood
graft: a union of different individuals by apposition, the rooted plant being termed the stock, the portion inserted the scion
grafting: the process of inserting a scion, which consists of a piece of stem and two or more buds of the plant to be propagated, into another plant (rootstock) with the intention that it will unite and grow
grain: of wood, the general direction or arrangement of the fibres; texture
gram-negative: losing the stain or decolorized by alcohol in Gram's staining method, which is a primary characteristic for bacteria with a cell wall consisting of a thin layer of peptidoglycan with an outer membrane of lipoprotein and lipopolysaccharide
gram-positive: retaining the stain or resisting decolorization by alcohol in Gram's staining method, which is a primary characteristic for bacteria with a cell wall consisting of a thick layer of peptidologlycan with attached teichoic acids
granular: divided into or bearing little knots or tubercles (also granulate)
granulocyte: any cell containing granules, especially leucocytes containing cytoplasmic granules

granuloma: imprecise term, applied to aggregations of either mononuclear inflammatory cells or modified macrophages; granuloma formation represents a chronic inflammatory response

green manure: green leafy material applied to and mostly worked into the soil to enrich the soil with nutrients and organic matter

gregarious: growing in associated groups or clusters but not matted; at the same time; in bamboos gregarious flowering is used to indicate that a whole population flowers over a period of 2–3 years and then dies, although sometimes the rhizomes remain alive

gum: a colloidal polysaccharide substance that is gelatinous when moist but hardens on drying; gum is exuded by plants or extracted from them

gynoecium: the female part or pistil of a flower, consisting, when complete, of one or more ovaries with their styles and stigmas

gynophore: a stalk supporting the gynoecium formed by elongation of the receptacle

habit (botany): external appearance or way of growth of a plant

habitat: the kind of locality in which a plant grows

haematuria: the presence of blood in the urine

haemolysis: disruption of the integrity of the red blood cell membrane, causing release of haemoglobin

haemolytic: pertaining to, characterized by, or producing haemolysis

haemoptysis: expectoration of blood or blood- sputum from some part of the respiratory tract

haemorrhage: bleeding; the escape of blood from blood vessels

haemostasis: the arrest of bleeding

haemostatic: arresting the flow of blood; an agent that checks the flow of blood

hallucinogenic: inducing hallucinations

hangover: disagreeable physical effects following heavy consumption of alcohol or from the use of drugs

hardboard: homogenous thin fibreboard having a density of not more than 16 kg/m^3

hardwood: the wood of an angiospermous tree as distinguished from that of a coniferous tree

hastate: with more or less triangular basal lobes diverging laterally

head: a dense inflorescence of small crowded often stalkless flowers (a capitulum)

heartwood: wood from the inner portion of a tree in which the cells are dead and no longer engaged in sap conduction and food storage

hemi-: prefix, meaning half

hemiparasite: a facultative parasite; a parasitic plant that contains some chlorophyll and is therefore capable of photosynthesis

hemiplegia: paralysis of one side of the body

hepatalgia: pain in the liver

hepatitis: inflammation of the liver

hepatocyte: liver cell

hepatomegaly: enlargement of the liver

hepatotoxic: having a toxic effect on liver cells

herb: any vascular plant which is not woody

herbaceous: with the texture, colour and properties of a herb; not woody

hermaphrodite: bisexual; in flowers, with stamens and pistil in the same flower

herpes: any of several inflammatory diseases of the skin caused by a herpesvirus and characterized by clusters of vesicles

herpes simplex: group of acute infections caused by herpes simplex virus type 1 or type 2, characterized by the development of one or more small fluid-filled vesicles on the skin or mucous membrane, and occurring as a primary infection or recurring because of reactivation of a latent infection

heterodistylous: with two kinds of plants, having either short or long styles

heterogeneous: lacking in uniformity; exhibiting variability

heterostylous: having styles of two or more distinct forms or of different lengths

hexaploid: having six sets of chromosomes ($6n$)

hilum: the scar left on a seed indicating its point of attachment

hirsute: with rather coarse stiff hairs

hirtellous: minutely hirsute

hispid: covered with long rigid hairs or bristles

hispidulous: minutely hispid

histological: relating to the microscopic structure of the tissues of organisms

histopathological: pertaining to the histology of diseased tissues

HIV (human immunodeficiency virus): a virus that is the aetiological agent of acquired immunodeficiency syndrome (AIDS). Two serotypes are distinguished: HIV-1, with a worldwide distribution, and HIV-2, which is largely confined to West Africa

hoarseness: to be rough or harsh in sound

homeostasis: a tendency to stability in the normal body states of the organism

homogamous: bearing one kind of flowers

homogeneous: uniform as to kind; showing no variability

homologous: of one type

homonym (botany): a name rejected because of an earlier application of the same name to another taxon

homostylous: having styles of the same length and/or shape

husk: the outer covering of certain fruits or seeds

hybrid: the first generation offspring of a cross between two individuals of different species or taxa

hybridization: the crossing of individuals of different species or taxa

hydrolysable tannins: see tannins

hydrolysis: a chemical reaction of water in which a bond in the reactant other than water is split and hydrogen and hydroxyl are added

hydrophilic: having a strong affinity for water

hydrophobia: any morbid dread of water; rabies

hygroscopic: susceptible to extending or shrinking on application or removal of water or vapour

hypanthium: a cup-like receptacle usually derived from the fusion of the floral envelopes and androecium on which are seemingly borne the calyx, corolla and stamens

hypercholesterolaemia: an excess of cholesterol in the blood

hyperglycaemia: an abnormally increased glucose concentration in the blood

hyperglycaemic: pertaining to, characterized by, or causing hyperglycaemia

hypertension: high arterial blood pressure

hypocholesterolaemic: pertaining to, characterized by, or producing hypocholesterolaemia

hypocotyl: the young stem below the cotyledons

hypocrateriform: saucer-shaped, with a long and narrow tube and limbs at right angles to the tube

hypogeal: below ground; in hypogeal germination the cotyledons remain below ground within the testa

hypoglycaemic: pertaining to, characterized by, or producing an abnormally decreased glucose concentration in the blood (hypoglycaemia)

hypolipidaemic: promoting the reduction of lipid concentration in the serum

hypotension: an abnormally low blood pressure

imbricate: overlapping like tiles; in a flower bud when one sepal or petal is wholly external and one wholly internal and the others overlapping at the edges only

imidazole alkaloids: a subgroup of the alkaloids; see also alkaloids

imparipinnate: of leaves, pinnate with an unpaired terminal leaflet

impetigo: a contagious, purulent skin disease, caused by group A streptococci or *Staphylococcus aureus*, and mostly seen in children, usually on the face

implantation: the embedding of the fertilized egg in the uterus; the insertion or grafting of material into the body

impotence: lack of power, specifically lack of copulative power in the male due to failure to initiate or maintain an erection

impressed: marked with slight depressions

in situ: in the natural environment; in medicine: in the natural or normal place

in vitro: outside the living body and in an artificial environment

incised: cut deeply

incompatibility: in floral biology: not capable of cross- or self-fertilization; in plant propagation: not capable of making stock–scion combinations resulting in a lasting union

indehiscent: not opening when ripe

indented: forced inward to form a depression

indigenous: native to a particular area or region

indigestion: lack or failure of digestion

indole alkaloids: a subgroup of the alkaloids; see also alkaloids

indumentum: a covering, as of hairs, scales, etc.

induplicate: with the margins bent inwards and the external face of these edges applied to each other without twisting; V-shaped in cross section, trough-shaped

inferior: beneath, lower, below; an inferior ovary is one which is situated below the sepals, petals and stamens

inflammation: a protective response of the body in response to injury, infection, irritation, etc., aimed at destroying or isolating the injurious agent and injured tissue, and characterized by redness, pain, heat, and swelling

inflexed: bent or curved inward toward the centre

inflorescence: the arrangement and mode of development of the flowers on the floral axis; the branch that bears the flowers, including all its bracts and branches

influenza: an acute highly contagious virus disease characterized by sudden onset, fever, prostration, severe aches and pains, and progressive inflammation of the respiratory mucous membrane

infrageneric: referring to any taxon below the genus level

infraspecific: referring to any taxon below the species level

infructescence: a ripened inflorescence in the fruiting stage

infundibular: funnel-shaped

infusion: a liquid extract obtained by steeping or soaking something in a liquid for the purpose of extracting its medicinal principles without boiling; the therapeutic introduction of a fluid, other than blood, into a vein

inner bark: the secondary phloem; the living part of the tissue outside the cambium

inoculation: grafting, more properly budding, a single bud only being inserted; introduction of microorganisms, infective material, serum and other substances into tissues of living plants and animals, or culture media promote growth

inoculum: material used for inoculation, e.g. rhizobia in soil to promote the growth of certain *Leguminosae*

inotropic: affecting the force or energy of muscular contractions (positive: increasing the force; negative: weakening the force)

insecticidal: destroying or controlling insects

insecticide: an agent that destroys insects

insomnia: sleeplessness

insulin: a protein hormone produced by ß-cells of the islets of Langerhans in the pancreas, which is secreted in response to elevated glucose and amino acid levels in the blood and promotes their storage and utilization. Insulin deficiency is often the cause of diabetes, and exogenous insulin is used to control that disease

intercostal: between the veins of a leaf or a leaf-like structure

interfloral: between the flowers

internode: the portion of the stem (culm) between two nodes

interpetiolar: of stipules placed between the petioles of opposite leaves

intragastric: within the stomach

intramarginal: placed within the margin near the edge; of a vein, running near and parallel with the margin

intrapetiolar: of stipules, positioned within the petiole axil

intraspecific: occurring within a species or involving members of one species

intrastaminal: within the stamens

introrse: turned inward, towards the axis, as the dehiscence of an anther

inulin: linear polysaccharide made up of fructose units, a storage carbohydrate in the roots, rhizomes and tubers of many *Compositae*

involucral: belonging to an involucre

involucre: a ring of bracts (involucral bracts) surrounding several flowers or their supports, as in the heads of *Compositae* or the umbels in *Umbelliferae*

iridoids: monoterpenes (C_{10}) characterized by a cyclopentanotetrahydropyran ring system, also known as the iridane skeleton; seco-iridoids can be regarded as being formed from iridoids by opening of the cyclopentane ring between C_7 and C_8

isodiametric: having equal diameters

isoflavonoids: a subgroup of the flavonoids, in which the basic structure is the 3-phenyl chromane skeleton; see also flavonoids

isomer: a compound, radical or ion containing the same numbers of atoms of the same elements in the molecule as one or more others, and hence having the same molecular formula, but differing in the structural arrangement of the atoms and consequently in one or more properties

isoprenoids or terpenoids: a large group of secondary metabolites, in which isopentenyl pyrophosphate ('active isoprene' or 'C_5-unit') is the building block; isopentenyl pyrophosphate is derived via the mevalonic acid pathway; mevalonic acid itself is formed from 3 molecules of acetate, but the mevalonic acid pathway channels acetate into a different series of compounds than does the acetate pathway

isoquinoline alkaloids: a subgroup of the alkaloids; see also alkaloids

jaundice: a syndrome marked by hyperbilirubinaemia and deposition of bile pigments in the skin, mucous membranes and eyeball, resulting in yellowish pigmentation of these body parts

jugate: connected or yoked together; e.g. in leaves 1–n-jugate: with 1–n pairs of leaflets

keel (carina): a ridge like the keel of a boat; the two anterior and united petals of a papilionaceous corolla; the principal vein of a sepal or glume

keeled (carinate): having a keel or carina

kerangas: heath forest, a type of tropical forest generally consisting of comparatively small trees with thin trunks (pole forest), often overlying a podsolic soil

kernel: the nucellus of an ovule or of a seed, that is, the whole body within the coats

knee: an abrupt bend in a stem or tree-trunk

labellum: lip; the lowest petal of an orchid; petaloid anterior staminode in *Zingiberaceae*

lac insect: a scale insect (*Laccifer lacca*, synonym *Kerria lacca*) that produces lac, a resinous gold-coloured substance used for lacquerware

lacerate: torn; irregularly cleft or cut

laciniate: slashed, cut into narrow lobes

lamellate: made up of thin plates

laminate, laminated: consisting of plates or layers

lanate: with woolly hairs

lanceolate: lance-shaped; much longer than broad, being widest at the base and tapering to the apex

larvicidal: destroying insect larvae

laryngitis: inflammation of the larynx

lateral: on or at the side

latex: a juice, usually white and sometimes sticky, exuding from broken surfaces of some plants

laticifer: a latex-bearing cell or vessel

laticiferous: latex-bearing

lax: loose, distant

laxative: aperient, mildly purgative; an agent that promotes evacuation of the bowel

layer: a branch caused to root while still connected to the parent and used for propagation (layering)

LC_{50}: median lethal concentration, i.e. the concentration of a chemical that kills fifty percent of the organisms in a test population

LD_{50}: median lethal dose, i.e. the amount of an agent that kills fifty percent of the organisms in a test population

leaflet: one part of a compound leaf

lectins: proteins of glycoproteins, which are not antibodies or enzymes, but which have the ability to attach themselves to specific sugars; the binding is not covalent, and the sugar can either be free or constituent part of a larger molecule, which may be present, e.g. in a membrane

