Plant Resources of South-East Asia is a multivolume handbook that aims to summarize knowledge about useful plants for workers in education, research, extension and industry. The following institutions are responsible for the coordination of the Prosea Programme and the Handbook:

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Plant Resources of South-East Asia

No 6

Rattans

J. Dransfield and N. Manokaran (Editors)

Pudoc Scientific Publishers, Wageningen 1993

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Dr N. Manokaran graduated with a BSc degree in 1971 from the University of Malaya in plant ecology and obtained his MSc degree in 1978 on the subject of nutrient and hydrological cycles in a forested ecosystem. In 1988 he obtained his PhD from the University of Aberdeen on the subject of tree population dynamics in tropical forests. Since 1974 he has worked as a forest ecologist attached to the Forest Research Institute Malaysia (FRIM, Kepong), specializing in the ecology and silviculture of forest trees and rattans. He has published widely on these subjects as well as being editor of 'Malaysian Forester', the international journal on tropical forestry, from 1979–1985. He has been the rattan consultant to the International Development Research Centre (IDRC, Canada) since 1983.

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Foreword

Rattans are the most important forest product after timber throughout much of South-East Asia. They are of great social significance as a source of income to some of the poorest communities in the region, yet have been traditionally neglected by forestry programmes preoccupied with the timber trade. Within the last two decades there has been an upsurge of research activity that has led to an appreciation of the importance of rattan and a growing awareness that rattan cultivation has real potential.

Much of the rattan entering international trade for the furniture industry is collected from the wild from primary and logged-over forests. At present the resource is seriously threatened by loss of habitat as forests are converted to agricultural and other land uses, and by overexploitation of the remaining stocks. Traditional trading patterns have also been drastically altered by the introduction of export controls that have added to the pressure on wild stocks in areas not subjected to control, and have seriously affected the livelihood of rattan gatherers where the controls have been introduced.

From being a neglected minor forest product, research and development over the last two decades has laid the basis for the development of large-scale rattan cultivation. Commercial estates have been established, but as can be seen from the data presented in this volume, much remains to be discovered.

All countries in the region have been involved in some way in the rattan trade and in current developments. Nevertheless, much more could be achieved with greater regional cooperation and exchange of genetic material. In particular there are still many rattans occurring in the forests of South-East Asia that are scarcely known botanically, and whose silvicultural potential has yet to be appreciated. The need for broader-based research is clearly indicated, for which funding from the international community will be essential.

As the newly established commercial rattan estates come to maturity and more is learned of cultivation and harvesting methods, some of the data in this volume is bound to be superseded. Furthermore, the rattans of much of the eastern part of Indonesia and Papua New Guinea remain poorly if at all known, and what little is known suggests that there may be many promising silvicultural subjects in this area. Nevertheless, the present volume contains a wealth of information on rattans, on their botany, their uses, their cultivation and their potential; information that will be essential reading for all interested in this extraordinary forest resource.

The contributors, editors and all others of the Prosea offices involved in the publication of this very useful book are to be congratulated. The Interna-

tional Development Research Centre (IDRC), Ottawa, is also to be thanked for the financial support provided.

Kuala Lumpur, July 1993

Dr M.N. Salleh
Director-General Forest Research Institute of Malaysia

1 Introduction

1.1 General

1.1.1 What is a rattan?

Rattans are spiny climbing palms occurring in the Old World tropics and subtropics. They are the source of cane for the cane furniture industry, while at the same time being used for a wealth of minor purposes locally. Most cane entering world trade is collected from the wild, and throughout much of South-East Asia rattan represents the most important forest product after timber. At a local level, rattan may be of great social significance in providing a not always sustainable source of income for the poorer societies living near the forest. These people may use rattan growing in the forest as a source of income for tiding over difficult periods in the agricultural cycle. Recently there has been great interest in the possibility of cultivating rattan.

The most important product of rattan is cane, that is the rattan stem stripped of its leaf-sheaths; canes are sometimes confused with bamboo and, when processed into strips, may be difficult to identify as such. Bamboo is almost always hollow, and even in the few solid species it is not easily bent. Rattan is always solid and can usually be bent easily without gross deformation. The greatest diversity of rattans occurs within South-East Asia.

1.1.2 Choice of species

The selection of species to be discussed in this volume has presented several problems. Almost all species of rattan are used for some purpose somewhere within their range of distribution. Rattans may be used by hunter-gatherers for binding or thatching small temporary shelters in the forest, and their ripe fruits may be eaten. For example, Penan people living near the Mulu National Park in Sarawak could suggest uses for almost all the 71 taxa occurring within the National Park (Dransfield, 1984a). However, local species are, for the most part, not included in this volume. Most attention is given to those species which are cultivated, show great silvicultural potential, or are extensively and selectively harvested for the commercial trade. Also included are species (*Calamus andamanicus* Kurz, *C. egregius* Burr., *C. ovoideus* Thw. ex Tr., *C. simplicifolius* Wei, *C. tetradactylus* Hance, *C. wailong* Pei & Chen, and *Daemonorops margaritae* (Hance) Becc.) which occur naturally outside the region covered by Prosea and which are cultivated and show potential, or which may serve as silvicultur-

Table 1. Rattan species not included in this volume.

Calamus acidus Becc.	*C. viridissimus* Becc.
C. adspersus Bl.	*C. winklerianus* Becc.
C. asperrimus Bl.	*Ceratolobus* spp.
C. billitonensis Becc. ex Heyne	*Daemonorops affinis* Becc.
C. cawa Bl.	*D. forbesii* Becc.
C. corrugatus Becc.	*D. geniculata* (Griff.) Mart.
C. equestris Willd.	*D. gracilis* Becc.
C. filispadix Becc.	*D. loheriana* Becc.
C. foxworthyi Becc.	*D. longipes* (Griff.) Mart.
C. graminosus Bl.	*D. mirabilis* Mart.
C. impar Becc.	*D. mollis* (Blanco) Merr.
C. jenningsianus Becc.	*D. niger* Bl.
C. melanoloma Mart.	*D. oligolepis* Becc.
C. meyenianus Schauer	*D. palembanica* Bl.
C. paucijugus Becc.	*D. pannosa* Becc.
C. pisicarpus Bl.	*D. pedicellaris* Becc.
C. radulosus Becc.	*D. trichroa* Miq.
C. rumphii Bl.	*D. urdanetana* Becc.
C. samian Becc.	*D. verticillaris* (Griff.) Mart.
C. schistoacanthus Bl.	*Plectocomia* spp.
C. scleracanthus Becc.	*Plectocomiopsis triquetra* (Becc.) J. Dransf.
C. spectabilis Bl.	*Pogonotium* spp.
C. tolitoliensis Becc.	*Retispatha dumetosa* J. Dransf.
C. vinosus Becc.	

al models. Species which are fairly consistently used for particular purposes, even though these may be of minor importance, are included in this volume. Inevitably, species of little significance will have been omitted from this account. In Table 1, certain species previously recorded by Heyne (1927) and others as important have been excluded for the following reasons: unsound taxonomic basis of the data, the species are known to be extremely rare, the uses ascribed to the species are questionable or insignificant, and the lack of authentic information.

1.1.3 Origin and geographic distribution

True rattans are strictly Old World palms belonging to subfamily *Calamoideae*. Two genera of palms in the New World have climbing members: *Desmoncus* Mart. (all species) in the tribe *Cocoeae* subfamily *Arecoideae,* and *Chamaedorea* Willd. (one only of about 100 species) in tribe *Hyophorbeae* subfamily *Ceroxyloideae*. Stems of *Desmoncus* are used for weaving and furniture, but they are of inferior quality and little commercial significance except locally. Stems of *Chamaedorea elatior* Mart. are too soft to be of use.

In the Old World, rattans are distributed in equatorial Africa, the Indian subcontinent, Sri Lanka, the foothills of the Himalayas, southern China through the Malay Archipelago to Australia and the western Pacific as far as Fiji. The greatest diversity of genera and species is in the western part of Malesia.

Table 2. Size and distribution of rattan genera.

Genus	Number of species	Distribution
Calamus L.	370–400	equatorial Africa, India, southern China, southwards to Australia and the western Pacific
Calospatha Becc.	1	Peninsular Malaysia
Ceratolobus Bl.	6	Peninsular Malaysia, Sumatra, Borneo, Java
Daemonorops Bl.	115	India, southern China, southwards through the Malay Archipelago to western New Guinea
Eremospatha (G. Mann & H. Wendl.) H. Wendl.	c. 12	humid tropical Africa
Korthalsia Bl.	c. 26	Indo-China and Burma to New Guinea
Laccosperma (G. Mann & H. Wendl.) Drude	c. 7	humid tropical Africa
Myrialepis Becc.	1	Indo-China, Thailand, Burma, Peninsular Malaysia and Sumatra
Oncocalamus (G. Mann & H. Wendl.) G. Mann & H. Wendl.	1–3	humid tropical Africa
Plectocomia Mart.	c. 16	Himalayas and southern China to western Malesia
Plectocomiopsis Becc.	5	Thailand, Peninsular Malaysia, Sumatra, Borneo
Pogonotium J. Dransf.	3	one in Peninsular Malaysia and Borneo, the other two endemic to Borneo
Retispatha J. Dransf.	1	Borneo

Source: largely from Uhl & Dransfield, 1987.

Three of the four genera recorded for Africa are endemic. A fourth genus, *Calamus* L., is represented by a single, very variable species (*C. deeratus* Mann & H. Wendl.). *Calamus*, the largest rattan genus with between 370–400 species, occurs throughout the geographical range of rattans. Although overwhelmingly the greatest diversity at both generic and specific levels occurs in western Malesia, the least specialized rattans in terms of inflorescence and floral morphology are the African genera *Laccosperma* (G. Mann & H. Wendl.) Drude and *Eremospatha* (G. Mann & H. Wendl.) H. Wendl.

The biogeography of the *Calamoideae* is in need of further study. The distribution of the rattan genera is summarized in Table 2.

Some rattans are widespread: for example, *Calamus scipionum* Lour. is found from Vietnam southwards to Borneo, Sumatra and Palawan, and *C. ornatus* Bl. and its varieties are found in Thailand, Peninsular Malaysia, Sumatra, Java, Borneo, the Philippines and Sulawesi. In contrast, other species seem to be very narrow endemics: for example, *Daemonorops oblata* J. Dransf. is found only in kerangas (Bornean heath forest) forest in northwest Borneo, and *D. unijuga* J. Dransf. is known from a single limestone hill in western Sarawak.

A striking feature of rattans is the abundance of species which occur sympatrically; as many as 30 species may be found in one locality in what is apparently rather uniform vegetation. However, there are probably microhabitat differences and subtle breeding barriers between rattan species which are not understood. Nevertheless, the abundance of rattan species in many forest types in Malesia is one of the distinctive and remarkable features of tropical rain forest in the region.

1.1.4 Uses

Because of their strength, flexibility and uniformity, the bare stems of rattans are used commercially for cane furniture and matting. The cane generally varies in diameter from 3–60(–70) mm or more, depending on the species. Perhaps 20% of the species are used commercially, either in whole or round form, especially for furniture frames, or in splits, peels and cores for matting and basketry. Other species may not be used because of rarity, shortness or poor mechanical properties.

In rural areas, many rattan species have been used for centuries for numerous purposes such as cordage, construction, basketry, thatching and matting. As Corner (1966) noted, long before the Portuguese brought rattan commerce to Europe with the opening of the Orient, rattans were so invaluable to village life that one could speak of a rattan civilization in South-East Asia.

Heyne (1927), Burkill (1935), Brown (1941–1943), Corner (1966) and Dransfield (1979) have listed the various local uses of rattans. The uses are so numerous that a complete enumeration is impossible. Rattans are used in the making of baskets, mats, furniture, broom handles, carpet beaters, walking sticks, fish traps, animal traps, sun blinds, bird cages – and for almost any other purpose requiring strength and elasticity combined with lightness. Houses, fences, bridges and even boats are bound together with rattan, often without the use of a single nail. Ropes for tethering buffaloes, mooring ropes, anchor and bridge cables are also made from rattans. Old rattan leaflets are woven for thatching, young leaflets are used as cigarette papers, young shoots or 'cabbage' are eaten, rattan fruits variously used as fruit and medicine, and 'Dragon's blood' obtained from the fruit scales of a few species was previously used as a dye, varnish and in local medicine.

1.1.5 History of the rattan trade

International trade in rattan dates to the mid-19th Century (Corner, 1966; Whitmore, 1973). However, village-level utilization in the Asian region spans many centuries. Some early trade information is given in Burkill (1935).

Singapore was the clearing-house for practically the entire rattan output of the South-East Asia and the western Pacific at the turn of the 20th Century. From 1922–1927 it exported from 27 500–16 000 t, mainly to Hong Kong, the United States and France, in that order. During this period, exports from Kalimantan and Sulawesi increased from 9 400–19 300 t and 10 300–21 800 t respectively. Much of the raw material from Kalimantan

was re-exported through Singapore and Sulawesi. However, processing and further conversion were mainly done elsewhere.

By the 1970s Indonesia had become the supplier of about 90% of the world's requirements of raw rattan. In 1977, Singapore, which has no commercially harvestable rattan resources, earned more than US$ 21 million from processing and converting rattan into semi-finished products, with about 90% of its supplies coming from Indonesia (Menon, 1980). In the same year, Hong Kong, also without raw rattan of its own, imported more than US$ 26 million worth of rattan and rattan products which, after conversion and manufacture, was worth US$ 68 million in export value. By comparison, Indonesia's share of the trade, mainly of unprocessed canes, was only US$ 15 million.

External trade in rattan and rattan products has undergone great expansion in recent decades. Details of world trade in rattan and rattan products are provided by Manokaran (1990a). The increases in the value of exports from the main producer countries are striking: 250-fold over 17 years in Indonesia, 75-fold over 15 years in the Philippines, 23-fold over 9 years in Thailand, and 12-fold over 8 years in Malaysia. The combined value of exports for these four countries had risen to an annual figure of almost US$ 400 million by the late 1980s, with Indonesia accounting for almost US$ 200 million. The entire export of the Philippines and Thailand, and almost half of that of Malaysia, was of furniture. Net revenue derived from the sale of rattan goods by the two 'middle-men' countries, Taiwan and Hong Kong, together totalled about US$ 200 million in the late 1980s. Much of the partially processed and semi-finished rattan material exported to European countries was converted to high value-added products, mostly furniture.

During the 1980s, Thailand, the Philippines, Indonesia and Malaysia banned the export of rattan except as finished products. These bans have been imposed in order to stimulate the development of rattan-based industries and to protect the wild resource. Indonesia, with 75–80% of the world's present production, has targeted export earnings of about US$ 600 million in the near future. Malaysia's target for export earnings from rattan furniture is about US$ 60 million by 1995.

1.1.6 Problems of interpretation of vernacular names

The development of extensive local rattan taxonomies reflects the social significance of rattans. Classifications have evolved to deal with rattan as it grows in the forest and to serve the product in the trade. Widespread species may be referred to by many names, and where people from different language groups live near to each other, several names may be used even for local rattan species. Serious confusion has arisen from the uncritical use of vernacular names.

The following three examples illustrate the problems of interpreting local names. *Calamus caesius* Bl. is commonly referred to by Malay speakers as 'sega', yet in the rattan-growing area of Kalimantan Tengah, it is known as 'taman'; throughout Sarawak it is known as 'leutik', while 'sega' is used for the related species *Calamus optimus* Becc. In Palawan, the presence of true *Calamus caesius* remained unrecorded until 1979 because 'sika', the name

by which it is called in Palawan, is said to be the vernacular name of an unrelated and rather rare species (*Calamus spinifolius* Becc.) in Luzon (Merrill, 1922). Uncritical use of the lexicon of Philippine vernacular plant names obscured the presence of one of the best small-diameter furniture canes, for which a cultivation procedure had already been developed that could have been transferred earlier to the Philippines (Dransfield, 1980). Incidentally, it was also responsible for the incorrect recording of *Calamus spinifolius* in Palawan.

Another example is provided by the Malay name 'rotan batu': in Peninsular Malaysia this is used fairly consistently for *Calamus insignis* Becc., a species with a stem diameter of 8–10 mm; in Sabah it is used for an unrelated species, *Calamus subinermis* Becc., which has a stem diameter of 18–25 mm.

The final example is one of the most serious confusions: Heyne (1927) cites 'tohiti' as the vernacular name of a rare, poorly known species, *Calamus inops* Becc. ex Heyne; herbarium specimens of this species have a stem diameter of about 12 mm. 'Tohiti' is currently also used as a trade name for the best quality large-diameter (22–30 mm) canes in Sulawesi. There is evidence of the use of 'tohiti' for at least 4 species, yet the trade name 'tohiti' has uncritically been referred to as *Calamus inops*, which is unlikely to be correct because of the much smaller stem diameter of this species. Accounts of various aspects of the cane(s) known as 'tohiti' have been published under the scientific name *Calamus inops*, yet the results cannot refer to this species, and, in the absence of voucher specimens, the cane identity cannot be established; the experimental results are thus irreproducable and useless.

Therefore, great caution is required in the interpretation of vernacular names. In experimental work it is important to prepare herbarium specimens as vouchers, to provide an essential reference.

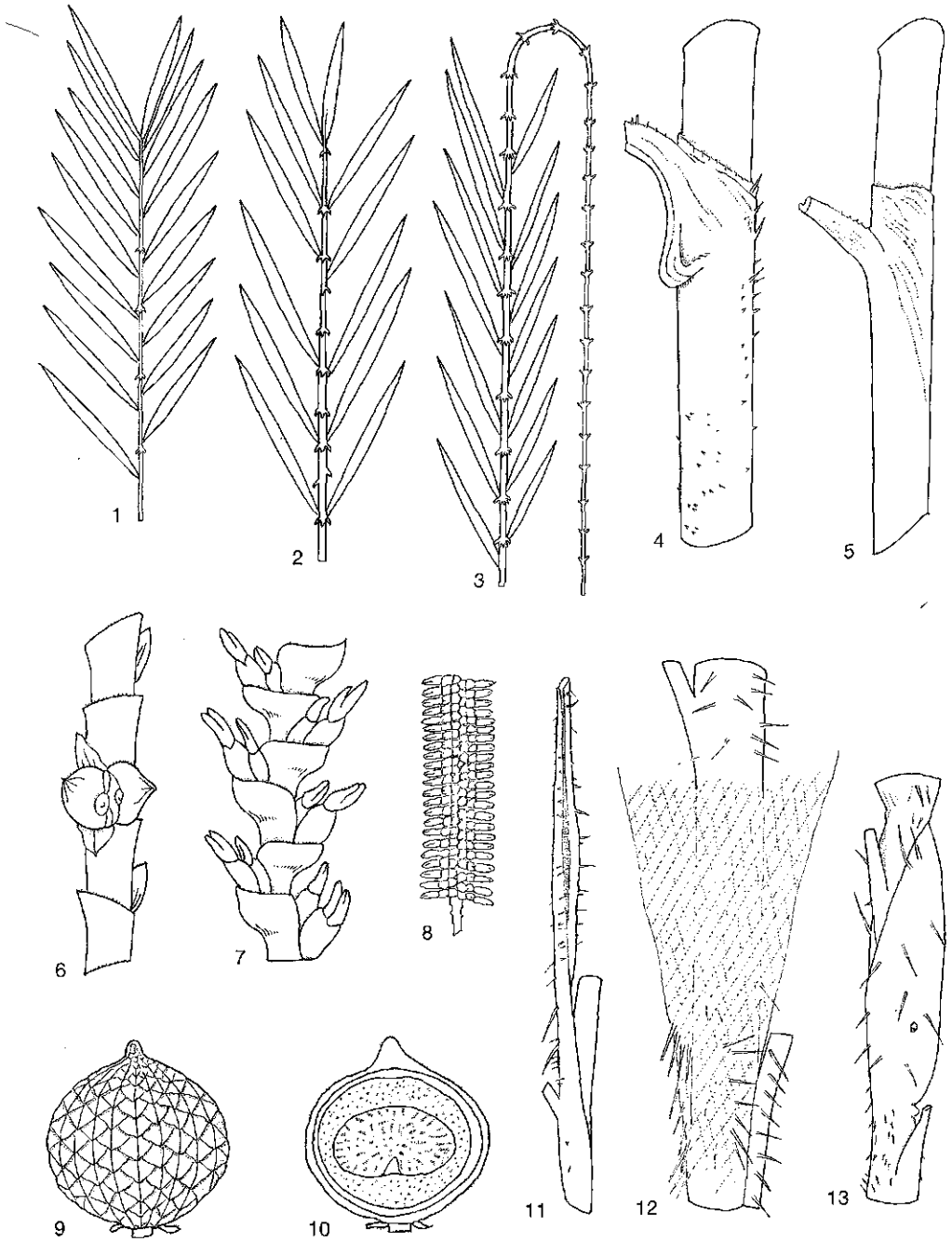
1.2 Botany

1.2.1 Morphology

Habit

Although most members of the 13 rattan genera are climbers, some species are short-stemmed or acaulescent undergrowth palms that scarcely fit into the definition of rattan. Nevertheless, they belong to rattan genera, and those that are used are mentioned in this volume. Those species which have subterranean stems, such as *Calamus minutus* J. Dransf., occur as rosettes on the forest floor. Another group of non-climbing rattan relatives are short-stemmed and tend to scramble weakly in the undergrowth, such as *Calamus myriacanthus* Becc.. In a third group the stems are stiff and erect; good examples are provided by *Calamus nanodendron* J. Dransf. and *C. arborescens* Griff.; their stems are generally too stiff and heavy to be used for furniture.

Rattans may be single-stemmed as in *Calamus manan* Miq., or multiple-stemmed as in *C. caesius*. The consequences for harvesting are obvious: sin-



Rattan structures – 1, ecirrate leaf; 2, subcirrate leaf; 3, cirrate leaf; 4, leaf-base – sheath with knee; 5, leaf-base – sheath without knee, with ocrea; 6, female rachilla of *Calamus* with flower scars; 7, female rachilla of *Calamus* with female and sterile male flowers; 8, male rachilla of *Daemonorops* with rows of single male flowers; 9, fruit with scales; 10, cross-section of fruit; 11, enrolled earlike ocrea (ant-infested) in *Korthalsia robusta*; 12, fibrous ocrea in *Korthalsia jala*; 13, ocrea of *Korthalsia echinometra* with swollen ant-filled ocrea and ant-made entrance.

gle-stemmed species provide a single harvest and do not regenerate from cut stumps, whereas multiple-stemmed species can be harvested continually. Clumps are built up by the development of sucker shoots produced from axillary or leaf-opposed buds at the base of the stem. Such buds usually develop as short rhizomes that then grow into aerial stems; in *C. trachycoleus* Becc. sucker shoots develop into stolons that may reach 3 m or more in length before metamorphosing into aerial stems. Usually vegetative buds are confined to the few basal nodes of the stem, and clumps are built up by the production of shoots from successive orders of suckers. Occasionally, vegetative shoots are produced some way up the aerial stem; the significance of such aerial shoots is not obvious as they rarely, if ever, seem to grow into new aerial stems. However, in most *Korthalsia* species and in *Laccosperma opacum* (G. Mann & H. Wendl.) Drude the stems regularly branch in the forest canopy, resulting in vast aerial entanglements that make harvesting these rattans extremely difficult. In a few unusual acaulescent rattans such as *Calamus pygmaeus* Becc. and *Daemonorops ingens* J. Dransf. vegetative reproduction can occur by the production of vegetative shoots from the tips of the inflorescences.

Root

Little is known about the root system of rattans. Casual observations indicate that the root system of *Calamus caesius* may be complex, with widely radiating, horizontally growing roots, and short vertical root systems, some growing geotropically (i.e. downwards) and some growing apogeotropically (i.e. upwards) (Dransfield, 1979). The apogeotropic roots may be concentrated in the leaf litter layer, and frequently bear patches of loose corky tissue, usually associated with gas exchange. Nur Supardi has reported that roots of *Calamus manan* can radiate from the base of the plant as far as 8 m.

Stem

Rattan stems, the canes of the rattan trade are, in the young state, covered by tight, usually densely spiny, leaf-sheaths; as the stem ages and the lower leaves die and drop off, the stem becomes exposed. In most genera the leaf-sheaths eventually erode away to leave a clean and smooth stem surface, but in the endemic African genera and *Korthalsia* Bl., remnants of the sheaths remain adhering closely to the stem surface.

Stems can vary from a few mm to over 10 cm in diameter. The longest cane recorded was 175 m long (Burkill, 1935). If left unharvested, canes longer than 100 m would occur relatively frequently. Rattan stem does not increase in diameter with age. The seedling first grows in stem diameter and then increases in length, the early establishment growth being responsible for the diameter of the aerial stem. There is, however, some variation in diameter along the stem, the base usually being thicker and then decreasing in diameter upward, the diameter usually attaining a maximum when the rattan crown reaches the forest canopy or reproductive maturity. There may also be variations in diameter between nodes that produce inflores-

cences and those that do not, the former usually being thinner. All such variations in diameter may affect the quality of the harvested cane.
Most canes are more or less circular in cross-section, but in those species of *Calamus* which have flagella (see below at *climbing organ*) the position of the flagellum is marked by a vertical ridge on the internode, the position of the ridge being in line with the axil of the leaf that subtends it. In most species of *Plectocomiopsis* Becc. and *Eremospatha* the stem is more or less triangular in cross-section, thus restricting the uses to which the canes can be put. The growing point of the stem is concealed within the tightly enclosing upper leaf-sheaths; it is thus positioned some distance below the apparent stem tip as represented by the tip of the uppermost leaf-sheath. In almost all species this vital well-protected growing point is edible and is sometimes harvested and sold in markets. Just below the growing point, the stem is usually soft and poorly lignified, and thus cannot be used as cane.
Various studies have been done on the anatomy of rattan stems, starting with Tomlinson (1961). This was followed by two pilot studies, one by Siripatanadilok (1974) on the canes of Java, and Teoh (1978) on the canes of Peninsular Malaysia, aimed at providing a basis for the identification of bare harvested canes. More detailed research has been done by Liese & Weiner (1988) and Weiner & Liese (1990) and Weiner (1992), aimed at studying all genera and species of rattan. Recently there have been numerous anatomical studies of Indian canes (Bhat, 1991, 1992; Bhat & Thulasidas, 1989; Bhat & Varghese, 1991; Bhat et al., 1989, 1990, 1993). All these studies have shown that there are significant anatomical differences among most of the rattan genera, and that species or groups of species are anatomically distinct, and that the quality of cane can be correlated with anatomy to some extent. Generally, good quality cane has an even distribution of vascular bundles throughout the stem, and the ground parenchymatous tissue is uniformly lignified. Cane with little lignification and uneven distribution of vascular bundles is usually poor in quality.

Leaf

Leaves are produced sequentially one at a time; they consist of a tubular sheathing base, the leaf-sheath, which arises from the node of the stem. At its upper end, the sheath narrows into the petiole that continues into the rachis or leaflet-bearing portion of the leaf. Although a petiole is usually present, it is sometimes very short or absent. In many species the rachis is extended beyond the terminal leaflets into a barbed whip (cirrus) which acts as a climbing organ (see below at *climbing organ*).
The leaf-sheath develops from a soft meristematic (i.e. growing) area at its base; thus, the upper part of the sheath matures before its base. Only 1/4–1/3 of the length of the sheath is exposed beyond the shelter of the preceding (i.e. older) leaf. This length of exposed sheath is assumed to correspond with the length of the internode of the stem itself, and is usually densely spiny. Spine arrangement is extraordinarily diverse and frequently of diagnostic importance. In a few species, the leaf-sheaths lack spines; for example, in some forms of *Calamus laevigatus* Mart. and *C. ornatus* the sheaths are devoid of spines; these species are not totally spineless – the

leaf-rachis and cirri and flagella are still heavily armed. A wide range of hairs, scales and/or wax may occur between the spines. At the mouth of the sheath (i.e. the tip) where the sheath narrows into the petiole or leaf-rachis, there may be a prolongation of the main part of the sheath. Often this prolongation is tubular and encloses the sheath of the subsequent leaf. This is usually referred to as an ocrea. Sometimes the ocrea is split and the margins rolled. It may be leathery or papery in texture. All species of the genus *Korthalsia* bear ocreas, and in some species provide a home for ants. In *Pogonotium* J. Dransf. the prolongation consists of two lobes, one on each side of the petiole, referred to as auricles.

In many rattans there is a marked swelling on the leaf-sheath just below the petiole or leaf-rachis, known as the knee. It is only present in climbing members of the genera *Calamus, Ceratolobus* Bl., *Calospatha* Becc., *Daemonorops* Bl. and *Pogonotium*; in acaulescent members of these genera it is absent.

The petiole is variable in length; it is usually much longer in juvenile than in mature leaves, and, as indicated above, it may be absent altogether. The petiole is often characteristically armed with spines. In some species, there may be neat rows of very long, slender but tough spines on either side of the petiole that appear to function as organs for trapping litter from the forest canopy.

The leaf-rachis is defined as the part of the leaf axis which bears the leaflets. Frequently it bears reflexed grapnel-like spines on the lower surface and these contribute to the climbing process by locking onto support.

The rattan leaf is basically pinnate. In almost all rattans the leaflets consist of a single /\-shaped fold. Only in the endemic African genera and in the seedlings of *Plectocomiopsis* and *Myrialepis* Becc. are the leaflets sometimes composed of more than one fold. Leaflet shape, armature, hairiness and arrangement are all of diagnostic importance.

Climbing organ

There are two whip-like organs associated with climbing in rattans, superficially very similar, but not homologous. Climbing organs usually develop only when the aerial stem begins to develop. The cirrus is an extension of the leaf-rachis beyond the terminal leaflets, while the flagellum is a sterile inflorescence borne on the leaf-sheath near the knee. Both are whip-like and bear groups of short reflexed spines. In a cirrus the spines are borne directly on the extension of the leaf-rachis; in the flagellum an axis is covered with very tightly sheathing bracts that bear spines. Flagella are found only in the genus *Calamus* but not all species of *Calamus* have flagella – many, including the best commercial species, are cirrate. Usually, flagella and cirri are mutually exclusive, but in a few species of *Calamus* (e.g. *C. semoi* Becc.) there may be short flagella as well as well-developed cirri. In all Asiatic rattan genera the cirrus develops as a extension of the rachis beyond the terminal leaflets. In the African genera *Laccosperma, Oncocalamus* (G. Mann & H. Wendl.) G. Mann & H. Wendl. and *Eremospatha* there is a clearly defined cirrus bearing very large paired reflexed spines on either side, and also reflexed grapnel-like spines on the undersurface. The paired spines are in fact modified leaflets (known as acanthophylls). The re-

flexed grapnel spines serve to anchor the whips to potential support trees when they come in contact and further movement tends to strengthen the attachment.

Species of *Calamus* which bear flagella have internodes which are uneven in cross-section; this is due to the adnation (joining) of the base of the flagellum to the surface of the internode above the leaf which subtends it (Fisher & Dransfield, 1977). This means that, even though it may otherwise have a good internal structure, the cane is marred by the uneven cross-section. Canes such as those of *Calamus ornatus* are usually decorticated to remove the irregularities before they are used.

Not all rattans have cirri or flagella. Members of the genera *Pogonotium, Retispatha* J. Dransf. and *Calospatha* lack climbing whips but climb weakly in the forest with the aid of the reflexed spines on the lower surface of the leaf-rachis.

Inflorescence and flower

Inflorescences are produced singly at the node, borne in the leaf axil, and usually the lower part of the axis of the inflorescence is joined to the internode, and also to the leaf-sheath of the following leaf (Fisher & Dransfield, 1977). The result of the 'adnation' is that the internode of the cane above the leaf which subtends the inflorescence will be marked by a ridge representing the vascular supply to the inflorescence.

Inflorescences vary greatly in size and overall structure, and inflorescence structure offers the basis for separating the genera. Details of the inflorescences and their taxonomic significance may be found in Dransfield (1979, 1984) and Uhl & Dransfield (1987) (Section 1.2.2).