Leishmaniasis ('kala azar'): infection caused by *Leishmania*, and classified into cutaneous, mucocutaneous and visceral leishmaniasis (kala-azar)

lenticellate: having lenticels

lenticular: shaped like a double-convex lens

lepidote: covered with small scales

leprosy: a chronic, infectious, slowly progressive disease, caused by *Mycobacterium leprae*, characterized by lesions in the skin, mucous membranes, nerves, bones and viscera, and manifested by a broad range of clinical symptoms

leucoderma: a skin abnormality that is characterized by a usually congenital lack of pigment in spots or bands and produces a patchy whiteness

leucorrhoea: a whitish, viscid discharge from the female genitals

leukaemia: a malignant, progressive disease of the blood-forming organs, with distorted proliferation and development of the white corpuscles (leucocytes) and their precursors

liana: a woody climbing vine

lignans: a group of natural products (dimers) derived from condensation of 2 phenylpropane units

lignified: converted into wood or woody tissue

lignin: a colloidal polymer of varying chemical structure used as secondary wall material in xylem vessels, tracheids and sclerenchyma fibres

ligulate: possessing an elongated flattened strap-shaped structure or ligule

ligule: an elongated flattened strap-shaped structure; a membranous outgrowth on the upper surface of a grass leaf at the junction of the sheath and the blade which may be presented by a ridge or by a line of hairs

limb (botany): the expanded part of a tubular corolla, as distinct from the tube or throat; the lamina of a leaf or of a petal; the branch of a tree

linear: long and narrow with parallel sides

liniment: an oily liquid preparation to be used on the skin

lithiasis: the formation of stones or calculi in the body

lithotriptic: pertaining to or producing lithotripsy, i.e. the destruction of a stone in the gallbladder or urinary system stone in the bladder or kidneys

lobe: any division of an organ or specially rounded division

lobed: divided, but not to the base

locular: divided by internal partitions into compartments as in anthers and ovaries

locule: the cavity of an ovary or anther

loculicidal: the cavity of a pericarp dehiscent by the back, the dorsal suture

longitudinal: lengthwise

lotion: a liquid suspension or dispersion for external application to the body

lumbago: pain in the lumbar region of the back (loins); lumbar rheumatism

lumen (plural: lumina): the space enclosed by the walls of a cell or organ, such as the central cavity of a cell

lymphoma: any neoplastic disorder of the lymphoid tissue; the term is often used alone to denote malignant lymphoma

lysozyme: an enzyme of the hydrolase class, occurring in saliva, tears, egg white and many animal fluids, and catalysing the breakdown of some bacterial cell walls

macerate: to reduce to a soft mass by soaking

maceration: a method of extract preparation in which the matter to be extracted is mixed with the prescribed extraction solvent, and allowed to stand in a closed container for an appropriate time; the residue is separated from the extraction solvent, and if necessary, pressed out; in the latter case, the two liquids obtained are combined; see also percolation

macrophage: any of the many forms of mononuclear phagocytes (cells capable of ingesting particulate matter) found in tissues
Malesia: the biogeographical region including Malaysia, Indonesia, the Philippines, Singapore, Brunei and Papua New Guinea
mangrove: a brackish-water coastal swamp of tropical and subtropical areas that is partly inundated by tidal flow
marcotting: air layering, a form of layering in which soil (rooting medium) is brought to the branch to be layered; the ball of soil in a polyethene cover is wrapped around the girdled branch; after adventitious roots grow out above the girdle, the layer can be separated
margin: the edge or boundary line of a body
mass spectroscopy: a technique of analysis in which the molecules of a pure compound are subjected to bombardment with high energy electrons; the molecules of the sample are fragmented and separated according to their masses, producing a graphical 'fragmentation pattern'; the molecular structure of the compound can be derived from this pattern
mast cell: a connective tissue cell whose specific physiological function remains unknown
mastitis: inflammation of the mammary gland or breast
median: belonging to the middle
medifixed: attached or fixed by the middle
medulla: the central looser portion of the flesh in certain fungi and algae
melanoma: a tumour arising from the melanocytic system of the skin and other organs; when used alone, the term refers to malignant melanoma
membranous: thin and semi-transparent, like a fine membrane
menorrhagia: excessive uterine bleeding, occurring at regular intervals, with the period of flow being of usual duration; also called hypermenorrhoea
mericarp: one of the separate halves or parts of a fruit, as in *Umbelliferae*
meristem: undifferentiated tissue of the growing point whose cells are capable of dividing and developing into various organs and tissues
merous: 4-, 5- etc., with 4, 5 etc. parts or numbers of sepals, petals etc.
mesocarp: the middle layer of the pericarp or fruit wall which is often fleshy or succulent
metabolism: the sum of all the physical and chemical processes by which living organized substance is produced and maintained, and also the transformation by which energy is made available for the uses of the organism; biotransformation
metabolite: any substance produced by metabolism or by a particular metabolic process
metritis: inflammation of the uterus
midrib: the main vein of a leaf which is a continuation of the petiole
mildew: a superficial, usually whitish growth on living plants produced by fungi
mistletoe: any of numerous hemiparasitic plants of the family *Loranthaceae*
mitogen: a substance that induces blast transformation, the synthesis of DNA, RNA and proteins, and the proliferation of lymphocytes
mitogenic: causing or inducing mitosis or cell proliferation
moisture content: the weight of water expressed as a percentage of the dry weight
molluscicidal: destroying molluscs such as snails
monadelphous: of stamens, united into one group by their filaments
moniliform: necklace-shaped
monocarp: a plant that flowers and fruits only once during its lifetime; the single carpel of an apocarpous fruit
monoecious: with unisexual flowers, but male and female flowers borne on the same plant
monomer: the simple unpolymerized form of a chemical compound having relatively low molecular weight
monomorphic: with a single form, uniform
monopodial: of a primary axis which continues its original line of growth from the same apical meristem to produce successive lateral branches
monoterpene: a terpene of molecular formula $C_{10}H_{16}$, e.g. limonene, myrcene and phellandrene; most monoterpenes are readily oxidized to coarse-smelling products, so essential oils containing them must be carefully preserved to minimize this tendency
monoterpenes: a subgroup of the isoprenoids, formed by coupling of 2 C_5 units; see also isoprenoids
monotypic: consisting of a single element, e.g. of a genus consisting of only one species
monsoon forest: a deciduous tropical woodland experiencing periodic drought
mordant: a compound that serves to fix a dye in or on a substance, e.g. a textile fibre, often a salt or hydroxide of chromium, aluminium or tin
mucilage (mucilaginous): a gelatinous substance that is similar to gum but that swells in water without dissolving and forms a slimy mass
mucilaginous: slimy

mucous: pertaining to, resembling, producing, containing or covered with mucus
mucro: a sharp terminal point
mucronate: ending abruptly in a short stiff point
mucronulate: diminutive of mucronate
mulch: plant or non-living materials used to cover the soil surface with the object of protecting it from the impact of rainfall, controlling weeds, temperature and evaporation
multiple sclerosis (MS): disease caused by sclerosis occurring in patches in the brain and/or spinal cord, leading to tremors, failure of coordination and various nervous and mental symptoms
multiseriate: arranged in several rows
muricate: rough, with short and hard tubercular excrescences
musculotropic: affecting, acting upon, or attracted to muscular tissue
mutagen: an agent inducing or increasing genetic mutations by causing changes in DNA
mutagenesis: the induction of genetic mutation
mutagenic: capable of inducing genetic mutation
mydriasis: physiological, morbid or drug-induced dilation of the pupil
myocardial ischemia: deficiency of blood supply to the heart muscle, due to constriction or obstruction of the coronary arteries
myocardium: the middle and thickest layer of the heart wall, composed of cardiac muscle
narcotic: pertaining to or producing narcosis or stupor; an agent that in moderate doses dulls the senses, relieves pain and induces sleep, but in excessive doses may cause stupor, coma, convulsions and death
nasopharynx: the upper part of the alimentary canal continuous with the nasal passages
naturalized: introduced into a new area and established there, giving the impression of wild growth
nausea (nauseous): an uncomfortable feeling in and about the stomach associated with aversion to food and a need to vomit
necrosis: in plants, death of a portion of tissue often characterized by a brown or black discoloration; in humans, the sum of morphological changes indicative of cell death and affecting groups of cells, parts of structures, or organs
nectar: a sweet fluid exuded from various parts of the plant (e.g. by the flower to attract pollinators)
nectariferous: containing or exuding nectar
nectary: a group of modified subepidermal cells in flowers or leaves (extrafloral) secreting nectar
nematode: small elongated cylindrical worm-like micro-organism, free-living in soil or water, or parasitic in animals or plants
nephritis: inflammation of the kidney
nephrotic syndrome: general name for a group of diseases involving defective kidney glomeruli
nephrotoxicity: the quality of being toxic or destructive to kidney cells
nerve: in botany: a strand of strengthening and/or conducting tissue running through a leaf, which starts from the midrib and diverges or branches throughout the blade; in medicine: a cordlike structure consisting of nerve fibres, which convey impulses between the central nervous system and other body parts
neuralgia: pain radiating along the course of one or more nerves
neurasthenia: a syndrome of chronic mental and physical weakness and fatigue, which was thought to be caused by exhaustion of the nervous system
neuropathy: a functional disturbance or pathological change in the peripheral nervous system
neurotrophic: pertaining to neurotrophy, i.e. the nutrition and maintenance of nervous tissue
neutrophil: a granular leucocyte, having the properties of chemotaxis, adherence to immune complexes and phagocytosis
nociception: sensation of pain
nocturnal: of flowers, flowering during the night
node: the point on the stem or branch at which a leaf or lateral shoot is borne
nodulation: formation of root-nodules
nucleus (plural: nuclei): an organized proteid body of complex substance in the protoplasm of cells; the central point in a starch granule
nut: a one- to many-seeded indehiscent fruit with a hard dry pericarp or shell
nutlet: a little nut
oblanceolate: reverse of lanceolate
obligate: necessary, essential; the reverse of facultative
oblique: slanting; of unequal sides
oblong: longer than broad, with the sides parallel or almost so
oblongoid: a solid object which is oblong in section
obovate: reverse of ovate
obovoid: a solid object which is obovate in section
obtuse: blunt or rounded at the end
ocrea: a tubular stipule or pair of opposite stipules so combined; an extension of the leaf sheath beyond the petiole insertion
oedema: the presence of abnormally large amounts of fluid in the intercellular tissue spaces of the body

oestrogen: a sex hormone produced especially in the ovaries

oliguria: reduced urine excretion

operculum: a lid or cover which separates by a transverse line of division

ophthalmia: severe inflammation of the eye, or of the conjunctiva or deeper structures of the eye

opposite: of leaves and branches when two are borne at the same node on opposite sides of the stem

orbicular: flat with a more or less circular outline

orchitis: inflammation of a testis

orifice: an opening by which spores, etc., escape; ostiole

orthotropic: having a more or less vertical direction of growth

ostalgia: pain in a bone or in the bones

outer bark: the periderm or rhytidome; the non-living layer of fibrous or corky tissue outside the cambium in woody plants which may be shed or retained

oval: see ovate

ovary: in plants, that part of the pistil, usually the enlarged base, which contains the ovules and eventually becomes the fruit; in humans, one of the two sexual glands in which the female reproductive cells (ova) are formed

ovate: egg-shaped in outline or in section; a flat surface which is scarcely twice as long as broad with the widest portion below the middle

ovicidal: destructive to the eggs of certain organisms

ovoid: a solid object which is egg-shaped (ovate in section)

ovule (botany): the immature seed (egg) in the ovary before fertilization

oxidation: the processes of combining a compound with oxygen, dehydrogenating, or increasing the proportion of the electro-negative part

palmate: of leaflets, leaf-lobes or veins, with the different elements arising from the same point

panacea: a universal remedy; a herb credited with remarkable healing properties

panicle: an indeterminate branched racemose inflorescence

paniculate: resembling a panicle

pantropical: distributed throughout the tropics

papilionaceous flower: a butterfly-like, pea-like flower, with standard, wings and keel

papillae: soft superficial glands or protuberances

papillate: having minute nipple-like protuberances

papilloma: a benign epithelial tumour producing finger-like or warty projections

papillose: covered with minute nipple-like protuberances

pappus: the various tufts of hairs on achenes or fruits; the limb of the calyx of *Compositae* florets

papyraceous: papery, like paper

parang: a short sword, cleaver or machete

parasitic: deriving nourishment from some other organism

parasympatholytic: producing effects which resemble those of interruption of the parasympathetic nerve supply to a body part; an agent that opposes the effects of parasympathetic nerve impulses; also called anticholinergic

parasympathomimetic: producing effects resembling those of stimulation of the parasympathetic nerve supply to a part

parenchyma: in plants: ground tissue composed of thin-walled, relatively undifferentiated cells, e.g. the pith and mesophyll; in humans: the soft cellular substance of glandular and other organs, or the essential elements of an organ

parietal: placentation type, when the ovules are attached to the wall of a one-celled ovary

paripinnate: a pinnate leaf with all leaflets in pairs

particle board: board made from bonded particles of wood and/or other ligno-cellulosic material

partite (parted): cleft, but not quite to the base

patent (botany): spreading out widely

pectoral: of, or pertaining to, the chest or thorax; relieving disorders of the respiratory tract; any medicine against ailments of the chest

pedate: palmately divided or parted with the lateral divisions two-cleft

pedicel: the stalk of an individual flower

pedicellate: furnished with a pedicel

peduncle: the stalk of an inflorescence or partial inflorescence

pedunculate: furnished with a peduncle

peel: the rind or skin of the fruit

pellucid: translucent

peltate: of a leaf, with the stalk attached to the lower surface, not at the edge

pendent, pendulous: drooping; hanging down from its support

penninerved: pinnately veined, parallel veins arise at an angle from a midvein (as in *Musa*)

pentamerous: having five parts in a flower-whorl

perennial: a plant living for many years and usually flowering each year

perfume: a harmonious composition prepared from natural and/or synthetic aromatic materials having aesthetic appeal alone, or after incorporation in an end-product *perianth*: the floral leaves as a whole, including both sepals and petals if both are present

pericarp: the wall of the ripened ovary or fruit whose layers may be fused into one, or may be more or less divisible into exocarp, mesocarp and endocarp

perisperm: the nutritive tissue of some seeds derived from the nucellus

peristalsis: the movement by which the digestive tract and other tubular organs with both longitudinal and circular muscle fibres propel their contents

peritonitis: inflammation of the peritoneum, i.e. the serous membrane that lines the abdominal cavity

persistent: remaining attached; not falling off, not deciduous; applies to organs that remain in place after they have fulfilled their natural functions

petal: a member of the inner series of perianth segments (corolla) which are often brightly coloured

petaloid: petal-like

petiolar: borne on, or pertaining to a petiole

petiolate: having a petiole

petiole: the stalk of a leaf

petiolule: the stalk of a leaflet

phagocytosis: endocytosis (uptake by a cell of material by invagination of its plasma membrane) of particulate material, such as microorganisms and cell fragments

pharmacopoeia: an authorative treatise on drugs and their preparations; a book containing a list of products used in medicine, with descriptions, chemical tests for determining identity and purity, formulas for certain mixtures of these substances, and generally also statements of average dosage

pharyngitis: inflammation of the pharynx

phenolics: phenols are compounds which have an aromatic ring with an alcoholic group attached to it

phenology: the complex annual course of flushing, quiescence, flowering, fruiting and leaf fall in a given environment

phlegm: a viscid, stringy mucous secretion, like that produced by the mucous membranes of the respiratory tract, as during a cold

phloem: the principal food-conducting tissue of vascular plants; the bast element of a vascular bundle and basically composed of sieve elements, parenchyma cells, fibres and sclereids

phloroglucinols: derivatives of 1,3,5-trihydroxybenzene

photoperiod: the relative duration of illumination in a cycle of light and darkness, whether occurring naturally (day and night) or imposed in an artificial way

photosensitization: the development of abnormally heightened reactivity of the skin to sunlight

phthisis: wasting away of (a part of) the body; tuberculosis, especially of the lungs

phyllody: transformation of flower parts into leaves

phyllotaxis: the arrangement of leaves or floral parts on an axis or stem

phytosterols: a group name for the widespread plant sterols sitosterol, campesterol and stigmasterol

phytotherapy: treatment by use of plants

pickle: steep or soak in a solution for preservation, conditioning etc.; a preserving, flavouring liquid; an object preserved in a pickle

pilose: hairy with rather long soft hairs

pinna (plural: pinnae): a primary division or leaflet of a pinnate leaf

pinnate: arranged in pairs along each side of a common axis

pinnatifid: pinnately divided about halfway to the midrib

pinnatilobed: pinnately divided to about half-way to the midrib

pinnatipartite: pinnately parted

pinnatisect: pinnately divided down to the midrib

pioneer species: a species able to establish itself on bare ground, starting primary succession, often showing rapid growth and producing large amounts of diaspores

piperidine alkaloids: a subgroup of the alkaloids; see also alkaloids

piscicidal: poisonous to or controlling fish

pistil: the female part of a flower (gynoecium) of one or more carpels, consisting, when complete, of one or more ovaries, styles and stigmas

pistillate: a unisexual flower with pistil, but no stamens

pistillode: a sterile, often reduced pistil

pith: the soft core occurring in the structural centre of a log; the tissue, sometimes soft, in the centre of the stem of a non-woody dicotyledon

pits: recesses in the secondary wall of a cell, often in walls connecting two elements of a vessel (intervessel pits), these can be arranged in ladder-like series (scalariform), in horizontal rows (opposite) or in diagonal rows (alternate)

placenta: in plants, the part of the ovary to which the ovules are attached; in higher mammals, the vascular, spongy organ of interlocking maternal and foetal tissue by which the foetus is nourished in the uterus

placentation (botany): the way in which the placentae are arranged in the ovary

plagiotropic: having an oblique or horizontal direction of growth

plagiotropic by apposition: with an oblique or horizontal orientation resulting from a continued active terminal meristem being replaced by a more vigorous lateral meristem

plano-convex: flat on one side and convex on the other

platelet activating factor: a substance released by basophils and mast cells in immediate hypersensitivity reactions and macrophages and neutrophils in other inflammatory reactions. It is an extremely potent mediator of bronchoconstriction and of the platelet aggregation and release reactions

pleiochasium (plural: pleiochasia): a cymose inflorescence in which each axis produces more than 2 branches

pleurisy, pleuritis: inflammation of the pleura (the membrane between thorax and lung), which may be acute or chronic

pleuritis: pleurisy

pleurogram: a characteristic fissure in the epidermal pallisade layer in some leguminous seeds (*Caesalpinioideae*, *Mimosoideae*); it is a U-shaped or horseshoe-shaped single or double line found on both faces of the seed and sometimes continuous between them and an important constant character to identify genera

plicate: folded to and fro, like a fan

ploidy: degree or repetition of the basic number of chromosomes

plywood: a panel material consisting of wood veneers glued together with the grains of adjacent layers arranged at right angles or at a wide angle

pneumonia: inflammation of the lungs, with the lungs becoming firm following the filling of air spaces with exudate

pod: a dry fruit composed of a single carpel and dehiscing by sutures, as in legumes; a general term for a dry dehiscent fruit

pollen: spores or grains borne by the anthers containing the male element (gametophyte)

pollination: the transfer of pollen from the dehiscing anther to the receptive stigma

pollinia: regularly shaped masses of pollen formed by the cohesion of a large number of pollen grains, as in orchids

polyene: an organic chemical compound containing many double bonds

polygamous: with unisexual and bisexual flowers in the same plant

polymorphic, polymorphous: with several or various forms; variable as to habit

polyphenol: a polyhydroxy phenol

polyphyletic: of a group of species or taxa, a non-natural group in which the most recent common ancestor for all species (or taxa) is assigned to another group, the characterization of the group being based on convergent similarity

polyploid: with more than two sets (genomes) of chromosomes in the somatic cells, e.g. triploid (3 sets), tetraploid (4), pentaploid (5), hexaploid (6), heptaploid (7), octoploid (8), etc.

polyploidy: the state of having more than two full sets of homologous chromosomes

posterior: next to or towards the main axis

poultice: a soft, moist, usually heated and sometimes medicated mass spread on cloth and applied to sores or other lesions to create moist local heat or counterirritation

preservative: a chemical formulation (usually in liquid form) used for the treatment of timber to increase its durability

primary vegetation: the original, undisturbed plant cover

proanthocyanidins: see tannins

procumbent: lying along the ground; in wood anatomy also of ray parenchyma cells with their longest dimension in radial direction

progeny: offspring

prolific: fruitful, producing offspring

prostaglandins: the prostaglandins, leucotriens and thromboxanes are a large group of modified C_{20} fatty acids; they are known to occur widely in animal tissues, but only in tiny amounts, and they have been found to exert a wide variety of pharmacological effects (e.g. mediators of inflammation, platelet aggregation) on humans and animals

prostrate: lying flat on the ground

protandrous: of flowers, shedding pollen before the stigma is receptive

proteolytic: pertaining to, characterized by, or promoting proteolysis

protogynous, proterogynous: of flowers, the stigma is receptive before the pollen is shed; of inflorescences, the female flowers mature before the male ones

provenance: origin; a collection of pollen, seed or propagules from a certain restricted locality

proximal: in botany: the part nearest the axis (as opposed to distal); in human anatomy: relatively nearer to the central part of the body or point of origin

pruning: cutting off the superfluous branches or shoots of a plant for better shape or more fruitful growth
pruritus: itching; any of various conditions marked by itching
pseudocarp: false fruit, a fruit not derived solely from the ovary, but also from adnate parts, e.g. a pome, an aggregate fruit
pseudoraceme: raceme-like inflorescence but not a true raceme
psoriasis: a common chronic, scaly dermatosis with polygenic inheritance and a fluctuating course
psychomotor: pertaining to motor effects of cerebral or psychic activity
psychosis: a mental disorder marked by gross impairment in reality testing, reflected in delusions, hallucinations, incoherent speech or disorganized and agitated behaviour; also used in a more general sense for mental disorders in which impairment of mental functioning interferes with the capacity to meet the ordinary demands of life
puberulent: covered with down or fine hairs
puberulous: minutely pubescent
pubescent: covered with soft short hairs
pulp: the soft fleshy part of the fruit; mechanically ground or chemically digested wood used in manufacturing paper and allied products
pulses: dry edible seeds of legumes
pulvinate: cushion-shaped
pulvinus: a minute gland or swollen petiole base.
punctate: marked with dots or translucent glands
pungent: bearing a sharp point; causing a sharp or irritating sensation
purgative: causing evacuation of the bowels; an agent causing evacuation of the bowels, especially through stimulating peristaltic action; also called cathartic
pustular, pustulate: with blister-like prominences
pyrene: a nutlet or kernel; the stone of a drupe or similar fruit
pyrexia: fever; an abnormal elevation of the body temperature
pyriform: resembling a pear in shape
pyrrolizidine alkaloids: a subgroup of the alkaloids; see also alkaloids
quadrangular: four-cornered or four-edged
quadrate: approximately square or cubical
quassinoids: a subgroup of the saponins; the aglycone is a modified triterpene which has lost 10 carbons, and thus could be misinterpreted as a diterpene; most quassinoid structures also include a lactone function in the molecule; see also saponins
quinoline alkaloids: a subgroup of the alkaloids; see also alkaloids
quinones: a group of oxygen-containing homologues of aromatic derivatives, characterized by a diketo pattern (dione-structure)
raceme: an unbranched elongated indeterminate inflorescence with stalked flowers opening from the base upwards
racemose: raceme-like
rachis (plural: rachides): the principal axis of an inflorescence or a compound leaf beyond the peduncle or petiole
radial: lengthwise, in a plane that passes through the pith; radiating, as from a centre (cf. tangential)
radical: arising from the root, or its crown
radicle: the first root of an embryo or germinating seed
rain forest: a tropical forest receiving an annual rainfall of at least 1800 mm, characterized by lofty evergreen trees forming a continuous canopy below which terrestrial herbs and shrubs are poorly developed
ramification: branching
ramified: branched
ramiflorous: bearing flowers on the branches
raphe: a ridge on a seed, formed by a portion of the funicle that is adnate to the ovule, as in an anatropous ovule
raphid (plural: raphides): a needle-shaped crystal occurring typically as one of a closely packed, sheaf-like bundle and consisting of calcium oxalate
rash: a temporary eruption on the skin, as in urticaria
ray: the radiating branch of an umbel; the outer floret of an inflorescence of the *Compositae* with straplike perianth which differs from those in the centre or disk
receptacle (botany): the flat, concave or convex part of the axis from which the parts of the flower arise
recurved: bent or curved downward or backward
reduced: subnormal in size; connotes also either a failure to fulfil a normal function, or a diminution the expected number of parts in a set (of stamens, for example)
reflexed: abruptly bent or turned downward or backward
reforestation: the planting of a formerly forested area with forest trees
refrigerant: in medicine: an agent that relieves fever and thirst

regular: of a radially symmetrical flower; actinomorphic
reniform: kidney-shaped
repand: with an undulating margin
replum: a frame-like placenta from which the valves fall away in dehiscence
resin: solid to soft semisolid amorphous fusible flammable substance obtained as exudate or as an extract of plants
resinous: exuding, made of, or similar to resin
resolvent: promoting resolution or the dissipation of a pathological growth
restorative: capable of restoring health, strength, consciousness; an agent having this capability
reticulate: netted, as when the smallest veins of a leaf are connected together like the meshes of a net
retrorse: turned or directed backward or downward (opposed to antrorse)
retuse: with a shallow notch at a rounded apex
revolute: of leaves with the margins, rolled downwards towards the midrib
rheumatism: any of various disorders, characterized by inflammation, degeneration, or metabolic derangement of the connective tissue structures of the body, especially the joints and related structures, and accompanied by pain, stiffness or limited mobility of these parts
rhinitis: inflammation of the mucous membrane of the nose
rhizobia: bacteria of the genus *Rhizobium* capable of forming symbiotic nodules on the roots of leguminous plants and able to fix atmospheric nitrogen
rhizome: an underground stem which is distinguished from a root by the presence of nodes, buds, and leaves or scales
rhombic: shaped like a rhomb, an equilateral oblique-angled figure
rhomboid (botany): quadrangular, diamond-shaped with the lateral angles obtuse
ringworm: popular name for tinea, which is a term used to describe various fungal skin infections. The name refers to the ring-shaped lesions
riparian: growing on the banks of streams or rivers
rootstock: see rhizome; a stock for grafting consisting of a root and part of the main axis
rosette: a cluster of leaves or other organs in a circular form
rostrum: a beak-like extension
rosulate: collected in a rosette
rot: disintegration of tissue due to the action of invading organisms, usually bacteria or fungi; a disease so characterized
rotate: wheel-shaped; circular and flat
rotund: rounded in outline, somewhat orbicular, but a little inclined towards oblong
rubefacient: reddening the skin by causing hyperaemia (an excess of blood); an agent that reddens the skin
rudimentary: of organs, imperfectly developed and non-functional
rugose: wrinkled
ruminate: of endosperm, mottled in appearance, due to the infolding of a dark inner layer of the seed-coat into the paler coloured endosperm
rust: a disease caused by, and a species in, the class *Urediniomycetes*, order *Uredinales*; so called because of the yellowish to orange brown colour of the spores
saccate: pouched
sagittate: shaped like an arrowhead; of a leaf base with two acute straight lobes directed downwards
samara: an indehiscent winged fruit
saponin: a glycoside with soap properties
saponins: the term is applied to a group of glycosides which have the ability to lower the surface tension of aqueous solutions
sapwood: the outer layers of wood adjacent to the bark which in the living tree contain living cells and reserve materials
sarcoma: any of a group of tumours usually arising from connective tissue, most of which are malignant
scaberulous: somewhat rough
scabies: a contagious dermatitis caused by the itch mite (*Sarcoptes scabiei*) that burrows under the skin and deposit eggs, causing intense itching
scabrid, scabrous: rough to the touch
scale: a thin scarious body, often a degenerate leaf or a trichome of epidermal origin
scandent: climbing
scape: a leafless floral axis or peduncle arising from the ground
scarification: of seed, the cutting or softening of the wall of a hard seed to hasten germination
schistosomiasis: infection with flukes of the genus *Schistosoma*; sometimes called bilharzia
schizocarp: a dry fruit formed from a syncarpous ovary which splits into one-seeded portions, mericarps or 'split fruits'
schizocarpous: in the form of a schizocarp
scleroderma: chronic hardening and thickening of the skin, which may be a finding in several different diseases
scorpioid: circinate; coiled as to resemble a scorpion

scrofula: tuberculosis of the lymph nodes of the neck
scrub: vegetation whose growth is stunted because of lack of water coupled with strong transpiration
scurf: abnormal skin condition in which small flakes or scales become detached
scurfy: bearing small scales on the surface (lepidote; scaly)
scurvy: a disease resulting from a deficiency of vitamin C in the body, characterized by weakness, anaemia, spongy gums, bleeding from mucous membrane, etc.
seborrhoea: excessive secretion of an oily substance (sebum) from certain glands of the skin (sebaceous glands), which are abundant on the scalp, face, chest, back, armpit and groin
secondary vegetation: a plant cover that has been disturbed by natural causes or by man
section (botany): a taxonomic rank between the genus and the species accommodating a single or several related species
sedative: allaying activity and excitement; an agent that allays excitement
seed: the reproductive unit formed from a fertilized ovule, consisting of embryo and seed-coat, and, in some cases, also endosperm
seedling: a plant produced from seed; a juvenile plant, grown from a seed
segment: one of the divisions into which a plant organ, as a leaf or a calyx, may be cleft; the division of a palmate or costapalmate leaf
self-incompatible: self-sterile, i.e. not capable of producing seed without cross-pollination
semi-: prefix, meaning half or incompletely, e.g. semi-inferior
seminal vesicle: either of the paired, sacculated pouches attached to the posterior part of the urinary bladder
senescence: advancing in age
sensu lato (s.l.): in the broad sense
sensu stricto (s.s.): in the strict sense
sepal: a member of the outer series of perianth segments
septate: divided by one or more partitions
septicidal: dehiscing along the septa of the ovary
septum (plural: septa): a partition or cross-wall
seriate: serial, disposed in series of rows
sericeous: silky
serrate: toothed like a saw, with regular pointed teeth pointing forwards
serrulate: serrate with minute teeth
sesquiterpene: a terpene of molecular formula $C_{15}H_{24}$, e.g. caryophyllene and farnesene
sesquiterpenes: a subgroup of the isoprenoids, formed by coupling of 3 C_5 units; see also isoprenoids
sessile: without a stalk
seta (plural: setae): a bristle-like body
setulose: set with small bristles or bristle-like elements
shaggy: villous
sheath: a tubular structure surrounding an organ or part, as the lower part of the leaf clasping the stem in grasses
shell: the hard envelope of a nut
shellac: a purified lac resin prepared by heating and filtering lac from lac insects
shingles: an acute, infectious skin disease, characterized by neuralgia and eruptions sometimes extending half round the body like a girdle; also called herpes zoster
shoot: the ascending axis, when segmented into dissimilar members it becomes a stem; a young growing branch or twig
shrub: a woody plant which branches from the base, all branches being equivalent (see also tree)
sialagogue: an agent promoting the flow of saliva
sigmoid, sigmoidal: doubly curved in opposite directions, like the letter s
siliceous: containing silica
silique: a dry and many-seeded dehiscent fruit splitting into 2 valves with a false partition
silviculture: the theory and practice of controlling the establishment, composition, constitution, and growth of forests; the science and art of cultivating forest crops
simple (botany): not compound, as in leaves with a single blade
sinuate: with a deep wavy margin
sinuous: wavy
sinusitis: inflammation of a sinus (cavity)
softwood: the wood of a coniferous tree
sole crop: one crop grown alone in pure stands (also called single crop)
solubility: the weight of a solute required to saturate 100 g of a solvent at a given temperature
solvent extraction: see extraction
somatic embryogenesis: the production of embryo-like structures (embryoids) from sporophytic or somatic cells of the plant, as opposed to gametophytic or germ cells (zygotic embryogenesis)
soporific: a drug or other agent that induces sleep
sore: popular term for almost any lesion of the skin or mucous membranes
spadix: a flower spike with a fleshy or thickened axis, as in aroids and some palms