The basic branching pattern of the inflorescences of rattans is more or less the same. Differences between rattan genera are found in the elaboration or reduction of the bracts and differences in the degree of persistence, and also in the number of orders of branching. The main axis bears a basal bract or prophyll which may be short and tubular, or large, and which encloses the entire inflorescence. Branches are borne in the axils of subsequent bracts. The branches in turn bear bracts, the lowermost of which is usually empty, subsequent bracts subtending branches, and so on. The ultimate flower-bearing branches are termed 'rachillae'. In most species of *Calamus* and *Daemonorops* male flowers are borne on branches of the third order, whereas in the female inflorescence flowers are borne on branches of the second order.

All species of *Korthalsia, Laccosperma* and *Eremospatha* have hermaphroditic flowers. *Oncocalamus* is monoecious, bearing male and female flowers in tight clusters. All other rattan genera are dioecious – that is, male and female flowers are borne on separate plants. Details of flower structure may be found in Uhl & Dransfield (1987).

Fruit

The fruits of all rattans are covered with vertical rows of overlapping reflexed scales. Beneath the scales lies the rest of the pericarp. In *Korthalsia,*

Laccosperma, *Eremospatha* and *Oncocalamus* the mesocarp is thick and fleshy at maturity and the seed-coat is dry. In all other genera, the pericarp is thin and dry at maturity, and the seed is covered with a fleshy outer layer, the sarcotesta. Fruit maturity is usually indicated by a slight change of colour of the scales. There is usually only one seed in each fruit but some rattans may regularly have up to three seeds. Within the integuments lies the endosperm which can be variously shaped. The endosperm is homogeneous or ruminate and the embryo lies in a shallow pit basally or laterally.

Seedling

Germination of rattan seeds is adjacent-ligular (Uhl & Dransfield, 1987). The first sign of germination is the emergence of a short plug from the embryo pit. From this emerge roots and then an irregular swelling, out of which emerges the shoot. The first foliage organ to emerge from the plug is a small, bladeless structure. The first leaf which bears a blade (eophyll) is usually the next foliar organ to emerge. The shape of the eophyll and the number of leaflets it bears vary from species to species and are of importance in identifying rattans at the seedling stage.

1.2.2 Taxonomy

In the most recent classification of the palms (Uhl & Dransfield, 1987) the rattan genera are included in subfamily *Calamoideae* in tribe *Calameae* (Table 3). However, there are remarkable differences in inflorescence and

Table 3. The classification of rattan genera.

Palmae (*Arecaceae*)
- Subfamily *Calamoideae*
  - Tribe *Calameae*
    - Subtribe *Ancistrophyllinae*
      - *Laccosperma*
      - *Eremospatha*
    - Subtribe *Metroxylinae*
      - *Korthalsia*
    - Subtribe *Calaminae*
      - *Daemonorops*
      - *Calamus*
      - *Calospatha*
      - *Pogonotium*
      - *Ceratolobus*
      - *Retispatha*
    - Subtribe *Plectocomiinae*
      - *Myrialepis*
      - *Plectocomia*
      - *Plectocomiopsis*
    - Subtribe *Oncocalaminae*
      - *Oncocalamus*

Source: Uhl & Dransfield, 1987.

flower structure between groups of rattan genera. *Laccosperma* (synonym *Ancistrophyllum* (G. Mann & H. Wendl.) H. Wendl.) and *Eremospatha* from equatorial Africa resemble each other in vegetative and inflorescence morphology and the flowers are hermaphroditic and borne in pairs. Because of this, the two genera are grouped together in subtribe *Ancistrophyllinae*. The third endemic African genus *Oncocalamus* is vegetatively very similar to the other two genera, but its flowers are quite different: they are unisexual and are borne in tight complex clusters in the hollows of the bracts. The structure and development of these unique flower clusters have yet to be elucidated. Nevertheless, they are so peculiar that *Oncocalamus* has been included in its own subtribe *Oncocalaminae*. Asiatic *Korthalsia* has hermaphroditic flowers, but borne singly in the axils of bracts on cylindrical branches reminiscent of those of the non-climbing sago palms, *Metroxylon* Rottb. *Korthalsia* is thus included in the same subtribe as *Metroxylon* – *Metroxylinae*.

Calamus, Calospatha, Ceratolobus, Daemonorops and *Pogonotium* all share unusual characters in the inflorescences with the non-climbing genera *Salacca* Reinw. and *Eleiodoxa* (Becc.) Burr. The plants are dioecious; in the male inflorescence the flowers may be borne singly or in pairs, whereas in the female inflorescence, each female flower is borne together with a sterile male flower, the anthers of which do not contain pollen. *Retispatha* lacks these sterile male flowers but is otherwise very similar to these other genera. They are all included in the subtribe *Calaminae*. The remaining rattan genera *Myrialepis*, *Plectocomia* and *Plectocomiopsis* share vegetative and inflorescence characters; they are dioecous, the flowering is terminal and is followed by the death of the flowering stem, and there are no sterile male flowers in the female inflorescence. These three genera are included together in their own subtribe *Plectocomiinae*.

The striking differences in reproductive characteristics between the groups of genera suggest that the climbing habit may have arisen more than once during the evolution of the *Calameae*.

Despite their importance and the recent upsurge of interest in the rattan resource, the rattan flora of much of the rattan-growing areas of South-East Asia remains poorly known. Some areas are now provided with taxonomic guides, e.g. Peninsular Malaysia (Dransfield, 1979), Sabah (Dransfield, 1984b), Sarawak (Dransfield, 1992) and Sri Lanka (de Zoysa). Introductory guides are available for Papua New Guinea (Johns & Taurereko, 1989a, 1989b; Johns & Zibe, 1989) but a complete taxonomic account of the rattans of the whole island of New Guinea will require much further taxonomic research. A guide to the rattans of India has recently been published (Basu, 1992). Although there has been recent rattan taxonomic survey work in Indonesia, a taxonomic guide will require a great deal more inventory and herbarium work. Rattans of Thailand have been studied by Vongkaluang and Dransfield but an identification manual has yet to be completed. Wei and Pei have both been active in working on the taxonomy of Chinese rattans. Fernando, Lapis and Madulid have worked on the rattans of the Philippines and the rattan flora is now relatively well known there.

Taxonomic inventory work provides an essential base for developing rattan, both as wild crop and in plantation. As there are so many species it is important that species delimitation is well understood. It is essential that the

economically important species can be distinguished by their fruits and seedlings as well as at maturity, as there are many instances where seedlings of commercially unimportant species may at first sight be closely similar to those of the best species. Among the six hundred or so species there may well be species of excellent quality and great silvicultural potential which remain taxonomically unknown, particularly in the Moluccas and New Guinea.

With so many species and complex synonymy, there are bound to be many nomenclatural problems. As the taxonomy of the rattans becomes better known, name changes will be inevitable (Dransfield, 1985). In order to catalogue the large number of names, a comprehensive nomenclatural data base of rattans is being developed at the Royal Botanic Gardens Kew.

1.2.3 Growth and development

Vegetative growth

Most rattans growing naturally produce abundant seedlings, but high mortality, presumably through competition for light, water and nutrients, and through predation, leads to only a few seedlings attaining maturity. For high-climbing rattans, earlier stem production from the rosette stage and greater production of stems in a clump are initiated by exposure to adequate light; light also enhances stem elongation (Manokaran, 1985). Stem elongation is continuous but variable from period to period.

Whereas there is no published information on the growth rates of rattans growing in the wild, such information is available for commercial species undergoing silvicultural trails. Some information is provided in Table 4.

Table 4. Growth rates of eight commercial species of rattan.

Species	Mean growth rate (m/yr)	Growth rate longest stem (m/yr)
Calamus caesius	1.9	3.9–5.6
C. egregius	.	0.8
		(2.0)
C. hainanensis	.	3.5
		(5.0)
C. manan	.	1.2
		(2.3)
		(3.0)
C. scipionum	0.1	1.0
C. tetradactylus	.	2.3
C. trachycoleus	.	(3.0)
		(5.0)
		(7.0)
Daemonorops margaritae	.	(2.0–2.5)

Sources: Manokaran (1985) and Xu (1985, 1989).
Figures in brackets are estimates, others are measured values.
. = data not available

Flowering and fruiting

Rattans display two main modes of flowering. In one (hapaxanthy), a period of vegetative growth is followed by the simultaneous production of inflorescences from the axils of the uppermost leaves. Flowering (in males) and fruiting is followed by the death of the stem which is usually replaced by sucker shoots. In the other flowering mode (pleonanthy), inflorescences are produced continually after a period of juvenile growth, and flowering and fruiting do not result in the death of the stem. All species of *Korthalsia, Plectocomia* Mart., *Plectocomiopsis, Myrialepis, Laccosperma* and *Oncocalamus* and a few species of *Daemonorops* are hapaxanthic; all other rattans are pleonanthic. The significance of the different methods of flowering is discussed in Dransfield (1978).

Information on time and periodicity of flowering, age at first flowering, fruit production and fruit maturation period have all been reviewed by Manokaran (1985).

For many rattan species, development of inflorescences and production of fruits are seasonal, triggered by some external influences. *C. caesius, C. manan, C. tumidus* Furt., *C. scipionum, C. speciosissimus* Furt., *C. trachycoleus* and *Plectocomiopsis wrayi* Becc. have been shown to belong to this category. The cue for flowering for many of these species may be a period of relative dryness, and hence of higher temperature, followed by a period of higher rainfall (Manokaran, 1989). In *C. caesius* it has been shown that certain clumps and individual stems flower almost every year. In other rattan species, flowering is independent of external influences. *Daemonorops angustifolia* (Griff.) Mart. and *Calamus filipendulus* Becc., for example, produce inflorescences continuously along the stem. Age at first flowering has been ascertained for species from one or other of these two categories. *C. caesius* flowered at 5.3 years from planting, *C. manan* at about 5.5 years from planting, *C. trachycoleus* almost 4 years from planting, and *C. filipendulus* at about 4.5 years from planting (Manokaran, 1985).

Anthesis in *C. caesius* has been shown to be 1.5–2 months from inflorescence emergence, and the period from inflorescence emergence to fruit production is 16–18 months for *C. caesius* and 16 months for *C. speciosissimus* (Manokaran, 1989). Fruits of *C. manan* have been shown to mature 15 months after flowering (Darus & Abdul Rasip, 1989) whereas fruits of *C. trachycoleus* have been observed to mature 14 months after flowering (Tan & Raja Barizan). Elsewhere in the seasonal climate of Bangladesh, fruits of *C. viminalis* Willd. have been observed to mature within 160–170 days from flower initiation.

Manokaran (1979) has reported that the clustering species *C. caesius* can have more than 2000 fruits maturing on a stem at any one time; on one occasion about 3000 fruits were obtained from one stem. *C. scipionum* (clustering species) and *C. manan* (solitary species) can likewise have respectively 2000–3000 and 3000–5000 fruits or more on a stem. Thus, during the lifetime of each stem of these pleonanthic species, the number of fruits produced by each stem probably runs into the tens of thousands. In the clustering species, the total number of fruits increases according to the number of mature stems produced.

At the other end of the scale, the rare *Pogonotium divaricatum* J. Dransf. produces only 1 or 2 fruits per inflorescence, and *Calamus gonospermus* Becc. produces only 5 (Dransfield, 1981). The solitary *C. laevigatus* may produce only 400–500 fruits on any one occasion, and the solitary *C. tumidus* and the clustering *C. ornatus* may produce 3000–4000 and up to 1000 fruits per stem respectively.

1.3 Ecology

The large number of rattan species and their wide geographical range is matched by great ecological diversity; consequently, generalizations concerning the ecology of rattans frequently need to be qualified and it is imprudent to draw inferences from observations which do not have a firm taxonomic base. Crude ecological preferences for rattan species have been obtained from observations made during taxonomic inventory work. They are summarized for Peninsular Malaysia, Sabah and Sarawak in Dransfield (1979, 1984, 1992). Such broad ecological summaries are invaluable as a basis for establishing cultivation procedures, even though they are not based on detailed ecological experimentation. A major gap in the knowledge of the ecology of rattans is an understanding of the population dynamics (demography); such knowledge is a prerequisite for developing strategies for sustainable rattan harvesting.

The restriction of rattan species to different climatic zones suggests that these species may have precise climatic requirements. At the extreme north of the range of rattans, it is possible that they may occasionally be subjected to temperatures below 0°C. In altitudinal range they occur from sea-level up to 3000 m, the highest altitude record being held by *Calamus gibbsianus* Becc. at 3000 m on Mount Kinabalu, Sabah. There are usually differences in the rattan flora at different altitudes.

Most rattans are vigorous climbers. Species such as *Calamus manan* and *C. ornatus*, which grow in primary forest, require light gaps for further growth and development. Those growing in secondary or disturbed forests such as *Plectocomiopsis geminiflora* (Griff.) Becc. and *Myrialepis paradoxa* (Kurz) J. Dransf. receive ample light for much of their lifespan. These species appear to need very high light intensities for maximum growth. Certain rattan species slowly grow to maturity in shade in the forest undergrowth. These include non-climbing short-stemmed species such as *Daemonorops calicarpa* (Griff.) Mart. and also climbers such as *D. didymophylla* Becc. and *D. collarifera* Becc.

It has been demonstrated that adequate light is an important factor for enhanced growth in *C. caesius* and *C. scipionum*, and has been observed to be so in *C. manan, C. trachycoleus, C. tumidus* Furt. and other commercial species. Despite the importance of light, however, seedlings of *C. scipionum, C. caesius* and *C. manan* cannot withstand full sunlight throughout the day because the leaves will become scorched and the plants appear unhealthy. This response may be true for most climbing rattan species.

In the forest there may be a wealth of different species of rattan growing sympatrically, occupying different niches, from dense undergrowth to large light gaps formed by the fall of large trees. There is a wide range of different

light regimes in the forest and there appears to be a corresponding range of rattans adapted to different light regimes (Dransfield, 1979). At one extreme are rattan species adapted to grow in the low light regimes of the forest undergrowth; at the other extreme are species adapted to the high light regimes of major gaps and land slips. The single most significant ecological factor affecting the growth of commercially important rattan species in plantation is light; unless sufficient light reaches the rattan plant, it may remain on the forest floor, stunted and in a state of perpetual juvenility.

Within the natural distribution range of rattans, rattan species can be found in most forest types and on most soils and rock types. Mangrove, however, is generally devoid of rattans except on the landward fringe. Some species of rattan are restricted to forest on certain rock or soil types. For example, limestone and ultramafic rock carry distinctive rattan floras.

There is a range of rattans adapted to different soil moisture regimes from swamps to dry ridge tops. In cultivation, all species tested so far in trials have performed best in soils which are not subjected to severe drying out, but few rattans can withstand permanent waterlogging or prolonged flooding. For example, although *C. trachycoleus* is adapted to seasonally severely flooded habitats, it also grows quite well on higher and drier ground, provided total annual rainfall is as high as in its natural habitat.

The water and light requirements for the growth of some species of rattans have been amply demonstrated and reviewed by Manokaran (1985).

Despite being well protected by the tightly tubular sheaths that are themselves usually fiercely armed, the rattan growing point is not infrequently attacked by herbivores. Such attacks usually result in the death of the growing point and hence of the whole stem. The animals involved include pigs (when the rattan is accessible at ground level), rats and squirrels and, perhaps most destructive, elephants.

Animals seem to be the main agents of dispersal in rattans. The fleshy layer in the fruit wall or the sarcotesta appears to be attractive to birds and mammals. Fruit may be ingested whole or sucked and spat out. Sometimes the first signs of fruiting are twisted broken rachillae with fruit remains on the forest floor, presumably the work of apes or monkeys.

Several species of *Daemonorops, Korthalsia* and *Calamus* have morphological adaptions that provide nesting sites for ants; these adaptations include interlocking spines that form galleries and swollen ocreas or recurved proximal leaflets that enclose the sheathed stem. Details of ant/rattan relationships are given in Dransfield (1979) and Uhl & Dransfield (1987). This subject is of considerable interest and has been neglected until recently in ant/plant studies. The relationship usually also involves scale insects. It has been suggested (Dransfield, 1979) that the presence of ants may be of adaptive significance to the rattan in providing extra protection against herbivores, and circumstantial evidence seems to suggest that rattan species lacking ants may be preferentially eaten before those with ants (Dransfield, 1981). However, protection may not be the only significance. Rickson & Rickson (1986) have demonstrated an increase in nutrients available to *Daemonorops verticillaris* (Griff.) Mart. brought to the rattan by the foraging activities of the symbiotic ants. They suggest that this enhanced availability of nutrients may be of adaptive significance.

1.4 Exploitation and cultivation

1.4.1 History of rattan cultivation

Rattan has been cultivated at three scales: plantation scale for commercial use, village scale for domestic use and as a cash crop, and experimentally in small plots. Cultivation in botanic gardens is not reported here.

Indonesia

The first and most successful rattan plantations are those that were established in the areas around Barito, Kapuas and Kaharjan in Kalimantan about the year 1850 (van Tuil, 1929). Christian missionaries are said to have encouraged the planting of the two small-diameter clustering species *Calamus caesius* and *C. trachycoleus* by villagers on smallholdings. Since then, the area of the smallholdings along the alluvial flats of the Barito River and its tributaries in Central and South Kalimantan provinces has increased to 15 000 ha, mainly planted with *C. trachycoleus*. By the latter part of the 1980s these village-level plantations were contributing about 10% of Indonesia's raw rattan supplies.

In East Kalimantan province, shifting cultivators have, for a long time, planted *C. caesius* in forest land left fallow after clearance and production of food crops (Weinstock, 1983). Within a period of up to 15 years, the rattan is harvested for sale and the land cleared again for food crop production.

Cultivation trials of a few commercial species including *C. manan* were begun in the 1980s, mainly in Java. From 1988–1993 the state forestry corporations have planted several thousand ha mainly with *C. caesius*, and to a small extent *C. trachycoleus*, in both Java and East Kalimantan.

Malaysia

Cultivation of *C. caesius* was reported along the Pahang River in Peninsular Malaysia early this century (Brown, 1913) but this no longer exists today. In 1910 an attempt by the Forest Administration of Perak to plant *C. caesius* was unsuccessful. In Sabah, *C. caesius* was planted in several ha of secondary forest on the lower Labuk River (Meijer, 1965). This species is commonly cultivated by the Iban people along the Rejang River in Sarawak (Browne, 1955). Village-level cultivation in Sarawak of species such as *C. caesius, C. optimus, C. ornatus, C. javensis, C. scipionum, C. semoi, C. erioacanthus* Becc. and *Korthalsia cheb* Becc. has also been reported by Dransfield (1992). These species are cultivated in orchards, in secondary forest behind longhouses, or in rubber holdings, mainly for domestic use.

The earliest experimental planting of rattan in Peninsular Malaysia was undertaken in 1960 by the Forest Department of Selangor when *C. manan* was planted in small plots in the Ulu Langat Forest Reserve (Manokaran, 1977) and in Sungei Buluh Forest Reserve (Johari Bin Baharudin & Che'Aziz Bin Ali, 1982). A cultivation trial was later initiated in 1972 in Pahang. Beginning in 1975, experimental cultivation of *C. scipionum* and

C. caesius was undertaken by the Forest Research Institute of Malaysia (FRIM) (Manokaran, 1985). This institute undertook trials with *C. manan* beginning in 1978 (Nur Supardi & Wan Razali Mohd, 1989) and *C. manan* was also interplanted with rubber trees (Salleh & Aminuddin, 1986). *C. trachycoleus*, which is endemic to Kalimantan (Indonesia), has also been planted in trials by FRIM in recent years. The forest departments of some states in Peninsular Malaysia have also established rattan trial plots in recent years. During this period, a *C. caesius* plantation of a few hundred ha was established in Selangor. In all, over 1100 ha have been planted with rattan in Peninsular Malaysia.

The first commercial rattan plantation was developed over 4 years by the Sabah Forestry Development Authority (SAFODA) beginning in 1980–1981 in the Sandakan District. The 4000 ha plantation in logged forest is subject to severe annual flooding and consists of 70% *C. trachycoleus* and 30% *C. caesius*. Subsequently, a total of about 3000 ha of logged forest, abandoned rubber plantations and *Acacia mangium* Willd. plantations in various parts of Sabah have been planted with *C. manan, C. caesius* and *C. merrillii* Becc. by SAFODA. A further 2000 ha or more in Lahad Datu and Sandakan districts in Sabah have been planted with *C. manan* and *C. caesius* by two private companies in recent years. In Sarawak, two experimental plantings of *C. optimus* were carried out in small plots in 1982–1983. In 1989 about 100 ha were planted with rattan. In 1990 a private company began planting on a large scale in Ulu Bintulu, Sarawak, using *C. caesius, C. trachycoleus, C. optimus* and *C. manan*.

The Philippines

In the Philippines the Forest Research Institute (now the Ecosystems Research and Development Bureau) initiated cultivation trials of *C. merrillii* and *C. ornatus* var. *philippinensis* Becc. in Pagbilao, Quezon in 1977 (Pollisco, 1989). A plantation of 5000 ha, mainly of *C. merrillii*, was started in 1983 in Bislig in Mindanao by the Paper Industries Corporation of the Philippines. So far, plantings have been carried out in nearly 4000 ha of logged forest. Elsewhere, a private company (San Teodoro, Mindoro Oriental) planted 50 ha of logged forest with various rattan species in 1983. By early 1990, the same corporation had planted 500 ha of *C. merrillii* and 280 ha of *C. ornatus* var. *philippinensis* under a matchwood tree plantation of *Endospermum peltatum* Merr. in Agusan del Sur, Mindanao.

Papua New Guinea

In Papua New Guinea, village-scale plantings of small-diameter canes have been carried out for many generations in several areas (Zieck, 1972).

Thailand

In Thailand rattan cultivation first began in 1968 with the planting of *C. caesius* in Rangea District in Narathiwat Province (Bhodthipuks & Ramyarangsi, 1989); a total of 213 ha had been planted by 1978. Beginning in

1979 the Royal Forest Department in Thailand initiated cultivation trials of *C. caesius* of 16 ha each in Ranong, Surathani and Chumporn districts. Between 1980–1987 *C. manan* and *C. caesius* were planted on an area of 930 ha in Sukirin district of Narathiwat Province. In recent years, other cultivation trials of various species have been initiated in several regions.

China

For generations, clumps of rattan have been planted in forest or village fringes by villagers in southern Yunnan for domestic use. Decreasing domestic supplies from the wild, and increased demand for the raw material, led to large-scale cultivation of rattan in the 1970s. By 1980, 30 000 ha of forest on Hainan Island, Guangdong Province had been planted with 20 million seedlings, mainly of *C. tetradactylus* Hance and, to a lesser extent, of *Daemonorops margaritae* (Hance) Becc. (Xu, 1985, 1989). A rattan plantation of these species as well as of *C. egregius* Burret and *C. simplicifolius* Wei was also established in Lundao, Guangdong Province. Small-scale plantations have now been established in other areas in Guangdong and Fujian Provinces. Cultivation trials on various species have also been initiated within the last decade.

Other countries

In India various species have been cultivated (Badhwar et al., 1957). In recent years the Kerala Forest Research Institute started cultivation trials on various species of the genus *Calamus* (mainly *C. gamblei* Becc., *C. hookerianus* Becc., *C. pseudotenuis* Becc., *C. rotang* L. and *C. thwaitesii* Becc.).
In Sri Lanka *C. ovoideus* Thwaites ex Trimen, *C. zeylanicus* Becc.and *C. thwaitesii* Becc. have been planted experimentally in recent years (de Zoysa & Vivekanandan, 1989).
In Bangladesh cultivation trials, especially of *Daemonorops jenkinsiana* (Griff.) Mart. were carried out in the early 1980s (Wong, 1984).

1.4.2 Propagation

Aziah & Manokaran (1985) have reviewed the various ways in which rattans are propagated. Propagation is usually by seed; vegetative methods through the use of offsets and rhizome transplants, and tissue culture are rarely employed.

Propagation by seed

Generally the sarcotesta adheres closely to the seed and is difficult to separate. It is recommended that the outer scaly pericarp of the fruit and the fleshy sarcotesta be removed before the seed is sown, as seeds sown with the pericarp and sarcotesta intact show poor germination rates (Manokaran, 1978).

Direct sowing

Direct sowing of seed in soil at the planting site is unlikely to be successful as heavy losses of seeds and newly germinated plants will result from predation by animals and birds, from drying out in hot weather, and disease.
Cultivation of rattans is at present based entirely on seedlings raised in nurseries. The germinated seeds and seedlings in a nursery are protected from pests and are shielded from sun-scorch by overhead shelters of palm-frond thatching or by other crop plants in village backyard nurseries.
Where seeds are procured from the wild, seed supply is a problem because of the rapidly depleting rattan resources. This is compounded by the fact that almost all the commercially important rattans are dioecious, with only a proportion of the rattan plants of any species in any area bearing fruits. In mature plantations, however, vast amounts of seeds become available during the fruiting season.

Planting of wildings

The use of wildings obtained from the forest floor allows more rapid establishment of a plantation by circumventing the nursery stage. However, wildings of economic species are generally found in too low a density to be the source of propagating material for large-scale cultivation. Furthermore, survival rates tend to be low, and there may be problems in identification of wildings, resulting in the possibility of mixed plantings.

Vegetative propagation

Rattans can be propagated vegetatively by suckers, whole rhizomes, and by tissue culture.
Suckers from clustering rattans can be separated from the clump with some roots intact, potted immediately in a suitable soil mixture and transplanted to the field after a period of stabilization in the nursery. This method of propagation is feasible only when it is difficult to obtain seeds, and is applicable only to freely clustering species, and only when very small-scale or backyard planting is undertaken. As the treatment of growth-regulating substances induced better rooting of the suckers, observations are being made on the field performance of such treated suckers in India (Bhat et al., 1989).
The rhizome systems of clustering species support the numerous suckers that develop into stems. For propagation purposes, stems of a clump can be cut off flush with the ground, and the rhizome dug up and transplanted to the planting site; the clump then develops very quickly from the suckers left intact. Rhizome planting of *Daemonorops jenkinsiana* has only been carried out in Bangladesh (Wong, 1984).
The value of tissue culture for rattans would be in mass production of elite strains, and in the conservation of genetic variability. Tissue culture programmes in Malaysia and Thailand have yielded plantlets, but only in small quantities. Tissue culture methods must be developed further if they are to be used on a large commercial scale.

1.4.3 Management

At present wild rattan resources are rarely managed. Licences valid for variable periods of 6 months to a few years allow harvests from forested areas, often on an unsustainable basis.

Village-level rattan plantations have been managed on a sustainable basis in Central and South Kalimantan since the 1850s. During the last decade, rattan plantations have been developed and managed in Sabah (Malaysia) and in southern China.

In general, management of plantations begins soon after planting. It involves replacing planted seedlings that have died and those growing very poorly. This process should be completed within 3–6 months after planting. During the early stages, weeding is carried out to remove climbers that twine around the seedlings. Access paths are also kept passable by slashing weeds with a 'parang' or machete. This process is best carried out once in 6 months in the early years after planting.

As about 50% overhead light appears to be optimum for good growth of rattan seedlings, selective tree felling and removal of overhead branches may be necessary. This needs to be done soon after transplanting has been carried out.

In Kalimantan, the mother stems of *C. caesius* and *C. trachycoleus* are often pruned to stimulate earlier and more abundant suckering. In this area, no maintenance work is carried out in mature rattan gardens. At the time of harvest, paths are cut for access and to bring out the canes.

1.4.4 Diseases and pests

The plantations in Kalimantan appear to be relatively free from diseases and pests. In other plantations in southern China and Sabah and Sarawak (Malaysia), there have been few reports of any significant disease or pest problems. In Sabah, elephants have been reported occasionally to uproot young plants, and they also feed on mature apices. Rats, squirrels and porcupines can locally be very destructive to young plants. Small mammals are best controlled by a programme of systematic trapping. Rhinoceros beetle has been reported to destroy *C. manan* in plantations in Sabah (Lee); if such attacks become widespread there could be serious implications for rattan cultivation.

The only serious outbreak of a disease was that of leaf blight of *C. trachycoleus* in nurseries in Peninsular Malaysia (Norani et al., 1985). The various potential diseases and pests of rattans have been reviewed by Maziah et al. (1992).

1.4.5 Harvesting

Rattan is harvested mainly from the wild. Only a very small proportion is harvested from plantations in Central and South Kalimantan and in Sabah. There may be little control over the collection of rattans from the forest in many countries. In Malaysia, rattan collection licences for a particular forest area need to be obtained from the relevant authority.

Groups of 3–5 villagers go some distance into the forest on rattan collection expeditions. Collection of high-climbing rattans is laborious, unpleasant, and sometimes dangerous because of the falling of dead tree branches dislodged in the process of tugging at the rattan. It is also wasteful, as the top portions of the cut stem may have to be left behind if they are still entangled in the forest canopy after the collector has climbed a neighbouring tree to try to free them. The mature stem, cut above the ground, is normally twisted around a tree trunk as it is dragged down, to rid it of the spiny leaf-sheaths. The immature uppermost several metres of the stem are discarded, the stem cut into lengths of 2–3 m for large-diameter canes, and of 5–7 m for small diameter canes. Then they are bundled and carried out of the forest to be transported to the processing site.
It is much less laborious and difficult to harvest slender canes.

1.4.6 Yield

The mature plants of most commercial rattan species in the wild are found widely dispersed and no reliable information is available on yield per unit area of forest. Neither is there any sound information on yield from plantations of large-diameter canes, because none has yet reached harvestable age.
Variable yield estimates have been reported for smallholder cultivation of *Calamus trachycoleus* and *C. caesius* in Central and South Kalimantan. These have been summarized by Tan & Woon (1992). Because of the lack of standardization in reporting, the figures are difficult to compare. In general, *C. trachycoleus* is said to be ready for harvest 7–10 years after planting. Annual yields may be as low as 1–3.5 t/ha of green canes (Godoy & Tan, 1989), 2.2–3.9 t/ha (Priasukmana, 1989) or as high as 7 t/ha (Menon, 1980). The lower figures are probably the more reliable indicators of yield. *C. caesius* is said to be harvestable 9–10 years after planting, with annual yields varying from 3.5 t/ha (Menon, 1980), 5–7.5 t/ha of green cane (Tardjo, 1986) and 2.3–3.1 t/ha (Priasukmana, 1989).

1.4.7 Post-harvest handling

In general, large-diameter canes have to be cured with a hot oil mixture within 1–2 days after harvesting to prevent deterioration; this treatment is said to make the canes durable by removing gums, resins and water. The oil mixture may be of diesel, kerosene or coconut oil and the proportion varies from place to place. The curing bath tube is usually a trough made either of galvanized soft iron sheeting or of longitudinal halves of empty oil drums welded together. The trough of oil is heated by burning wood underneath and the canes are immersed in the hot oil (100–250°C) for 30 minutes or more. After curing, the canes are removed and rinsed or scrubbed with sawdust or gunny sacking to remove the oil from the surface. They are then placed upright against wooden frames in the open, or bundled and loosely tied at one end before being placed in wigwam-like fashion to dry in the sun. The period of drying varies from 1–3 weeks, depending on the species and weather conditions. The dried canes are then bundled and stored on

wooden racks in covered sheds to prevent contact with moisture before transport to buyers. Good quality canes may be fumigated with sulphur dioxide before sale. Poor quality large-diameter canes are decorticated and stained before sale.

Small-diameter canes are also dried soon after collection by laying them out on racks in the sun, and then sold whole. They may also be stored under water before being processed and dried. Processing involves scraping the nodes, fumigation with sulphur dioxide, drying in the sun, and then splitting or coring (usually by machine). From a length of cane 3–4 splits may be obtained. In coring, the outer layers of the cane are removed to provide the core. The outer layers, called 'peel', are also sold. Canes of *C. caesius* and *C. trachycoleus*, which possess a highly silicified epidermis, usually have the silica removed before being split. In this process (known as 'runti' or 'lunti'), the canes are rubbed with sand or pulled through a series of bamboo bars or wooden pulleys so that the silica layer snaps off in glassy flakes.