spasmodic: of the nature of a spasm, i.e. a sudden, violent, involuntary contraction of a muscle or of a group of muscles
spasmolytic: checking spasms; antispasmodic
spastic: of the nature of or characterized by spasms
spathaceous: resembling a spathe
spathe: a large bract enclosing a spadix, or two or more bracts enclosing a flower cluster
spatulate (also: spathulate): spoon-shaped
spectroscopy: examination by means of a spectroscope, i.e. an optical instrument for forming and analysing spectra emitted by substances or bodies
spermatogenesis: the process of formation of spermatozoa
spermatorrhoea: involuntary, abnormally frequent, and excessive emission of semen without copulation
spherical: globular
spicate: spike-like
spiciform: with the form of a spike
spike: a simple indeterminate inflorescence with sessile flowers along a single axis
spine (botany): a short, stiff, straight, sharp-pointed, hard structure usually arising from the wood of a stem
spinescent: ending in a spine or sharp point
spinose, spinous: having spines
spinulose: with small spines
spiral: as though wound round an axis
spore: in cryptogams a cell which becomes free and capable of direct development into a new bion; the analogue of seed in phanerogams
sprue: a chronic deficiency syndrome due to subnormal absorption of dietary constituents
stain: discoloration or variation from natural colour due to fungi, chemical action or other causes
stamen: one of the male reproductive organs of a flower; a unit of the androecium
staminate: a flower bearing stamens but no pistil
staminode: an abortive or rudimentary stamen without or with an imperfect anther
standard (botany): the fifth, posterior or upper petal of a papilionaceous corolla
starch: polysaccharide made up of a long chain of glucose units joined by α-1,4 linkages, either unbranched (amylose) or branched (amylopectin) at a α-1,6 linkage, and which is the storage carbohydrate in plants, occurring as starch granules in amyloplasts, and which is hydrolysed by animals during digestion by amylases, maltase and dextrinases to glucose via dextrins and maltose
steam distillation: distillation using steam injected under pressure into a distillation vessel
stellate: star-shaped, as of hairs with radiating branches, or of petals arranged in the form of a star
stem: the main ascending axis of a plant; in bamboos usually named culm, in other plant groups occasionally
stenosis: narrowing or stricture of a duct or canal
stereoisomer: one of two or more isomers that have the same structure (linkages between atoms) but different configurations (spatial arrangements)
sterile: unable to produce offspring; in plants: failing to complete fertilization and produce seed as a result of defective pollen or ovules; not producing seed capable of germination; lacking functional sexual organs (sterility)
steroid saponins: a subgroup of the saponins; see also saponins
steroidal alkaloids: a subgroup of the alkaloids; see also alkaloids
steroids: a group of modified triterpenes which contain a ring system of three 6-membered and one 5-membered rings
stigma: the portion of the pistil which receives the pollen
stigmatose: provided with stigmas or having them conspicuously
stimulant: producing a temporary increase of the functional activity or efficiency of an organism or any of its parts; an agent acting so
stipe: the stalk supporting a carpel or gynoecium
stipel: small secondary stipule at the base of a leaflet
stipitate: borne on a stipe or short stalk
stipulate: with or bearing stipules
stipule: a scale-like or leaf-like appendage at the base of a petiole
stoloniferous: bearing a stolon or stolons
stomachic: pertaining to the stomach; a medicine stimulating the action of the stomach
stone: the hard endocarp of a drupe containing the seed or seeds
straggling: extremely divergent, spreading very far apart; irregular, bushy
strain: a group of individuals of a common origin, usually a more narrowly defined group than a cultivar
strangury: slow and painful urination
stratification: a moist, cold treatment of seed to overcome physiological dormancy
striate: marked with fine longitudinal parallel lines, as grooves or ridges
strigillose: covered with minute stiff hairs

strigose: with short stiff hairs lying close along the surface

stump: seedling with trimmed roots and shoot and used as planting stock; the part of anything that remains after the main part has been removed, e.g. the part of a tree remaining attached to the root after the trunk is cut

style: the part of the pistil connecting the ovary with the stigma

styptic: astringent, tending to check bleeding through astringent properties; a remedy which is astringent and arrests bleeding

sub-: prefix, meaning somewhat or slightly (e.g. subacute), or below (e.g. subterranean) or less than, imperfectly

subfamily: a taxonomic rank between the family and the tribe denoting a part of a family

subglobose: nearly globular

subshrub: a small shrub which may have partially herbaceous stems

subspecies: a subdivision of a species, in rank between a variety and a species

subulate: awl-shaped, sharply pointed

succulent: juicy, fleshy

sucker: a shoot, usually originating from adventitious buds on the roots or basal stem parts, which does not fit in the architectural model, but is capable of repeating the model

sudorific: causing or promoting the flow of sweat; an agent causing sweating

suffrutescent: obscurely shrubby

sulcate: grooved or furrowed

superior: of an ovary, with the perianth inserted below or around its base, the ovary being attached at its base only

suture: the line of junction of two carpels; the line or mark of splitting open

symbiosis: the intimate living together of two dissimilar organisms in a mutually beneficial relationship

sympatholytic: opposing the effects of impulses conveyed by adrenergic postganglionic fibres of the sympathetic nervous system

sympathomimetic: mimicking the effects of impulses conveyed by adrenergic postganglionic fibres of the sympathetic nervous system

sympatrically: occupying an area together with another species

sympodial: of a stem in which the growing point either terminates in an inflorescence or dies, growth being continued by a new lateral growing point

synandrium: the cohesion of the anthers of each male flower, e.g. in certain *Araceae*

syncarp: a multiple or fleshy aggregate fruit, including fruit produced from a more or less entire inflorescence (as in *Artocarpus*, *Ananas*, *Morus*)

syncarpous: of an ovary composed of two or more united carpels

synergistic effect: the phenomenon of a mutually cooperating activity of substances, which in a mixture produce a greater effect than when taken alone

syphilis: a disease usually communicated by sexual contact, or via the blood or bite of an infected person, caused by a spirochete (*Treponema pallidum*) and characterized by a clinical course in 3 stages continued over many years

tachycardia: excessive rapidity of the heartbeat, usually applied to a pulse rate of more than 100 in an adult

taeniafuge: an agent expelling tapeworms

tannins: a large group of plant-derived phenolic compounds

taproot: the primary descending root, forming a direct continuation of the radicle

taxon (plural: taxa): a term applied to any taxonomic unit irrespective of its classification level, e.g. variety, species, genus, etc.

taxonomy: the study of principles and practice of classifying living organisms (systematics)

tepal: a segment of a perianth, applied when no distinction between sepals and petals can be made

teratogenic: tending to produce anomalies of formation or development

terete: cylindrical; circular in transverse section

terminal: placed at the end or apex; a termination, end or extremity

termite: ant-like organism of the order *Isoptera* damaging wood by characteristic irregular honeycombing or wide channels with dry bore-dust or dust cemented together

ternate: in threes

terpene: an unsaturated hydrocarbon of molecular formula $(C_5H_8)n$. In monoterpenes n=2, in sesquiterpenes n=3. The term terpene is often used to refer to a terpenoid

terpenes: see isoprenoids

terpenoid: a chemical compound derived from a terpene

terpenoids: see isoprenoids

terrestrial: on or in the ground

testa: the outer coat of the seed

tetanus: an acute, often fatal, infectious disease characterized by muscular contractions and abnormal reflexes, and caused by a toxin produced by *Clostridium tetani*, a bacillus which is usually introduced through a wound

tetrahedral: having or made up of four sides
tetraploid: having four times ($4n$) the basic number of chromosomes or twice the diploid number ($2n$)
theca (plural: thecae): a spore- or pollen-case
thinning: removing trees, stems or plants from immature or mature stands in order to stimulate the growth of the remaining trees, stems or plants
thorn: a woody sharp-pointed structure formed from a modified branch
throat (botany): of a corolla, the orifice of a gamopetalous corolla
thrombosis: the formation, development or presence of an aggregation of blood factors (thrombus), often causing vascular obstruction
thrush: infection of the mucous membrane of the mouth with a fungus of the genus *Candida*, especially *C. albicans*, and characterized by the formation of creamy, white, somewhat elevated lesions
thyrse (thyrsus): a compound inflorescence composed of a panicle (indeterminate axis) with the secondary and ultimate axes cymose (determinate)
thyrsiform: shaped like a thyrse
thyrsoid: like a thyrse
tiller: a shoot from the axils of the lower leaves, e.g. in some grasses and palms (making such shoots: tillering)
tincture: an alcoholic or hydroalcoholic solution of some principle used in medicine
tissue culture: a body of tissue growing in a culture medium outside the organism
tomentose: densely covered with short soft hairs
tomentum: pubescence
tonic: restoring or producing the normal tone (degree of vigour and tension) of tissue or organs; characterized by continuous tension (e.g. tonic spasm); medicinal preparation believed to have the power of restoring normal tone to tissue or organs
topical: pertaining to a particular surface area, as a topical anti-infective applied to a certain area of the skin and affecting only the area to which it is applied
torus: = receptacle
trailing: prostrate, but not rooting
tranquillizer: a drug with a calming, soothing effect
transgenic: pertaining to the experimental splicing of a segment of DNA from one genome to DNA of a different genome
transverse: straight across; of tertiary veins, connecting the secondary veins, not necessarily in a perpendicular way
trauma: a wound or injury, whether physical or psychic
tree: a perennial woody plant with a single evident trunk (see also shrub)
tribe: a taxonomic rank between the family and the genus
trifid: cleft in three parts
trifoliolate: with three leaflets
trigonous: three-angled, with plane faces
triploid: having three times the basic number of chromosomes, usually written $3n$
triquetrous: three-edged, with three salient angles
triterpene saponins: a subgroup of the saponins; see also saponins
triterpenes: a subgroup of the isoprenoids, formed by coupling of 6 C_5 units; see also isoprenoids
tropane alkaloids: a subgroup of the alkaloids; see also alkaloids
truncate: cut off more or less squarely at the end
trunk: the main stem of a tree apart from its limbs and roots
trypanosomiasis: the state of being infected with protozoa of the genus *Trypanosoma* (trypanosomes), which destroy the red corpuscles and cause serious and even fatal diseases, as the sleeping sickness
tuber: the swollen portion of an underground stem or root which acts as a storage organ and propagule; it is usually of one year's duration, those of successive years not arising directly from the old ones nor bearing any constant relation to them
tubercle: a small tuber-like excrescence
tuberculate: covered with warty protuberances
tuberculosis: any of the diseases in man and animals caused by *Mycobacterium* spp., characterized by the formation of lesions (tubercles) and necrosis in the tissue of the lung or other organs and having a tendency to great chronicity
tuberous: producing tubers or resembling a tuber
tufted: growing in tufts (caespitose)
tumour necrosis factor: a substance (lymphokine) produced by macrophages, capable of causing in vivo haemorrhagic necrosis of certain tumour cells, but not affecting normal cells
turbinate: top-shaped
tussock: a tuft of grass or grass-like plants
twining: winding spirally
tympanites: swelling of the abdomen, due to the accumulation of gas or air in the intestine or in the peritoneal cavity
tympanitis: inflammation of the lining membrane

of the tympanum (middle ear)
ulcer: an open sore on an external or internal body surface, usually accompanied by disintegration of tissue and formation of pus
ultrabasic: of soil, very low in silica and rich in ferromagnesian minerals as in e.g. serpentine soils
ultramafic: of rock, containing high concentrations (more than 70%) of magnesium (Mg) and iron (Fe) hence the term ultramafic
umbel: an indeterminate, often flat-topped inflorescence whose divergent peduncles (rays) and pedicels arise from a common point; in a compound umbel each ray itself bears an umbellule (small umbel)
umbelliform: umbrella-shaped
unarmed: devoid of thorns, spines or prickles
undershrub: any low shrub; partially herbaceous shrub, the ends of the branches perishing during the winter
undulate: wavy, said for instance of a leaf margin if the waves run in a plane at right angles to the plane of the leaf blade
unguiculate: contracted at the base into a claw
unifoliolate: with one leaflet only, but in origin a compound leaf
unilateral: one-sided
unilocular: one-celled
uniparous: bearing one, as a cyme giving forth one axis at each branching
uniseriate: in one horizontal row or series
unisexual: of one sex, having stamens or pistils only
urceolate: urn-shaped
urticaria: a vascular reaction, acute or chronic, which can have various causes and is characterized by the development of weals on the skin
uterotonic: giving muscular tone to the uterus
utricle: a small bladdery pericarp
vagotomy: interruption of the impulses carried by the vagus nerve or nerves
valvate: of perianth segments, with their edges in contact, but not overlapping in the bud
valve: one of the parts produced by a dehiscing capsule
variegated: irregularly coloured in patches, blotched
variety: a botanical variety which is a subdivision of a species; an agricultural or horticultural variety is referred to as a cultivar
vas deferens: the excretory duct of the testis, which unites with the excretory duct of the seminal vesicle to form the ejaculatory duct; also called ductus deferens (deferent duct)
vasoconstriction: diminution of the calibre of vessels, especially of arterioles
vasodilatation: a state of increased calibre of the blood vessels
vasodilation: dilation of a vessel, especially dilation of arterioles leading to increased blood flow to a part
vein (botany): a strand of vascular tissue in a flat organ, such as a leaf
velutinous: see velvety
velvety: with a coating of fine soft hairs; the same as tomentose but denser so that the surface resembles (and feels like) velvet
venation (botany): the arrangement of the veins in a leaf
veneer: a thin sheet of wood
veneer grafting: a form of side grafting in which a small slice of rootstock is removed and replaced by the scion base; the main cut on the rootstock is made nearly vertical to remove a comparatively thin sliver of bark and wood with a second horizontal cut at an angle of 45° at the base of the main cut; the scion is trimmed to a one-sided wedge which is laid on the rootstock wound and the cambial layers aligned on at least one side (= side-veneer grafting)
venereal: pertaining or related to or transmitted by sexual contact
venous: of or pertaining to the veins
ventral: in botany: facing the central axis (adaxial), opposed to dorsal (abaxial); in human anatomy: pertaining to the abdomen, or denoting a position more toward the belly surface than some reference object
ventricose: with a swelling or inflation on one side
ventricular: pertaining to a ventricle, i.e. a small cavity, such as one of the several cavities of the brain, or one of the lower chambers of the heart
vermifuge: an agent expelling worms or intestinal animal parasites; an anthelminthic
versatile (botany): turning freely on its support, as anthers on their filaments
verticillate: in a whorl with several elements arising at the same node
vertigo: an illusory sense that the surroundings or one's own body are revolving
vesicant: causing blisters; an agent that induces blistering
vesicle (botany): a small bladder or cavity
vesicular: bladder-like
vesicular stomatitis: a vesicular eruption caused by a virus and affecting pigs, cattle and horses
vestigial: small and imperfectly developed
viability: ability to live, grow and develop
villose (villous): with long weak hairs
vine: a plant having a stem that is too slender to

hold itself erect and therefore supports itself by climbing over an object; the stem itself

viscid: sticky

viscous: glutinous, or very sticky

vitiligo: a chronic, usually progressive, pigmentary anomaly of the skin, manifested by depigmented white patches that may be surrounded by a hyperpigmented border

viviparous: germinating or sprouting from seed or bud while attached to the parent plant

volatile: a volatile substance is one that evaporates at room temperature. It is an essential property of odorous materials

vulnerary: pertaining to wounds or the healing of wounds; an agent promoting the healing of wounds

warty: covered with firm roundish excrescences

waterlogged: flooded with water, generally for a period of at least a few weeks

wax: waxes are mixtures of esters of higher alcohols and higher fatty acids. Waxes are used as stiffening agents in the manufacture of cosmetics. Natural plant waxes are removed from concretes to produce absolutes

whorl: arrangement with more than two organs of the same kind arising at the same level

wilt: loss of turgidity, usually in leaves, typically caused by pathogens which colonize the vascular system

wind-break: one to several rows of closely spaced, preferably low branching trees planted to protect adjacent areas from strong winds

wing: any membraneous expansion attached to an organ; a lateral petal of a papilionaceous corolla

wood: the hard, compact, fibrous substance between pith and bark

woolly: clothed with long and tortuous or matted hairs

xenobiotic: a chemical foreign to the biological system

xerophytic: relating to a plant structurally adapted for life and growth with a limited water supply

xylem: the main water-conducting tissue in vascular plants which extends throughout the body of the plant and is also involved in transport of minerals, food storage and support; primary xylem is derived from the procambium, secondary xylem (e.g. the wood of trees and shrubs) from the vascular cambium; xylem is composed of tracheary elements: tracheids and (in angiosperms) vessel elements; both are elongated hollow cells, with thickened, usually heavily lignified walls, and lacking protoplasts when mature; they are joined end to end to form a continuous conducting tube

yaws: an infectious, tropical disease caused by a spirochete (*Treponema pertenue*), usually affecting children under 15, and marked by skin elevations (papules) and papilloma, with later manifestations including deformation of skin, bone and joints (also called framboesia)

zygomorphic: irregular and divisible into equal halves in one plane only

zygote: the cell formed from the fusion of two gametes; a fertilized egg

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sen nuttige Indische planten [Sketches of useful Indonesian plants]. Series 1 (1–50). Extra Bulletin van het Koloniaal Museum. J.H. de Bussy, Amsterdam, the Netherlands. p. 110 (flowering and fruiting twig). Redrawn and adapted by Iskak Syamsudin.