1.5 Breeding and genetic resources

As yet no breeding of rattans has been carried out, and even primary selection of species for cultivation is in a very preliminary stage. Of the large number of rattan species, less than 25 have been cultivated for their stems, and only *Calamus caesius* and *C. trachycoleus* have been intensively cultivated. Yet there is a wealth of rattan species growing wild in the forest, some of which may be just as suitable for intensive cultivation as *C. caesius*.

There has been much research on the cultivation of *C. manan* in recent years. As this large-diameter cane has stems of unsurpassed quality, it was an obvious choice for cultivation. Yet this species is single-stemmed. There may be multiple-stemmed large-diameter species more suited to cultivation. Clearly there is a need to screen other wild rattans. Only recently has research begun to investigate differences between different provenances of the commercially more important species. Such work could become the basis for an active selection and breeding programme.

1.6 Prospects

1.6.1 Management of the wild resource

Unfortunately it is extremely difficult to control rattan harvesting. Even in well-policed and controlled areas, high quality rattan stems continue to be harvested illegally. The value of rattan is now so high that any stem of a commercially important species is worth harvesting. Where logging roads have opened up areas previously difficult to reach, rattan pullers can go in and harvest rattan from a huge area. Even where licences are issued and royalties paid to forest departments, there is evidence to suggest that harvesting is carried out with little thought for sustainability. As the area of forest decreases due to logging activities, so pressure increases on the remaining rattan populations. This has been further exacerbated in parts of South-East Asia by the introduction of export controls in some countries.

Within the controlling countries, rates of harvesting may decrease initially, but elsewhere pressure has been enormously increased. Already much of the legally harvestable rattan in some parts of the region has been exhausted. Viable populations may survive in national parks, but even here they are collected, either legally (by forest-dwelling people who may have customary rights to collect) or illegally. It would seem essential that rattans be strictly protected within nature reserves, and that more attention be given by forest departments to the control of rattan harvesting. One promising approach is the granting of long-term rattan harvesting leases to give incentives to sustainable harvesting. It is essential to involve local people in developing rational harvesting strategies. The recently started demographic work on wild populations of rattan (Stockdale) may provide the basic data required for understanding possible rates of harvest.

As a conservation measure in countries like India, the following harvesting regulations have been stipulated to control the indiscriminate cutting of rattans:

- Only mature canes should be extracted from the clumps; immature or tender ones should not be collected or damaged.
- Digging of rhizomes or roots will not be permitted.
- No canes shall be extracted from outside the specified blocks.
- All the one-year-old canes plus six stems of the second year shall be retained in the clump.
- Clumps consisting of less than six stems shall not be worked.
- Felling should be done not less than 15 cm and no more than 30 cm from the ground level.

1.6.2 Cultivation

The successful cultivation of *Calamus trachycoleus* and *C. caesius* by smallholders in Central Kalimantan for over 100 years is an indication that cultivation of these two species can be carried out intensively on a smallholder basis, given suitable land and climate. The planting methods used by the smallholders were used and modified when setting up the first commercial estates in Sabah. Although growth rates have been astonishingly good in the new plantations, several important aspects of the cultivation, such as precise light and fertilizer requirements, spacing and line maintenance are not yet fully understood. Until large estates have reached maturity and have been harvested over several years, the commercial viability of such plantations will not be known, and rattan planting on such a large scale will be a risky, though promising, venture.

The cultivation of large-diameter canes is less well understood than that of the two small-diameter species mentioned above, and there are no records of successful smallholder cultivation of large-diameter canes. At present the only large-diameter canes to have received much research attention are the single-stemmed *Calamus manan* and the multiple-stemmed *C. ornatus, C. merrillii, C. ovoideus* and a few other more local species. No new commercial plantation of large-diameter cane has reached harvestable age. Smallholdings of *C. manan* under rubber in Peninsular Malaysia show promise, but there are several aspects of the cultivation procedure that re-

main contentious, in particular the ability of rubber to support densely planted mature *C. manan*.

It has often been said that there are few pests of rattan in cultivation, but this may only be a reflection of the fact that large rattan plantations have only recently been established. A recent outbreak of rhinoceros beetle in plantations of *C. manan* in Sabah (Lee) has serious implications for all would-be cultivators of this single-stemmed species. Despite this, rattan cultivation is certainly attractive enough for rigorously managed companies to risk investing capital in the establishment of new large plantations.

Although some rattan cultivation is undoubtedly successful, it cannot be assumed that the cultivation methods developed for one species in one habitat and climate can be applied in the cultivation of other species elsewhere. Much research needs to be done before untried species can be introduced into intensive cultivation.

Great potential exists for the development of rattan as a smallholder crop as part of social forestry schemes. Rattan requires tree support. It is already cultivated by villagers under fruit trees or in secondary forest near villages. Canes do not have to be harvested at fixed seasons; harvest times can be deferred if the selling price of cane is unattractive. Such cultivation augments villagers' income. Most importantly, rattan cultivation provides an incentive to leave forest cover intact and there are implications for the conservation of other forest organisms. SAFODA's Batu Putih Estate on the Sungei Kinabatangan in Sabah has large concentrations of wildlife including one of the densest populations of orang-utan in Sabah (Shim) and Commonwealth Development Corporations's plantation in Sarawak contains about half the entire rattan flora of Sarawak in the wild state. For the smallholder, forest cover maintained for rattan support provides the habitat for a wealth of other minor forest products from 'jungle meat' to medicine, and is essential for the maintenance of water catchments.

1.6.3 Trade

Rattan enjoys a still expanding international trade in furniture, matting and other manufactured goods. This external trade is estimated to be US$ 4 billion annually (World Resources Institute et al., 1985). A very conservative estimate of the total domestic trade is another US$ 2.5 billion (Manokaran, 1990a); this includes value of goods in urban markets and rural trade, and the value of rural usage of the material and products. In some way or another, of 0.7 billion of the world's 5 billion people use, or are involved in the trade of, rattan and rattan products.

The reduction in the forest area is resulting in loss of the resource in several producer countries. The resource base in some of the main producer countries is partially protected by bans on the export of the raw material; this also encourages the expansion of the domestic manufacturing industry. The increase in world population, expected to reach 8.2 billion by the year 2025 (World Resources Institute & International Institute for Environment and Development, 1988), is expected to lead to increased demand for the resource and finished goods. Research and development activities, especially into cultivation, have increased significantly during the last decade and are

likely to increase further. The rattan trade seems set to continue to expand both domestically in producer countries and globally.

1.6.4 Research priorities and development

Although pioneering research on rattans, essentially taxonomic, goes back several centuries, it is only during the last 15 years that in response to periodic shortages of supply research on rattan has been initiated and pursued vigorously in several producer countries in the Asia-Pacific region. During the last 15 years, with financial support mainly from Overseas Development Administration (UK), the International Development Research Centre (IDRC) (Canada), and the Food and Agriculture Organization of the United Nations (FAO), studies on taxonomy, propagation and utilization have been begun as national projects by research institutes, forest departments and universities in these countries. Today, these projects form a loose informal research network.

While a great deal has been accomplished over the past 15 years, much remains to be achieved. Research needs and priorities, discussed and summarized at recent international meetings, have been further elaborated on by Dhanarajan & Sastry (1989), International Development Research Centre (1989), Manokaran (1990b), and the International Fund for Agricultural Research (IFAR; see Williams, 1991) in an effort to gain support for the development of the rattan resource.

The priorities for rattan research and development are as follows:

(1) Survey existing resources:
- to establish the taxonomic and resource base and the rate of resource depletion;
- to document and use indigenous knowledge about rattan;
- to identify critical areas and under-utilized species that could be brought into use.

(2) Germplasm collection, storage, exchange and characterization:
- to expand greatly the extent of living collections of rattan;
- to explore the existing natural genetic diversity which is already at risk of depletion;
- to screen lines for adaptability to various ecological conditions, suitability for cultivation, and utility of diversified products.

(3) Development of propagation techniques:
- to permit the large-scale production of superior planting material for establishing plantations;
- to overcome the acknowledged difficulty of obtaining adequate supplies of seed.

(4) Investigation of technologies for plantation cultivation:
- to identify and test cultivation and management techniques for cultivating rattan economically at village level and on a commercial scale.

(5) Evaluation of domestic use:
- to quantify the value of domestic (urban and rural) use and of employment generated.

(6) Improved harvesting system, use and marketing:
- to explore opportunities for developing appropriate techniques for har-

vesting and processing including post-harvest protection, for improved use of added value products for domestic and international markets.

(7) National policies:

- to examine national policies covering the harvesting, use, marketing and development of the resources;
- to examine quarantine laws for possible solutions to allow the exchange of propagules and germplasm.

The list of priority fields on which future rattan research and development could be focused may be expanded further. Supported by adequate funds for research and training, substantial gains may be expected in the development of the resource.

2 Alphabetical treatment of species

Calamus caesius Blume

Rumphia 3: 57 (1849).
PALMAE
$2n$ = unknown

Vernacular names Rotan sega (general throughout region and in trade). Indonesia: rotan sego (Sumatra), rotan taman (southern and central Kalimantan). Philippines: sika. Thailand: wai ta kha thong.

Origin and geographic distribution *C. caesius* is widespread in the wetter parts of South-East Asia, occurring in Peninsular Malaysia, Sumatra, Borneo, Palawan (the Philippines), and southern Thailand (possibly introduced). In recent years it has also been introduced to China and a few countries in the South Pacific for trial planting.

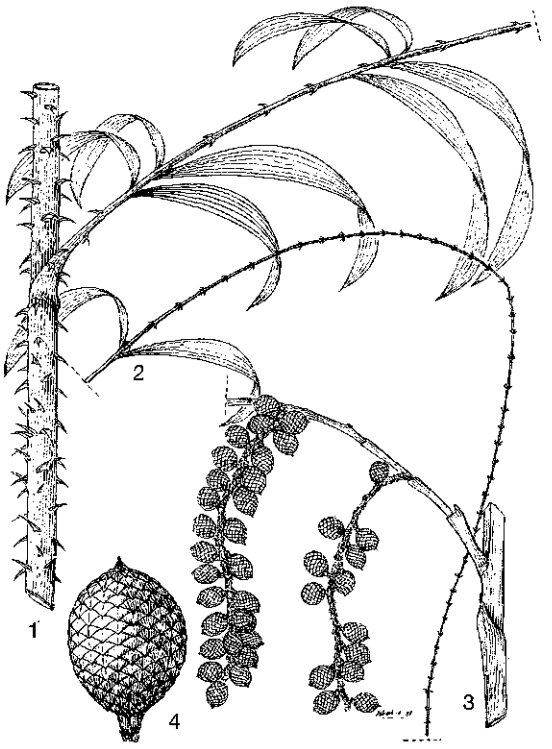
Uses Traditionally, *C. caesius* has been used by rural people for making baskets, mats, carpets, handicrafts, cordage, and in house construction, and sewing of 'atap' (thatch). The round cane, skin peel and core provide extremely important high-quality materials for the now highly developed and very sophisticated rattan furniture manufacturing industry. Its unique glossy golden cane surface makes it highly sought after for making 'tatami' mats or rattan carpets for the lucrative Japanese market. Its commercial usage has now surpassed traditional usage.

Production and international trade Traditionally, *C. caesius* has been collected from the wild in Indonesia, Malaysia and the Philippines either for local use or to be sold commercially. In Kalimantan, however, *C. caesius* has been extensively cultivated by smallholders for probably over a century, particularly along Mentaya River in Central Kalimantan. In this region, it is commonly planted in abandoned rubber holdings, the old rubber trees being used for shade and support. In East Kalimantan, *C. caesius* has been incorporated into the swidden farm system. There are no authoritative statistics on annual production of *C. caesius* either from the wild or from cultivated areas, although it is certain that Indonesia has been the largest producer. In Malaysia, 3000–4000 ha of commercial plantations of this species have been established in stages over the last 10 years. In the near future, Malaysia will become a major producer.

C. caesius is collected or harvested and sold to middlemen either in the raw form or after some cleaning, fumigation and drying. Middlemen in turn sell to large processing factories which are also usually engaged in exporting it as washed and sulphured round canes, split canes, skin peels, woven chaircane or core. In the past, raw materials from Malaysia and Indonesia were exported to Singapore and Hong Kong for further processing, grading and packing before they were sold to end users in Europe, the Philippines, Taiwan and China which have well developed rattan furniture manufacturing capability and capacity. These traditional trade routes have been drastically altered recently by the introduction of increased export levies and bans aimed at increasing processing and manufacture in the producing countries, thereby adding value to the exports.

Properties *C. caesius* has a resilient and durable cane with a smooth golden surface. It is particularly suited for making high-quality rattan carpets ('tatami' mats) because of the siliceous glossy surface. The quality of the cane is adversely affected by poor processing; it also depends on factors such as age, moisture content and the light conditions during growth (which affect the internodal length).

Description Clustering, moderate-sized, high-climbing, dioecious rattan, with stems ultimately to 100 m or more long, the clump tending to be rather close and dense. Stem without leaf-sheaths 7–12 mm in diameter, with sheaths to about 20 mm in diameter; internodes to 50 cm or more long. Leaf to 2 m long including the sheath; leaf-sheath dull-green, armed with sparse, pale, triangular spines to 10 mm × 5 mm, between the spines with grey hairs and sometimes with minute spicules and/or brown scales; petiole up to 50 cm long in juveniles, very short in adult climbing stems; rachis c. 75 cm long, bearing scattered reflexed spines on the lower surface, distally the rachis prolonged into a whip (cirrus) c. 75 cm long, bearing grapnel-like groups of reflexed spines; leaflets c. 15 on each side of the rachis, arranged irregularly, usually in alternate pairs, lanceolate, up to c. 30 cm × 5 cm, the upper surface dark-green, the lower surface usually conspicuously bluish-white. Inflorescence borne on the leaf-sheath of the leaf above the subtending axil, to 2 m long, the male and female superficially similar, the male branching to 3 orders, the female to 2; bracts tightly tubular, sparsely spiny and hairy; first-order branches 5–8, rather distant; flower-bearing branches rather slender, to 10 cm long



Calamus caesius Blume – 1, part of a young stem with leaf-sheath and proximal part of the blade; 2, distal part of the leaf with cirrus; 3, proximal portion of the infructescence; 4, fruit.

in the female, shorter in the male; male flower greenish-yellow, c. 5 mm × 3 mm; female flower, larger than the male, each borne in a pair together with a sterile male flower. Mature fruit 1-seeded, ovoid, c. 15 mm × 10 mm, covered in neat reflexed greenish-white scales, drying yellowish. Seed c. 12 mm × 7 mm, with an outer fleshy seed-coat (sarcotesta); endosperm ruminate, embryo basal. Seedling-leaf forked, with the two acute lobes only a quarter the length of the whole leaf, and held parallel to each other, upper surface dark green, the lower surface grey-white.

Growth and development Most seeds germinate within 3–4 weeks. After 12–14 months the primary stem may exceed 1 m; the first climbing whips and 1–2 sucker shoots may have developed. As the plant grows older, more and more suckers will be produced every year, probably up to ten per year. Some of these will develop into aerial stems while others remain dormant as bulbil-like shoots, thus forming a relatively compact cluster of aerial stems. By year 10, the number of aerial stems may vary from 20 to 60 or more per cluster, depending on conditions of growing site and weather.

Aerial stems may grow at rates exceeding 4–5 m per year. Annual flowering may commence at an age of 4–5 years. Up to 4 inflorescences may be produced on one flowering stem, with each infructescence bearing 1000–1500 fruits.

Other botanical information *C. caesius* is closely related to *C. optimus* Becc. and *C. trachycoleus* Becc. Whereas *C. caesius* and *C. optimus* produce short horizontal stolons not exceeding about 8 cm, *C. trachycoleus* produces long horizontal stolons up to 1 m or more long. As a result, *C. caesius* produces a relatively compact cluster of aerial stems whereas *C. trachycoleus* has a diffuse colony of aerial stems which are more widely spaced and hence compete less with each other. The diffuse colony of *C. trachycoleus* makes it an aggressive colonizer and a potentially higher cane yielder.

Ecology *C. caesius* is usually found in the lowlands on alluvial flats, seasonally flooded river banks, and margins of freshwater or peat-swamp forest, but not in permanent swamps. In Borneo, where the greatest morphological variation occurs, it is also found on drier sites up to 800 m above sea-level. On these drier sites, growth is less vigorous. Although it flourishes under mild and seasonal floodings, the seedlings cannot withstand severe floods.

Propagation and planting Although *C. caesius* can be propagated by using sucker shoots, cultivation is best effected using seed. Rattan fruits should be processed and sown as soon as possible after collection in order to maintain their viability. During processing, scales and sarcotesta are removed by repeated rubbing and washing. Cleaned seeds should be stored in a cool and shady place if they are not sown immediately after processing. Seeds are sown about 1 cm deep in a seed-bed constructed under shelter. The sowing medium should be sandy loam or loam with a top layer of 2 cm of sawdust to enhance moisture retention in the sowing medium. Regular watering is essential to keep the seeds and sowing medium moist. Seeds may be treated with fungicide prior to sowing. Seedlings are potted in black polythene bags of about 15 cm deep and 15 cm in diameter when the shoots have emerged 2–3 cm above the sawdust. Seedlings are nursed in these bags for 9 months or more under semi-shade provided by

plastic shading sheet, palm fronds or other appropriate materials. Regular watering, fertilizing with 5–10 granules of NPK compound fertilizer per seedling per month and spraying with some pesticides are routine maintenance measures. Seedlings 40–50 cm tall are ready for planting out in the field. Rubber trees, bungor (*Lagerstroemia* sp.) and even fruit trees have been used by smallholders to provide shade and support for *C. caesius*. Large-scale commercial planting has been carried out under logged-over natural forest and plantation forest. While smallholders adopt haphazard spacing, commercial planting adopts a spacing of 2 m × 10 m or 2 m × 8 m.

Husbandry Post-planting maintenance is relatively simple. Seedlings should be circle-weeded manually for 2–3 years. Overhead shade should be manipulated at about 6-monthly intervals for 2–3 years to ensure seedlings receive sufficient light to grow vigorously. About 50% light/shade conditions are ideal for rattan growth. A path 1 m wide may be maintained in the planting row to allow easy access and maintenance. NPK compound fertilizer needs to be applied at 6-monthly intervals if soil conditions are poor. Pesticide application has not been necessary.

Diseases and pests In the nursery, disease and pest attack is usually minimal if strict nursery hygiene is observed. However, seedlings may suffer leaf-spot diseases caused by *Curvularia, Colletotrichum, Phomopsis* and *Pestalotiopsis* species. Severely infected leaves will dry up. These diseases can be controlled by applying fungicides. Leaf blight caused by *Colletotrichum gloeosporioides* is more serious and may kill the seedlings in a few weeks. It can be controlled with fungicide applied at 10-day intervals. In the field, individual shoots may be attacked by rats, squirrels, porcupines and an unidentified weevil. In Sabah, elephants are known to pull out seedlings or feed on the shoots. Wild boars will uproot seedlings as they forage for roots and worms.

Harvesting Selective harvesting of mature canes can be carried out in the eighth year after planting. Harvesting is carried out by cutting the rattan cane at about 30 cm from the base, pulling the cane down out of the canopy as much as possible, removing the leaf-sheaths by twisting the cane around a tree trunk or hitting it with a knife. The cane, divested of its sheaths, is then cut into lengths of about 6 m and bent, and tied in bundles of 100 pieces. Inevitably, lengths of canes will be left in the canopy and cannot be pulled out because they are entangled with the tree branches. More efficient mechanical methods of harvesting for large commercial plantation have yet to be developed. Canes should be processed soon after harvesting, in order to maintain their quality.

Yield Highly variable figures, ranging from 1.5–3 t/ha per year, have been provided by cultivators and researchers. Based on a surviving population of 500 plants/ha in a commercial plantation, a cane growth rate of 2.5 m/year and 36 000 m of dry canes to yield one ton, the yield has been estimated to increase from 0.5 t/ha per year in year 9 from planting to 1.5 t/ha per year in year 12 and thereafter.

Handling after harvest Post-harvest treatment of canes involves washing to remove mud and remaining leaf-sheaths, drying, and sulphur fumigation to prevent attack by diseases and pests and to improve cane colour.

Genetic resources *C. caesius* has been collected and planted in a number of botanic gardens and arboreta in several countries. Recently, different provenances of this species have been collected for provenance trials by the Sabah Foundation in Sabah, Malaysia.

Breeding No breeding work has been carried out on *C. caesius*. Primary selection and provenance trials are needed before a breeding programme can be initiated.

Prospects Supply of *C. caesius* from natural forests has been dwindling fast, especially in Malaysia and the Philippines, due to overexploitation and destruction of its natural habitat when forest is converted for agriculture. Rich alluvial flats and other fertile land where *C. caesius* used to thrive best have practically all been converted to agricultural land. In Indonesia, fortunately, there is a long tradition of cultivating *C. caesius* by smallholders, thus very significantly supplementing supply from the wild. Rattan cultivation has provided a very important source of income for large numbers of otherwise impoverished smallholders, especially in Kalimantan. Several Indonesian companies have also started cultivating this rattan on a commercial scale as in Malaysia by government bodies and private companies.

Literature [1] Dransfield, J., 1979. C. caesius and C. trachycoleus compared. Gardens' Bulletin, Singapore 30: 75–78. [2] Dransfield, J., 1979. A manual of the rattans of the Malay

Peninsula. Malayan Forest Records No 29. Forest Department, Kuala Lumpur. p. 135. |3| Godoy, R. & Tan Ching-Feaw, 1991. Agricultural diversification among smallholder rattan cultivators in Central Kalimantan, Indonesia. Agroforestry Systems 13: 27–40. |4| Lembaga Pengembangan Perbankan Indonesia Proyek Pengembangan Agro Industri, 1989. Industri mebel rotan di Indonesia-Studi sektor [Rattan furniture industries in Indonesia – sectoral study]. 83 pp. and 10 pp. appendix. |5| Norani, Ahmad & Maziah, Zakaria, 1988. Diseases of Calamus spp. (Rattan). FRIM Technical Information No 4. 4 pp. |6| Shim, P.S. & Momen, M.A., 1985. A preliminary report on the growth forms of Calamus caesius and C. trachycoleus in SAFODA's Kinabatangan rattan plantation. In: Wong, K.M. & Manokaran, N. (Editors): Proceedings of the rattan seminar, Kuala Lumpur, 2–4 October 1984. Rattan Information Centre, Forest Research Institute of Malaysia, Kepong. pp. 63–71. |7| Weinstock, J.A., 1983. Rattan: ecological balance in a Borneo rainforest swidden. Economic Botany 37: 58–68.

C.F. Tan & P.S. Shim

Calamus egregius Burret

Notizbl. Bot. Gart. Berlin 13: 599 (1937).
PALMAE
$2n$ = unknown

Vernacular names China: duanye shengteng, liteng (Hainan).

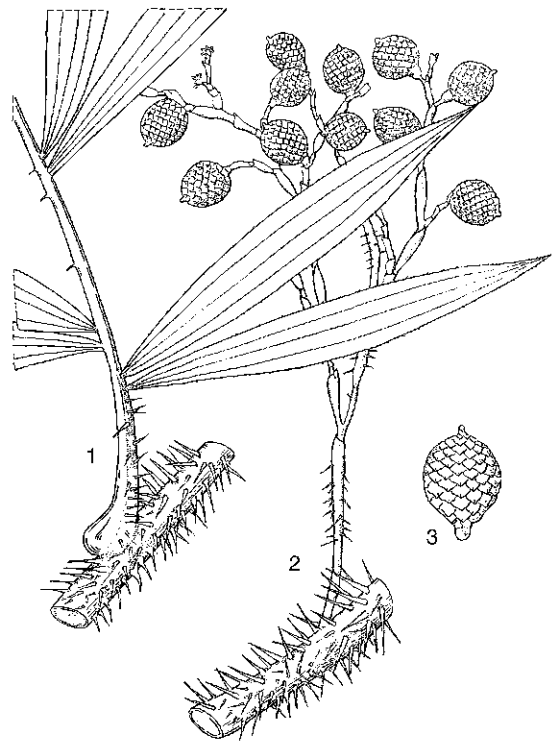
Origin and geographic distribution *C. egregius* is found only on Hainan Island, but has now been introduced into Guangdong and Guangxi Provinces in arboreta and botanical gardens.

Uses *C. egregius* produces an excellent cane of small to medium diameter, supreme for all types of binding and weaving in the furniture industry, widely used locally for cordage and house construction. New shoots can be eaten as a vegetable.

Production and international trade There are no reliable estimates of production and trade. In recent years, the annual output of the canes may be rather small because of the restricted distribution and overexploitation.

Properties Anatomical, physical and mechanical properties of the cane have yet to be examined. The cane has a creamy yellow colour and glossy outer surface, similar to that of *C. simplicifolius* Wei and *C. caesius* Blume.

Botany Clustering, moderate-sized, dioecious rattan, with stem climbing to 50 m long or more. Stem without leaf-sheaths 10–15 mm, with sheaths 30–50 mm in diameter; internodes to 40 cm in length. Leaf-sheath yellowish-green, armed with flattened triangular spines 5–20 mm; knee conspicuous; petiole short; leaf-rachis and petiole armed with small spines, cirrus to 1 m long; leaflets in groups of 2(3–4), lanceolate, 10–17 cm × 2–3 cm, with 4–5 major nerves, armed with brownish bristles along margins and at the top. Details of male and female flowers not recorded. Infructescence 50–80 cm long, the rachilla 1.5–4 cm long; calyx in fruit c. 3 mm long; corolla in fruit shorter than the calyx. Ripe fruit ovoid, c. 20 mm × 16 mm, with a beak to 2 mm long, covered in 20 vertical rows of pale brown scales with dark margins. Seed ovoid, c. 18 mm × 16 mm, deeply grooved and ruminate. Germination begins in 50–60 days; after 2–3 months the seedling-leaf has fully emerged; after 3 years, the first stem may exceed 1 m



Calamus egregius Burret – 1, part of leaf and stem with leaf-sheath; 2, part of infructescence; 3, fruit.

long. *C. egregius* forms small clumps of a few to 10 aerial stems. Flowering begins in May in the fifth year after sowing and thereafter, fruit begins to mature in October and ends in December. The growth rate may reach 1.5–2.0 m/year. *C. egregius* is closely related to *C. simplicifolius*.

Ecology *C. egregius* usually occurs in montane rain forest between 600–1000 m altitude. It grows well in rich and moist soil and requires adequate light for optimum growth of aerial stems but is unable to withstand full sunlight. Seedlings may be damaged by temperatures of –3°C.

Agronomy *C. egregius* is usually propagated by seed. Seed extraction and cleaning should be carried out soon after collection to ensure high germination rates. The cleaned seeds are usually sown in sand beds, and then transplanted to pots as the first leaf emerges. Seedlings are usually kept in partial shade for 10–12 months, and can then be interplanted in secondary forest, artificial plantation forests and agroforestry systems. The mother stem in a clump should be harvested 10–12 years after planting. Harvesting methods are similar to those for other small to moderate-sized canes.

Genetic resources and breeding Although *C. egregius* does vary in the wild, no attempt has been made to distinguish varieties. No research on breeding has been conducted. Basic biological studies have to be undertaken before breeding and cultivation programmes are initiated.

Prospects *C. egregius* is a very valuable species and may have great potential for development as a cultivated crop. It is of excellent quality and of good growth form, features that suggest it has potential outside China in the northern part of the Prosea region. However, the prospects for cultivation on a commercial scale have to be further researched. In the near future it may verge on extinction if not protected in nature reserves.

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H.C. Xu & G.T. Yin

Calamus exilis Griffith

Palms of British India: 51 (1850).

PALMAE

$2n$ = unknown

Synonyms *Calamus ciliaris* Blume sensu Ridley (1893), *C. curtisii* Ridley (1907), *C. ciliaris* Blume var. *peninsularis* Furt. (1956).

Vernacular names Indonesia: uwi pahe (Palembang), rotan gunung. Malaysia: rotan paku, rotan lilin.

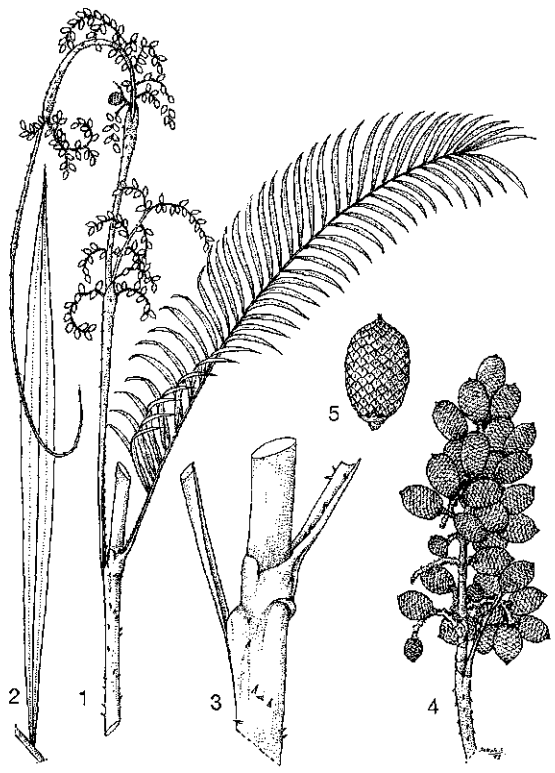
Origin and geographic distribution *C. exilis* is widespread in Peninsular Malaysia and Sumatra.

Uses Both in Peninsular Malaysia and in Sumatra this rattan is mostly used locally in binding and weaving. The local people of Sungai Tutung, Kerinci, Sumatra have for years produced baskets using the split cane of this rattan. The same material can be used to produce handicrafts such as lamps and vases.

Production and international trade To date, *C. exilis* has been collected from the wild mostly for local consumption. Although it is known that this rattan is also sold, the actual amount traded internationally is not known.

Properties *C. exilis* produces a good quality slender cane suitable for binding and weaving.

Botany Slender solitary or clustering rattan. Stem climbing to 10 m or sometimes to 15 m high; stem without leaf-sheaths 4–8 mm in diameter, with sheaths 8–20 mm; internodes 15 cm or more. Leaf 45–90 cm long including the petiole; leaf-sheath dull grey-brown, variable in armature, always densely covered by minute scabrid spines, often no other spines present or two or more triangular spines present on one leaf-sheath, or leaf-sheath densely armed with flat triangular spines irregularly arranged or arranged in partial whorls; knee and whip (flagellum) present on the sheath; petiole up to 30 cm long, scabrid as the sheath; rachis to 60 cm long, with rusty hairs along the upper surface, armed with scattered spines on the lower surface; leaflets 22–40 pairs, very regularly arranged, linear lanceolate, up to 40 cm × 2 cm, the upper surface usually densely hairy. Inflorescence to 1.5 m long, with terminal whip, the male and female superficially similar, usually the female more robust, the male branching



Calamus exilis Griffith – 1, sheathed stem with leaf and inflorescence; 2, leaflet; 3, base of leaf and peduncle; 4, part of infructescence; 5, fruit.

to 3 orders and the female to 2, the whole inflorescence scabrid as the sheath; bracts tightly tubular; first order branches 2–7, rather distant; flower-bearing branches slender, to 7 cm long in the female, shorter in the male; male flower greenish-yellow, 6 mm × 2 mm; female flower on a conspicuously stalked disk, 4 mm × 3 mm, each borne in a pair together with a sterile male flower. Mature fruit ovoid to oblong, 22 mm × 8 mm, with straw-coloured scales. Seed 12 mm × 3 mm, sinuous grooved, brain-like, covered with a thin green intensely bitter and fetid sarcotesta; endosperm homogenous, embryo lateral. Seedling-leaf pinnate, with rusty coloured hairs along rachis and about 10 leaflets on each side of the rachis, the uppermost leaflets much larger and broader than the lowermost.

No information on growth and development is available for this rattan. It is only known that *C. exilis* is a forest undergrowth species and in one trial at FRIM, Kepong, grew at a rate of 120 cm/year.

Ecology *C. exilis* is found in a wide variety of forest types. It has been found in peat-swamp forest, but mostly on ridges in hill and lower montane forests.

Agronomy A plantation trial has been established in Sungai Tutung, Kerinci, Sumatra. Sucker shoots were used as planting material, and transplanted beneath perennial crops. It was reported that after two months survival was high.

Genetic resources and breeding Besides the plantation trial at Kerinci, Sumatra, a few plants of *C. exilis* have been cultivated at the arboretum at FRIM, Kepong, Malaysia.

Prospects This rattan may be cultivated for local use.

Literature |1| Dransfield, J., 1979. A manual of the rattans of the Malay Peninsula. Malayan Forest Records No 29. Forest Department, Kuala Lumpur. p. 176. |2| Siebert, S.F., 1989. The dilemma of a dwindling resource: Rattan in Kerinci, Sumatra. Principes 33(2): 79–87.

P. Kramadibrata

Calamus javensis Blume

Rumphia 3: 62 (1847).

PALMAE

$2n$ = unknown

Synonyms *Calamus filiformis* Becc. (1902).

Vernacular names Indonesia: rotan opot (Sumatra, Bengkulu), howe cacing (western Java), rotan lilin (southern Kalimantan). Malaysia: rotan lilin (general throughout Peninsular Malaysia), coonk stook (Perak), lempinit ular-ular (Sabah). Philippines: arorog, arurug (Palawan), rotan cacing (also used for *C. heteroideus*, *C. unifarius* and *C. viminalis*). Thailand: rote batu, wai tek (southern), wai kuan (Pattani).

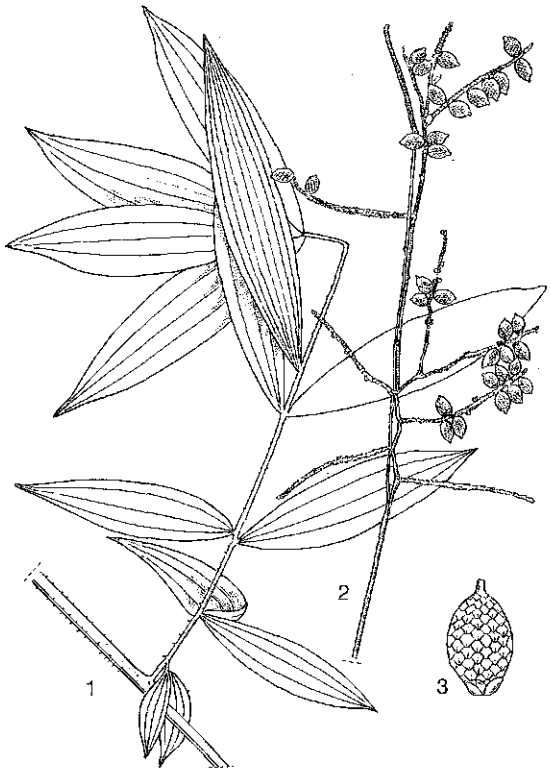
Origin and geographic distribution *C. javensis* is widely distributed in South-East Asia from southern Thailand, Malaysia, Singapore, Sumatra, Java, Borneo to Palawan.

Uses In Peninsular Malaysia the cane is used for cordage by the aboriginal people for making baskets, noose traps and musical instruments. The spiny leaf-sheaths were formerly used for making graters by Semai people, the edible raw cabbage for curing coughs and the cane for the covers of blowpipe quivers. In Sabah and Sarawak it is used for making baskets and as binding material.

Production and international trade It is sold locally as baskets, cordage and handicrafts.

Properties In Sarawak the cane is considered excellent because of its length and strength. In Palawan, it is said that the cane is second in quality to *C. caesius* Blume.

Botany Clustering, slender to very slender, dioecious rattan, sometimes forming low thickets to 2 m tall, sometimes climbing to 10 m or more. Stem without leaf-sheaths 2–6 mm in diameter, with sheaths to 10 mm in diameter; internodes to 30 cm, usually less. Leaf ecirrate, to 40 cm long, very variable in form, mature leaves always with a terminal flabellum formed by two apical leaflets joined along at least 3/4 of the length, lowermost pair of leaflets frequently convex and swept back across the stem enclosing a chamber; leaf-sheath bright green when fresh, sometimes to 30 cm long, usually less, when young frequently tinged reddish, slightly longitudinally striate with variable armature, varying from unarmed to covered with small horizontal spines; spines slender or triangular, rarely exceeding 5 mm; knee present; ocrea quite conspicuous, tinged deep crimson when young, eventually tattering; flagellum to 75 cm long; petiole 1–2 cm long; leaflets 4–12 on each side of the rachis, irregularly arranged in groups, rarely regular, the penultimate very close to the terminal flabellum and median leaflets somewhat opposite, exceptionally ovate in outline, 20 cm × 35 cm, with 3 main veins and conspicuous transverse veinlets, shiny green; young leaves reddish tinged. Male and female inflorescences superficially similar, at the base erect, in the middle rather curved and eventually pendulous, slender, to 1 m long, each bearing 2–5 partial inflorescences to 20 cm long, each partial inflorescence with 2–6 crimson rachillae to 10 cm long. Ripe fruit ovoid to rounded, 12 mm × 8 mm, covered in 15–21 vertical rows of pale greenish-white scales. Seed somewhat angular, 10 mm long; endosperm homogenous. Seedling-leaf with 4 broad shiny leaflets.



Calamus javensis Blume – 1, part of sheathed stem with leaf; 2, part of infructescence; 3, fruit.

C. javensis should not be confused with *C. penicillatus* Roxb. and *C. flabellatus* Becc. The inflorescence of *C. javensis* is quite different from that of *C. penicillatus*, while the leaves of *C. flabellatus* are dull matt green, turning black on drying. *C. kemamanensis* Furt., a species from Ulu Kemaman (Peninsular Malaysia), is considered to be a form of *C. javensis* by Dransfield. The species forms a complex of closely related taxa, some of which (e.g. *C. amplijugus* J. Dransf. and *C. acuminatus* Becc.) have been separated as distinct species. The morphology of the species varies in the leaf size, leaf-sheath form, leaflet arrangement and size, and number and form of partial inflorescences. At least eight varieties of *C. javensis* have been recognized: var. *acicularis* (Becc.) Ridl., var. *exilis* Becc., var. *intermedius* Becc., var. *peninsularis* Becc., var. *polyphyllus* (Becc.) Becc., var. *sublaevis* Becc., var. *tenuissimus* Becc. and var. *tetrastichus* Becc. However, these are not widely accepted at present.

Ecology *C. javensis* is very widespread, occurring from the lowlands to about 2000 m altitude, and is found on a wide range of soils in tropical rain forest. The chamber formed by the lowermost pair of leaflets is sometimes ant-infested.

Agronomy Propagation is by seed. In Sarawak, a few clumps have been cultivated by villagers and a plantation has been established by the Bidayuh people in Padawan.

The cane is first cut at the base of the stem 1 m above the ground, then the stem is pulled and

cut off at the end of the mature part. It is then cleaned of the remaining leaf-sheaths and rolled into a circle of about 40 cm diameter so it is easy to carry out of the forest.
As the cane is used only locally, it is air-dried.

Genetic resources and breeding There has been no attempt to form a germplasm collection. *C. javensis* is planted in several botanic gardens and arboreta.

Prospects *C. javensis* is unlikely to be traded on a commercial scale.

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J.P. Mogea

Calamus manan Miquel

J. Bot. Néerl. 1: 23 (1861).
PALMAE
$2n$ = unknown

Synonyms *Calamus giganteus* Becc. (1893).

Vernacular names Rotan manau (general throughout the region and trade). Malaysia: rotan manau telur (Peninsular).

Origin and geographic distribution *C. manan* is widespread, usually confined to the steep slopes of hill dipterocarp forest, occurring in Peninsular Malaysia, Sumatra and southern Borneo.

Uses *C. manan* is the most sought after large-diameter cane. It is the premier large furniture cane of unsurpassed quality.

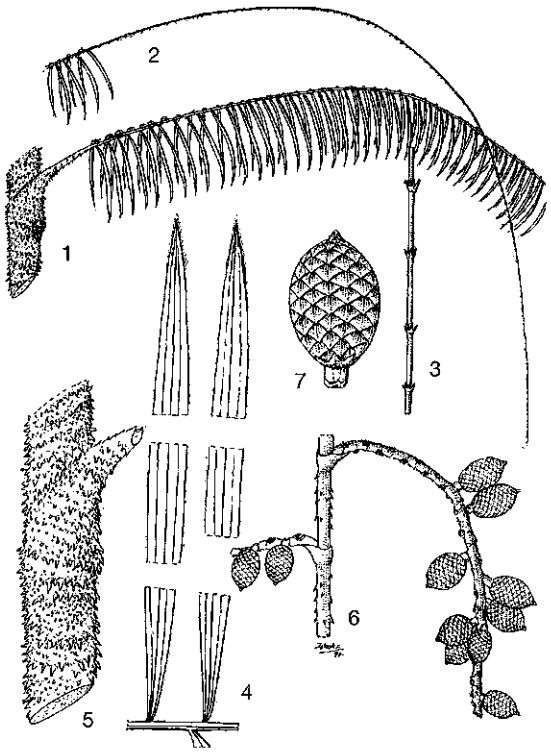
Production and international trade Because of its premier quality, *C. manan* is collected for trading wherever it is found. No production and trade figures are available. Due to overexploitation, this species is facing depletion, and several large-diameter species that produce canes of similar appearance and lower quality are now used as substitutes.

Properties *Calamus manan* is variable in size and colouration. It has a durable cane of great strength and flexibility and is used mainly as the framework of furniture.

Description Solitary, massive, high climbing, dioecious rattan with stems eventually reaching over 100 m. Stem without leaf-sheaths to 80 mm in diameter, with sheaths to 110 mm in diameter; internodes to 40 cm long. Leaf to 8 m long including sheath; leaf-sheath dull grey-green, densely armed with black hairy edged triangular spines arranged in lateral groups or scattered; between spines thin white wax abundant; petiole short, to 12 cm long by 5 cm wide in mature plants, much longer in juveniles, armed densely as is the rachis with short triangular spines both on the upper surface and beneath, with scattered grey indumentum between; rachis to 15 cm long, bearing scattered reflexed spines on the lower surface, distally the rachis prolonged into a whip (cirrus) to 3 m long, bearing grapnel-like groups of reflexed spines; leaflets irregular in juvenile leaves, regular in mature leaves, to 45 on each side of the rachis, lanceolate, the largest to 60 cm × 6 cm, pale grey-green, bristly near the tip; knee conspicuously armed as leaf-sheath; ocrea ill-defined. Inflorescences massive, with the male much more finely branched than the female, to 2.5 m long with up to 9 partial inflorescences on each side, up to 70 cm long; all bracts rather densely armed with triangular spines to 3 mm high and red-brown indumentum. Ripe fruit rounded to ovoid, to 28 mm × 20 mm, shortly beaked, and covered with 15 vertical rows of yellowish scales with blackish-brown margins. Seed ovoid, to 18 mm × 12 mm, with finely pitted surface; endosperm densely and deeply ruminate. Seedling-leaf with 2 divergent cucullate leaflets with a waxy blue-grey bloom on a pale dull green surface.

Growth and development Seeds germinate in 3 to 15 weeks; about 24 months after field planting, the cirri develop, after which the aerial stems may grow at rates between 1–3 m or more per year. Flowering may begin in the fifth year after planting and is annual thereafter.

Other botanical information The closely related *C. tumidus* Furtado differs from *C. manan* in its smaller size, different leaf-sheath arma-



Calamus manan Miquel – 1, basal part of leaf and sheathed stem ; 2, top part of leaf with cirrus; 3, part of cirrus; 4, two leaflets; 5, leaf-sheath; 6, part of infructescence; 7, fruit.

ture and the very large bulbous swollen knee.

Ecology *C. manan* is usually confined to hill dipterocarp forest and is rarely found in lowland dipterocarp forest (mainly near steep slopes). It has an altitudinal range between 50–1000 m and is most abundant between 600–1000 m altitude. Seedlings are abundant in hill forest.

Propagation and planting Seed stored will not tolerate temperatures below 10°C for periods exceeding 2 months and seed moisture content needs to be about 50%; whole fresh fruits can be stored up to 2 weeks in well ventilated conditions at 22–28°C without appreciable loss of viability. In contrast, seeds separated from the sarcotesta desiccate rapidly and lose viability in a few days. Propagation is best effected from seeds. The fruit wall and the fleshy seedcoat must be removed before sowing and the clean seeds kept moist, as any drying out will cause the embryo to die. Seeds are usually sown in seed-beds in the shade and potted in polybags when the first leaf has emerged. Once potted, seedlings should be kept in the shade and provided with plenty of moisture without waterlogging. Seedlings are usually ready for planting 9–12 months after transplanting into bags and require tree support. Seedlings require about 50% relative light intensity for establishment and growth. Rubber smallholders may plant them in between rubber planting rows. Silvicultural trials have been established in Peninsular Malaysia. On a commercial scale, it has been planted in secondary forest. The planting distance should be 6 m × 3 m.

Husbandry Post-planting maintenance is relatively simple. Just before or after planting, the existing canopy needs to be manipulated to allow for 50% light/shade conditions for vigorous growth of the rattan seedlings. Circle-weeding of seedlings is done 3–4 times a year for up to 3 years. Planting lines need to be kept clean, to a distance of 1 m on either side, for easy access and maintenance. Fertilizer application at 6-monthly intervals in the first 3 years enhances growth.

Diseases and pests A few diseases and pests have been recorded. In the field, collar rot disease of planted seedlings is so far the only serious disease. In the nursery, leaf diseases (shot holes, brown rings and brown spots) are evident on the leaves of young growing stock. The severity varies from mild to severe and control is by spraying appropriate fungicide at 10-day intervals. *Calamus* leaves are reported to be attacked by *Artona catoxanta* (moth), *Botryonopa sanguinea, Protocerius colossus* and *Rhabdocnemis leprosa* (all beetles). Fruits have been observed to be attacked by beetles before they are ripe. Stunted growth may result from beetle larvae damaging the swollen basal part of the stem.

Harvesting Harvesting of the stems varies slightly from place to place. Essentially, it involves dragging the rattan from the canopy, removing dead leaf-sheaths and debris and discarding the uppermost 2–3 m, which are immature and too soft for use. The leaf-sheaths and debris are usually removed by coiling and pulling the rattan stem around a conveniently placed small tree trunk, resulting in a clean stem. The cane is then cut into 3 m lengths suitable for bundling and transport out of the forest to the processor. A period of 15 years is estimated for plantation-grown *C. manan* to reach harvestable state.

Handling after harvest Harvested rattan is sorted into species that need treatment and those that do not. Species such as *C. manan* are usually treated to protect them against attack from staining fungi and powder-post beetle. The canes are boiled in a mixture of diesel and coconut oil, or of diesel and kerosene, or of diesel and palm oil, for varying lengths of time. After boiling the canes are rubbed with sawdust, ragwaste or gunny-sacking and then tied loosely in a bundle at one end and stood upright with the untied end on the ground in wigwam-like fashion for drying in the sun for a period of one to two (rarely three) weeks. They may also be fumigated over burning sulphur, which not only prevents attack by diseases and pests but also improves the colour of the rattan skin.

Genetic resources Attempts are now being made in Sabah to establish collections to represent the considerable variation found in this species in the wild. *C. manan* is represented in several botanical gardens, arboreta and silvicultural plots.

Breeding Initial steps have been taken to collect seeds from different areas in Peninsular Malaysia. Seedlings produced have been planted in four different locations in the country. A comparative study of seedlings raised through tissue culture and those from seeds has been initiated.

Prospects The future of this rattan species in the wild is uncertain owing to severe overexploitation. The steps taken by government agencies in Peninsular Malaysia, Sabah and Sarawak to plant *C. manan* on a plantation scale are very encouraging. This will ensure a constant supply in years to come. The feasibility of growing *C. manan* in rubber plantations is being tested and the results so far seem promising.

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Aminuddin bin Mohamad

Calamus merrillii Beccari

Webbia 1: 347 (1905).

PALMAE

$2n$ = unknown

Synonyms *Calamus maximus* Merrill (1922), not of Blanco (1837).

Vernacular names Philippines: palasan (Biko, Marobo, Tagalog), parasan (Bisaya).

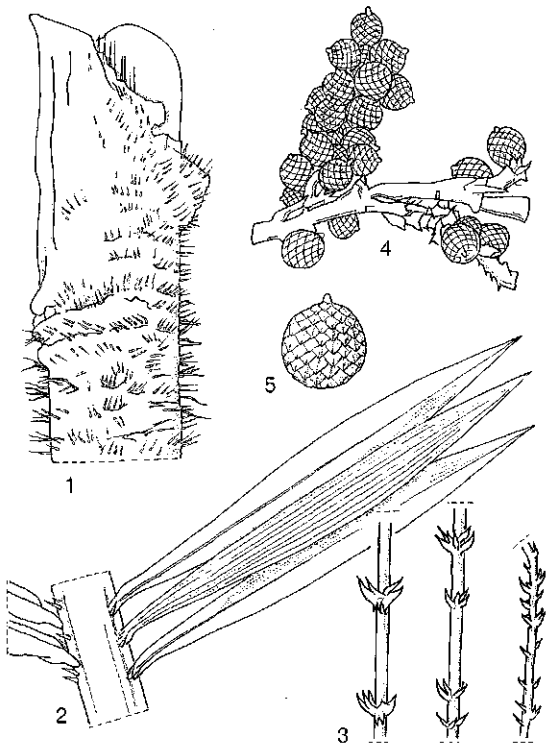
Origin and geographic distribution *C. merrillii* is endemic to the Philippines and found in Rizal, Laguna and Tayabas in Luzon; Agusan, Lanao, and Davao in Mindanao; Masbate and Basilan.

Uses This is the most popular and most sought-after rattan cane in the Philippines. The entire stems are used for making 'bent wood' chair frames, as cables for ferry boats, for hauling logs, standing-rigging on small sailing vessels, and sometimes to support short suspension bridges. The split canes are used for making mats, hats, baskets, chairs, various types of fish traps, and the bottoms and backs of 'cane-bottomed' chairs. The interior parts of the stem, which are softer than the outer part, are used for making 'reed' furniture.

Production and international trade *C.mer-*

rillii is the most preferred rattan cane in the Philippines and is now overexploited. Since 1977, *C. merrillii* and *C. ornatus* Blume var. *philippinensis* Becc. have been planted on 100 ha in Pagbilao (Quezon) by the Forest Research Institute. The Paper Industries Corporation of the Philippines has planted *C. merrillii* in 5000 ha of logged-over forest in Bislig, Surigao del Sur. *C. merrillii* and other rattan species were planted on 50 ha of logged-over forest in San Teodoro (Mindoro Oriental) in 1983 by a private company. Since 1984, this company has planted *C. merrillii* only on about 100 ha in Talacogon, Agusan del Sur.

Description Very large and high climbing, clustering rattan. Stem without leaf-sheaths 25–45 mm in diameter, 60–70 mm in diameter with sheaths. Leaf very large, cirrate; leaf-sheath thick, woody, reddish-brown, armed with numerous small spicules or rigid and very brittle bristles, 5–10 mm long, often confluent and forming short collars; knee conspicuous; ocrea short, represented by a brown bristly-hispid rim at the mouth of the sheaths; petiole very robust, to 35–40 mm broad, polished, unarmed at the base and beneath, shallowly and broadly channelled above, armed on the margins with numerous short straight erect spines; rachis rounded beneath, slightly channelled and with two acute spinulous angles above and above side-faces, distally armed on lower surface with very robust reflexed spines; cirrus very robust, bearing groups of very stout-based black-tipped reflexed spines; leaflets very numerous, equidistant, approximately 15–20 mm apart in the basal and intermediate portion, further apart towards the apex, elongate-ensiform, narrowing and deeply plicate at the base, gradually acuminate, 40–45 cm × 25–27 mm, the apical ones shorter, concolorous when full grown, apparently slightly mealy-white beneath when young, mid-vein unarmed or sparingly bristly only near the tips, the side veins slender, bearing long bristles, transverse veinlets inconspicuous, margins armed with small spinules. Male inflorescence large, triangular in outline, shorter than the leaves, about 1.2 m long with an erect rigid axis, and with about 5 distichous close partial inflorescences on each side, not flagelliferous at the apex; primary bracts rather short, 10–12 cm long in the exposed part, tubular, closely sheathing, upper primary bracts more or less cylindrical, slightly enlarged above, thinly coriaceous, often longitudinally split but not tattering, with scattered, small solitary, short spines; partial inflorescences with a long penduncle-like base; secondary bracts tubular, about 3 cm long in the exposed part, shortly apiculate at one side, glabrous; tertiary bracts shortly tubular; rachillae to about 25 mm long, bearing 11–12 closely spaced flowers on each side. Female inflorescence superficially similar to male but branched to 2 orders only; rachillae to 90 mm long, bearing up to 20 flowers on each side. Fruit more or less spherical, c. 12 mm in diameter, covered in pale brown scales. Seed somewhat flattened, to 9 mm × 6 mm. Seedling-leaf with a fan of about 6 leaflets.



Calamus merrillii Beccari – 1, leaf-sheath; 2, part of leaf; 3, three parts of the cirrus; 4, part of infructescence; 5, fruit.

Growth and development *C. merrillii* is a fast-growing rattan and attains its full length of 15 m or more after 5–8 years. It grows best in semi-open forest.

Other botanical information *C. merrillii* has frequently been referred to as *C. maximus*. Blanco's description of *C. maximus* is so ambiguous that it could refer to almost any species

of *Calamus*. Taxonomy is better served by using the name *C. merrillii* Becc., a name that is clearly and unambiguously typified.

Ecology *C. merrillii* is found mostly in the interior of primary forest at low altitude, sometimes up to 1200 m. Occasionally it is found at the edges of primary forest or in secondary forest.

Propagation and planting *C. merrillii* is best propagated by seeds. The fruits are thoroughly washed to remove the fleshy coat and most seeds are sown in beds. The seedlings are kept in shade and usually potted in plastic bags after some weeks, and watered daily until they attain a height of 20–30 cm. These are then transplanted to the forest (allowing some light to penetrate through the canopy).

An attempt to propagate *C. merrillii* by tissue culture showed that it is possible to develop plantlets from meristematic tissues of the shoots.

Husbandry Little care is given to *C. merrillii* once the seedlings are planted by villagers. For commercial planting, silvicultural treatments similar to those for *C. manan* Miq. should be given. In the latter case, post-planting maintenance is relatively simple. Just before or after planting, the existing canopy needs to be manipulated to allow for 50% light/shade conditions for vigorous growth of the rattan seedlings. Circle-weeding of seedlings is done 3–4 times a year for up to 3 years. Planting lines need to be kept clean up to a distance of 1 m on either side, for easy access and maintenance. Fertilizer application at 6-monthly intervals in the first 3 years enhances growth.

Harvesting Gatherers cut the cane off above the surface of the ground and pull down the entire stem. The rattan is then stripped of leaves and the cane is cut into convenient lengths, ranging from 3–6 m, which are bent sharply at the middle and tied into bundles for convenient transportation. The external part may be stripped from the cane in the forest or the entire canes may be transported, depending on how the product is to be used.

Handling after harvest After harvest, the canes are subjected to various processes to prevent decay or attack by staining fungi. Canes may be air-dried, which usually takes 3–4 weeks, or kiln-dried in a special drier which usually takes a shorter time. Anti-staining chemicals are usually applied to the freshly-cut canes.

Genetic resources and breeding *C. merrillii* is included in the rattan gene bank established at the University of the Philippines, Los Baños, Laguna.

Prospects Large-scale plantations of *C. merrillii* have been established in some privately-owned rattan plantations in Mindanao. The future of this rattan as a cultivated crop has not yet been proved since the plantations are still not mature. Nevertheless, every effort should be directed towards successfully establishing a commercial plantation of *C. merrillii*. This species has also been planted on a trial basis in Sabah and Sarawak.

Literature |1| Baja-Lapis, A., 1982. Gross morphological characteristics of twelve commercial Philippine rattans. Master of science thesis in forest biology, University of the Philippines, College, Laguna. 119 pp. |2| Brown, W.H. & Merrill, E.D., 1920. Philippine palms and palm products. Department of Agriculture and Natural Resources Bulletin 22: 158–178. |3| Dransfield, J., 1979. Report on consultancy on rattan development. FAO. 40 pp. |4| Generalao, M.C., 1981. How to grow rattan. Forest Development Research Institute How-to Series No 1. Forest Research Institute, College, Laguna. 24 pp. |5| Madulid, D.A., 1991. The Philippines: Palm utilization and conservation. In: Johnson, D. (Editor): Palms for human needs in Asia. Balkema, Rotterdam & Brookfield. pp. 181–225. |6| Philippine Council for Agriculture, Forestry and Natural Resources Research and Development, 1985. The Philippines recommends for rattan. PCARRD Technical Bulletin Series No 55. 61 pp. |7| Tongacan, A.L., 1985. Proposed Philippine grading rules for unsplit rattan and its derivatives. In: Wong, K.M. & Manokaran, N. (Editors): Proceedings of the rattan seminar, Kuala Lumpur, 2–4 October 1984. Rattan Information Centre, Forest Research Institute of Malaysia, Kepong. pp. 169–178. |8| Umali-Garcia, M., 1985. Tissue culture of some rattan species. In: Wong, K.M. & Manokaran, N. (Editors): Proceedings of the rattan seminar, Kuala Lumpur, 2–4 October 1984. Rattan Information Centre, Forest Research Institute of Malaysia, Kepong. pp. 23–31.

D.A. Madulid

Calamus mindorensis Beccari

Philipp. J. Sci. 2: 235 (1907).
PALMAE
$2n$ = unknown

Vernacular names Philippines: tumalim (Tagalog), tumaram (Bikol).

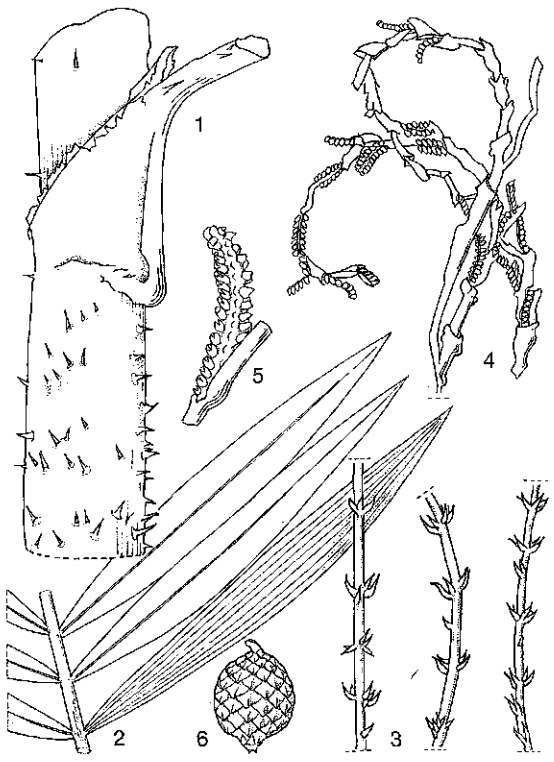
Origin and geographic distribution *C. mindorensis* is endemic to the Philippines and is found in Laguna and Quezon provinces in Luzon, Mindoro, and Agusan, Misamis Oriental and Bukidnon provinces in Mindanao.

Uses *C. mindorensis* is one of the popular large-diameter rattan canes in the Philippines. Unsplit stems are used mainly for furniture. The stems are also split and made into baskets, cordage or used to thatch houses.

Production and international trade Tumalim is sold both locally and internationally as rattan poles.

Properties *C. mindorensis* is one of the commercial rattans in the Philippines. Under the Philippine government's classification and grading of rattan system, it is registered under the trade name 'tumalim', and is characterized as having a stem diameter 15–25 mm and a general colour of light cream to cream. The general requirement for commercial 'tumalim' is that its moisture content should be from 12–20%, minimum length 4 m, diameter at small ends 15–30 mm, and its stem colour light cream to cream.

Description Rather robust and high climbing, solitary rattan. Stem without leaf-sheaths 15–25 mm, with sheaths 40–50 mm in diameter. Leaf large, about 2 m long; leaf-sheath woody, greenish, very thinly covered when young with grey indumentum; knee conspicuous, feebly armed with very small, scattered, 3–4 mm long, horizontal spines; ocrea very short; petiole very short, 3 cm broad, armed along the margins with rather stout, straight spines; rachis in the intermediate portion obtusely 3-angled, armed underneath at the base with rather few, solitary, black-tipped spines; cirrus very robust and strongly clawed; leaflets numerous, up to about 50, equidistant, rather rigidly papery, slightly paler underneath, narrowly elliptical-lanceolate, intermediate leaflets 45–47 cm × 4.5–5 cm, the lower ones smaller, and proportionately narrower. Male inflorescence 2 m long, branching to 3 orders; primary bracts thinly coriaceous, greenish-yellow, tubular, tightly sheathing and smooth; partial inflorescences flexuous, long and slender, up to 1.2 m long, with about



Calamus mindorensis Beccari – 1, leaf-sheath; 2, part of leaf; 3, three parts of the cirrus; 4, part of inflorescence; 5, rachilla with flower buds; 6, fruit.

12 branches distichously inserted on each side; secondary bracts tubular, tightly sheathing, 3–4 cm long, smooth, entire, truncate, also ciliate at the mouth, and prolonged at one side into a triangular point; rachillae arched to 2 cm long, bearing about 20 flowers on each side; flower bud 2.5–3 mm long, cylindrical. Female inflorescence similar but branched to 2 orders; partial inflorescence 40–50 cm long with 10–12 rachillae on each side; secondary bracts narrowly tubular, unarmed; rachillae (when bearing the fruit) spreading or horizontal, with a distinct axillary callus, 10–12 cm long with 20 to 22 distichous flowers on each side. Fruiting perianth shortly but distinctly stalked. Fruit small, spherical, 6.5 mm in diameter, with stout beak; scales in 18–20 vertical rows, glossy, convex and not grooved along the centre, dirty straw-yellowish. Seed one, small, globose.

Growth and development Although no detailed study has been done on the growth and

development of *C. mindorensis* is estimated that it would take 8–10 years from planting before the rattan reaches harvestable size.

Other botanical information Juvenile plants have distinct whitish indumentum near the shoot apex. The young leaf-sheath has very few to no spines and is grey-green when fresh, but the knee is well-developed, even in the juvenile stage.

Ecology *C. mindorensis* is found mostly in the interior of primary forests at 200–500 m altitude. Occasionally it is found at the edge of primary forest or in secondary forest.

Propagation and planting Propagation of *C. mindorensis* is best from seeds. A preliminary attempt to propagate *C. mindorensis* by means of tissue culture failed.

Husbandry Little care is needed once the seedlings are established. It is important to weed the area surrounding the seedlings occasionally.

Diseases and pests *C. mindorensis* is apparently resistant to diseases and pests in the wild.

Harvesting As in other large-diameter rattans the stem is first pulled down from the canopy. This may require the combined strength of 2–3 persons. The stem is then cleaned of its thorny leaf-sheaths by means of a knife. The bare stem is then cut into lengths of 4 m or longer and tied in bundles for transport to the market.

Handling after harvest After harvest the canes are subjected to various processes to prevent decay or attack by staining fungi. The canes may be air-dried, which usually takes 3 to 4 weeks, or may be kiln-dried in a special drier which usually takes a shorter time. Anti-staining chemicals are usually applied to the freshly-cut canes.

Genetic resources and breeding A rattan gene bank has been established at the University of the Philippines campus at Los Baños, Laguna, which includes *C. mindorensis*. However, there has been no attempt to establish a collection to represent the variation found in the wild.

Prospects Some rattan plantations have been developed in the Philippines, many of them less than 10 years old, while others are still in the trial stage. The preferred rattan species for planting include *C. mindorensis* and *C. merrillii* Becc. However, there is still no large-scale commercial plantation of rattans.

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D.A. Madulid

Calamus optimus Beccari

Nelle foreste di Borneo: 610 (1902).

PALMAE

$2n$ = unknown

Vernacular names Indonesia: rotan taman (Central Kalimantan), suko (South Kalimantan), rotan sego (Sumatra: Bengkulu). Malaysia: uwai telong, wi sego (Sarawak).