Basilicum polystachyon: Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G. (Editors), 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. p. 317, fig. 4.143. Redrawn and adapted by Achmad Satiri Nurhaman.

Biophytum sensitivum: Backer, C.A., 1938. Onkruidflora der Javasche suikerrietgronden. Handboek ten dienste van de suikerriet-cultuur en de rietsuiker-fabricage op Java. Deel 7(12–13) (atlas) [Weed flora of Javanese sugar-cane fields. Handbook for the cultivation of sugar-cane and manufacturing of cane-sugar in Java. Vol. 7(11–12)(atlas)]. Vereeniging het Proefstation voor de Java-Suikerindustrie, Pasuruan, Indonesia. pl. 373. (flowering plant habit). Redrawn and adapted by Iskak Syamsudin.

Boerhavia diffusa: Liu, T.-S., 1976. Nyctaginaceae. In: Li, H.-L., Liu, T,-S., Huang, T.-C., Koyama, T. & DeVol, C.E. (Editors): Flora of Taiwan. Vol. 2. Epoch Publishing Co., Taipei, Taiwan, Republic of China. p. 298, fig. 301 (flowering and fruiting stem, flower, part of infructescence). Redrawn and adapted by Achmad Satiri Nurhaman.

Borreria laevis: Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G. (Editors), 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. p. 497, fig. 4.232. Redrawn and adapted by Achmad Satiri Nurhaman.

Breynia vitis-idaea: Matthew, K.M., 1988. Further illustrations on the Flora of the Tamilnadu Carnatic. The Rapinat Herbarium, St. Joseph's College, Tiruchirapalli, India. p. 544, pl. 544 (twig, male flower, female flower, female flower in longitudinal section, male flower with calyx partly removed). Redrawn and adapted by Achmad Satiri Nurhaman.

Caesalpinia bonduc: Council of Scientific and Industrial Research, 1950. The wealth of India: a dictionary of Indian raw materials & industrial products. Vol. 2. Publications and Information Directorate, New Delhi, India. p. 3, fig. 2 (flowering twig); Tomlinson, P.B., 1986. The botany of mangroves. Cambridge University Press, Cambridge, United Kingdom, New York, United States & Melbourne Australia. p. 256, fig. B.33, p. 257, fig. B.34 (node with pinnate stipules, male flower side view, male flower frontal view, part of infructescence). Redrawn and adapted by Achmad Satiri Nurhaman.

Callicarpa candicans: Gutierrez, H.G., 1982. An illustrated manual of Philippine materia medica. Natural Research Council of the Philippines, Tagig, Metro Manila, the Philippines. Vol. 2. p. 440 (flowering and fruiting twig; detail of inflorescence); Munir, A.A., 1982. A taxonomic revision of the genus Callicarpa L. (Verbenaceae) in Australia. Journal of the Adelaide Botanic Gardens 6(1). p. 21, fig. 4,(flower, opened flower). Redrawn and adapted by Achmad Satiri Nurhaman.

Calotropis gigantea: Watt, G., 1900. II. Madar (Calotropis gigantea R. Br.). Kew Bulletin 1900. p. 8a (flowering branch, gynostegium in longitudinal section); Matthew, K.M., 1988. Further illustrations on the Flora of the Tamilnadu Carnatic. The Rapinat Herbarium, St. Joseph's College, Tiruchirapalli, India. p. 437, pl. 437 (pollinium, follicle). Redrawn and adapted by Achmad Satiri Nurhaman.

Capparis zeylanica: Jacobs, M., 1960. Capparidaceae. In: van Steenis C.G.G.J. (Editor): Flora Malesiana. Series 1, Vol. 6. Wolters-Noordhoff, Groningen, the Netherlands. p. 72, fig. 5 (flowering twig, leaves still young, flower, fruiting branch with opened fruit). Redrawn and adapted by Achmad Satiri Nurhaman.

Cassytha filiformis: Chang, C.-E., 1976. Lauraceae. In: Li, H.-L., Liu, T,-S., Huang, T.-C., Koyama, T. & DeVol, C.E. (Editors): Flora of Taiwan. Vol. 2. Epoch Publishing Co., Taipei, Taiwan, Republic of China. p. 410, fig. 354 (plant habit, flower, glandular stamen, eglandular stamen, fruit). Redrawn and adapted by Achmad Satiri Nurhaman.

Cayratia japonica: Lu, F.-Y., 1976. Vitaceae. In: Li, H.-L. et al. (Editors): Flora of Taiwan. Vol. 3. Epoch Publishing Co., Taipei, Taiwan, Republic of China. p. 669, pl. 770 (flowering branch, flower and bud, part of infructescence). Redrawn and adapted by Iskak Syamsudin.

Celastrus paniculatus: Chuakul, W., Saralamp, P., Paonil, W., Temsiririrkkul, R. & Clayton, T. (Editors), 1997. Medicinal plants in Thailand. Vol. II. Department of Pharmaceutical Botany, Faculty of Pharmacy, Mahidol University, Bangkok, Thailand. p. 60 (male inflorescence, infructescence); Matthew, K.M., 1982. Illustrations on the flora of the Tamilnadu Carnatic. Vol. 2. The Rapinat Herbarium, St. Joseph's College, Tiruchirapalli, India. p. 142, pl. 142 (male flower, female flower detail of pistil). Re-

drawn and adapted by Achmad Satiri Nurhaman.

Centipeda minima: Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G. (Editors), 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. p. 71, fig. 4.21 (plant habit, flower head); Matthew, K.M., 1982. Illustrations on the Flora of the Tamilnadu Carnatic. The Rapinat Herbarium, St. Joseph's College, Tiruchirapalli, India. pl. 358 (disk flower, marginal flower, achene of disk flower, achene of marginal flower). Redrawn and adapted by Iskak Syamsudin.

Cerbera odollam: Middleton, D.J., 1999. Apocynaceae. In: Santisuk, T., & Larsen, K. (Editors). Flora of Thailand. Vol. 7(1). The Forest Herbarium, Royal Forest Department, Bangkok, Thailand. p. 68, fig. 22 (flowering twig, flower, dissected flower, fruit). Redrawn and adapted by Iskak Syamsudin.

Cissus quadrangularis: Matthew, K.M., 1988. Further illustrations on the Flora of the Tamilnadu Carnatic. The Rapinat Herbarium, St. Joseph's College, Tiruchirapalli, India. p. 102, pl. 102 (flowering stem, flower, infructescence). Redrawn and adapted by Achmad Satiri Nurhaman.

Clausena excavata: Soepadmo, E. & Wong, K.M. (Editors), 1995. Tree flora of Sabah and Sarawak. Vol. 1. Sabah Forestry Department, Forest Research Institute Malaysia and Sarawak Forestry Department, Kepong, Malaysia. p. 368, fig. 4 (flowering branch, part of inflorescence (one flower with 2 petals removed), part of infructescence). Redrawn and adapted by Achmad Satiri Nurhaman.

Cleome viscosa: Liu, T.-S. & Liao, J.C., 1996. Capparidaceae. In: Huang, T.-C. (Editor): Flora of Taiwan. 2nd Edition. Vol. 2. Editorial Committee of the Flora of Taiwan, Taipei, Taiwan, Republic of China. p. 674, pl. 444 (flowering and fruiting stem, detail of dehiscing fruit); Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G. (Editors), 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. p. 125, fig. 4.48 (flower, side view); Jacobs, M., 1960. Capparidaceae. In: van Steenis C.G.G.J. (Editor): Flora Malesiana. Series 1, Vol. 6. Wolters-Noordhoff, Groningen, the Netherlands. p. 103, fig. 32 (fruit, seed). Redrawn and adapted by Achmad Satiri Nurhaman.

Clerodendrum inerme: Hsiao, J.Y., 1978. Verbenaceae. In: Li, H.-L., Liu, T,-S., Huang, T.-C., Koyama, T. & DeVol, C.E. (Editors): Flora of Taiwan. Vol. 4. Epoch Publishing Co., Taipei, Taiwan, Republic of China. p. 422, pl. 1058 (flowering branch); Saralamp, P., Chuakul, W., Temsiririrkkul, R. & Clayton, T. (Editors), 1996. Medicinal plants in Thailand. Vol. I. Department of Pharmaceutical Botany, Faculty of Pharmacy, Mahidol University, Bangkok, Thailand. p. 71 (detail of flower); Munir, A.A., 1989. A taxonomic revision of the genus Clerodendrum L. (Verbenaceae) in Australia. Journal of the Adelaide Botanic Garden 11(2). p. 111, fig. 1 (fruit with persistent calyx). Redrawn and adapted by Iskak Syamsudin.

Combretum sundaicum: Exell, A.W., 1954. Combretaceae. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Series 1, Vol. 4. Noordhoff-Kolff N.V., Djakarta, Indonesia. p. 543, fig. 6 (flowering twig, flower, fruit); Lecompte, O., 1969. Combretaceae. In: Tardieu-Blot, M.-L. (Editor): Flore du Cambodge, du Laos et du Viêtnam [Flora of Cambodia, Laos and Vietnam]. Vol. 10. Muséum National d'Histoire Naturelle, Paris, France. p. 45, pl. 6 (longitudinal section of flower). Redrawn and adapted by Iskak Syamsudin.

Commelina benghalensis: Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G. (Editors), 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. p. 129, fig. 4.50 (flowering stem, inflorescence, opened spathe with fruits, seed). Redrawn and adapted by Achmad Satiri Nurhaman.

Cordia dichotoma: Riedl, H., 1997. Boraginaceae. In: Kalkman, C., Kirkup, D.W., Nooteboom, H.P., Stevens, P.F. & de Wilde, W.J.J.O. (Editors): Flora Malesiana. Series 1. Vol. 13. Rijksherbarium/Hortus Botanicus, Leiden, the Netherlands. p. 76, fig. 4 (flowering branch, corolla with stamens and style, opened corolla with stamens, pistil, fruiting branch). Redrawn and adapted by Achmad Satiri Nurhaman.

Crateva magna: Koorders, S.H. & Valeton, T., 1918. Atlas der Baumarten von Java im Anschluss an die 'Bijdragen tot de kennis der boomsoorten van Java' [Atlas of tree species of Java in 'contribution to the knowledge of the tree species of Java']. Vol. 4. P.W.M. Trap. Leiden, the Netherlands. fig. 795 (tree habit, leaf, top of inflorescence, inflorescence (with slightly withered flowers), infructescence). Redrawn and adapted by Achmad Satiri Nurhaman.

Crescentia cujete: Purseglove, J.W., 1968. Tropical crops. Dicotyledons. Longman, London, United Kingdom. p. 631, fig. 96(habit, leafy shoot, flower, opened corolla). Redrawn and adapted by Iskak Syamsudin.

Crinum asiaticum: Hsieh, C.-F., 1978. Amaryllidaceae. In: Li, H.-L., Liu, T,-S., Huang, T.-C., Koyama, T. & DeVol, C.E. (Editors): Flora of Taiwan. Vol. 5. Epoch Publishing Co., Taipei, Taiwan, Republic of China. p. 92, fig. 1288 (flowering and fruiting plant, flower, fruit). Redrawn and adapted by Achmad Satiri Nurhaman.

Croton tiglium: Gutierrez, H.G., 1982. An illustrated manual of Philippine materia medica. Vol. 2. Natural Research Council of the Philippines, Tagig, Metro Manila, the Philippines. p. 447 (flowering and fruiting twig); Baillon, H., 1874. Histoire des plantes. Vol. 5. Géraniacées, Linacées, Trémandracées, Polygalacées, Vochysiacées, Euphorbiacées, Térébinthacées, Sapindacées, Malpighiacées, Méliacées [History of plants. Vol. 5. Geraniaceae, Linaceae, Tremandraceae, Polygalaceae, Vochysiaceae, Euphorbiaceae, Terebinthaceae, Sapindaceae, Malpighiaceae, Meliaceae]. Librairie Hachette & co., Paris, France & London, United Kigdom. p. 131, fig. 198, 200 (male flower in longitudinal section, female flower in longitudinal section). Redrawn and adapted by Iskak Syamsudin.

Cullen corylifolium: Matthew, K.M., 1982. Illustrations on the Flora of the Tamilnadu Carnatic. The Rapinat Herbarium, St. Joseph's College, Tiruchirapalli, India. p. 215, pl. 215 (flowering and fruiting twig); Nguyen Van Thuan, Dy Phon, P. & Niyomdhan, C., 1987. Légumineuses- Paplionoïdées [Leguminosae-Papilionoideae]. In: Lescot, M. (Editor): Flore du Cambodge, du Laos et du Viêtnam [Flora of Cambodia, Laos and Vietnam]. Vol. 23. Muséum National d'Histoire Naturelle, Paris, France. p. 149, pl 26 (stipules, base of leaflet, flower, pod). Redrawn and adapted by Achmad Satiri Nurhaman.

Cyathula prostrata: Liu, T.-S. & Kao, M.-T., 1996. Amaranthaceae In: Huang, T.-C. (Editor): Flora of Taiwan. 2nd Edition. Vol. 2. Editorial Committee of the Flora of Taiwan, Taipei, Taiwan, Republic of China. p. 404, pl. 188 (plant habit, flower cluster, stamens, urticle with seed). Redrawn and adapted by Achmad Satiri Nurhaman.

Deeringia amaranthoides: Backer, C.A., 1949. Amaranthaceae. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Series 1, Vol. 4. Noordhoff-Kolff, Djakarta, Indonesia. p. 71. fig. 1 (flowering and fruiting branch); Schinz, H., 1894. Amaranthaceae. In: Engler, A. & Prantl, K. (Editors): Die natürlichen Pflanzenfamilien [The natural plant families]. Part 3(1). Wilhelm Engelmann, Leipzig, Germany. p. 99, fig. 49 (part of inflorescence, flower). Redrawn and adapted by Achmad Satiri Nurhaman.

Dendranthema ×grandiflorum: Soreng, R.J. & Cope, E.A., 1991. On the taxonomy of cultivated species of the Chrysanthemum genus-complex (Anthemideae; Compositae). Baileya 23(3). p. 148, fig. 1 (flowering stem). Redrawn and adapted by Iskak Syamsudin.

Dendrobium crumenatum: Liu, T.-S. & Horng, J.-S., 1978. Orchidaceae. In: Li, H.-L. et al. (Editors): Flora of Taiwan. Vol. 5. Epoch Publishing Co., Taipei, Taiwan, Republic of China. p. 959, pl. 1578 (plant habit, inflorescence, flower, column). Redrawn and adapted by Achmad Satiri Nurhaman.