Origin and geographic distribution *C. optimus* is found in Borneo (Sabah, Brunei, Sarawak, Kalimantan) and possibly also in Sumatra (southern Bengkulu). It has apparently been cultivated by villagers in Sampit and Muara Aman (Central Kalimantan) ever since *C. caesius* Blume has been cultivated in that area.

Uses In Sarawak the cane is used in the making of mats, for weaving, to bind furniture and as cordage. In Central and South Kalimantan the split cane is important in commerce for the same purposes.

Production and international trade The canes of *C. optimus* are apparently treated in

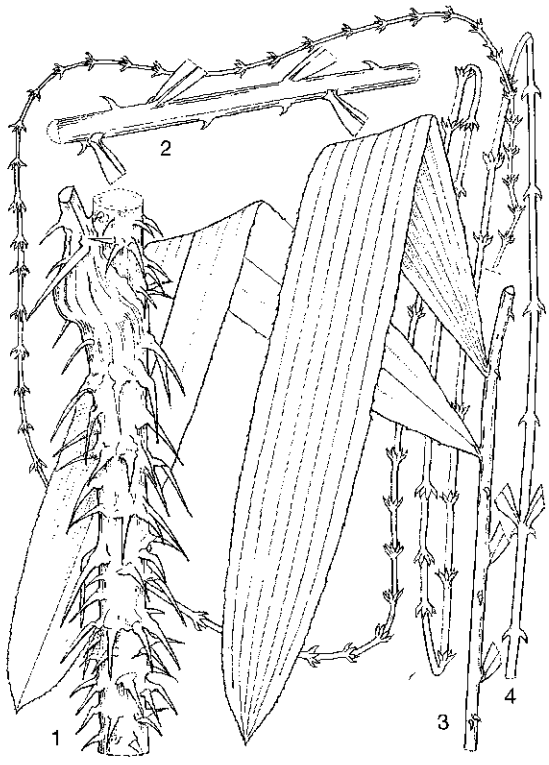
the same way as *C. caesius*, and are sold mixed with the latter species. A plantation has been established by the Kelabit people in Pa Tik (Sarawak); villagers cultivate a few clumps for domestic use of the cane.

Properties The cane has a quality similar to that of *C. caesius*, except that it is generally slightly larger in diameter. It is a resilient and durable cane with a smooth golden surface. Its uniform texture makes it particularly suitable to be split into fine strips (chair cane). The quality of the cane is adversely affected by poor processing; it also depends on factors such as age, moisture content and light conditions during growth.

Description Moderately robust, clustering rattan reaching 50 m, dioecious. Stem without leaf-sheaths 15 mm in diameter, with sheaths c. 30 mm; internodes to 15 cm, sometimes longer in juvenile stems. Leaf up to 2.5 m long, including a cirrus of up to 1.5 m; leaf-sheaths dark green, armed with scattered, large, convex-based, triangular, flattened, black-tipped spines, and abundant caducous black scales; knee grossly swollen; ocrea small, c. 5 mm; petiole very short, scarcely exceeding 5 cm; leaflets up to 8 on each side arranged in 2–3 groups, narrow ovate or spathulate, the largest to 85 cm × 11 cm, very stiff and coriaceous, somewhat plicate, on upper surface dark green, on under surface usually covered with buff indumentum, margin armed with short black bristles, transverse veinlets conspicuous. Inflorescences pendulous, the male similar to the female, the male inflorescence 1.5 m long with c. 10 partial inflorescences, each consisting of c. 20 slender, rather upcurved rachillae, 2.5 cm long; each rachilla bearing c. 26 male flowers; flowers ellipsoid, c. 3 mm long. Ripe fruit ellipsoid, 15 mm × 10 mm, tipped with a short beak to 1.5 mm long, covered in 15 vertical rows of pale yellowish-brown scales. Seed to 10 mm × 8 mm; endosperm deeply ruminate. Seedling-leaf with 2 parallel leaflets joined together for much of their length.

Growth and development Studies on growth have been conducted in Sarawak since 1982 but no results are available.

Other botanical information *C. optimus* is closely related to *C. caesius*. The gross morphology of the inflorescences is very similar. The main differences are that *C. optimus* is more robust, its leaf-sheaths are covered with more massive spines and black scales, its leaflets are very much larger, and the undersurface of the leaflets is covered by buff rather than by white indumentum.



Calamus optimus Beccari – 1, sheathed stem; 2, leaf-base; 3, mid portion of leaf; 4, cirrus.

Ecology *C. optimus* grows in lowlands in primary mixed dipterocarp forest; once found growing well in Sabah at 300 m in secondary forest dominated by *Dillenia suffruticosa* (Griff.) Mart.; elsewhere known in scattered localities.

Propagation and planting Propagation is by seeds. *C. optimus* is planted in the same way as *C. caesius* except that it can be planted in drier soils. Nursery and fertilizer trials by the Forest Department, Sarawak, are in progress.

Husbandry Post-planting maintenance is relatively simple. The soil around the plants should be kept weed-free manually for 2–3 years. Overhead shade should be manipulated at about six-monthly intervals for 2–3 years to ensure sufficient light for the seedlings to grow vigorously. About 50% light/shade conditions are ideal for rattan growth. A path 1 m wide may be maintained in the planting row to allow

easy access and maintenance. NPK compound fertilizer needs to be applied every 6 months if soil conditions are poor.

Diseases and pests In the nursery, disease and pest attack is usually minimal if strict nursery hygiene is observed. However, seedlings may suffer leaf-spot diseases caused by *Curvularia, Colletotrichum, Phomopsis* and *Pestalotiopsis* species. Severely infected leaves will dry up. These diseases can be controlled by applying fungicides. Leaf blight caused by *Colletotrichum gloeosporioides* is more serious and may kill the seedlings in a few weeks. It can be controlled with fungicide applied at 10-day intervals. In the field, individual shoots may be attacked by rats, squirrels, porcupines and an unidentified weevil. In Sabah, elephants are known to pull out seedlings or feed on the shoots. Wild boars will uproot seedlings as they forage for roots and worms.

Harvesting Mature canes can be harvested selectively in the eighth year after planting. Harvesting is carried out by cutting the rattan cane at about 30 cm from the base, pulling the cane down out of the canopy as much as possible, removing the leaf-sheaths by twisting the cane around a tree trunk or hitting it with a knife. The cane, divested of its sheaths, is then cut into lengths of about 6 m and bent, and tied in bundles of 100 pieces. Inevitably, variable portions of canes will be left in the canopy and cannot be pulled out because of entanglement with tree branches. More efficient mechanical methods of harvesting have yet to be developed for large commercial plantations.

Handling after harvest Canes should be processed soon after harvesting, in order to maintain their quality. Post-harvest treatment of canes involves washing to remove mud and remaining leaf-sheaths, drying, and sulphur fumigation to prevent attack by diseases and pests and to improve cane colour.

Genetic resources *C. optimus* has been collected and planted in a number of botanic gardens and arboreta in several countries. Recently, different provenances of this species have been collected for provenance trials by the Sabah Foundation in Sabah, Malaysia.

Breeding No breeding work has been carried out on *C. optimus*. Primary selection and provenance trials are needed before a breeding programme can be initiated.

Prospects Supply of *C. optimus* from natural forests has been dwindling fast, especially in Malaysia, due to overexploitation and destruction of its natural habitat when forest is converted for agriculture. Rich alluvial flats and other fertile land where *C. optimus* used to thrive best have practically all been converted to agricultural land. In Indonesia, fortunately, there is a long tradition of smallholders cultivating *C. optimus*, thus very significantly supplementing supply from the wild. Rattan cultivation has provided a very important source of income for large numbers of otherwise impoverished smallholders, especially in Kalimantan. Several Indonesian companies and Malaysian government bodies and private companies have also started cultivating this rattan on a commercial scale.

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J.P. Mogea

Calamus ornatus Blume

Rumphia 3: 58 (1847).

PALMAE

$2n$ = unknown

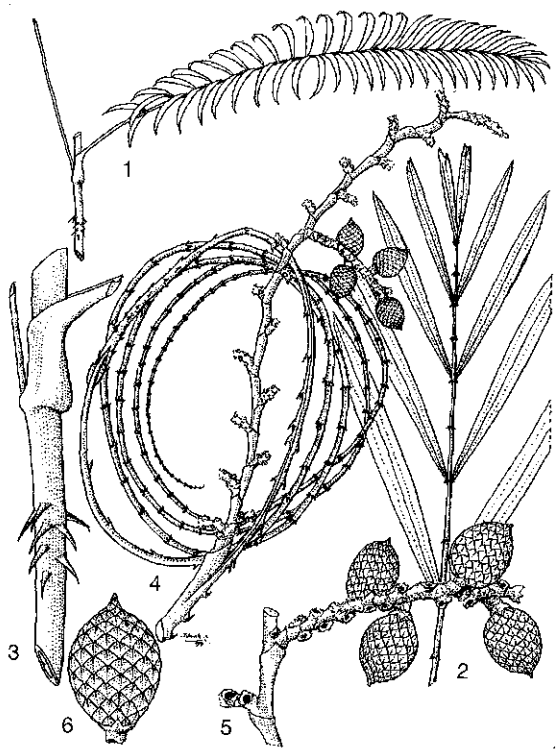
Vernacular names Indonesia: rotan kesup (Bengkulu), rotan buku dalam (northern Sulawesi), rotan lambang (central Sulawesi). Malaysia: rotan dok (Selangor), sek batang (Pahang), we maliang (Sarawak). Philippines: limuran (Luzon), rimoran (Palawan), borongan (Mindanao). Thailand: waai chaang (Pattani).

Origin and geographic distribution *C. ornatus* is widespread in secondary to primary forest from southern Thailand, Sumatra, Java, Borneo, Sulawesi (var. *celebicus* Becc.) to the Philippines (var. *pulverulentus* Fernando and var. *philippinensis* Becc.).

Uses The major use of the cane is for making furniture (Indonesia) and as core (Peninsular Malaysia). Other uses in Peninsular Malaysia include the making of walking sticks, handles

for umbrellas, axes and parangs, and flooring. Semai people of Peninsular Malaysia consider it to be one of seven plant species whose leaves help in the avoidance of epidemic diseases. The water from the raw cabbage is said to cure stomachache and diarrhoea. During childbirth, women in Sarawak may drink the extract of the roots to alleviate pain. The ash of the stem is believed to cure yaws. In the Philippines raw fruits of var. *philippinensis* are edible and are sold in markets. Fruits are also occasionally sold in Brunei and Sarawak.

Description Massive clustering rattan, climbing to 50 m, dioecious. Stem without leaf-sheaths slightly angular, to 40 mm in diameter, with sheaths to 70 mm in diameter; nodes rather prominent, internodes to 30 cm. Leaves massive; leaf-sheath pale to dark green, armed to various degrees with narrow to large flattened triangular black spines with yellowish bases, 4 cm × 1 cm, spines irregularly arranged and pointing somewhat upward; knee conspicuous; ocrea short, tattering; flagellum massive, dark green, to 10 m long or more, armed with short black yellow-based spines in partial whorls; petiole linear, to 1 m × 4 cm, usually less; leaflets regular, 20–30 on each side, the lowermost 50 cm × 5 cm, the largest one in the middle, 80 cm × 8 cm, decreasing to small at the tip, 4 cm × 0.5 cm, the rachis forming a subcirrus; upper surface of the leaflets conspicuously prickly near the tip and along the upper main veins. Inflorescence flagelliferous, to 8 m long, bearing 4–6 partial inflorescences to 80 cm, the female with robust reflexed rachillae, the male with more branched rachillae. Ripe fruit ellipsoid, 3 cm × 2 cm, short beaked, covered in 15 vertical rows of yellow brown to matt black scales, slightly lighter in colour at their bases. Seed ellipsoid, 2 cm × 0.8 cm, rather angular with grooves on flattened lateral face, covered in sour sarcotesta; endosperm homogenous. Seedling-leaf bifid, shiny green.



Calamus ornatus Blume – 1, leaf; 2, top part of leaf; 3, leaf-sheath; 4, part of infructescence with apical flagellum; 5, part of infructescence; 6, fruit.

Other botanical information *C. ornatus* is very distinctive, likely to be confused only with *C. scipionum* Lour. and *C. peregrinus* Furt. It can be distinguished from *C. peregrinus* by the much broader leaflets. It can only be distinguished from *C. scipionum* with ease in the climbing stage, when *C. scipionum* has large terminal leaflets (ecirrate) and *C. ornatus* has minute terminal leaflets (subcirrate). In inflorescence structure they are very different, and the seedling of *C. scipionum* has 4 rather than 2 leaflets. Variation is considerable and largely continuous. It has been suggested that var. *horridus* Becc. and var. *sumatranus* Furt., separated on differences in leaf-sheath armature, should be regarded as being the same as *C. ornatus* var. *ornatus*. However, there are still other published varieties such as var. *javanicus* Becc., var. *mitis* Becc. and var. *philippinensis* Becc. which have not yet been accounted for. The var. *celebicus* Becc. in Sulawesi ('rotan susu') is still maintained. From the Philippines (Mindanao and Palawan) var. *pulverulentus* Fernando has been described recently. Variation in this polymorphic species is in need of a complete reassessment.

Ecology *C. ornatus* is very common and widespread in primary as well as secondary tropical rain forest at altitudes up to 1000 m. It is not found in peat swamps or on extremely poor ridgetop soils.

Agronomy Propagation is by seed. In Peninsular Malaysia, cultivation trials have been es-

tablished. In Sarawak and Brunei a few clumps are cultivated by villagers for their edible fruits. In Mindanao, a 280 ha area has been planted with *C. ornatus* var. *philippinensis* by the Ecosystems Research & Development Bureau (ERDB).

Little care is needed once the seedlings are established, apart from occasional weeding. *C. ornatus* is apparently resistant to diseases and pests in the wild. The same harvesting and handling-after-harvest methods are used as for other large-diameter canes such as *C. manan* Miq.

Genetic resources and breeding *C. ornatus* has been planted in several botanic gardens and arboreta and in silvicultural trials.

Prospects As a clustering species with a large diameter, *C. ornatus* has reasonable prospects for cultivation on a commercial scale.

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J.P. Mogea

Calamus ovoideus Thwaites ex Trimen

Journal of Botany 23: 269 (1885).
PALMAE
$2n$ = unknown

Vernacular names Sri Lanka: thuda rena (Sinhala, south-western), sudu wewel (Sinhala, less commonly in south-western), ma wewel (Sinhala, in trade, collective term for large-diameter rattan).

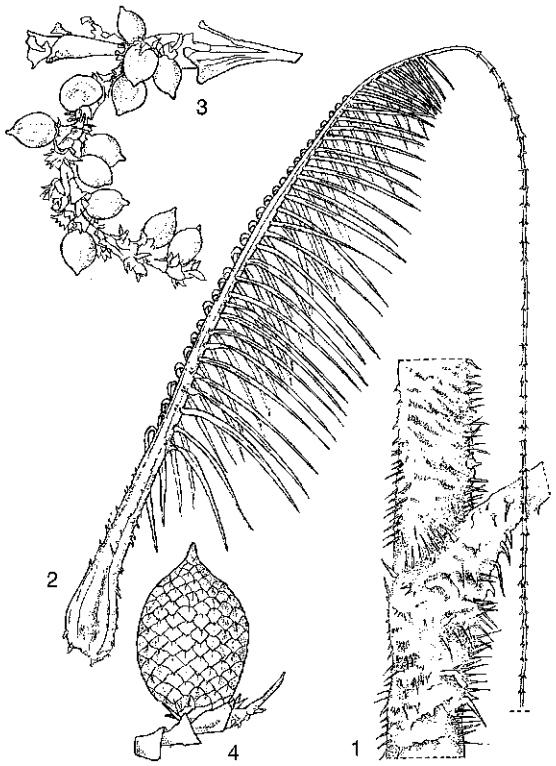
Origin and geographic distribution *C. ovoideus* is found only in Sri Lanka and is restricted to the south-western part of the country.

Uses In Sri Lanka split cane of *C. ovoideus* is used for weaving baskets, and whole canes for furniture frames. Split cane cores are used for less refined woven products.

Production and international trade There is no trading of *C. ovoideus* outside Sri Lanka. A negligible amount of rattan products reach the tourist and export market. Locally all trade is within the south-western part of the country. Products traded are mainly furniture and basketware for household and agricultural purposes, gem mining and the tea industry. At present *C. ovoideus* is scarce and is used mainly for basket making by villagers living close to forest areas. It is not available in sufficient quantity for furniture making. There is no estimate of the volume of rattan harvested. It is evident, however, that at present supplies are harvested illegally from forest reserves.

Properties *C. ovoideus* has a smooth, pale brown cane with diameter of 30–50 mm and internode length of 30 cm or more. The inner core is pale with hardly any soft pith. The cane is heavy and durable. It produces very good quality rattan for furniture frames and is well suited for good quality split rattan for basket work. The main factor affecting the quality of the cane is the harvesting of immature canes with high levels of moisture; these canes are apt to shrink and are easily attacked by insects.

Description Clustering, robust, high climbing, dioecious rattan, with stems ultimately to 50–70 m or more in length, the clump tending to have 2–10 well-spaced stems. Stem without leaf-sheaths, 30–50 mm in diameter, with sheaths to about 40–80 mm in diameter; internodes to 30 cm or more in length. Leaf to 3–4.5 m long including the sheath; leaf-sheath dull green, densely armed with oblique rings of flat triangular dark brown spines 10 mm long, interspersed with smaller spines and fine hairs; knee not prominent, marked by a neat ridge 1 cm wide and 1 cm high; petiole prominent, at least 50 cm long in adult climbing stems; rachis c. 2.5–4 m long, bearing scattered stout reflexed



Calamus ovoideus Thwaites ex Trimen – 1, sheathed stem; 2, leaf with petiole and cirrus; 3, part of inflorescence; 4, fruit.

spines on the lower surface and grapnel-like groups of reflexed spines containing 3–6 spines; distally the rachis extends into a cirrus c. 2 m long, bearing grapnel-like groups of reflexed spines; leaflets c. 130 on each side of the rachis, arranged regularly in alternate pairs, lanceolate, up to c. 60 cm × 2.5 cm, upper surface dark green, lower surface with a waxy coating giving the fronds a grey-green appearance. Inflorescence borne on leaf-sheaths, usually 6–8 at one time, pendulous, with stout peduncles; male and female superficially similar, with male to 2–2.5 m long, branching to 3 orders, female shorter to 1 m long, branching to 2 orders; bracts tightly tubular in proximal portion, sparsely spiny becoming funnel-shaped in distal part; first order branches rather distant; rachillae slender, to 3 cm in the male, larger in the female; male flower pale yellow, c. 5 mm × 3 mm; female flower larger than the male, each borne in a pair together with a sterile male flower. Mature fruit 1-seeded, ovoid, c. 15 cm × 10 cm, covered in small, neat, reflexed, dark green scales, deeply channelled in the middle with faintly orange-brown margins, turning pale yellow-green when ripe. Seed c. 11.5 cm × 7.5 cm, with an outer fleshy seed-coat (sarcotesta); endosperm ruminate, embryo basal. Seedling-leaf pinnate with c. 5 leaflets, spread out, about one-third the length of the whole leaf; upper surface of the leaflets light green with fine spines along the midrib and secondary veins; petiole and leaf-sheath sparsely covered with long narrow spines ending in a needle-fine dark tip.

Growth and development Seeds germinate after 2.5–3 months; after 12–14 months seedling leaves may reach a height of 30–50 cm and for 4 years the plant usually remains in a rosette state with seedling leaves reaching 2 m or more in height. By the 5th year the primary stem starts to develop and the first climbing whips begin to appear. By the 6th year the climbers may have grown up to 6 m long, and by the 7th year they attain a height of 8–10 m and suckers begin to develop. Information on growth is available from the earliest research trials started in 1985 on *C. ovoideus* under-planted in *Pinus caribaea* Morelet plantations. The trial plantings in natural forest show slower growth, indicating that the availability of light is an important factor. Observations of growth patterns of rattan plants in pine plantations suggest that a sudden increase of light may trigger the climbing habit. *C. ovoideus* flowers in April, fruits take 5–6 months to mature, ripening during September and October. Plants with 8 infructescences can bear up to 2000 fruits. Flowers appear to be pollinated by bees and seed dispersal seems to be effected mainly by polecats, civets (*Viverridae*), fruit bats, giant squirrels and leaf monkeys.

Other botanical information The closely related *Calamus zeylanicus* Becc. often occurs together with *C. ovoideus*, has a similar ecology and is also a large-diameter rattan suitable for cultivation.

Ecology *C. ovoideus* occurs in lowland and lower montane rain forest areas below 1500 m altitude, with daylength 10–12 hours, an average temperature of 27°C, annual rainfall of 5000 mm evenly distributed throughout the year, and a relative humidity of 80–90%. The soils here are mainly lateritic. The UNESCO system classifies this forest type as a tropical humid Sri Lankan rain forest of the Indo-

Malayan realm. *C. ovoideus* grows on well-drained slopes and is frequently found in forest gaps and other open sites. Juvenile clumps occur scattered in the forest undergrowth, but mature climbers are often associated with disturbance, natural or man-made, in forest gaps, logged forest and edges of clearings.

Propagation and planting *C. ovoideus* is most effectively propagated from seed. It is difficult to propagate by removal of sucker shoots. Seed collection is tedious as the infructescence may be several meters above the ground and entangled with other vegetation. For fruit collection on a large scale, the infructescence is inserted into a bag and the stalk cut. This prevents the fruits from being scattered on the forest floor. The seeds are extracted by removing the fruit wall and the fleshy seed-coat. A single seed weighs about 1 g. The cleaned seeds must be kept moist until sown because they lose viability if they dry out. Seeds are sown in beds prepared with a mixture of soil and sawdust or a similar loose mixture. This enables germinated seed to be removed easily without damaging the root. Nursery beds are partially shaded to allow plenty of diffuse sunlight. The sown seeds are covered with a thin layer of soil. Deep shade and deep burial of seed tend to delay germination. Seeds begin to germinate between 2.5–3.5 months after sowing. The seedlings are potted after the first leaf has emerged. They are then kept in the shade and provided with plenty of moisture. Seedlings are ready for planting at 12–14 months; however, survival rates are better when the seedlings are about 16–18 months old. Seedlings are planted in natural forest, in forest plantations (*Pinus caribaea* and mahogany), other tree crop plantations (rubber) and home gardens where a tree crop exists, because the plants need support. Trial plantings in *Pinus caribaea* plantations have shown the best results. If planting in a tree crop plantation, a spacing of 10 m × 5 m is recommended to avoid tangling when the plants climb. In natural forest and home gardens selective planting can be done in forest gaps and close to a supporting tree.

Husbandry When seedlings are planted in the natural forest, it is advisable to thin the canopy to allow more light, to speed up growth. For seedlings planted in forest plantations where weeds are abundant, patch weeding around the plant to keep it free of undergrowth in the first two years will improve survival. Canopy thinning about two years after transplanting is also recommended. If porcupine damage is severe, plant guards made of bamboo or wooden sticks can be used until the seedlings are established. In fire-prone areas such as pine plantations, the rattan must be protected by growing fire breaks as they are easily destroyed. Fertilizer application is recommended if planting sites are degraded reforested areas such as pine plantations. A regular NPK fertilizer or urea has been used successfully.

Diseases and pests Few diseases and pests have been reported. There have been instances when rats have clipped off the new leaves of seedlings in the nursery. Damage by porcupines, once the seedlings are planted out, has been especially severe in pine plantations.

Harvesting Rattans are tugged down from the canopy and the leaf-sheaths pulled off the stem with the help of a knife. Often a considerable part of the cane may be left behind in the canopy. The cane is then cut into lengths of 5–10 m and transported. The canes are dragged along on the long journey out of the forest, which causes some damage. Current methods of harvesting are very wasteful.

Handling after harvest Post-harvest treatment is minimal. The canes are cleaned of the remains of leaf-sheaths. Villagers prepare canes for their own use by further cleaning, sun drying, splitting and coring. Otherwise, the raw rattan is cut into lengths and transported to the nearest town with commercial craft establishments. Here the canes may be further air or sun dried and debarked in order to obtain a clean cane with uniform dimensions. Canes used for furniture are smoothed with sand paper and coated with coconut oil to produce lustre. Fungal staining and attack by powder-post beetles are very common. Processing is very simple and there is an urgent need to develop better methods to minimize waste and increase the quality of the cane.

Genetic resources Although *C. ovoideus* is the most prized Sri Lankan rattan species, there has been no systematic collection of plant material for adequate representation of the species. The several hundred thousands of seedlings raised in the last 7 years by the Forest Department are from a narrow genetic base of a few clumps in the Sinharaja Forest. This is due to the scarcity of mature clumps, and so far this is the only known large seed source (about 6000 plants) accessible for regular supply. *C. ovoideus* has been recently introduced to

the botanic gardens in Peradeniya. Seeds have been sent abroad on various occasions.

Breeding No breeding work has been attempted. If such programmes are to be initiated, the scarcity of seed-bearing mature clumps will be a serious impediment. Major breeding objectives should be to select for quick growth and early formation of suckers.

Prospects *C. ovoideus* is a rattan species with many desirable characteristics. It is of large diameter, with a heavy durable cane, a clustering habit and indivual stems can produce large quantities of seed annually. Because of its excellent quality and clustering habit, there is great potential for developing the species for plantation establishment in the Asian region. It is currently under trial in Malaysia. Its restricted distribution i.e. to the south-western part of Sri Lanka where it occurs in fragmented rain forests, makes it an exceptionally endangered resource. Efforts should combine protecting wild stocks and stepping up cultivation. In a network of selected natural forest sites, mature climbers must be allowed to reach the seed-bearing stage both by stricter legislation and by enlisting support from local people. Planting material should be obtained from as wide a genetic base as possible and selection done for desirable characters. So far, planting has been done almost entirely in state-owned forests with little or no maintenance, resulting in poor survival and growth. Greater success may be ensured if craft workers and entrepreneurs take up cultivation on private land. Seed material must be distributed to other countries in the region on a systematic basis. Techniques should be developed for propagating *C. ovoideus* by tissue culture.

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N. de Zoysa

Calamus palustris Griffith

Ann. Roy. Bot. Gard. Calcutta 11: 405 (1908).
PALMAE
$2n$ = unknown

Synonyms *Calamus dumetorum* Ridley (1907).

Vernacular names Malaysia (Peninsular): rotan buku hitam, rotan teling (Kedah/Perlis), rotan sega beruang (Pahang), rotan pasir (Perak). Thailand: waai khring (Trang).

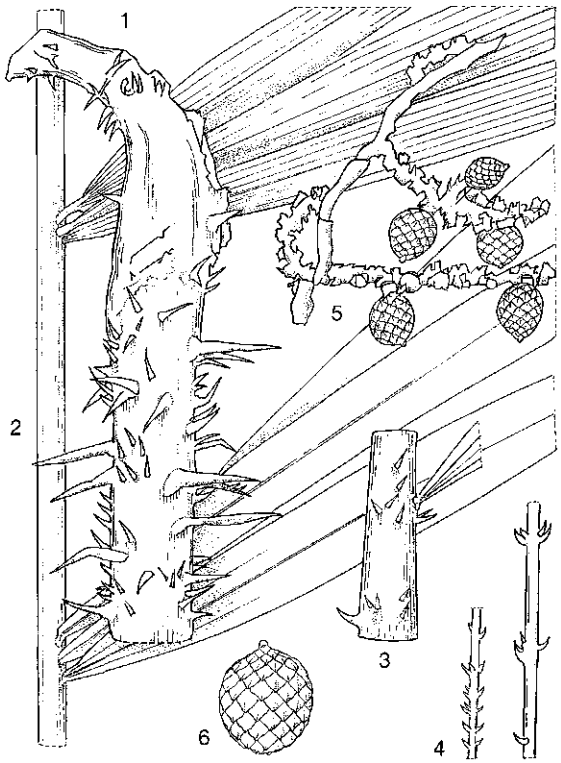
Origin and geographic distribution *C. palustris* is widespread, occurring from Burma and southern China southwards to Peninsular Malaysia and the Andaman Islands.

Uses *C. palustris* produces an excellent cane used in making the framework of furniture. Because of its great similarity in appearance and properties to *C. manan* Miq., the supreme cane of the furniture industry, it is traded as *C. manan*.

Properties The beautiful glossy, yellowish cane of excellent appearance has morphological and strength properties that differ very little from those of *C. manan*, except the diameter is slightly smaller than the average diameter of the latter. Internode length ranges from 15–30 cm.

Description Clustering rattan climbing to 30 m tall, flowering when quite short. Stem without leaf-sheaths 15–20 mm in diameter with internodes to 30 cm, with leaf-sheaths to 35 mm. Leaf cirrate, to 2.5 m long including the cirrus to 1 m; leaf-sheath bright green, armed with scattered brown yellow-based spines to 3 cm long, usually less, with much smaller spines scattered in between, reddish-brown indumentum abundant on young sheaths; knee conspicuous; ocrea to 3 mm long, dark brown, unarmed; petiole short, about 10–15 cm long, semicircular in cross-section, the upper flat surface armed with short erect spines; leaflets to about 21 on each side of the rachis, arranged in twos to fours, broad, spathulate, to about 35 cm × 4 cm, unarmed or very sparsely armed. Inflorescences to about 1 m long, usually less in female; male rachillae 2 cm long, up to 5 cm in female; bracts sparsely armed. Fruit globular, about 9 mm in diameter, weight 0.6 g, tipped with a beak 2 mm long, and covered in 12 vertical rows of straw-coloured scales with brown margins. Seed about 9 mm × 7 mm × 5 mm, deeply pitted, the pits penetrating the endosperm. Seedling-leaf bifid, midrib pale yellow.

Cane anatomy The peripheral zone consists



Calamus palustris Griffith – 1, part of stem with leaf-sheath; 2, part of leaf; 3, base of leaflet; 4, two parts of the cirrus; 5, part of infructescence; 6, fruit.

of up to 10 rows of lignified parenchyma cells. The outer 3–4 cells are rectangular and appear more strongly lignified. The vascular bundles consist of 1 metaxylem vessel (approximate diameter 300–350 µm) and 2 phloem fields located laterally and containing 4–6 sieve tubes each. The surrounding fibre sheath is extensive and strongly lignified. Fibre with length 1.5 mm, diameter about 18 µm, wall thickness approximately 4 µm and lumen diameter about 10 µm. The ground tissue consists of large and generally thin-walled parenchyma cells of irregular outline, intercellular spaces large and numerous.

Growth and development Germination begins 6 weeks after sowing. At 31 months after planting under stands of *Pinus caribaea* Morelet, stem lengths ranged from 2–4 m, with one stem (3.5 m long) having produced a female inflorescence. Growth is better in young secondary forest or in old rubber plantations (5–15 stems per clump), where there is more light, than in regenerated forest (1–5 stems per clump). Each fruit bunch contains 500–1000 fruits.

Other botanical information *C. palustris* resembles *C. axillaris* Becc., but in the latter the petiole is channelled on the upper surface, and is unarmed, as opposed to flat and densely armed. The inflorescences of the two species are also clearly distinct. Based on variation in armature and leaflet arrangement several varieties have been distinguished: var. *malaccensis* Becc. in northern Peninsular Malaysia, var. *cochinchinensis* Becc. in Indo-China, var. *amplissima* Becc. from cultivated material, and var. *longistachys* Pei & Chen from China. The separation of varieties is in need of reassessment. As the varieties themselves are so variable, there is probably little justification for recognizing them.

Ecology *C. palustris* is found in various habitats such as regenerated forest and young secondary forest, and in old rubber plantations near villages, suggesting cultivation. It grows on lower slopes up to 900 m altitude.

Agronomy Although *C. palustris* is a clump-forming species, and the sucker shoots could be used in propagation, seedlings raised from seeds are the best source of planting material. Nursery procedures and outplanting techniques are similar to those described for other species such as *C. manan* and *C. subinermis* Becc. Likely planting sites are secondary forest areas in the lowlands. The only plantings known are of a few plants under a stand of *Pinus caribaea* in Kedah. Clumps seen in old rubber plantations near villages have probably been planted. Little maintenance is required, apart from initial weeding and where necessary, opening the canopy sufficiently to allow light to reach the seedlings. There is no information on diseases and pests of *C. palustris* in the wild or in the nursery.

It is not known at what age the cane can be harvested. The harvesting method is similar to that for other medium- to large-diameter canes. As for other medium- and large-diameter canes, the cut canes are washed and cleaned before being boiled in an mixture of diesel and coconut oil, diesel and kerosene or diesel and palm oil, for varying lengths of time. They are then rubbed with gunny sacking and stood upright to dry in the sun, after which they are bundled.

Genetic resources and breeding No collec-

tion of genetic variability has been carried out so far and no breeding work has been initiated.

Prospects *C. palustris* has the potential to be cultivated on a commercial scale because of its quality, which is comparable to that of *C. manan*, and of its clustering habit that allows for multiple harvests. It is a species that should be thoroughly researched.

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N. Manokaran

Calamus pogonacanthus Beccari ex H. Winkler

Engl. Bot. Jahrb. 48: 91 (1912).
PALMAE
$2n$ = unknown

Vernacular names Malaysia: wi tut (Iban, Sarawak), wi pale (Kayan, Sarawak).

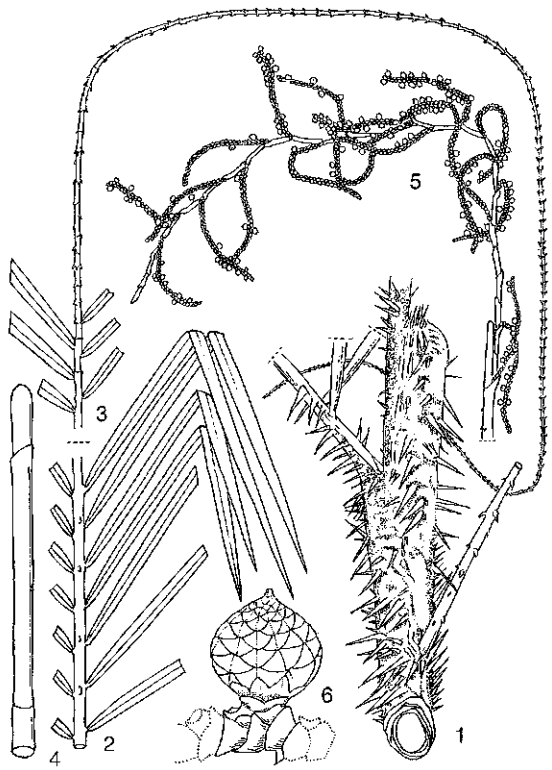
Origin and geographic distribution *C. pogonacanthus* is endemic to and very widespread in Borneo. In Sarawak, it is abundant in Ulu Baleh and Ulu Mengiong, Kapit District.

Uses The cane of *C. pogonacanthus* is of good quality and is used for tying and binding. It is also used for making coarse mats.

Production and international trade It is used locally and usually traded under the name 'rotan tut' in the market. No information is available on the price and the exact volume used per year.

Properties *C. pogonacanthus* produces a durable cane. It can be split quite easily and uniformly.

Botany Clustering, moderate-sized, dioecious, high climbing rattan with stems to 30 m or more. Stem without leaf-sheaths to 25 mm in diameter, with sheaths to 35 mm diameter; internodes to 30 cm long. Leaf cirrate, to 2 m long including the short petiole to 10 cm and the cirrus to 80 cm; leaf-sheath grey-green, armed with black hairy spines to 20 mm long; knee conspicuous; vestigial flagellum to 30 cm long; cirrus bearing scattered rather than grouped



Calamus pogonacanthus Beccari ex H. Winkler – 1, part of stem with leaf-sheaths; 2, central part of leaf; 3, upper part of leaf with cirrus; 4, bare cane; 5, part of inflorescence; 6, fruit.

spines; leaflets 20–25 pairs, irregularly arranged, usually subregular near the base and grouped in threes or fours near the cirrus, the longest 40 cm × 2 cm, armed with scattered bristles along the main veins on both surfaces. Inflorescences c. 1.5 m long with up to 8 lax partial inflorescences, arranged rather regularly; main bracts tubular, covered with spines and rarely splitting; male rachilla 30 mm × 3 mm, female to 150 mm × 4 mm, bracts and bracteoles dull grey-brown. Mature fruit spherical or almost depressed, 8 mm × 10 mm, tipped with a beak to 1.5 mm × 1.5 mm, covered with 24 vertical rows of white reflexed scales. Seed c. 8 mm in diameter, sarcotesta sweet, astringent; endosperm deeply ruminate. *C. pogonacanthus* seeds germinate in 5–12 weeks.

It is a highly variable species especially in leaflet arrangement and degree of armature on the leaf-sheaths. It is closely related to *C. pseudoulur* Becc., *C. semoi* Becc., *C. mesilauensis* J.

Dransf. and *C. hepburnii* J. Dransf. and forms with them a taxonomically difficult complex.

Ecology *C. pogonacanthus* is usually found in the lowlands, on river banks and in disturbed areas in lowlands and in hill forests up to 200 m altitude.

Agronomy *C. pogonacanthus* is propagated from seed.

Genetic resources and breeding No efforts have been taken to conserve *C. pogonacanthus*. Four plants have been planted at the Forest Research Institute of Malaysia at Kepong. No breeding work has been carried out.

Prospects *C. pogonacanthus* has the potential to be cultivated. The stems can grow to 30 m length. The cane can be harvested within 7–10 years from planting.

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L. Tipot

Calamus scipionum Loureiro

Fl. Cochin., ed. 1: 210 (1790).
PALMAE
$2n$ = unknown

Vernacular names Rotan semambu (general throughout region and in trade). Thailand: waai maithao (peninsular).

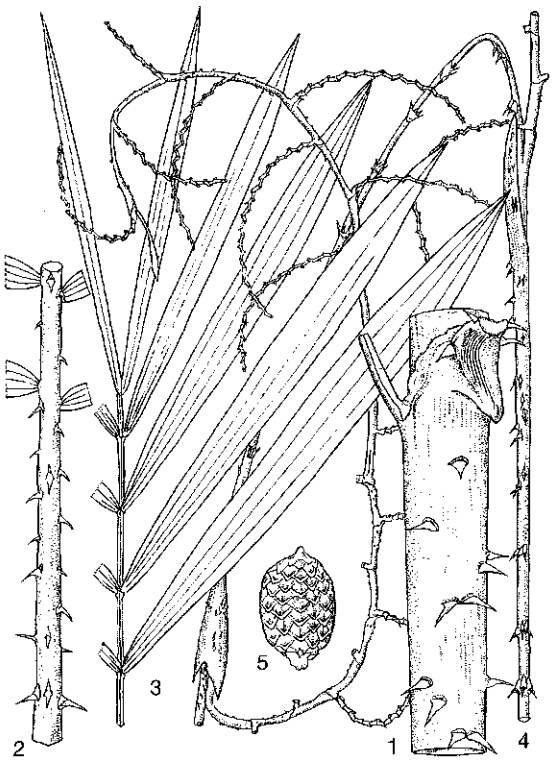
Origin and geographic distribution *C. scipionum* is widespread throughout Burma, Vietnam, Thailand, Peninsular Malaysia, Sumatra, Borneo and Palawan.

Uses Cane of *C. scipionum* is used for making furniture of moderate quality. Cane with long internodes is valued for making walking sticks, umbrella handles, etc.

Production and international trade *C. scipionum* is collected from the wild and used or traded mainly domestically, although some is traded internationally. The estimate by the Rattan Manufacturers' Association of Malaysia of monthly production in Peninsular Malaysia in 1989 was 1 000 000 sticks of 3 m each.

Properties Cane surface light brown or light to darker brown throughout the length, or with brown patches. Internode lengths mostly > 30 cm, often very long but sometimes to 28 cm or less, node raised and swollen at one point, for 10 mm or more of its circumference, swelling arising longitudinally from internode below, hence cane is acylindrical. In a test, the following mechanical properties were measured: oven-dry density 0.56 g/cm^3, the modulus of rupture 27 N/mm^2, modulus of elasticity 4283 N/mm^2, compression 63 N/mm^2, shear 2.44 N/mm^2.

Description Massive clustering rattan climbing to great heights, reaching lengths of 50 m or more. Stem without leaf-sheaths to 25–35 mm in diameter, with rather prominent nodes, and slightly lopsided in transverse section; internodes very long, sometimes exceeding 1 m, with



Calamus scipionum Loureiro – 1, portion of stem with leaf-sheath; 2, upper part of petiole; 3, upper part of leaf; 4, part of female inflorescence; 5, fruit.

sheaths 50 mm in diameter. Leaf ecirrate to about 2 m in length; leaf-sheath mid-green, armed with large, triangular, flattened, yellowish-based, black spines to 5 cm long and 1.5 cm wide at the base, and abundant grey indumentum when young; knee conspicuous; ocrea short, quickly tattering; flagellum massive, dark green, frequently exceeding 7 m in length, armed with whorls of black tipped, reflexed spines; petiole to about 30 cm; leaflets about 25 on each side of the rachis, regularly arranged, the lowermost to 40 cm × 3 cm, mid-leaflets to 60 cm × 6 cm, the uppermost to 20 × 3 cm, very sparsely bristly at tips. Inflorescences male and female, superficially similar, to 6 m or more in length with about 7 short to elongated partial inflorescences, sometimes to 1.5 m long, with slender reflexed rachillae in the female, and finely branched rachillae in male. Ripe fruit ovoid, to 14 mm × 9 mm, very shortly beaked, covered in 14–15 vertical rows of dull green scales. Seed ovoid, about 10 mm × 5 mm with scattered pits, the pits penetrating very slightly the otherwise homogeneous endosperm. Seedling-leaf with 4 leaflets displayed in a fan.

Cane anatomy The peripheral zone consists of up to 10 rows of lignified parenchyma cells. The outer 3–4 cells are rectangular and appear more strongly lignified. The vascular bundles consist of 1 metaxylem vessel (approximate diameter 300–350 µm) and 2 phloem fields located laterally and containing 4–6 sieve tubes each. The surrounding fibre sheath is extensive and strongly lignified. Fibre length 1.5 mm, diameter about 18 µm, wall thickness approximately 4 µm, lumen diameter about 10 µm. The ground tissue consists of large and generally thin-walled parenchyma cells of irregular outline, intercellular spaces large and numerous.

Growth and development Germination begins 4 weeks after sowing, but may take up to 27 weeks. Germination rates are variable, ranging from 30–66%. High light intensity accelerates the formation of sucker shoots and stem-length growth. Growth rates are poor compared to those of *C. manan* Miq., *C. caesius* Blume and *C. trachycoleus* Becc. Mean stem growth is 0.1 m per year, and optimum growth is 1 m per year. Flowering is in July–August in Peninsular Malaysia, with 2000–3000 fruits per stem once maximum production capacity has been reached.

Other botanical information *C. scipionum* is very distinctive, likely to be confused only with *C. ornatus* Blume. Both are very similar in the rosette stage, but the climbing stems of *C. scipionum* have large terminal leaflets (ecirrate) whereas *C. ornatus* has minute terminal leaflets (subcirrate). In inflorescence structure they are very different, and the seedling-leaf of *C. scipionum* has 4 rather than 2 leaflets.

Ecology *C. scipionum* is a widespread lowland species rarely occurring above 200 m altitude. It appears to favour better soils such as alluvial soils in the floodplains of rivers. It is very tolerant of forest clearance, and is often found in secondary forest. *C. scipionum* has not been found in primary lowland dipterocarp forest.

Propagation and planting Sucker shoots could be used in propagation but cultivation is more efficient with seedlings raised from seeds. Nursery procedures and outplanting techniques are similar to those described for other species such as *C. manan* and *C. subinermis* Becc. Likely planting sites are secondary forest areas in the lowlands.

Husbandry Little maintenance is required, apart from initial weeding, and where necessary, opening the canopy sufficiently to allow light to reach the seedlings.

Diseases and pests There is no information on diseases and pests of *C. scipionum* in the wild or in the nursery. Seedlings planted in regenerating lowland dipterocarp forest have been severely attacked by rats and squirrels.

Harvesting It is not known at what age the cane could be harvested but it is unlikely to be less than 15 years after planting and probably longer than that because of slow initial growth. The harvesting method is similar to that of other large-diameter canes such as *C. manan*.

Handling after harvest As for other large-diameter canes, the cut canes are washed and cleaned before being boiled in a mixture of diesel and coconut oil, or of diesel and kerosene, or of diesel and palm oil, for varying lengths of time. They are then rubbed with gunny sacking and placed upright to dry in the sun, after which they are bundled.

Genetic resources and breeding No collection of genetic variability has been carried out so far and no breeding work has been initiated.

Prospects Large-scale cultivation of large-diameter rattans is likely to centre on those such as *C. manan, C. merrillii* Becc., *C. ornatus, C. ovoideus* Thwaites ex Trimen, *C. subinermis, C. tumidus* Furtado, and *C. zollingeri* Becc. De-

spite its clustering habit, *C. scipionum* is unlikely to be considered for commercial-scale cultivation because of its inferior quality when compared with species such as those mentioned above.

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N. Manokaran

Calamus simplicifolius Wei

Guihaia 6(1/2): 36 (1986).

PALMAE

$2n$ = unknown

Vernacular names China: danye shengteng (Hainan).

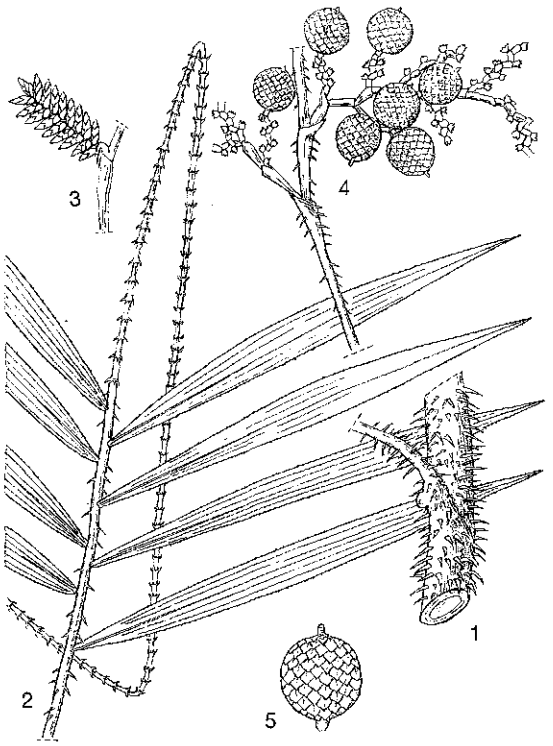
Origin and geographic distribution *C. simplicifolius* is found on Hainan Island. It has been introduced for cultivation trials in southern China.

Uses *C. simplicifolius* is the best Chinese cane of medium diameter, supreme for all types of binding and weaving in the furniture industry and widely used locally for cordage, house construction and the finest basketware when it is abundant. New shoots can be eaten as a vegetable.

Production and international trade The canes are collected wherever they occur because of their high economic value. Due to its restricted distribution, production occurs only in a few places and no reliable figures are available on annual output. After harvesting the canes are sold to middlemen and then shipped to manufacturers in cities on the mainland for making furniture and handicrafts.

Properties *C. simplicifolius* has excellent appearance with its creamy yellow colour and highly glossy surface. Its uniform texture makes it particularly suited to being split into strips or being used whole for furniture making. Specific gravity is 0.488. Tensile strength is 51.2 N/mm^2. Lignin content is 20%. One seed weighs 0.8 g.

Description Clustering, rarely forming dense clumps, moderate-sized dioecious rattan, climbing high into canopy, with stems ultimately up to 50 m long. Stem without leaf-sheaths 12–15 mm in diameter, with sheaths 50 mm in diameter; internodes c. 30 cm long. Whole leaf up to 3 m long; leaf-sheath yellowish-green, armed with flattened triangular spines 20–40 mm long and 5–8 mm wide at the base; knee conspicuous; ocrea conspicuous, purplish, glabrous; petiole up to 20 cm in juveniles, very short in adults; leaf-rachis bearing scattered spines on the lower surface, distally the rachis prolonged into a whip (cirrus) up to 1.5 m long, bearing grapnel-like groups of reflexed spines; leaflets c. 22 on each side of the rachis, arranged irregularly, usually solitary, but sometimes 2–4 leaflets grouped, lanceolate, up to 40 cm × 5 cm, with 5 major veins. Inflorescence borne on the sheath of the leaf above the subtending axil, to 1 m long, the male and female superficially similar, the male branching to 3 orders, the female to 2; bracts tightly tubular; flower-bearing branches to 4.5 cm long, with c. 20 flowers; male flower ovoid to oblong, c. 7.5 mm long, calyx to c. 4.5 mm; female flowers not recorded. Mature fruit 1-seeded, spherical, c. 25 mm × 20 mm, with a beak to 3 mm long, covered in 18 vertical rows of neat reflexed yellowish-white scales. Seed ovoid to oblong, c. 13 mm × 12 mm, with an outer fleshy sarcotesta; endosperm very deeply ruminate; hilum concave; embryo basal. Seedling-



Calamus simplicifolius Wei – 1, leaf-sheath; 2, upper part of leaf with cirrus; 3, part of inflorescence; 4, part of infructescence; 5, fruit.

leaf bifid.

Cane anatomy The epidermal zone is built up of one layer of rectangular, silicified cells, and the sub-epidermal zone of 3–4 layers of lignified parenchyma cells. The vascular bundle density is 4–6 /mm^2. The length of fibres in outer zone and bark is 1.5 mm and 1.4 mm respectively.

Growth and development Seed germinates 50–60 days after sowing with a few seeds germinating after 120 days; after 2–3 months the seedling-leaf emerges; after 3 years, the first stem may exceed 1 m long, the first climbing whips are produced and 1–2 suckers in a clump may appear from very short horizontal rhizomes. Three to four years after establishment, the stem may grow at rates exceeding 2.0–2.5 m/year under suitable conditions. At 10 years old, a clump may consist of 12 aerial stems. Flowering begins in the 5th year after sowing, and is annual thereafter. Phenological cycle has little variability from place to place; generally inflorescences emerge in August, flower buds from February to March of the following year, anthesis starts in April, peaks in May and ends in June when fruiting begins; fruit maturation starts in late October, peaks in November and ends in early December.

In humid rain forest, its prime habitat, only one of the stems in a clump, rarely two, grows up to be a long aerial stem, reaching the forest canopy. Knowledge of the basic biology of this rattan is limited.

Other botanical information The closely related *C. egregius* Burret differs from *C. simplicifolius* in the arrangement of the leaflets, which, in *C. egregius* occur in pairs or groups of 3–4.

Ecology It is usually found growing in natural mountain rain forest between 600–1100 m altitude. For optimum growth, *C. simplicifolius* as well as *C. egregius,* prefers moisture in abundance and adequate light. The annual average growth rate of the stems growing under semi-shade canopy conditions is 3 times as high as that of stems growing in dense forest. However, young seedlings cannot withstand full sunlight throughout the day as young leaves may become scorched. Young leaves and new shoots may easily be damaged by temperatures of below –2°C.

Propagation and planting *C. simplicifolius* can be propagated by sucker shoots but propagation is best effected from seeds. Seed propagation includes removing the fruit wall and fleshy seed-coat, cleaning the seeds, sowing seeds in sand beds for germination, and transporting the sprouted seed (the first foliage leaf unexpanded) in potting bags into a nursery under semi-shade. Seedlings 11–15 months old and with 6–7 leaves are usually ready for planting out. Although seedlings require the support of pre-existing tree crops and forest canopy, they also require adequate sunlight for healthy and fast growth. On a small scale, seedlings can be planted in scattered clumps in agroforestry systems; on a commercial scale the species can be planted in lines, on a grid of about 4 m × 5 m in logged-over forests or in planted broadleaved forests but the forest canopy should be manipulated to allow light to reach the seedlings. Group planting, 2–3 seedlings per clump, is considered to be suitable for this species.

Husbandry Planting lines have to be cleared and the forest canopy has to be thinned to allow sufficient light through to reach the seedlings in the first three years after planting. Fertilizer

application may enhance seedling growth.

Diseases and pests Leaf blight and leaf-spot diseases caused by fungi occur in poorly managed nurseries. So far, no serious pest problems have been reported, apart from rats attacking seedlings.

Harvesting Harvesting is carried out in the wild by dragging the stem out of the canopy, removing of the leaves, leaf-sheaths and debris, cutting the cane into lengths of about 4–5 m, tying in bundles and transporting to the village for sale.

Yield It is estimated that 10–11 years after establishment the plantation will be ready for initial harvest, with an estimated yield of about 3.5 t/ha. It is also estimated that within a 25-year management period, canes may be harvested 5 times in a rotation of 5 years, providing a total yield of about 11.5 t/ha.

Handling after harvest This is usually carried out by middlemen in the processing village. The first steps involved in preliminary processing are cleaning and drying the canes to prevent attack by staining fungi and powder-post beetle and sorting according to length and quality. Further processing performed by manufacturers involves grading into size classes, rubbing, and splitting and coring into strips.

Genetic resources and breeding *C. simplicifolius* has been planted in several botanic gardens and arboreta in southern China, but no attempt has been made to establish a collection to represent the considerable variation in the wild.

Prospects *C. simplicifolius* has high commercial value. However, owing to its restricted distribution and severe overexploitation, it may soon be on the verge of extinction. The prospects for *C. simplicifolius* and the closely related *C. egregius* as cultivated crops are good. Because of its excellent quality and growth form, it has great potential to be planted not only in subtropical areas in southern China but also in the northern part of the Prosea region. On a small scale, it can be planted in agroforestry systems as a potential source of income for rural people.

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H.C. Xu & G.T. Yin

Calamus subinermis H. Wendl. ex Beccari

Rec. Bot. Survey India 2: 212 (1902).
PALMAE
$2n$ = unknown

Vernacular names Malaysia: rotan batu, rotan tunggal (Malay), mangkawayan (Kadazan/Dusun).

Origin and geographic distribution *C. subinermis* is found along the coast of Sabah (Malaysia), from Labuan on the west coast to Tawau on the east coast and probably extends south along the coast of East Kalimantan in Indonesia and into Sarawak. It is also found in Palawan, the Philippines. It does not occur far inland.

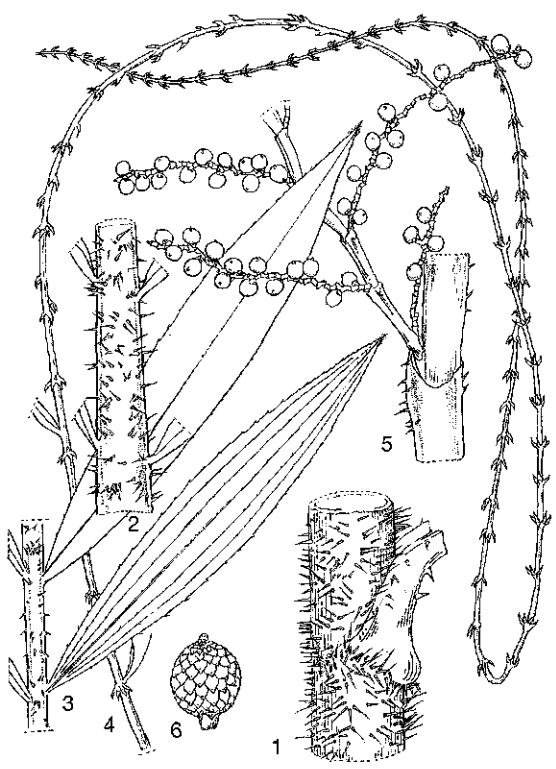
Uses *C. subinermis* is used mainly as a structural cane in the manufacture of furniture. Very little of it is used for handicrafts. The shoot apex is cooked as a vegetable and the fruits are sometimes eaten.

Production and international trade *C. subinermis* is exported from Sabah mainly to Singapore for re-export overseas. At the peak of trading in 1987, no more than 3000 t were exported. Due to over-harvesting both in Sabah and in Palawan, export has now dropped drastically.

Properties Apart from its slightly smaller diameter, *C. subinermis* is similar to the high quality furniture cane *C. manan* Miq. in many respects. It is a hard cane suitable for nailing, with a smooth, yellowish surface and an even diameter, and is much sought after as a structural cane in furniture manufacture. There are about 4700 cleaned seeds in 1 kg.

Description A large-diameter rattan which

may be solitary or clustering with stems reaching 40 m or more. Stem without leaf-sheaths 18–30 mm in diameter, rarely to 40 mm, attaining 50 mm or more with sheaths; internodes 15–30 cm. Leaf to 4 m long including cirrus; leaf-sheath covered with greyish indumentum, spineless to densely covered with fine horizontal black spines 15 mm long; knee prominent, unarmed; ocrea to 5 mm high; petiole to 10 cm or more in juvenile fronds; rachis to 2 m long with 25 pairs of leaflets or more; leaflets lanceolate, up to 40 cm × 6.5 cm, armed with black spines on upper surface of the 5 main veins and margins, unarmed on lower surface; cirrus to 2 m. Inflorescences: the male branching to 3 orders, the female to 2 orders, to 1.5 m long with up to 10 pairs of partial inflorescences, longest to 75 cm; male rachillae crowded, to 40 mm long, bearing distichous flowers; female rachillae to 15 cm, bearing up to 27 pairs of flowers. Mature fruit round to ovoid, 10–11 mm diameter, covered with 7–8 vertical rows of pale greenish scales with pale brown margins. Seeds 7 mm × 6 mm × 5 mm, deeply pitted.



Calamus subinermis H. Wendl. ex Beccari – 1, part of stem with leaf-sheath; 2, leaf-base; 3, mid portion of leaf; 4, leaf-tip with cirrus; 5, part of infructescence; 6, fruit.

Growth and development After germination, forked leaflets are produced, followed by leaves with regularly arranged leaflets. By the third year an aerial stem may be produced. If clustering, leafy suckers normally remain dormant, rarely 2–3 stems elongate at the same time. First flowering takes place about the 6th year after sowing.

Other botanical information Scattered clumps with spineless leaf-sheaths occur among normal clumps with spiny sheaths. These should be selected for plantations for ease of harvesting canes. Some plants are single-stemmed throughout their life, whereas others produce several suckers.

Ecology *C. subinermis* is found only along the coast. It grows on sandy soils derived from sandstone on hill slopes, raised sandy beaches and also on alluvial soils on flat land in coastal dipterocarp forest but not in *Casuarina* forest. It has also been recorded in forest on ultramafic igneous rocks.

Propagation and planting Soon after harvest, the fruits are crushed and rubbed over quarter-inch wire mesh and under running water to remove the scaly pericarp and the fleshy sarcotesta. The cleaned seeds are then spread in seed-beds filled with either loam, loam and sawdust or sawdust only, and watered twice a day. The beds are also sprayed with fungicide to prevent fungal attack. After planting, most seeds germinate in about one month, although some do not germinate until 1.5 years later. Seed-beds are given full overhead shade.

When seedlings are 5 cm tall, they are potted into polybags 15 cm deep and about 15 cm in diameter filled with forest topsoil. They are watered twice a day and 50% overhead shade is provided by netting. Fertilizers and fungal sprays are applied whenever necessary. Seedlings are ready for planting 12 months after potting into polybags. They may be planted under rubber trees or in secondary forest at a spacing of 2 m × 10 m or wider. In secondary forest, lanes 3 m wide are cut and staked before planting. Canopy manipulation is carried out so that sufficient light reaches the seedlings to stimulate early stem elongation.

Husbandry Apart from initial weeding and canopy opening, little maintenance is required.

Diseases and pests Fungal diseases occur in

seedlings but large plants are normally free from attack. Elephants uproot the plants and eat the cabbage. Small trials of *C. subinermis*, planted inland, were completely destroyed by *Chalcosoma atlas*, a beetle whose larvae bore down the apex of the cane and destroy the meristem.

Harvesting The cane is cut at the base and pulled. Only the length reachable by the harvester is extracted and the rest left behind to rot. The leaf-sheaths are removed and the cane is then cut into 3.5 m long poles.

Handling after harvest After harvesting, canes are washed and cleaned before being boiled in diesel, after which they are stood upright to dry in the sun. When dried to a moisture content of less than 20%, the canes are not attacked by staining fungi or borers. The nodes are then trimmed before bundling.

Genetic resources and breeding The Research Centre of the Forest Department, Sabah is at present setting up a provenance trial with provenances from throughout Sabah. Future selection should be for individuals with long internodes, thornless leaf-sheaths and multiple stems.

Prospects There is a scarcity of high quality large-diameter canes throughout South-East Asia, due to extensive and intensive harvesting. The prospects for commercial planting of *C. subinermis* along the coast are very good because of the clustering nature of the plant, providing for multiple harvests. Trials are required in areas away from the sea, and an effective treatment against beetle attack needs to be established.

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P.S. Shim

Calamus tetradactylus Hance

Journ. Bot. 13: 289 (1875).

PALMAE

$2n$ = unknown

Vernacular names China: baiteng (generally known as white rattan throughout southern China).

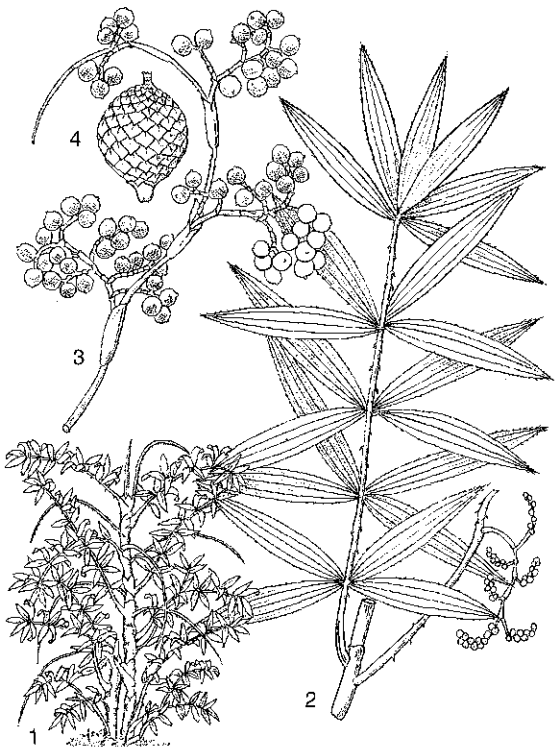
Origin and geographic distribution *C. tetradactylus* occurs on Hainan Island, in the southern parts of Guangdong, Guangxi and Fujian Provinces to the south of latitude 23°30'N, and Hong Kong. It has also been introduced to West Guangxi, South Yunnan and the middle of Fujian Provinces, and a few plants have been introduced to the arboretum at Kepong, Peninsular Malaysia. In China it is commonly planted on a small scale.

Uses *C. tetradactylus* in China is a first class cane of small diameter and one of the most important sources of cane for making rattan handicrafts, basketware and furniture. On Hainan Island, where it is abundant, it is also used as cordage, to bind thatch and to make implements.

Production and international trade Production of *C. tetradactylus* occurs mainly in Hainan Island and to a small extent in southern Guangdong and Guangxi. Hainan Island produces 70–80% of the total supply of canes in China, but it is difficult to indicate what percentage of this is actually *C. tetradactylus*. In comparison with South-East Asian countries, China has a well developed rattan manufacturing industry but poor indigenous cane resources. To supply the rattan-based cottage and furniture making industries with rattan, China needs to import about 30 000 t of canes annually. Traditionally, canes collected from the wild are sold to buying stations where a certain amount of processing is carried out before the canes are shipped to manufacturers in Haikou, Guangzhou and other places for making furniture and handicrafts for the local market and export.

Properties *C. tetradactylus* has a resilient and durable cane and its uniform texture makes it suitable for being split into fine strips for weaving handicrafts and making furniture. The cane has a light-yellowish colour and a glossy surface. Internodes vary from 10–30 cm in length. The specific gravity is 0.432. Tensile strength is 38.0 N/mm^2. Lignin content is 18.7%. Quality of the cane depends on age, moisture content and growing conditions (e.g. light, water and soil, etc.), which affect the internodal length and diameter, and the degree of resilience of the canes. Quality is also adversely affected by poor processing. Being a small-sized cane, the ratio of bark of the cane to tissue is rather high in comparison with other species.