Dendrocnide stimulans: Chew, W.-L., 1969. A monograph of Dendrocnide (Urticaceae). The Gardens' Bulletin Singapore 25(1). p. 14, fig. 2 (female twig, detail female inflorescence, detail male inflorescence, detail infructescence, fruits). Redrawn and adapted by Achmad Satiri Nurhaman.

Dendrolobium triangulare: Dy Phon, P., Ohashi, H. & Vidal, J.E., 1994. Légumineuses – Desmodiées [Leguminosae (Fabaceae) Papilionoideae – Desmodieae]. In: Lescot, M., Vidal, J.E. & Vidal, Y. (Editors): Flore du Cambodge, du Laos et du Viêtnam [Flora of Cambodia, Laos and Vietnam]. Vol. 27. Muséum National d'Histoire Naturelle, Paris, France. p. 17, pl. 3 (flowering twig, flower, detail of infructescences, a selection of pods). Redrawn and adapted by Achmad Satiri Nurhaman.

Dianella ensifolia: Liu, T.-S. & Ying, S.-S., 1978. Liliaceae. In: Li, H.-L. et al. (Editors): Flora of Taiwan. Vol. 5. Epoch Publishing Co., Taipei, Taiwan, Republic of China. p. 50, pl. 1278 (plant habit, flower, dorsal and frontal view of stamen); Dahlgren, R.M.T., Clifford, H.T. & Yeo, P.F., 1985. The families of the Monocotyledons. Springer Verlag, Berlin, Heidelberg, Germany, New York, United States & Tokyo, Japan. p. 173. fig. 78 (fruit). Redrawn and adapted by Achmad Satiri Nurhaman.

Dichroa febrifuga: World Health Organisation & Institute of Materia Medica, 1990. Medicinal plants of Viet Nam. World Health Organisation Regional Publications, Western Pacific Series No 3. WHO/WPRO, Manila, the Philippines & Institute of Materia Medica, Hanoi, Vietnam (leafy shoot, roots); van Steenis, C.G.G.J., 1972. The mountain flora of Java. E.J. Brill, Leiden, the Netherlands. pl. 50-3 (inflorescence, detail of infructescence). Redrawn and adapted by Iskak Syamsudin.

Dichrocephala integrifolia: Li, H.-L., 1978. Compositae. In: Li, H.-L., Liu, T,-S., Huang, T.-C., Koyama, T. & DeVol, C.E. (Editors): Flora of Taiwan. Vol. 4. Epoch Publishing Co., Taipei, Taiwan, Republic of China. p. 848, fig. 1221 (flowering plant, pinnatifid leaf, head in cross-section, disk flower with opened corolla). Redrawn and adapted by Iskak Syamsudin.

Dioscorea zingiberensis: Doan Thi Nhu, Nguyen Thuong Thuc, Do Huy Bich & Vu Thuy Huyen (Editors), 1990. Les plants médicinales au Vietnam. Livre 2. Médicine traditionelle et pharmacopée [The medicinal plants of Vietnam. Volume 2. Traditional medicine and pharmacopoeia]. Agence de coopération Culturelle et Technique, Paris, France. p. 50, fig. 144 (tuber, flowering stem, infructescence, fruit). Redrawn and adapted by Achmad Satiri Nurhaman.

Dodonaea viscosa: Adema, F., Leenhouts, P.W. & Van Welzen, P.C., 1994. Sapindaceae. In: Kalkman, C., Kirkup, D.W., Nooteboom, H.P., Stevens, P.F. & de Wilde, W.J.J.O. (Editors): Flora Malesiana. Series 1, Vol. 11. Rijksherbarium/Hortus Botanicus, Leiden, the Netherlands. p. 525, fig. 24 (fruiting twig, fruit); Rivers, E.M., 1971. Variation in dioecism in cultivated Dodonaea viscosa. New Zealand Journal of Botany 9. p. 551, fig. 1 (male flower, bisexual flower, female flower). Redrawn and adapted by Iskak Syamsudin.

Eclipta prostrata: Backer, C.A. & van Steenis, C.G.G.J., 1973. Atlas of 220 weeds of sugar-cane fields in Java. Greshoff's Rumphius Fund, Amsterdam, the Netherlands. pl. 725 (plant habit); Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G. (Editors), 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. p. 77, fig. 4.24 (ligulate flower, tubular flower, achene). Redrawn and adapted by Iskak Syamsudin.

Elaeocarpus angustifolius: Sosef, M.S.M., Hong, L.T. & Prawirohatmodjo, S. (Editors), 1998. Plant Resources of South-East Asia No 5(3). Timber trees: Lesser-known timbers. Backhuys Publishers, Leiden, the Netherlands. p. 205 (tree habit, flowering twig, petal, anther, infructescence, stone).

Entada phaseoloides: Verdcourt, B., 1979. A manual of New Guinea legumes. Botany Bulletin No 11. Office of Forests, Division of Botany, Lae, Papua New Guinea. p. 136, fig. 33 (flowering twig, flower, pod, seed). Redrawn and adapted by Achmad Satiri Nurhaman.

Eriosema chinense: Verdcourt, B., 1979. A manual of New Guinea legumes. Botany Bulletin No 11. Office of Forests, Division of Botany, Lae, Papua New Guinea. p. 555, fig. 138 (habit, staminal column with pistil, pod); Nguyen Van Thuan, 1979. Légumineuses-Paplionoïdées Phaséolées [Leguminosae-Papilionoideae Phaseoleae]. In: Vidal, J.E. & Vidal, Y.(Editors): Flore du Cambodge, du Laos et du Viêtnam [Flora of Cambodia, Laos and Vietnam]. Vol. 17. Muséum National d'Histoire Naturelle, Paris, France. p. 139, pl. 22 (flower, details of corolla, tuber). Redrawn and adapted by Achmad Satiri Nurhaman.

Erythrina fusca: Faridah Hanum, I. & van der Maesen, L.J.G. (Editors), 1997. Plant Resources of South-East Asia No 11. Auxiliary plants. Backhuys Publishers, Leiden, the Netherlands. p. 122 (habit, flowering branch, flower, flower (petals removed), pod).

Eucommia ulmoides: Oliver, D. 1895. Hooker's Icones Plantarum 24: t. 2361 (fruiting twig). Redrawn and adapted by Achmad Satiri Nurhaman.

Evolvulus alsinoides: Van Oostroom, S.J., 1953. Evolvulus. In: van Steenis, C.G.G.J. (Editor). Flora Malesiana. Series 1, Vol. 4. Noordhoff-Kolff N.V., Djakarta, Indonesia. p. 397, fig. 5 (plant habit); Matthew, K.M., 1982. Illustrations on the Flora of the Tamilnadu Carnatic. The Rapinat Herbarium, St. Joseph's College, Tiruchirapalli, India. p. 479, pl. 479 (flower, part of corolla, cut open, pistil); Chang, C.-E., 1978. Convolvulaceae. In: Li, H.-L., Liu, T,-S., Huang, T.-C., Koyama, T. & DeVol, C.E. (Editors): Flora of Taiwan. Vol. 4. Epoch Publishing Co., Taipei, Taiwan, Republic of China. p. 359, fig. 1038 (fruit). Redrawn and adapted by Iskak Syamsudin.

Excoecaria agallocha: Matthew, K.M., 1982. Illustrations on the Flora of the Tamilnadu Carnatic. The Rapinat Herbarium, St. Joseph's College, Tiruchirapalli, India. p. 638, pl. 638 (twig with male inflorescences, fruiting twig); Tomlinson, P.B., 1986. The botany of mangroves. Cambridge University Press, Cambridge, United Kingdom, New York, United States & Melbourne Australia. p. 239, fig. B. 27(male inflorescence at early anthesis, male flower side view). Redrawn and adapted by Achmad Satiri Nurhaman.

Fallopia multiflora: Doan Thi Nhu, Nguyen Thuong Thuc, Do Huy Bich & Vu Thuy Huyen (Editors), 1990. Les plants médicinales au Vietnam. Livre 1. Médicine traditionelle et pharmacopée [The medicinal plants of Vietnam. Volume 1. Traditional medicine and pharmacopoeia]. Agence de coopération Culturelle et Technique, Paris, France. p. 126, fig. 083 (flowering stems, female flower, fruit, rhizome). Redrawn and adapted by Achmad Satiri Nurhaman.

Flemingia strobilifera: Matthew, K.M., 1988. Further illustrations on the Flora of the Tamilnadu Carnatic. The Rapinat Herbarium, St. Joseph's College, Tiruchirapalli, India. p. 163, pl. 163 (flowering twig, details of corolla, staminal column with pistil); Huang, T.-C. & Ohashi, H., 1993. Leguminosae. In: Huang, T.-C. (Editor): Flora of Taiwan. 2nd Edition. Vol. 3. Editorial Committee of the Flora of Taiwan, Taipei, Taiwan, Republic of China. p. 287, pl. 142 (inflorescence within bract, fruit). Redrawn and adapted by Iskak Syamsudin.

Gelsemium elegans: Leenhouts, P.W., 1962. Loganiaceae. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Series 1, Vol. 6. Wolters-Noordhoff Publishing, Groningen, the Netherlands. p. 344, fig. 27 (habit); Ornduff, R., 1970. The systematics and breeding system of Gelsemium. Journal of the Arnold Arboretum 50. p. 11, fig. 2 (short-homostyle flower, long-styled flower, short-styled flower, mature capsules, seed). Redrawn and adapted by Iskak Syamsudin.

Gleditsia fera: Ding Hou, Larsen, K. & Larsen, S.S., 1996. Caesalpiniaceae (Leguminosae-Caesalpinioideae). In: Kalkman, C., Kirkup, D.W., Nooteboom, H.P., Stevens, P.F. & de Wilde, W.J.J.O. (Editors): Flora Malesiana. Series 1, Vol. 12(2). Rijksherbarium/Hortus Botanicus, Leiden University, the Netherlands. p. 620, fig. 34 (flowering twig, leafy branch, flower bud, flower, pod). Redrawn and adapted by Iskak Syamsudin.

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Gmelina elliptica: Koorders, S.H. & Valeton, T., 1914. Atlas der Baumarten von Java im Anschluss an die 'Bijdragen tot de kennis der boomsoorten van Java' [Atlas of tree species of Java in 'contribution to the knowledge of the tree species of Java']. Vol. 2. P.W.M. Trap. Leiden, the Netherlands. fig. 278 (flowering twig, flower, detail of leaf base). Redrawn and adapted by Achmad Satiri Nurhaman.

Goniothalamus amuyon: Li, H.-L., 1976. Annonaceae. In: Li, H.-L., Liu, T,-S., Huang, T.-C., Koyama, T. & DeVol, C.E. (Editors): Flora of Taiwan. Vol. 2. Epoch Publishing Co., Taipei, Taiwan, Republic of China. p. 394, pl. 348 (leafy twig, part of leafless twig with infructescences); Gutierrez, H.G., 1982. An illustrated manual of Philippine materia medica. Vol. 2. Natural Research Council of the Philippines, Tagig, Metro Manila, the Philippines. p. 245 (flower). Redrawn and adapted by Achmad Satiri Nurhaman.

Guazuma ulmifolia: Pott, A. & Pott, V. J., 1997. Plants of Pantanal. Embrapa SPI, Brasilia, Brazil. p. 274 (flowering twig, fruit); Matthew, K.M., 1982. Illustrations on the Flora of the Tamilnadu Carnatic. The Rapinat Herbarium, St. Joseph's College, Tiruchirapalli, India. p. 75, pl. 75 (flower, petal, staminal column, pistil). Redrawn and adapted by Achmad Satiri Nurhaman.

Harrisonia perforata: Blanco, M., 1882. Flora de Filipinas. Lâminas 1 [Flora of the Philippines. Plates 1], Manila, the Philippines. No. 23 (flowering and fruiting twig); Nooteboom, H.P., 1962. Simaroubaceae. In: van Steenis C.G.G.J. (Editor): Flora Malesiana. Series 1, Vol. 6. Wolters-Noordhoff, Groningen, the Netherlands. p. 208, fig. 9 (flowering twig, flower). Redrawn and adapted by Achmad Satiri Nurhaman.

Hedychium coronarium: Moo, C.-T., 1978. Zingiberaceae. In: Li, H.-L., Liu, T,-S., Huang, T.-C., Koyama, T. & DeVol, C.E. (Editors): Flora of Taiwan. Vol. 5. Epoch Publishing Co., Taipei, Taiwan, Republic of China. p. 844, fig. 1536 (flowering stem, flower, longitudinal section of flower, frontal and dorsal view of anther, with style and stigma). Redrawn and adapted by Iskak Syamsudin.

Hedyotis auricularia: Backer, C.A. & van Steenis, C.G.G.J., 1973. Atlas of 220 weeds of sugar-cane fields in Java. Greshoff's Rumphius Fund, Amsterdam, the Netherlands. pl. 644 (flowering and fruiting stem, detail interpetiolar stipule and infructescence). Redrawn and adapted by Iskak Syamsudin.

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Illicium anisatum: von Siebold, P.F. & Zuccarini, J.G., 1835. Flora Japonica 1. Leiden, the Netherlands. pl. 1 (flowering twig, fruit side view, fruit seen from above). Redrawn and adapted by Achmad Satiri Nurhaman.

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Inula helenium: Ross-Craig, S., 1960. Drawings of British plants. Parts XIV–XVIII. Adoxaceae, Caprifoliaceae, Rubiaceae, Valerianaceae, Dipsacaceae, Compositae. The Camelot Press Ltd., London and Southampton, United Kingdom. pl. 19A (flowering stem, lower leaf, tubular fower) and pl. 19B (ligulate flower). Redrawn and adapted by Iskak Syamsudin.

Ipomoea pes-tigridis: Chang, C.-E., 1978. Convolvulaceae. In: Li, H.-L. et al. (Editors): Flora of Taiwan. Vol. 4. Epoch Publishing Co., Taipei, Taiwan, Republic of China. p. 372, pl. 1044 (flowering and fruiting branch, fruiting head, opened corolla and stamens, pistil, fruit and calyx, seeds). Redrawn and adapted by Iskak Syamsudin.

Kadsura scandens: Saunders, R.M.K., 1997. Schisandraceae. In: Kalkman, C., Kirkup, D.W., Nooteboom, H.P., Stevens, P.F. & de Wilde, W.J.J.O. (Editors): Flora Malesiana. Series 1. Vol. 13. Rijksherbarium/Hortus Botanicus, Leiden, the Netherlands. p. 200, fig. 1 (flowering branch, gynoecium, androecium); van Steenis, C.G.G.J., 1972. The mountain flora of Java. E.J. Brill, Leiden, the Netherlands. pl. 29-3b, 29-3c (cauliflorous female flowers, aggregate fruit). Redrawn and adapted by Iskak Syamsudin.

Kibatalia arborea: Sosef, M.S.M., Hong, L.T. & Prawirohatmodjo, S. (Editors), 1998. Plant Resources of South-East Asia No 5(3). Timber trees: Lesser-known timbers. Backhuys Publishers, Leiden, the Netherlands. p. 314 (tree habit, flowering twig, flower, fruit, seed).

Laportea decumana: Chew, W.-L., 1969. A monograph of Laportea (Urticaceae). The Gardens' Bulletin Singapore 25(1). p. 140, fig. 10 (flowering twig, detail of leaf surface, male flower, female flower, achene). Redrawn and adapted by Achmad Satiri Nurhaman.

Leea guineensis: Lu, F.Y., 1993. Leeaceae. In: Huang, T.-C. (Editor): Flora of Taiwan. 2nd Edition. Vol. 3. Editorial Committee of the Flora of Taiwan, Taipei, Taiwan, Republic of China. p. 712, pl. 363 (fruiting branch, fruit); Ridsdale, C.E., 1974. A revision of the family Leeaceae. Blumea 22(1). p. 64, fig. 4, p. 66, fig. 5 (flower at anthesis, variation in stipules). Redrawn and adapted by Achmad Satiri Nurhaman.

Leonurus sibiricus: Backer, C.A. & van Steenis, C.G.G.J., 1973. Atlas of 220 weeds of sugar-cane fields in Java. Greshoff's Rumphius Fund, Amsterdam, the Netherlands. pl. 530 (flowering stem); Doan, T., 1936. Labiatae. In: Gagnepain, F. (Editor): Flore générale de l'Indo-Chine [General flora of Indo-China]. Vol. 4. Masson & Cie, Paris, France. p. 1026, fig. 107 (detail of inflorescence, flower). Redrawn and adapted by Achmad Satiri Nurhaman.

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Lindernia crustacea: Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G. (Editors), 1987.

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Lobelia nicotianaefolia: Kao, M.-T. & Devol, C.E., 1978. Campanulaceae. In: Li, H.-L. et al. (Editors): Flora of Taiwan. Vol. 4. Epoch Publishing Co., Taipei, Taiwan, Republic of China. p. 755, pl. 1188 (leafy stem and roots, inflorescence, flower, corolla removed, opened corolla, stamens, fruit). Redrawn and adapted by Achmad Satiri Nurhaman.

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Melanolepis multiglandulosa: Hsieh, C.-F., Chaw, S.-M. & Wang, C.-F., 1993. Euphorbiaceae In: Huang, T.-C. (Editor): Flora of Taiwan. 2nd Edition. Vol. 3. Editorial Committee of the Flora of Taiwan, Taipei, Taiwan, Republic of China. p. 491, pl. 256 (twig with male inflorescence, female flower, male flower, infructescence, underside leaf with glands along the margin). Redrawn and adapted by Iskak Syamsudin.

Melastoma malabathricum:Backer, C.A., 1940. Onkruidflora der Javasche suikerrietgronden. Handboek ten dienste van de suikerriet cultuur en de rietsuiker fabricage op Java. Deel 7(14) (atlas) [Weed flora of Javanese sugar-cane fields. Handbook for the cultivation of sugarcane and manufacturing of cane-sugar in Java. Vol. 7(14) (atlas)]. Vereniging het Proefstation voor de Java-Suikerindustrie, Pasuruan, Indonesia. pl. 442 (flowering twig, fruiting twig). Redrawn and adapted by Achmad Satiri Nurhaman.

Merremia tridentata ssp. *hastata*: Chang, C.-E., 1978. Convolvulaceae. In: Li, H.-L. et al. (Editors): Flora of Taiwan. Vol. 4. Epoch Publishing Co., Taipei, Taiwan, Republic of China. p. 386, pl. 1050 (flowering and fruiting stem, calyx and pistil, corolla and stamens, fruit). Redrawn and adapted by Achmad Satiri Nurhaman.

Micromelum minutum: Jones, D.T., 1995. Rutaceae. In: Soepadmo, E. & Wong, K.M. (Editors): Tree flora of Sabah and Sarawak. Vol. 1. Sabah Forestry Department, Forest Research Institute Malaysia and Sarawak Forestry Department, Kepong, Malaysia. p. 401, fig. 11 (fruiting twig). Redrawn and adapted by Iskak Syamsudin.

Millettia sericea: Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische groenten', 1931). Asher & Co., Amsterdam, the Netherlands. p. 395, fig. 246 (young shoot, leaf, inflorescence, detail of inflorescence, infructescence). Redrawn and adapted by Iskak Syamsudin.

Mitragyna speciosa: Valeton, T., 1932. Mitragyna speciosa. Nova Guinea: résultats des expeditions scientifiques à la Nouvelle Guinee [Nova Guinea: uitkomsten der Nederlandsche Nieuw-Guinea expeditie] 14, Table 28 (flowering branch, flower with bracteoles). Redrawn and adapted by Iskak Syamsudin.

Mollugo pentaphylla: Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G. (Editors), 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. p. 363, fig. 4.166 (plant habit, flower, pistil, capsule, seed). Redrawn and adapted by Achmad Satiri Nurhaman.

Nymphaea nouchali: Verdcourt, B., 1989. Nymphaeaceae. In: Polhill, R.M. (Editor): Flora of Tropical East Africa. A.A. Balkema, the Netherlands & Brookfield, United Kingdom. p. 8, fig. 1

(leaf, flower, stamens, seed). Redrawn and adapted by Achmad Satiri Nurhaman.

Ochrosia oppositifolia: Boiteau, P., 1981. Apocynacées [Apocynaceae]. In: Flore de la Nouvelle Calédonie et dépendances [Flora of New Caledonia (incl. Loyalty Islands)]. Vol. 10. Muséum national d'histoire naturelle, Paris, France. p. 67, pl. 12 (flowering branch, fruit); Middleton, D.J., 1999. Apocynaceae. In: Santisuk, T., & Larsen, K. (Editors). Flora of Thailand. Vol. 7(1). The Forest Herbarium, Royal Forest Department, Bangkok, Thailand. p. 66, fig.21 (flower, dissected flower). Redrawn and adapted by Achmad Satiri Nurhaman.

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Ophiorrhiza mungos: Valeton, T., 1914. Tabula CCCLXXXV. Ophiorrhiza mungos L. Icones Bogorienses 4: 262 (flowering branch, flower, flower bud, flower, corolla removed, opened corolla). Redrawn and adapted by Achmad Satiri Nurhaman.

Oroxylum indicum: Corner, E.J.H., 1988. Wayside trees of Malaya. 3rd Edition. The Malayan Nature Society, Kuala Lumpur, Malaysia. Vol. 1. p. 178, pl. 31 (habit); Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische groenten', 1931). Asher & Co., Amsterdam, the Netherlands. p. 78, fig. 46 (part of inflorescence); Kessler, P.J.A. (Editor), 2000. Secondary forest trees of Kalimantan, Indonesia. A manual to 300 selected species. Tropenbos Kalimantan Series 3. MOFEC Tropenbos-Kalimantan Project, Wanariset Samboja, Balikpapan, Indonesia. p. 221, fig. 18 (detail of leaf, fruit); Santisuk, T. & Vidal, J.E., 1985. Bignoniaceae. In: Lescot, M. (Editor): Flore du Cambodge, du Laos et du Viêtnam [Flora of Cambodia, Laos and Vietnam]. Vol. 22. Muséum National d'Histoire Naturelle, Paris, France. p. 11, pl. 1 (seed). Redrawn and adapted by Iskak Syamsudin.

Paederia foetida: Kaempfer, E., 1791. Icones selectae plantarum quas in Japonica collegit et delineavit [Selected drawings of plants, collected and drawn in Japan]. t. 9 (flowering stem, infructescence); Schumann, K., 1897. Rubiaceae. In: Engler, A. & Prantl, K. (Editors): Die natürlichen Pflanzenfamilien [The natural plant families]. Part 4(4). Wilhelm Engelmann, Leipzig, Germany. p. 126, fig. 40B (flower, vertical section). Redrawn and adapted by Achmad Satiri Nurhaman.

Pangium edule: Sleumer, H., 1954. Pangium. In: van Steenis, C.G.G.J. (Editor): Flora Malesiana. Series 1, Vol. 5. Noordhoff-Kolff N.V., Djakarta, Indonesia. p. 38, fig 14 & 15 (twig, detail of fruiting twig, pericarp and pulp of one fruit removed halfway); Koorders, S.H. & Valeton, T., 1914. Atlas der Baumarten von Java im Anschluss an die 'Bijdragen tot de kennis der boomsoorten van Java' [Atlas of tree species of Java in 'contribution to the knowledge of the tree species of Java']. Vol. 2. P.W.M. Trap. Leiden, the Netherlands. fig. 347 (female flower, male flower). Redrawn and adapted by Achmad Satiri Nurhaman.

Parameria laevigata: Middleton, D.J., 1996. Revision of Aganonerion Pierre ex Spire, Parameria Benth. & Hook.f and Urceola Roxb. (Apocynaceae). Blumea 41(1). p. 77, fig. 2 (flowering branch, flower in bud, flower, fruit, seed). Redrawn and adapted by Iskak Syamsudin.

Parkia timoriana: Sosef, M.S.M., Hong, L.T. & Prawirohatmodjo, S. (Editors), 1998. Plant Resources of South-East Asia No 5(3). Timber trees: Lesser-known timbers. Backhuys Publishers, Leiden, the Netherlands. p. 432 (base of trunk, leaf, flowering heads, flower, fruit).

Pavetta indica: Wight, R. & Walker-Arnott, G.A., 1839. Icones plantarum Indiae Orientalis [Drawings of plants of India]. pl. 148 (leafy twig, inflorescence); Robbrecht, E., 1988. Tropical woody Rubiaceae. Opera Botanica Belgica 1, Meise, Belgium. p. 78, fig. 26I (young flower). Redrawn and adapted by Achmad Satiri Nurhaman.

Pericampylus glaucus: Forman, L.L., 1986. Menispermaceae. In: van Steenis, C.G.G.J. & de Wilde, W.J.J.O. (Editors): Flora Malesiana. Series 1, Vol. 10. Kluwer Academic Publishers, Dordrecht, the Netherlands. p. 228, fig. 15 (flowering twig, male plant, male flower, one sepal removed, female flower, front sepal, petal and one staminode removed, fruit, endocarp). Redrawn and adapted by Achmad Satiri Nurhaman.

Persicaria barbata: Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G. (Editors), 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. p. 483, fig. 4.225 (flowering stem, flower, pistil, ocrea, fruit in perianth, fruit). Redrawn and adapted by Achmad Satiri Nurhaman.

Phaeanthus ebracteolatus: Mols. J.B. & Kessler, P.J.A., 2000. Revision of the genus Phaeanthus (Annonaceae). Blumea 45. p. 206, fig. 1 (flowering twig, flower, flower with one inner petal removed, infructescence). Redrawn and adapted by Achmad Satiri Nurhaman.

Phyla nodiflora: Backer, C.A. & van Steenis, C.G.G.J., 1973. Atlas of 220 weeds of sugar-cane fields in Java. Greshoff's Rumphius Fund, Amsterdam, the Netherlands. pl. 518 (habit); Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G. (Editors), 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. p. 557, fig. 4.262 (inflorescence); Matthew, K.M., 1982. Illustrations on the Flora of the Tamilnadu Carnatic. The Rapinat Herbarium, St. Joseph's College, Tiruchirapalli, India. p. 553, pl. 553 (flower). Redrawn and adapted by Iskak Syamsudin.

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Physalis angulata: Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G. (Editors), 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. p. 551, fig. 4.259 (plant habit, flower, ventral view, flower, lateral view, berry, calyx partly removed, seed). Redrawn and adapted by Achmad Satiri Nurhaman.

Picria fel-terrae: Yamazaki, T., 1985. Scrophulariacées [Scrophulariaceae]. In: Leroy, J.-F. (Editor): Flore du Cambodge, du Laos et du Viêtnam [Flora of Cambodia, Laos and Vietnam]. Vol. 21. Muséum National d'Histoire Naturelle, Paris, France. p. 23, pl. 4 (fruiting stem, opened corolla, fruit with opened calyx, seed). Redrawn and adapted by Iskak Syamsudin.

Piper umbellatum: Wight, R. & Walker-Arnott, G.A., 1853. Icones plantarum Indiae Orientalis [Drawings of plants of India]. pl. 1925 (flowering stem, pistil and stamens). Redrawn and adapted by Achmad Satiri Nurhaman.

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Pisonia aculeata: Liu, T.-S., 1976. Nyctaginaceae. In: Li, H.-L., Liu, T,-S., Huang, T.-C., Koyama, T. & DeVol, C.E. (Editors): Flora of Taiwan. Vol. 2. Epoch Publishing Co., Taipei, Taiwan, Republic of China. p. 303, fig. 304 (flowering branch, infructescence); Whitehouse, B.A., 1996. Nyctaginaceae. In: Polhill, R.M. (Editor): Flora of Tropical East Africa. A.A. Balkema, the Netherlands & Brookfield, United Kingdom. p. 18, fig. 5 (male flowers, female flowers). Redrawn and adapted by Iskak Syamsudin.

Pistia stratiotes: Majo, S.J., Bogner, J. & Boyce, P.C., 1997. The genera of Araceae. Royal Botanical Gardens, Kew, United Kingdom. p. 287, pl. 105 (plant habit, inflorescence, longitudinal section of lateral view of inflorescence, fruit, seed). Redrawn and adapted by Achmad Satiri Nurhaman.

Platycladus orientalis: Morgan, C.S., 1999. Platycladus orientalis. Cupressaceae. Curtis's Botanical Magazine 16(3). pl. 368 & p. 189 B (fruiting twig, detail of shoot). Redrawn and adapted by Achmad Satiri Nurhaman.

Pluchea indica: Ochse, J.J. & Bakhuizen van den Brink, R.C., 1980. Vegetables of the Dutch East Indies. 3rd English edition (translation of 'Indische groenten', 1931). Asher & Co., Amsterdam, the Netherlands. p. 139, fig. 85 (flowering branch); Wagner, W.L., Herbst, D.R. & Sohmer, S.H. (Editors), 1990. Manual of the flowering plants of Hawaii. Vol. 1. University of Hawaii Press, Hawaii, United States. p. 348, pl. 33 (achene). Redrawn and adapted by Achmad Satiri Nurhaman.

Pogostemon auricularius: Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G. (Editors), 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. p. 325, fig. 4.147 (flowering stem, pistil, frontal and dorsal view of nutlet); Matthew, K.M., 1982. Illustrations on the Flora of the Tamilnadu Carnatic. The Rapinat Herbarium, St. Joseph's College, Tiruchirapalli, India. p. 573, pl. 573 (flower). Redrawn and adapted by Achmad Satiri Nurhaman.

Polygala paniculata: Soerjani, M., Kostermans, A.J.G.H. & Tjitrosoepomo, G. (Editors), 1987. Weeds of rice in Indonesia. Balai Pustaka, Jakarta, Indonesia. p. 481, fig. 4.224 (plant habit, flower, dorsal side, flower, ventral side, pistil with asymmetrical stigma, opened corolla showing filaments, capsule, seed). Redrawn and adapted by Achmad Satiri Nurhaman.

Polygonum aviculare: Kuo, C.-F., Liu, H.-Y. & Yang, Y.-P., 1996. Polygonum. In: Huang, T.-C. (Editor): Flora of Taiwan. 2nd Edition. Vol. 2. Editorial Committee of the Flora of Taiwan, Taipei, Taiwan, Republic of China. p. 297, pl. 144 (flowering stem, dissected flower, inflorescence, fruit). Redrawn and adapted by Iskak Syamsudin.

Pouzolzia pentandra: Bennett, J.J., Brown, R. & Horsfield, T, 1838. Plantae Javanicae rariores. W.H. Allen, London, United Kingdom. t. 14 (flowering and fruiting twig, male flower seen from below, male flower seen from within, ripe fruit enclosed in its 2-winged perianth, achene (fruit perianth removed). Redrawn and adapted by Iskak Syamsudin.