Description Clustering, slender, dioecious rattan, climbing to 30 m or more. Stem without leaf-sheaths varying from 5–8 mm in diameter,



Calamus tetradactylus Hance – 1, habit; 2, leaf and infructescence base; 3, part of infructescence; 4, fruit.

with sheaths to about 12 mm in diameter; internodes to 20 cm or more in length. Whole leaf to 80 cm including leaf-sheath; leaf-sheath dull-green, armed with scattered spines c. 0.5 mm × 0.2 mm; petiole up to 15 cm long in juveniles, very short in adult climbing stems, armed with scattered, triangular short spines; flagellum borne on leaf-sheath, armed with short spines; leaf-rachis to 50 cm long, no cirrus; leaflets generally arranged in groups of 2, sometimes singly near the base, 7–11 on each side of the rachis, the uppermost, 4–6 in a group and always with terminal flabellum formed by two apical leaflets joined along at least 2/3 length, lanceolate, up to 15 cm × 3 cm, with 3–5 distinct veins, dark green, armed with bristles along margins and grouped at the tip. Inflorescences borne on the leaf-sheath, up to 1 m long, the male and female superficially similar, the number of branches varying from 4–7, and each branch bearing 9–23 rachillae, female rachilla to 3.5 cm long, with 3–13 flowers. Ripe fruit 1-seeded, generally rounded, 7–10 mm in diameter, rather conspicuously beaked, covered in 21–23 vertical rows of neat reflexed whitish-yellow scales, 10–12 scales in each row. Seed globose, to 7 mm in diameter, weighing c. 0.1 g, pitted, endosperm deeply ruminate, embryo basal. Seedling-leaf forked, with 6 leaflets, dark green.

Cane anatomy The epidermis is built up of one layer of rectangular silicified cells and the sub-epidermal layer is composed of 3–4 layers of lignified parenchyma cells. The density of vascular bundles is 9–14/mm^2. The average length of fibre is 1.28 mm.

Growth and development Usually seed starts to germinate 15–25 days from sowing; a few seeds germinate after 60–90 days. The development of the seedling is slow; the first leaf appears after 2–3 months; after 18–30 months, the primary stem may exceed 50 cm in length, and the first flagellum and 2–3 sucker shoots may have developed. Suckers at the stem base develop as short horizontal rhizomes, never longer than 10 cm. Due to competition between aerial stems, most suckers may remain dormant. Two to three years after establishment, the aerial stem may grow at rates exceeding 2.0 m/year. At 7 years old, a clump growing under suitable conditions may already consist of over 30 aerial stems, with individual stems growing to a maximum length of 15 m, and the total stem length of such a clump may reach 78 m. Flowering begins 3–4 years after planting. Clumps consisting of over 100 aerial stems with a total stem length of over 350 m have been found in the wild. The phenological cycle is as follows: inflorescence appears in March; flower buds form from May to June; the earliest flowering starts in the middle of June, reaches its peak in August and ends in September when fruiting begins, but the fruit does not mature until April or May of following year. There are a few variations in the phenological cycle from place to place.

Other botanical information Rather little is known of the basic biology of *C. tetradactylus*. It is very similar to *C. bonianus* Becc. but differs in inflorescence, size of leaf, stem and seed; *C. bonianus* has denser partial inflorescences, longer leaflets, but smaller seed.

Ecology *C. tetradactylus* occurs in the lowlands to hillslopes under 600 m altitude in primary or secondary tropical forests and in subtropical broadleaved forest to the south of latitude 23°30'N. The most favourable niche for this rattan is wet hollows and mountain valleys,

but young seedlings may not be able to withstand severe flooding. In general, ecophysiological requirements of *C. tetradactylus* for normal growth are as follows: air temperature of 20–30°C (–2°C and lower may kill seedlings), more than 1300 mm annual rainfall with relative humidity of over 78%, 50% sunlight, fertile and damp soil with medium to high amount of humus and pH value of 4.5–6.5.

Propagation and planting Like other clustering rattans, *C. tetradactylus* can be propagated by sucker shoots, but propagation by seeds is a more common method. Seeds should be extracted and cleaned immediately after the mature fruits are collected, in order to obtain high germination percentage. The outer scaly pericarp of the fruits and the sarcotesta can be removed completely by rubbing the seeds in water with some sand, then the extracted seeds have to be cleaned and kept at a moisture content of 25–35%. Seed moisture content of less than 25% will decrease viability and below 20%, the seeds may dry out, causing the embryo to die. Germination percentage of fresh mature seeds can reach 98%. Normal nursery practice in China is first to soak seeds in clear water for 1–3 days, then to sow seeds in clean sand beds under shade. After 50–70 days, young seedlings, with the primary leaf unexpanded, can be transplanted into potting bags containing soil with mixed nutrients (the ratio of forest topsoil to pond mud to composted manure is 50:50:1); the potted seedlings have to be placed in the nursery under semi-shade which is the optimum light regime for *C. tetradactylus* seedlings. Maintenance has to be carried out to ensure fast and healthy growth. It includes providing plenty of moisture without waterlogging, and weeding, loosening soil, applying fertilizer and controlling diseases and pests. Seedlings 15 to 18 months old and with 7–9 leaves are ready for planting out in the field. Because seeds are readily available, *C. tetradactylus* is the most commonly planted species in China.

Smallholders plant *C. tetradactylus* in agroforestry systems, e.g. under fruit trees or around gardens; on a commercial scale, it has been intercropped in lowland forests, logged-over forests, scrub, plantation forest, and also in rubber plantations. Site preparation involves thinning the forest canopy to permit 40–50% light penetration, cutting and cleaning planting lines and preparing planting holes. Seedlings need organic manure for optimum growth. Planting should be carried out in the rainy season. At present, it is uncertain as to what the optimum spacing is for this species. In southern China, planting is at a spacing of 1 m × 3 m, 2 m × 3 m, and 1 m × 4 m. Seedlings are planted singly or in groups of 2. Cultivators prefer close spacing rather than sparse planting, so as to increase the yield per unit area; this may pose problems in that profuse development of sucker shoots and growth of aerial stems result in damage to other immature stems at the time of harvest. Although it is recognized that *C. tetradactylus*, like *D. margaritae* (Hance) Becc., has the capacity to grow well in open areas, young leaves may be scorched by full sunlight. *C. tetradactylus* gives the highest yield when planted as a sole crop.

Husbandry To encourage growth of *C. tetradactylus*, the following measures have to be taken once or twice a year in the first 3 years after planting: cleaning the planting lines and thinning the forest canopy to allow more light to reach the seedlings; loosening the soil and mulching around the clumps; and adding adequate fertilizers. After 3 years, the plant requires little attention apart from protection from animals that eat its cabbage.

Diseases and pests Few diseases and pests have been reported. Leaf-spot, leaf blight, and ringspot diseases usually occur in nurseries but are the result of poor management; the pathogens responsible are *Pestalotia* sp., *Pyrenochaeta* sp., and *Conithyrium* sp.. The most important pests of *C. tetradactylus* and other rattan species are locusts, moths, scale insects and *Dynastes gideon*. It is reported that rats can seriously damage not only young plants but also adult plants.

Harvesting Harvesting of *C. tetradactylus* varies slightly from that of moderate-sized rattans, but essentially consists of cutting the mature stem at the bottom, removing the dried leaf-sheaths, dragging the stem out of the canopy, cutting away the green leaves, and discarding the uppermost metre which is immature and hence useless, and then divesting the canes of leaf-sheaths and debris. The cane is then cut into lengths of about 4–5 m or more and bent, tied in bundles and carried to the village. Smallholders may cut stems but leave them until the leaves and sheaths are dry, and then collect the canes so as to make harvesting operations easier. In such cases, harvesting is carried out in the dry season.

Yield In the experimental plantations in Guangdong Province of China, *C. tetradactylus* established on hillsides is ready for harvest at 7 years after planting, with a yield of about 1.2 t/ha; the second harvest at the 11th year after planting yields about 1.1 t/ha; and further harvesting is possible 4 times in a rotation of 3 years. The projected yield may reach a total of 6 t/ha within a management period of 25 years. These yields are rather low in comparison with *D. margaritae* and *C. simplicifolius* Wei because *C. tetradactylus* is a small-sized cane. However, under good conditions, it has the potential to develop more aerial stems and yields could exceed 15 t/ha in a management period of 25 years.

Handling after harvest Post-harvest treatments are usually applied by middlemen at purchase stations, where canes are re-cleaned of the remains of leaf-sheaths, sun-dried, and sorted. Canes are then transported to manufacturers, where additional treatments to remove silica and nodal scars are carried out to further improve the quality of the canes.

Genetic resources Although no specific collection has been established to represent the considerable variation of *C. tetradactylus* in the wild, it is represented in several botanic gardens and arboreta in southern China.

Breeding There has been no breeding of *C. tetradactylus* in China. Selection of superior phenotypes through provenance trials has to be done for this and other rattan species.

Prospects *C. tetradactylus* is an endemic species of southern China. Owing to the exploitation of natural forest for timber and conversion for agriculture, its habitat has largely been destroyed, and this has been compounded by severe overexploitation of the species. Although cultivation of rattan in China is in its early stages, initial results show that *C. tetradactylus* and *D. margaritae* as cultivated crops have a great potential as a source of income for rural people. However, prospects for *C. tetradactylus* as a large-scale plantation crop have yet to be proven. The yields in plantation are lower when compared with those of *D. margaritae* and *C. simplicifolius*. *C. tetradactylus* has been widely planted in southern China because it is an adaptable species and there is a rich source of seeds. It is currently under trial in Malaysia. Further studies on this species are needed and should be focused on provenance trials, genetic improvement, plantation and harvesting technology, socio-economic aspects, and utilization.

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H.C. Xu & G.T. Yin

Calamus trachycoleus Beccari

Ann. Roy. Bot. Gard. Calcutta 11 (Appendix): 108 (1913).

PALMAE

$2n$ = unknown

Vernacular names Indonesia: rotan irit (Kalimantan).

Origin and geographic distribution *C. trachycoleus* is endemic to the Barito-Kapuas floodplains of South and Central Kalimantan in Indonesia between latitudes 2–3°S where it is widely planted by villagers along river banks. It is now also planted on a fairly large scale (4000–5000 ha) in the Malaysian state of Sabah, and to a smaller extent in the states of Sarawak and Pahang.

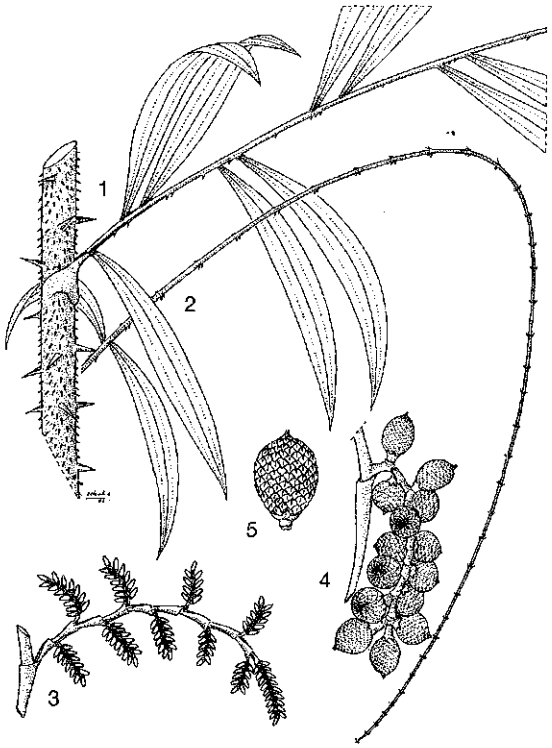
Uses In commerce, *C. trachycoleus* is used mainly as skin peels for the weaving of chair seats and backs, and unsplit for furniture. The cores are also used for furniture and basket

making. In recent years, because of the shortage of *C. caesius* Blume canes, it has been used extensively as a substitute for the production of rattan mats ('tatami' in Japanese, or known as 'lampit' locally). Villagers utilize it to make baskets and fish traps, as rope in raft building, and as cordage.

Production and international trade The 1984 consumption of *C. trachycoleus* in Indonesia was about 125 t (out of a total production of 150 000 t). Since more than 12 000 ha has been planted with *C. trachycoleus* around Dadahup in Central Kalimantan since 1850, production is expected to be much higher than published, as most *C. trachycoleus* harvested has been sold as *C. caesius* in order to fetch a higher price. Before Indonesia banned the export of round canes in 1986, most of the export of unprocessed canes was to Singapore where they were re-exported, mainly to Hong Kong and Taiwan. By 1988, finished products were exported directly to consumer countries, with Japan, Europe and the United States being the major buyers.

Properties Diameter of canes varies from 4.5–13.5 mm, with most between 5–8 mm. This variation is due to increase in diameter of the cane with length. The siliceous layer gives the cane a glossy appearance and after fumigation with sulphur and sun drying, it is golden yellow in colour. The canes are lighter and more pliable than *C. caesius*. Because it is more pliable, the peels are preferred for weaving as they are easier to work with. Partly because of its smaller average diameter, between 7500–8000 pieces of 6 m long air-dried canes make a ton. Internodal lengths vary from 15–30 cm or more.

Description Clustering, stoloniferous, dioecious rattan climbing to 60 m or more. Stolons 2–3 m long, 3–4 cm in diameter. Stems in diffuse, open colonies, medium-size, 4.5–13.5 mm without leaf-sheaths, to 20 mm in diameter with sheaths; internodes 15–30 cm or more long. Leaf cirrate, to 2.3 m long, including cirrus to 1 m and a short petiole 1.5–2.5 cm long; leaf-sheath to 95 cm long, exposed upper portion with scattered large spines, dark brown at the tip and green at the base, 10 mm long and 6 mm wide at the base and with numerous spicules 2 mm long in between; ocrea a low ridge 4 mm high; petiole semicircular to broadly triangular in cross-section, armed as the sheath on lower surface, unarmed on upper surface; leaflets to 15 pairs, irregularly arranged, lanceolate, largest to 33 cm × 3.7 cm with 3 main longitudinal veins on each side of the mid-vein, armed only along margin with 1.5 mm long brown spines. Male and female inflorescences superficially similar, to 170 cm long with 11–14 pairs of partial inflorescences, longest to 67 cm, branching to 3 orders in male and to 2 orders in the female; bracts tubular; male rachillae more crowded than in female, to 16 cm long with 6–12 pairs of distichous flowers; female rachillae to 10 pairs on most branches except apical ones. Fruit ovoid, 1 cm in diameter, with 9 or more vertical rows of scales. Seed 9 mm × 6 mm × 5 mm, shallowly grooved.



Calamus trachycoleus Beccari – 1, part of stem with basal part of leaf; 2, upper part of leaf with cirrus; 3, part of inflorescence; 4, part of infructescence; 5, fruit.

Growth and development During germination a plug emerges, pushing aside the inner integument. This occurs from the second day after the seeds have been cleaned and up to 6 weeks; most of the seeds have germinated by the 3rd–4th week. The stem begins to elongate from the 5th–6th month followed by the production of short rhizomes and more aerial stems. This

method of vegetative reproduction is the same as that for *C. caesius*; however, unlike *C. caesius*, long stolons are produced from year 2–3 onwards. When a stolon is 1–3 m long, it metamorphoses into an aerial stem. At the point of metamorphosis, two branches are produced, one from each adjacent node, which elongate to form new stolons. The stolons are thus very invasive and there is a potential for exponential increase in aerial stems, but the distal branch of the stolon usually develops more slowly and sometimes remains dormant. In *C. caesius*, competition for growing space is greater because of the short rhizomes, and rhizomes are forced to grow upwards or downwards, producing three or even four tiers of rhizomes. The severe competition causes many of the branches to remain dormant as bulbil-like shoots and expansion is thus nowhere as rapid as in *C. trachycoleus*. Production of stolons in *C. trachycoleus*, however, does not mean that the production of short rhizomes ceases. There is thus a denser central clump surrounded by diffuse canes from stolons. Inflorescences are produced by the 4th year. Not all canes flower at the same time. Flowering canes produce between 1–4 inflorescences. Fruits normally abort at first flowering. Between 1000–1500 fruits are borne per infructescence.

Ecology *C. trachycoleus* grows best on raised alluvial soils of floodplains subject to seasonal flooding, e.g. river levées and foothills, but cannot withstand stagnant water. Seedlings, however, can survive being submerged under flood waters for over a month, provided the water is flowing (and thereby providing oxygen). The species grows most profusely on river banks because of abundant light. It does not occur in deep peat, and is generally not planted by villagers in such areas in Kalimantan. *C. trachycoleus* also does not occur in areas affected by salt or brackish water.

Propagation and planting Propagation is from seed, but villagers along the Barito River also use wildlings and stolons for planting. In commercial nurseries fruits are lightly crushed to break up the seed-coat before being rubbed on quarter-inch wire mesh to remove the sarcotesta. The cleaned seeds are treated with a fungicide and sown without delay, either in trays or seed-beds. Seed-beds are usually filled with forest topsoil. The seeds are evenly spread over the topsoil and covered with 2 cm of sawdust. Seed-beds are shaded and well watered. Sawdust alone is used in germination trays. The seeds are similarly spread thinly and covered with 2 cm of sawdust. One month after sowing, when the shoots are 2–3 cm above the sawdust, the seedlings are potted into polybags 15 cm deep and about 15 cm in diameter, variously filled with topsoil or 75% topsoil mixed with 25% sand mixed with chicken dung or commercial fertilizers. The seedlings are provided with overhead shade and are watered twice a day. Villagers normally use palm fronds for shade, but netting providing 50–60% shade is more commonly used in commercial nurseries. The potted seedlings are periodically sprayed with fungicide and fertilized for continued and vigorous growth. At 8–9 months, when the seedlings are between 40–50 cm tall, they are planted in the field. Residual trees in logged-over riverine forest are used as support for the canes. Planting lanes 2–4 m wide and running east–west are cut and staked before planting. Various spacings of 2 m × 10 m, 8 m × 10 m to 20 m × 20 m are used. Unlike *C. caesius* which is clump-forming, very wide spacings can be used because *C. trachycoleus* soon spreads over the whole planting area. It has also been successfully planted under abandoned rubber holdings which have been thinned, leaving some trees for support. Where tapping of rubber is continued, *C. trachycoleus* spreads all over the plantation and hinders access and tapping. For this reason it is not suitable for planting under fruit trees.

Husbandry After planting, the seedlings have to be weeded 2–3 times a year for the first 2–3 years. After the third year, when stolons have been produced, weeding is not possible because workers may cut the canes accidentally. Canopy manipulation is required to allow sufficient light to reach the seedlings for rapid growth. Along the Barito River, villagers systematically girdle other trees leaving behind *Lagerstroemia* sp. as support trees because these trees grow evenly in height to 10–15 m making harvesting of canes easy. These trees are also strong enough to support the weight of the climbing canes.

Diseases and pests Seedlings in the nursery are attacked by fungi belonging to the genera *Curvularia, Colletotrichum, Phomopsis* and *Pestalotiopsis* that cause leaf-spot diseases. Severely infected leaves dry up. Such diseases can be controlled by spraying the seedlings with a fungicide. Leaf blight caused by *Colletotrichum gloeosporioides* is more serious and may kill the seedlings in a few weeks. Control is by spraying

with fungicide (e.g. triadimefon) at 10-day intervals. In the plantation, squirrels gnaw at the shoots and an unidentified weevil bores down the shoot, destroying the meristem. Other pests observed are elephants which pull out seedlings as they feed along the planting lanes, and wild boars that uproot seedlings when they forage for roots and worms. Elephants also pull down canes to eat the shoots, including the growing tips of stolons.

Harvesting Older canes of the clumps are ready for harvesting 8 years after planting. The lower fronds have by this time turned brown and fallen off, leaving behind the dead leaf-sheaths. The canes are cut some 30 cm from the base and the dead leaf-sheaths removed by hitting the cane with the blade of a jungle knife. Green fronds and leaf-sheaths are stripped by either standing on the fronds and pulling the cane upwards or by pulling the cane between the fork of a branch or tree. Canes are pulled down in stages, usually by two men, as the leaf-sheaths are removed. If a cane cannot be completely pulled down because the upper portion is entangled in branches, it is cut as high up as possible. In Indonesia, entangled canes are cut with a knife attached to the end of a long pole. After the cane has been pulled down, it is cut into 6 m long pieces, and the apical 5–6 m discarded as it is immature and snaps easily after fumigation. A hundred pieces 6 m long are bent in the middle, tied into a bundle and carried to the nearest road for transportation to the processing centres. If the canes cannot be brought out the same day, they are placed over a log to drain off excess water.

Yield Yield estimates from Kalimantan are 2 t dry canes per ha at year 8 followed thereafter by 1.5–2.2 t dry canes/ha per year. It is because of the high yield that villagers along the Barito River plant more *C. trachycoleus* than *C. caesius*, although the quality and price are higher in the latter species.

Handling after harvest In Central Kalimantan, canes are traditionally deglazed within 24 hours. Deglazing ('runti') is carried out for several reasons: to remove the silicified epidermis which will otherwise blunt the splitting tools and damage the machines, to effectively prevent the substitution of inferior kinds of canes, and to make the skins more pliable. The most common techniques used in deglazing are pulling the cane backward and forward through a hole made in a piece of bamboo tied to a tree ('runti gosok'), through a loop suspended between three bamboo poles 1 m above the ground or through a thick metal ring and rubbing briskly with a chain ('runti jala'), or by hitting the cane with a piece of wood or plaited rattan ('runti pelari'). Since 1987, harvesters have tended to leave the glaze on the canes, selling them as *C. caesius* for the manufacture of rattan carpets because of the increase in the number of factories making rattan mats ('tatami' mats) and the shortage of *C. caesius* canes for this purpose in Central Kalimantan.

Canes with a glaze are first washed in a river or stream and scrubbed with a metal brush or with sand to remove dirt and any dead leaf-sheaths remaining after harvesting. The canes are then stacked loosely in an airtight fumigation shed or over racks and covered with plastic tarpaulin and fumigated overnight with sulphur to turn the surface golden yellow as well as to destroy all borers and staining fungi. The amount of sulphur used for fumigation varies from 2–2.5 kg per half t of canes to 3–4 kg for 10 t. The canes are then removed from the fumigation shed and dried over racks in full sun for 5–7 days, during which time the moisture content is brought down to 5–10%. This is necessary because both fungal and insect attacks begin when moisture content is 20% or more. After drying, canes are graded according to diameter size and severity of fungal attack, with golden yellow canes as premium quality. Graded canes are tied into 50 kg bundles. Depending on the end-use, splitting, peeling and coring may be carried out. Low-grade canes are normally used for the manufacture of poor quality furniture for the domestic market.

Genetic resources and breeding No breeding work has been carried out so far. There is, however, a substantial base population in plantations from which to work on, and selection of superior phenotypes is beginning.

Prospects Prospects for cultivation of *C. trachycoleus* are very good, especially in areas of seasonal flooding where *C. caesius* and other agricultural crops will not survive. It is an ideal crop for smallholders, as demonstrated by villagers in Central and South Kalimantan. Because of its colonizing nature, it is an attractive crop for commercial cultivation as there is no need for replanting. The diameter of the cane is also ideal for splitting. With selection it may be possible to obtain plants producing high quality canes with long internodes, fetching the

high price of *C. caesius*. An additional bonus in the planting in riverine forest is the minimum disturbance to the ecosystem.

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P.S. Shim & C.F. Tan

Calamus tumidus Furtado

Gardens' Bull. Singapore 15: 105 (1956).
PALMAE
$2n$ = unknown

Vernacular names Rotan manau tikus (general throughout Peninsular Malaysia and Sumatra). Malaysia: rotan manau buku hitam (northern Peninsular).

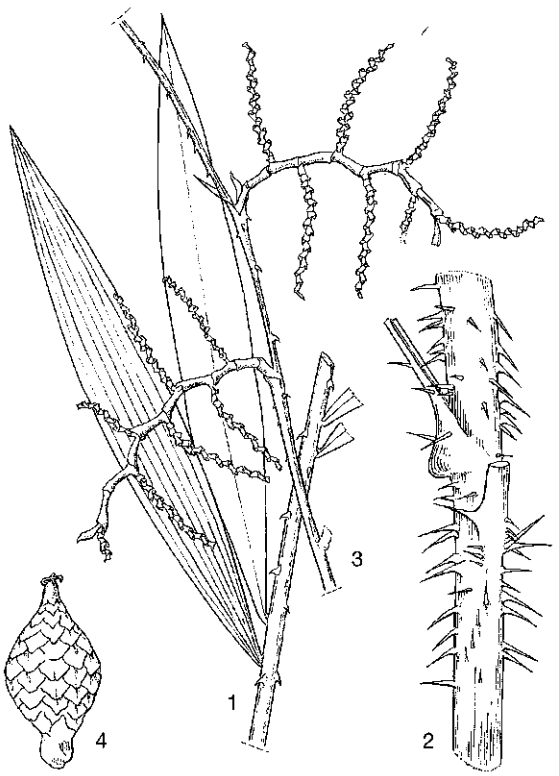
Origin and geographic distribution *C. tumidus* is a common and distinctive rattan in the lowlands of the eastern part of Peninsular Malaysia and in Sumatra.

Uses The canes of larger diameter are sold as rotan manau in the trade, and used in furniture making while smaller-diameter canes are sold with other smaller-diameter canes for various uses including parts of furniture.

Production and international trade The amount of cane produced and entering international trade is not known.

Properties An excellent cane whose quality is affected by poor processing and depends on factors such as age, moisture content and light conditions during growth. The diameter of the cane is not as regular as that of *C. manan* Miq. and it also has shorter internodes.

Description Solitary, high climbing, dioecious rattan with stems eventually reaching over 60 m. Stem without leaf-sheaths about 12 mm in diameter near base, and about 25 mm in upper part of the mature plant, with sheaths to about 45 mm in diameter; upper internodes about 12 cm long, lower internodes to 30 cm. Leaf robust, cirrate, to about 4 m long including the cirrus 1.5 m in length; leaf-sheath with large spines and indumentum; knee greatly swollen; ocrea short, rather inconspicuous; petiole about 30 cm in length, newly emerged petiole reddish-brown to crimson in colour, quickly turning dull yellowish-green, lower and upper petiole surfaces unarmed and without indumen-



Calamus tumidus Furtado – 1, part of leaf; 2, part of stem with leaf-sheaths; 3, part of female inflorescence; 4, young fruit.

tum; leaflets about 25 on each side of the rachis grouped in pairs, about 40 cm × 6 cm, pale yellowish-green to glaucous, conspicuously white waxy on the lower surface when young, black bristly along margins. Inflorescences, male and female superficially similar, to about 1 m long with spiny bracts and up to 8 partial inflorescences on each side of the rachis; rachillae about 15 cm long. Mature fruit ellipsoid, about 22 mm × 18 mm, shortly beaked, covered with 15 vertical rows of convex yellowish-brown scales. Seed 1.6 cm × 1.2 cm × 1 cm, flattened, covered in yellowish-green sarcotesta, irregularly pitted and deeply ruminate. Seedling-leaf bifid.

Growth and development Seeds germinate between 6 to 31 weeks. After about 24 months from field planting, cirri develop after which the aerial stems may grow (at rates still unknown). No phenological work has been documented. Plantation-grown *C. tumidus* is estimated to be harvestable at year 15.

Other botanical information *C. tumidus* differs from the closely related *C. manan* in that the former is smaller, has different leaf-sheath armature and a very large bulbous swollen knee.

Ecology *C. tumidus* is very common in the lowlands of the eastern part of Peninsular Malaysia and in Jambi Province of Sumatra. It is most commonly found in freshwater swamp forest; it has also been found in peat-swamp forest and on alluvial flats. It is apparently absent from hillslopes where *C. manan* replaces it.

Propagation and planting Propagation is best effected from seeds. The fruit wall and the fleshy seed-coat must be removed before sowing and the clean seeds kept moist, as any drying out will cause the embryo to die. Seeds are usually sown in seed-beds in the shade and potted in polybags when the first leaf has emerged. Once potted, seedlings should be kept in the shade and provided with plenty of moisture without waterlogging. Seedlings are usually ready for planting 9–12 months after transplanting into bags and require tree support. Seedlings require about 50% relative light intensity for establishment and growth. The planting distance should be 6 m × 3 m or variations of this.

Husbandry Once the seedlings are planted in the field, thinning of tree canopy along planting lines in the establishment phase may be necessary to allow light to reach the seedlings. During the first three years, about 50 g of compound fertilizer per seedling is added per year.

Diseases and pests Few diseases and pests have been recorded on *Calamus* species generally. In the field, collar rot disease of plant seedlings is so far the only serious fungal disease. In the nursery, leaf diseases (shot holes, brown rings and brown spots) are evident on the leaves of young growing stock of *C. tumidus*. The severity varies from mild to severe and control is by spraying fungicide at 10-day intervals. *Calamus* leaves are reported to be attacked by *Artona catoxanta* (moth), *Botryonopa sanguinea, Protocerius colossus* and *Rhabdonemis leprosa* (all beetles). The fruits have been observed to be attacked by beetles before they are ripe. Stunted growth may result from beetle larvae damaging the swollen basal part of the stem.

Harvesting Harvesting of the stems varies slightly from place to place. Essentially, it involves dragging the rattan from the canopy, removing dead leaf-sheaths and debris and discarding the uppermost 2–3 m, which are immature and too soft for use. The leaf-sheaths and debris are usually removed by coiling and pulling the rattan stem around a conveniently placed small tree trunk, resulting in a clean stem. The cane is then cut into 3 m lengths suitable for bundling and transport out of the forest to the processor.

Handling after harvest *C. tumidus* is treated for protection against attack by staining fungi and powder-post beetle. The canes are boiled in a mixture of diesel and coconut oil, or of diesel and kerosene, or of diesel and palm oil, for varying lengths of time. After boiling, the canes are rubbed with sawdust, ragwaste or gunny sacking and then made into a bundle tied loosely at one end and stood upright with the untied end on the ground in wigwam-like fashion for drying in the sun for a period of 1–2 (rarely three) weeks. They may also be fumigated over burning sulphur, which not only prevents attack by diseases and pests but also improves the colour of the rattan skin.

Genetic resources No attempt has been made to establish a collection to represent the considerable variation found in this species in the wild. However, *C. tumidus* is represented in silvicultural plots.

Breeding No breeding has been carried out. Early selection and provenance trials are needed since *C. tumidus* is sold as rotan manau (cane with larger diameter) in the market.

Prospects The future of this and other com-

mercial rattan species in the wild is uncertain, owing to severe overexploitation. As both *C. manan* and *C. tumidus* are solitary species, and as *C. tumidus* is usually of smaller diameter, *C. manan* is preferred for cultivation.

Literature [1] Aminuddin Mohamad, 1990. Ecology and silviculture of Calamus manan in Peninsular Malaysia. Ph.D. Thesis. University of Wales. 245 pp. [mimeographed] [2] Dransfield, J., 1979. A manual of the rattans of the Malay Peninsula. Malayan Forest Records No 29. Forest Department, Kuala Lumpur. pp. 145–147. [3] Manokaran, N., 1978. Germination of fresh seeds of Malaysian rattans. Malaysian Forester 41: 319–324. [4] Manokaran, N., 1985. Some information of rattan species undergoing silviculture trials. Rattan Information Centre Bulletin 4(4): 1–4. [5] Norani, A., Tho, Y.P. & Hong, L.T., 1985. Pests and diseases of rattans and rattan products in Peninsular Malaysia. In: Wong, K.M. & Manokaran, N. (Editors): Proceedings of the rattan seminar, Kuala Lumpur, 2–4 October 1984. Rattan Information Centre, Forest Research Institute of Malaysia, Kepong. pp. 131–135.

Aminuddin bin Mohamad

Calamus wailong S.J. Pei & S.Y. Chen

Acta Phytotaxonomica Sinica 27(2): 138 (1989).
PALMAE
$2n$ = unknown

Synonyms *Calamus platyacanthus* Wei non Warb. ex Becc.

Vernacular names China: wailong (general name among indigenous Dai group); da-teng (formal botanical name in Chinese).