Psychotria rostrata: Valeton, T., 1909. Tabula CCXC. Psychotria rostrata Bl. Icones Bogorienses 3: 248 (flowering branch, flower, opened corolla, fruit, stone, seed). Redrawn and adapted by Achmad Satiri Nurhaman.

Pycnarrhena manillensis: Pancho, J.V., 1983. Vascular flora of Mt. Makiling and vicinity (Luzon, Philippines) Part I. Kalikasan. The Philippine Journal of Biology Supplement No. 1. p. 276 (flowering branch (male), fruiting branch, male flower). Redrawn and adapted by P. Verheij-Hayes.

Quassia indica: Soepadmo, E.& Wong, K.M.(Editors), 1995. Tree flora of Sabah and Sarawak. Vol. 1 Sabah Forestry Department, Forest Research Institute Malaysia and Sarawak Forestry Department, Kepong, Malaysia. p. 438, fig. 7 (fruiting twig; inflorescence); Nooteboom, H.P., 1962. Simaroubaceae. In: van Steenis C.G.G.J. (Editor): Flora Malesiana. Series 1, Vol. 6. Wolters-Noordhoff, Groningen, the Netherlands. p. 200, fig. 3 (fruit). Redrawn and adapted by Achmad Satiri Nurhaman.

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Rhus succedanea: Hsieh, T.-H., 1993. Rhus L. In: Huang, T.-C. (Editor): Flora of Taiwan. 2nd Edition. Vol. 3. Editorial Committee of the Flora of Taiwan, Taipei, Taiwan, Republic of China. p. 586, pl. 301. (fruiting twig, flower, dissected flower). Redrawn and adapted by Achmad Satiri Nurhaman.

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Rubus rosifolius: Verheij, E.W.M. & Coronel, R.E. (Editors), 1991. Plant Resources of South-East Asia No 2. Edible fruits and nuts. Pudoc Scientific Publishers, Wageningen, the Netherlands. p. 278 (branch with flowers and fruits).

Rumex crispus: Liu, T.-S., Ying, S.-S. & Lai, M.-J., 1976. Polygonaceae. In: Li, H.-L., Liu, T,-S., Huang, T.-C., Koyama, T. & DeVol, C.E. (Editors): Flora of Taiwan. Vol. 2. Epoch Publishing Co., Taipei, Taiwan, Republic of China. p. 291, fig. 299 (flowering and fruiting branch, flower, pistil, nutlet with perianth, nutlet). Redrawn and adapted by Achmad Satiri Nurhaman.

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Index of compounds

Index of pharmaceutical terms

Index of scientific plant names

Page numbers printed in bold refer to main treatment.

Index of vernacular plant names

Page numbers printed in bold refer to main treatment. For transcriptions of Vietnamese names, see at the end of the index.

Transcriptions of Vietnamese characters

[aa]	= â	[ar]	= ả	[ax]	= ã	[ej]	= ẹ	[oo]	= ô	[ow]	= ơ	[uj]	= ụ	[uwx]	= ữ
[aaf]	= ầ	[as]	= á	[ee]	= ê	[er]	= ẻ	[oof]	= ồ	[owf]	= ờ	[ur]	= ủ	[ux]	= ũ
[aaj]	= ậ	[aw]	= ă	[eef]	= ề	[es]	= é	[ooj]	= ộ	[owj]	= ợ	[us]	= ú		
[aar]	= ẩ	[awf]	= ằ	[eej]	= ệ	[ex]	= ẽ	[oor]	= ổ	[owr]	= ở	[uw]	= ư		
[aas]	= ấ	[awj]	= ặ	[eer]	= ể	[if]	= ì	[oos]	= ố	[ows]	= ớ	[uwf]	= ừ		
[aax]	= ẫ	[awr]	= ẳ	[ees]	= ế	[is]	= í	[oox]	= ỗ	[owx]	= ỡ	[uwj]	= ự		
[af]	= à	[aws]	= ắ	[eex]	= ễ	[of]	= ò	[or]	= ỏ	[ox]	= õ	[uwr]	= ử		
[aj]	= ạ	[awx]	= ẵ	[ef]	= è	[oj]	= ọ	[os]	= ó	[uf]	= ù	[uws]	= ứ		

The Prosea Foundation (Plant Resources of South-East Asia)

Name, location, legal status and structure

- Prosea is a Foundation under Indonesian law, with an international charter, domiciled in Bogor. It is an autonomous, non-profit, international agency, governed by a Board of Trustees. It seeks linkage with existing regional and international organizations;
- Prosea is an international programme focusing on the documentation of information on plant resources of South-East Asia;
- Prosea consists of a Network Office in Bogor (Indonesia) coordinating 6 Country Offices in South-East Asia, and a Publication Office in Wageningen (The Netherlands).

Participating institutions

- Forest Research Institute of Malaysia (FRIM), Karung Berkunci 201, Jalan FRIM, Kepong, 52109 Kuala Lumpur, Malaysia;
- Indonesian Institute of Sciences (LIPI), Sasana Widya Sarwono, Jalan Gatot Subroto 10, Jakarta 12710, Indonesia;
- Institute of Ecology and Biological Resources (IEBR), Nghia Do, Cau Giay, Hanoi, Vietnam;
- Papua New Guinea University of Technology (UNITECH), Private Mail Bag, Lae 411, Papua New Guinea;
- Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD), Los Baños, Laguna, the Philippines;
- Thailand Institute of Scientific and Technological Research (TISTR), 196 Phahonyothin Road, Chatuchak, Bangkok 10900, Thailand;
- Wageningen University (WU), Costerweg 50, 6701 BH Wageningen, The Netherlands.

Objectives

- to document and make available the existing wealth of information on the plant resources of South-East Asia for education, extension work, research and industry;
- to make operational a computerized data bank on the plant resources of South-East Asia;
- to publish the results in the form of an illustrated, multi-volume handbook in English;
- to promote the dissemination of the information gathered.

Target groups

- those professionally concerned with plant resources in South-East Asia and working in education, extension work, research and commercial production (direct users);
- those in South-East Asia depending directly on plant resources, obtaining relevant information through extension (indirect users).

Activities

- the establishment and operation of data bases;
- the publication of books;
- the sponsorship, support and organization of training courses;
- research into topics relevant to Prosea's purpose;
- the publication and dissemination of reports and the research results.

Implementation

The programme period has been tentatively divided into 4 phases:
- preliminary phase (1985–1986): publication of 'Plant Resources of South-East Asia, Proposal for a Handbook' (1986);
- preparatory phase (1987–1990): establishing cooperation with South-East Asia through internationalization, documentation, consultation and publication; reaching agreement on the scientific, organizational and financial structure of Prosea;
- implementation phase (1991–2000): compiling, editing and publishing of the handbook; making operational the computerized data bank with the texts and additional information; promoting the dissemination of the information obtained.
- Prosea beyond 2000 (Phase 2001–2005): handbook finalization; emphasis on lesser-known useful plants, and making the information services demand-driven.

Documentation

A documentation system has been developed for information storage and retrieval called Prosea Data Bank. It consists of 7 data bases:
- BASELIST: primarily a checklist of more than 6200 plant species;
- CATALOG: references to secondary literature;
- PREPHASE: references to literature from South-East Asia;
- ORGANYM: references to institutions and their research activities;
- PERSONYM: references to specialists;
- TEXTFILE: all Prosea publications and additional information;
- PHOTFILE: photographs of useful plants of South-East Asia.

Publication

The handbook in blue cover (hardbound) is distributed by Backhuys Publishers, Leiden, the Netherlands (formerly by Pudoc, Wageningen, the Netherlands). The handbook in green cover (paperback) is distributed in two price-classes: a low-price paperback, distributed by Prosea South-East Asia for all developing countries; a medium-price paperback, distributed by Backhuys Publishers, Leiden, the Netherlands, and by Prosea South-East Asia for developed countries (becoming available two years after publication of the hardbound edition). The bibliographies are distributed by Prosea South-East Asia.

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In brief, Prosea is

- an international programme, focused on plant resources of South-East Asia;
- interdisciplinary, covering the fields of agriculture, forestry, horticulture and botany;
- a research programme, making knowledge available for education and extension;
- ecologically focused on promoting plant resources for sustainable tropical land-use systems;
- committed to conservation of biodiversity;
- committed to rural development through diversification of resources and application of farmers' knowledge.

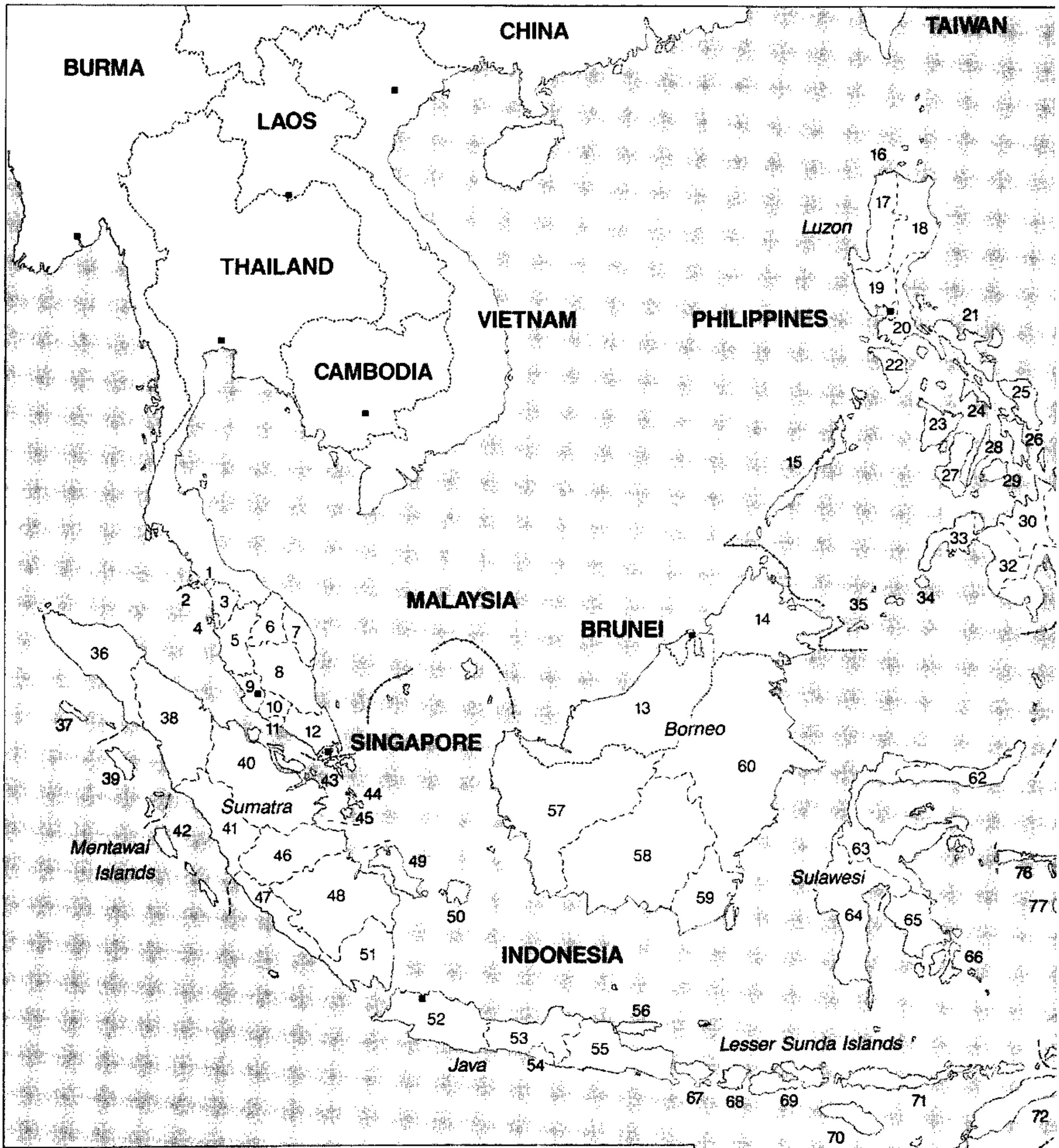
Prosea Network Office

Research and Development Centre for Biology
Jalan Ir. H. Juanda 22
P.O. Box 332
Bogor 16122, Indonesia
tel: +62 251 322859, 370934
fax: +62 251 370934
e-mail: info@proseanet.org

Prosea Publication Office

Wageningen University
Haarweg 333
P.O. Box 341
6700 AH Wageningen, the Netherlands
tel: +31 317 484587
fax: +31 317 482206
e-mail: prosea@pros.dpw.wag-ur.nl

Homepages: http://www.proseanet.org and http://www.prosea.nl



MAP OF SOUTH-EAST ASIA FOR PROSEA

Names of countries in capital letters and islands in lower case; numbers refer to the key.

Key of islands (*i*), states (*s*), regions (*r*) and provinces (*p*).

MALAYSIA
East Malaysia *r* 13-14
Johor *s* 12
Kedah *s* 3
Kelantan *s* 6
Langkawi *i* 2
Melaka *s* 11
Negeri Sembilan *s* 10
Pahang *s* 8
Peninsular Malaysia (West Malaysia) *r* 1-12
Perak *s* 5
Perlis *s* 1
Pinang *s* 4
Sabah *s* 14
Sarawak *s* 13
Selangor *s* 9
Terengganu *s* 7

PHILIPPINES
Babuyan Islands *i* 16
Basilan *i* 34
Bicol *r* 21
Bohol *i* 29
Cagayan Valley *r* 18
Cebu *i* 28
Central Mindanao *r* 32
Central Luzon *r* 19
Ilocos *r* 17
Leyte *i* 26
Masbate *i* 24
Mindoro *i* 22
Negros *i* 27
Northern Mindanao *r* 30
Palawan *i* 15
Panay *i* 23
Samar *i* 25
Southern Tagalog *r* 20
Southern Mindanao *r* 31
Sulu Archipelago *i* 35
Western Mindanao *r* 33

INDONESIA
Aceh *p* 36
Ambon *i* 79
Aru Islands *i* 82
Bali *i* 67
Bangka *i* 49
Belitung *i* 50
Bengkulu *p* 47
Buru *i* 77
Butung *i* 66
Central Java *p* 53
Central Kalimantan *p* 58
Central Sulawesi *p* 63
East Java *p* 55
East Kalimantan *p* 60
Flores *i* 71
Halmahera *i* 74
Irian Jaya *p* 84
Jambi *p* 46
Kai Islands *i* 83
Lampung *p* 51
Lingga *i* 44
Lombok *i* 68
Madura *i* 56
Morotai *i* 73
Nias *i* 39
North Sulawesi *p* 62
North Sumatra *p* 38
Obi *i* 75
Riau *p* 40
Riau Archipelago *i* 43
Seram *i* 78
Siberut *i* 42
Simeuluë *i* 37
Singkep *i* 45
South-East Sulawesi *p* 65
South Kalimantan *p* 59
South Sulawesi *p* 64
South Sumatra *p* 48
Sula Islands *i* 76
Sumba *i* 70
Sumbawa *i* 69
Talaud Islands *i* 61
Tanimbar Islands *i* 81
Timor *i* 72
West Daya Islands *i* 80
West Java *p* 52
West Kalimantan *p* 57
West Sumatra *p* 41
Yogyakarta *p* 54

PAPUA NEW GUINEA
Bougainville Island *i* 87
D'Entrecasteaux Islands *i* 88
Louisiade Archipelago *i* 89
New Britain *i* 86
Papua *r* 85