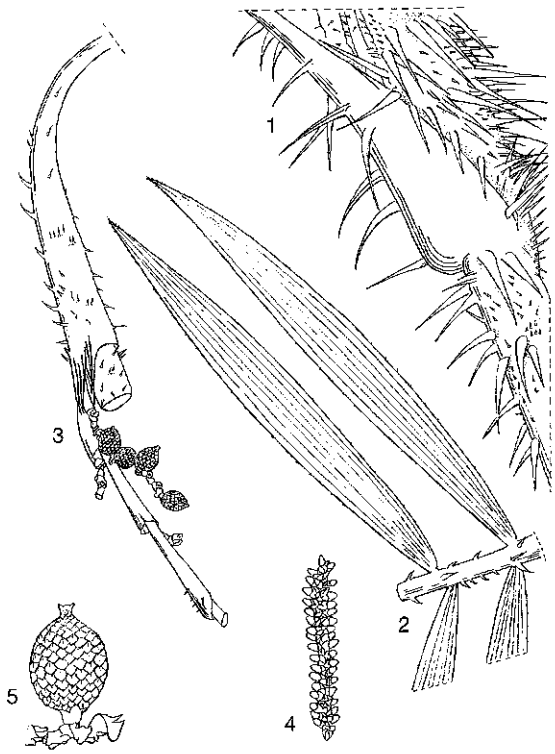
Origin and geographic distribution *C. wailong* is naturally distributed over the eastern part of the mountain region of Xishuangbanna Prefecture, Yunnan Province of China. It occurs naturally in tropical rain forest and since recently has been cultivated by villagers in the region.

Uses Cane of *C. wailong* is extensively used in weaving and in the making of furniture among local communities of this region in China; the split cane is used to weave chairs, small tables, rice-boxes, suitcases and mats. The round stems are used as sticks for the framework of furniture and for house construction.

Production and international trade In the 1960s there was an estimated production of *C. wailong* cane in Mengla county of Yunnan Province of 1000 t per year. The government therefore constructed a road of 80 km from the main highway in order to transport cane from this region. Later, however, the production of the cane in Mengla county fell to about 50 t a year. The total commercial production of rattan cane from 29 different species and varieties between 1980 and 1989 in Yunnan Province was 667 t per year, and the highest was 2239 t in 1988. The rattan canes were transported to cities such as Kunming, Guangzhou and Fushan for processing and weaving fine rattan products for the export and domestic market. Traditionally, the cane of *C. wailong* is mainly consumed by local villagers, and only a small portion is supplied to the cottage industry workshops in the region. As import of cane from international markets has become extremely difficult in recent years, government agencies and local communities are anxious to increase domestic cane production.

Properties *C. wailong* has a large and strong cane. It can produce more fine strips from splitting than other local rattans. As the cane is durable, it is suitable for making furniture and farming tools. Quality of the canes is normally affected by storage conditions, e.g. when after harvesting, the cane is stored in open, unsheltered conditions, the quality detoriates.

Description Clustering, robust, large, high climbing, dioecious rattan. Stem without leaf-sheaths 20 mm in diameter, with sheaths to 40 mm in diameter, internodes to 50 cm or more long. Leaf to 2.5 m long; leaf-sheath dull-green, armed with straight and curved spines to 5 cm long; knee conspicuous; ocrea short; leaflets large, to 55 cm × 7 cm, arranged irregularly on the rachis; rachis prolonged into a cirrus c. 1.5–2.5 m long, bearing dense, short, erect spines. Male and female inflorescences superficially similar; the male inflorescence branching to 3 orders, c. 1.5 m long; primary bracts long, tubular or cylindrical, with robust, curved spines, bract apex tattered; secondary bracts tubular; tertiary bracts short, tubular, cup-shaped with few recurved spines; male flower ovoid to 4 mm long; calyx 3-lobed; corolla twice as long as calyx; female flower ovoid, to c. 3 mm or more long; calyx divided to middle, with 3 triangular lobes. Fruit slightly stalked, ovoid or oblong, to 17 mm × 11 mm, covered with straw-coloured scales in 19–21 longitudinal rows. Seed ovoid, 10–11 mm × 7–8 mm, slightly flattened;



Calamus wailong S.J. Pei & S.Y. Chen – 1, leaf-sheath; 2, part of leaf; 3, part of inflorescence; 4, young male rachilla; 5, fruit.

endosperm ruminate; embryo basal.

Growth and development Seed of *C. wailong* germinates after 15–25 days from sowing; after 14–15 months the primary stem may exceed 1 m; after 5–6 years the stem may reach as long as 4–5 m.

Other botanical information *C. wailong* is closely related to *C. palustris* Griff. and its variety *amplissima* Becc., as well as the poorly known Chinese species *C. platyacanthus* Warb. ex Becc. with the difference that *C. wailong* has a rather large and robust female inflorescence and its leaflets usually are solitary, rarely grouped in pairs on the rachis.

Ecology *C. wailong* is found in the altitudinal range of 600–900 m on slopes in montane rain forests where relative humidity is high all year round, with average annual temperature of 20–21°C, and tropical red loamy soils.

Agronomy It is recommended to propagate *C. wailong* by seed. Fruits of *C. wailong* mature from November to December, so seed should be collected in time, and the pericarp and the fleshy seed-coat removed very soon after. It is best to sow seed in nursery beds. Seeds should first be sown on beds of river sand or rice bran and covered 1–1.5 cm with the same material, and kept moist throughout. In this way germination rates of 75–85% can be obtained in 25 days after sowing. One year after germination, each seedling has 5–7 leaves. The seedlings are then transported to the planting field, either natural forest or forest plantation; the planting distance may be 4 m × 5 m.

Once established, the seedlings require little attention apart from clearing the lines to allow light to reach the seedlings.

The canes are usually harvested in spring. Harvesting involves pulling the rattan down out of the canopy, and twisting the cane around a tree trunk to remove the leaf-sheaths. The cane, divested of its leaf-sheaths, is then bent and tied into bundles and transported to the village. This traditional method of harvesting and treating rattans damages the canes and reduces the cane quality. To prevent or minimize this deterioration, it is recommended that harvested canes be cut into 3–5 m lengths, tied into bundles containing 50–100 sticks, and the bundles placed upright against the walls of houses to dry. Such bundles are easily transported by trucks.

Genetic resources and breeding A collection of native rattan species has been established at Xishuangbanna Tropical Botanical Garden since 1980, and this includes some plants of *C. wailong*.

Prospects With the scarcity of the rattan resource and the huge marketing potential in China, native rattan species including *C. wailong* can be cultivated as a cash crop in mountain landuse systems of tropical China. Other species such as *C. yunnanensis* Pei & Chen and *Plectocomia himalayana* Griff. also have traditionally been cultivated in natural forests and swidden fields by some indigenous communities of Yunnan Province, China. It is suggested that local practices be incorporated into commercial-scale rattan cultivation in the montane forests of tropical China, including cultivation in community forests, protected forest lands and agroforestry systems. *C. wailong* almost certainly also occurs in northern Thailand. It is one of the best quality species in the region.

Literature [1] Chen, S.Y. & Yu, C., 1987. Rational exploitation of rattan resources and

suggestions for development rattan production in Yunnan Province. In: Selected papers of rational exploitation and utilization of Yunnan's biological resources. Yunnan Science and Technology Press, China. pp. 329–333. |2| Pei, S.J., Chen, S.Y. & Tong, S.Q., 1989. New materials for Palmae from China. Acta Phytotaxonomica Sinica 27(2): 132–146. |3| Pei, S.J. & Chen, S.Y., 1990. The resolution of rattan resource crisis in Yunnan Province of China. Paper presented at SUAN V Symposium on Rural-Urban Ecosystems Interactions in Development, Bandung, Indonesia, May 21–24, 1990.

S.J. Pei & S.Y. Chen

Calamus zollingeri Beccari

Ann. Roy. Bot. Gard. Calcutta 11: 386 (1908).
PALMAE
$2n$ = unknown

Vernacular names Indonesia: rotan batang, pondos batang (Sulawesi), rotan air (Moluccas, Seram).

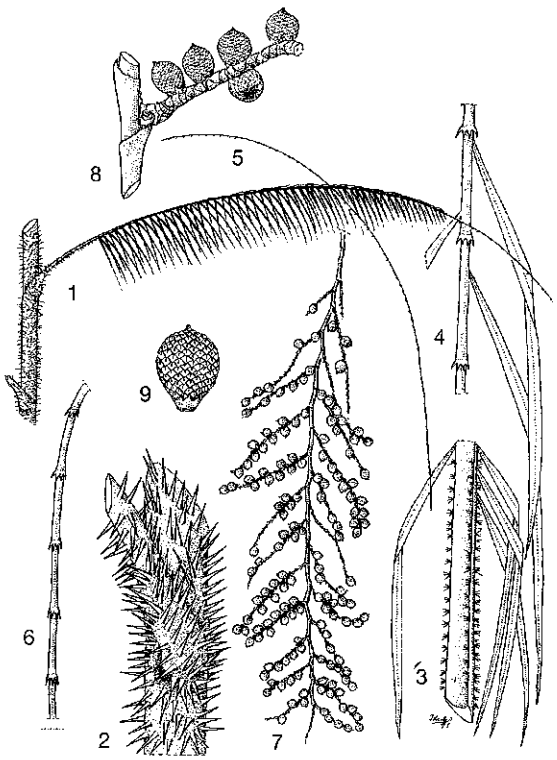
Origin and geographic distribution *C. zollingeri* is found in Sulawesi and the Moluccas.

Uses *C. zollingeri* provides an excellent cane for the framework of furniture and is used extensively in Sulawesi. It is not used locally in the Moluccas but was once exported to Hong Kong and sold in the raw state in Java.

Production and international trade The cane of *C. zollingeri* is used extensively commercially. No trade statistics are available. Since 1985, local forestry officials have established two experimental gardens of 5–10 ha each for the species in Noongan (North Sulawesi) and near Palu (Central Sulawesi).

Properties *C. zollingeri* is a large-diameter (25–40 mm) cane of good quality, but is inferior to *C. manan* Miq.

Description Clustering, robust, dioecious rattan. Stem to 40 m long, without leaf-sheaths 25–40 mm in diameter, with sheaths to 60 mm in diameter, internodes to 40 cm long. Leaf cirrate, to 7 m long including 80 cm long petiole, 5 m long rachis and 2 m long cirrus bearing grapnel-like groups of reflexed spines; leaf-sheath 30–40 cm long, dull green, armed to varying degrees with dull brown to black tough triangular spines to 5.5 cm long, the bases of every 8–12 adjacent spines often united to form collars to 2.5 cm long; knee conspicuous; petiole bearing



Calamus zollingeri Beccari – 1, sheathed stem and leaf; 2, leaf-sheath; 3, basal part of leaf; 4, upper part of leaf; 5, cirrus; 6, detail of cirrus; 7, part of infructescence; 8, detail of infructescence; 9, fruit.

abundant spines on the lower surface only, none on the upper surface, the spines to 3 cm long, similar in form to the ones on the leaf-sheaths; leaflets 60–85 on each side of the rachis, arranged regularly, pendulous, linear, to 50 cm × 3 cm, with 3 lateral veins, leaflet upper and lower surfaces bearing bristly hairs to 2.5 cm long 1.4 cm apart. Inflorescences erect, robust, to 110 cm long; male inflorescence similar to the female. Ripe fruit globose, 5 mm in diameter, dark brown, immature fruit green, turning to white in dried herbarium specimens. Seed one per fruit; endosperm homogenous. Seedling-leaf with 2 leaflets, 70 mm × 6.5 mm.

Other botanical information Beccari included *C. zollingeri* in a group consisting of *C. andamanicus* Kurz, *C. erinaceus* (Becc.) J. Dransf., *C. merrillii* Becc., *C. ovoideus* Thwaites ex Trimen, *C. polystachys* Becc., *C. warburgii* K. Schum. and *C. zeylanicus* Becc. In Sulawesi,

due to the similar size of vegetative parts in sterile material, *C. zollingeri* is often misidentified as *Daemonorops robusta* Warb. The main difference is that the leaf-sheaths of *D. robusta* bear numerous slender hairy spines and the upper surface of the petiole is densely armed with spines as well and the leaflets are rather stiff and pointed, not pendulous.

Ecology *C. zollingeri* is found in primary forest from lowlands to altitudes of 800 m, usually near streams.

Agronomy Propagation is by seed and possibly also by using sucker shoots. The stem is cut at the base and the plant is pulled out manually by 2–3 men while an assistant climbs the nearest tree and cuts off leaves which are entangled in the canopy to facilitate the removal of the stem, very often leaving behind a portion of the upper part of the stem that cannot be extricated. After removing old leaf-sheaths and debris from the stem, the cane is cut into 4 m lengths. The collector usually carries a bundle of 10–12 pieces on his shoulder for a journey that can last 4 hours to 2 days (or even a week by river) to the nearest marketplace. The cane is treated in the same way as *C. manan*.

Genetic resources and breeding In a project started in 1989, more than 2000 seeds of *C. zollingeri* from Central Sulawesi have been collected and germinated, and the seedlings raised for planting. No breeding activities have been carried out. Preliminary selection and provenance trials are needed before a breeding programme can be initiated.

Prospects As there is a large demand for high quality large-diameter canes, there is great promise for the cultivation of *C. zollingeri* which, although of inferior quality compared to *C. manan*, has the advantage of being multi-stemmed.

Literature |1| Beccari, O., 1908. Asiatic palms – Lepidocaryeae. Part 1. The species of Calamus. Annals of the Royal Botanic Garden, Calcutta 11: p. 387, Plate 165 & 166; Analytical section: Plate 7. |2| Panjatap, 1985. Laporan team studi rotan [Report of the rattan study team]. Panitia Kerja Tetap Pengembangan Ekspor, Jakarta. 17 pp. [mimeographed report]

J.P. Mogea

Daemonorops margaritae (Hance) Beccari

Rec. Bot. Surv. Ind. 2: 220 (1902).

PALMAE

$2n$ = unknown

Vernacular names China: huangteng, hongteng (yellow and red rattan).

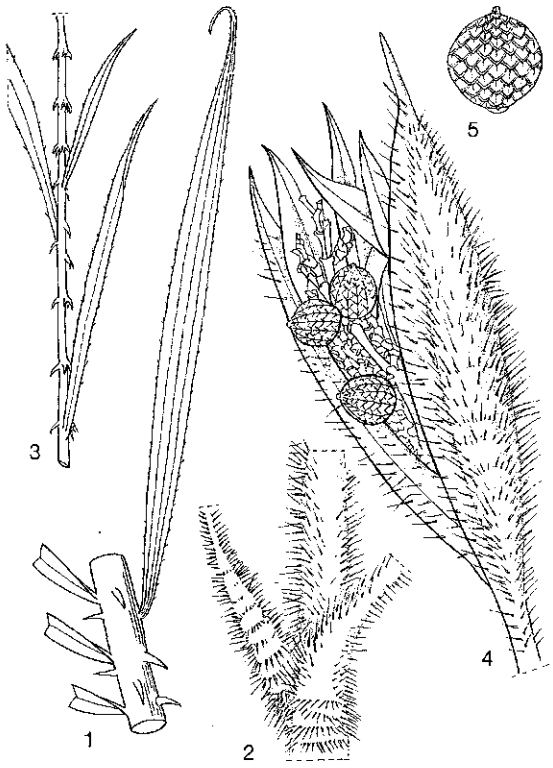
Origin and geographic distribution *D. margaritae* is widespread in the tropical and subtropical parts of southern China, occurring on Hainan Island, southern Guangdong and Guangxi Provinces, and in cultivation extending to southern Fujian and Yunnan Provinces.

Uses *D. margaritae* is an important cane of medium-large diameter in China. It is used for all types of weaving and basketware. Seeds are used for making necklaces. Fresh shoots are collected as a vegetable.

Production and international trade It is estimated that 20–25% or 800–1000 t/year of rattan production in China comes from this species.

Properties The cane is yellow with a glossy surface. Specific gravity is 0.399. Tensile strength is 49.1 N/mm^2. Lignin content is 21.8%.

Description Clustering, dioecious rattan; stems climbing to 50 m, the clump tending to be rather close and dense. Stem without leaf-sheaths 8–18 mm in diameter, with sheaths 25–30 mm in diameter; internodes up to 40 cm long. Whole leaf to 3 m long including the sheath; leaf-sheath dull green, armed with scattered, triangular red-brown spines to 3.5 cm × 5 mm, and red-brown indumentum; knee conspicuous; ocrea poorly developed; petiole about 35 cm long, armed with straight, claw-like, long/short spines joined and in groups; rachis c. 1.2 m long, bearing scattered reflexed spines on the lower surface, distally the rachis prolonged into a whip to 1 m long, bearing grapnel-like groups of reflexed spines; leaflets 50–75 on each side of the rachis, regularly arranged, narrow, crowded, up to 45 cm × 2 cm, with 3–5 major veins, armed with bristles on the midrib and lateral veins on the upper surface, along the margins and at the tip. Male and female inflorescences very similar, sessile, to 40 cm × 15 cm, with a beak c. 8 cm long; 2–4 inner bracts enclosed within the outermost bract, outermost bract rather densely armed with brown spines scattered and grouped, and covered with dense red-brownish indumentum; rachillae rather slender and sinuous, densely crowded and enclosed



Daemonorops margaritae (Hance) Beccari – 1, leaflet with part of rachis; 2, leaf-sheath; 3, apical leaflets and basal part of cirrus; 4, infructescence; 5, fruit.

within the inner bracts, to 12 mm long, 4–7 flowers borne on either side, light yellow; calyx to 2 mm, petals to 5 mm, filaments to 1.5 mm long; in female flower ovary ovoid, with 3 stigmas. Ripe fruit 1-seeded, rarely 2-seeded, ovoid, to 22 mm in diameter, covered in 21–23 vertical rows of yellowish-brown scales. Seed to 15 mm × 12 mm, weighing c. 1.5 g, covered in a fleshy sarcotesta, kidney-shaped, endosperm ruminate, embryo basal. Seedling-leaf with 5 acute leaflets, dark green.

Cane anatomy The epidermis is built up of one layer of rectangular silicified cells and the sub-epidermis is composed of 3–4 layers of lignified parenchyma cells. Vascular bundle density is 4–6/mm^2. Metaxylem vessels are 171 μm in diameter. Fibre length is 1.1 mm.

Growth and development Most seeds germinate 50–60 days after sowing. After 60–90 days the primary leaf emerges, and after 24–36 months the first stem exceeds 1 m length and the first climbing whips appear. *D. margaritae* may have the potential to produce an exponential increase in the number of aerial stems, but because of competition between them, most of the suckers may not be able to develop into stems. Two to three years after establishment the aerial stems may grow at a rate of 2 m/year. Flowering begins 5–6 years after sowing. At 8–10 years old, a clump may already consist of over 30 aerial stems. In China, flowering is from July – October; fruiting is from November – February; mature fruits do not drop. New leaves of seedlings are sometimes light red.

Other botanical information This is the only species of *Daemonorops* found in China.

Ecology *D. margaritae* is found from the lowlands to the hills below 1000 m altitude, in primary or secondary tropical rain forest and subtropical broadleaved forest. In general, the ecophysiological requirements for optimal growth are: a temperature of 20–32°C (–3°C or lower may kill young seedlings); more than 1500 mm annual rainfall with over 80% relative humidity; 30–50% shade; fertile and damp soil with medium to high amount of humus content (2.5–4.5%) and pH 4.5–6.5. Seedlings require more sunlight than others for optimum growth.

Propagation and planting Although it can be propagated by vegetative means, propagation by seeds is a more common method. Seeds should be extracted and cleaned before sowing. The moisture content of seeds should be kept higher than 29%; the germination rate of ripe and fresh seeds may be 85% or more. In order to improve germination, the inner integument that covers the embryo is sometimes sliced through in the nursery. However, the normal nursery practice is to sow the cleaned seeds in sand beds in the shade; young seedlings (the first true leaf unexpanded) are transplanted into plastic pots containing soil and added nutrients and then kept moist and under 20–30% shade. Fertilizer is applied and diseases and pests controlled. Seedlings are ready to plant out when 12–15 months old. Although *D. margaritae* requires the support of a pre-existing tree crop or forest canopy for climbing, it requires sufficient sunlight to encourage the development of aerial stems. However, the new leaf of young seedlings may be scorched by full sunlight. In China, smallholders plant *D. margaritae* in scattered clumps in agroforestry systems; on a commercial scale it has been intercropped in forest at spacings of 3 m × 4 m.

Husbandry In the first 3 years after planting, maintenance involves clearing the lines to allow light to reach the seedlings, loosening soil around the clumps, and mulching. This should be done twice a year. If possible, it is best to supply fertilizer to seedlings (N 30 g, P 10 g and K 15 g per clump) once a year for the first 3 years after planting.

Diseases and pests Diseases of seedlings and stem shrinkage, and anthracnose are caused by *Botryodiplodia* sp. and *Colletotrichum* sp. respectively; fungal diseases are usually the result of poor management and bad growing conditions. Pests of the seedlings such as moths, locusts and rats have also been reported.

Harvesting Harvesting is carried out by pulling the cane out of the canopy, divesting it of leaf-sheaths, and then cutting the canes into 4–5 m lengths, tying them in bundles and transporting to the village. Sometimes the harvesters may cut the mature stems in the forest but leave the stems over until the leaves and leaf-sheaths dry, so as to collect the canes more easily.

Yield It has been estimated that the yield of initial harvest of *D. margaritae* could be about 7.9 t/ha 10–11 years after establishment, and in the following years reharvesting may be carried out 4 times in a rotation of five years. Total projected yield may possibly reach 38.7 t/ha within a management period of 25 years. However, these estimates are in need of critical confirmation.

Handling after harvest The harvested canes are usually sun-dried by middlemen to prevent attack by staining fungi and powder-post beetle, then sorted and transported to manufacturers for further processing such as rubbing, bleaching and splitting.

Genetic resources *D. margaritae* is present in several botanical gardens and arboreta in China but no attempt has been made to establish a collection to represent the considerable variation found in the field.

Breeding No breeding has been carried out in China so far. Selection of superior phenotypes through provenance trials is necessary.

Prospects Recent studies show that the cultivation of *D. margaritae* has been successful, at least on a small scale. The prospects for this species, not only as a cultivated crop on a smallholding scale but also on a commercial scale, are good within China. However, the major problem of extending cultivation is the lack of seeds and the longer return period for investment. Outside China, the significance of this species to rattan development is likely to be as a silvicultural model.

Literature |1| Cai, Z.M., 1989. Distribution of vascular tissue in four rattan canes. Acta Botanica Sinica 31(8): 569–575. |2| Pei, S.J. & Chen, S.Y., 1991. Flora reipublicae popularis sinicae 13(1). Science Press, Beijing, China. pp. 59–60. |3| Rao, A.N. & Vongkaluang, I. (Editors), 1989. Recent research on rattans. Proceedings of the International Rattan Seminar, Chiangmai, 12–14 November 1987. Faculty of Forestry, Kasetsart University, Thailand and International Development Research Centre, Canada. pp. 130–136. |4| Xu, H.C., Zhou, Z.Z. & Yin, G.T., 1991. Nutrition evaluation of shoots of two rattan species. Rattan Information Centre Bulletin 10(4): 17–20. |5| Yin, G.T. & Xu, H.C., 1988. A preliminary study on the effect of different levels of light intensity on the growth of rattan seedlings. Forest Research 1(5): 548–551. |6| Zhou, Z.Z., Xu, H.C. & Yin, G.T., 1991. A financial appraisal of three commercial rattan plantations. Forest Research 5(1): 47–55.

H.C. Xu & G.T. Yin

Daemonorops robusta Warb.

Ann. Roy. Bot. Gard. Calcutta 12: 101, plate 39 (1911).

PALMAE

$2n$ = unknown

Vernacular names Indonesia: rotan susu (northern Sulawesi), batang merah (central Sulawesi), rotan bulu rusa (western Seram, Ambon). The local name 'rotan susu' in Sulawesi is also used for *Calamus ornatus* Blume var. *celebicus* Becc.

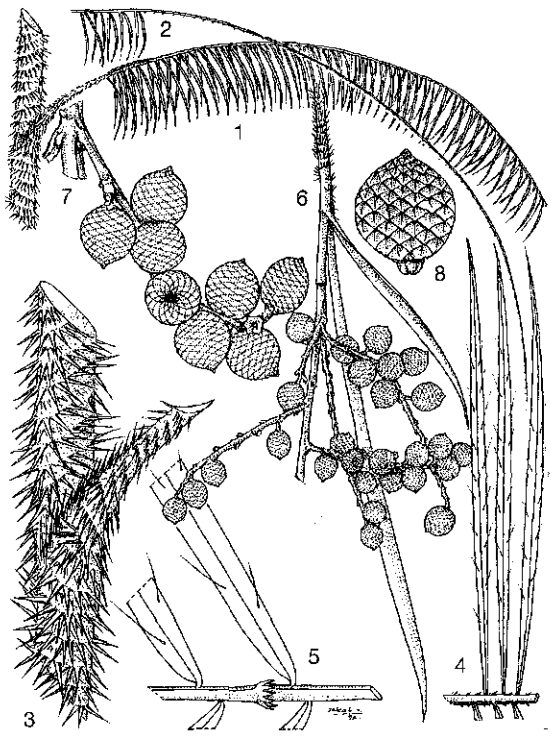
Origin and geographic distribution *D. robusta* is only found in Indonesia, in Sulawesi and the Moluccas (Halmahera, Seram, Buru, Ambon).

Uses The cane is used locally for making the framework of furniture of moderate quality.

Production and international trade The cane is traded locally only but no production statistics are available.

Properties *D. robusta* is a medium-diameter cane, second grade to *Calamus zollingeri* Becc.

Botany Clustering, robust, dioecious rattan, up to 20 m tall. Stem without leaf-sheaths 23 mm in diameter, with sheaths 40 mm in diameter; internodes to 23 cm long. Leaf cirrate, c. 5.5



Daemonorops robusta Warb. – 1, sheathed stem and basal part of leaf; 2, upper part of leaf with cirrus; 3, leaf-sheath; 4, three leaflets; 5, detail of rachis with leaflets; 6, part of infructescence; 7, detail of infructescence; 8, fruit.

m long, including petiole, rachis and cirrus; leaf-sheath yellow to pale green, armed densely with whitish-brown to black slender and often soft spines and with black indumentum, spines to 7 cm long, sometimes flat, triangular to 3.2 cm long; knee conspicuous; petiole 0.4 m long, with long black spines all around, spines up to 4 cm long; rachis 4 m and cirrus 1.2 m long, bearing grapnel-like groups of reflexed spines; leaflets c. 60 on each side of the rachis, stiff, the lower ones as long as the upper leaflets, linear, 50 cm × 3 cm, bearing long bristles. Male inflorescence similar to female, pendulous, to 50 cm long, long-spiny. Ripe fruit somewhat globose, 17 mm long and 20 mm in diameter, with 14–15 vertical rows of white scales, bright brown when dried. Seed one per fruit, subglobose, 15 mm × 18 mm.

It is suspected that *D. beguinii* Burret may be conspecific (and hence synonymous) with *D. robusta*. For differences between *D. robusta* and *Calamus zollingeri*, see notes on the latter.

Ecology *D. robusta* is found in lowland forest up to 100 m altitude, usually near streams.

Agronomy *D. robusta* is propagated by seed. There are no plantations of this rattan. The stem is cut at the base and the plant is pulled out manually by 2–3 men while an assistant climbs the nearest tree and cuts off leaves which are entangled in the canopy to facilitate the removal of the stem, very often leaving behind a portion of the upper part of the stem that cannot be extricated. After removing old leaf-sheaths and debris from the stem, the cane is cut into 4 m lengths. The collector usually carries a bundle of 10–12 pieces on his shoulder for a journey that can last 4 hours to 2 days (or even a week by river) to the nearest market place. The cane is treated in the same way as *C. manan* Miq.

Genetic resources and breeding Some seeds have been collected from several areas in Sulawesi and planted in the nursery in Bogor.

Prospects Since *D. robusta* clusters and produces medium-diameter cane, it is a promising rattan for cultivation. Further studies on improvement of cane quality are desirable.

Literature |1| Beccari, O., 1911. Asiatic palms – Lepidocaryae. Part 2. The species of Daemonorops. Annals of the Royal Botanic Garden, Calcutta 12: 101.

J.P. Mogea

Daemonorops sabut Beccari

Flora British India 6: 469 (1893).

PALMAE

$2n$ = unknown

Vernacular names Indonesia: jungan (East Kalimantan). Malaysia: rotan sabut, toan pekat (Sabah), wi lepoh (Sarawak). Thailand: waai phon khon non.

Origin and geographic distribution *D. sabut* is widespread in Peninsular Malaysia and Borneo.

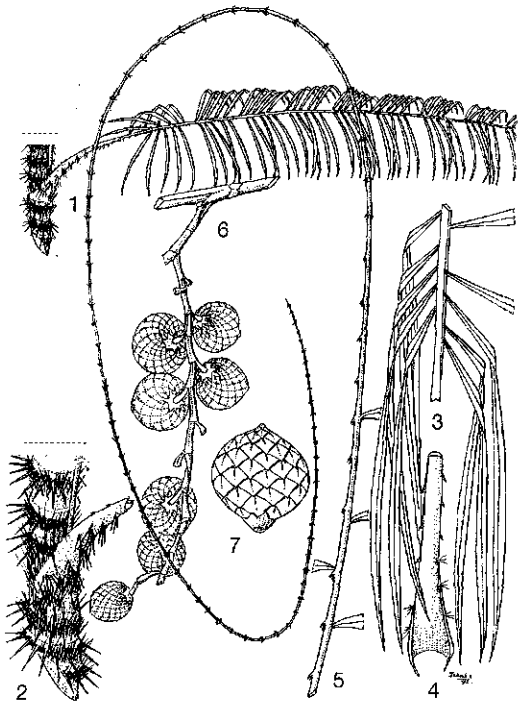
Uses In Sarawak, the cane is used as splits and woven into mats and carrying baskets, for binding and tying roofs. A natural red dye similar to 'dragon's blood' can be prepared from its fruit.

Production and international trade In Sarawak, the cane is often sold as split canes with good market value. However, no statistics are available.

Properties The cane is small in diameter (1.5 cm), durable, and considered one of the best materials for making local baskets ('selabit').

Botany Clustering, dioecious rattan of moderate size, to 40 m or more in length. Stem without leaf-sheaths 15 mm in diameter, with sheaths to 30 mm in diameter; internodes to 10 cm long. Leaf cirrate, to 2.5 m long including petiole and the 1.2 m long cirrus; leaf-sheath dark green, densely armed with collars of black and brown horse-hair-like spines varying from 1–6 cm in length, collars frequently somewhat oblique, caducous, blackish-brown indumentum between the collars, at least some of the collars interlocking to form tunnels usually occupied by ants; knee conspicuous; ocrea inconspicuous; petiole 60 cm long with scattered reflexed spines to 5 mm long and small groups of black spicules on collars near the base; leaflets to 20 on each side of the rachis, very irregularly clustered, in up to 5 groups of 3–6 leaflets each, the lowermost group often very crowded pointing in several directions, the longest, usually the most basal, rather narrow to 45 cm × 3 cm, unarmed except for short marginal bristles. Inflorescence pendulous, male and female superficially similar, to 60 cm long; with up to 6 partial inflorescences to 30 cm long; the prophyll long persistent, armed with collars and black bristles like the leaf-sheaths, other bracts quickly falling at anthesis. Mature fruit rounded to ovoid, very short beaked, about 16 mm × 12 mm, covered in 14–17 vertical rows of yellowish reflexed scales. Seed 12 mm × 9 mm, densely pitted; endosperm deeply ruminate. Seedling-leaf with divergent leaflets.

Characteristic for *D. sabut* are the tunnels of the leaf-sheaths. Many species in the genus, in fact, have spines forming such tunnels, namely *D. crinita* (Miq.) Bl., *D. forbesii* Becc., *D. formicaria* Becc., *D. macrophylla* Becc., *D. mirabilis* Mart., *D. oligophylla* Becc. and *D. verticillaris* (Griff.) Mart. In *Calamus*, *C. polystachys* Becc. has such tunnels. They are usually occupied by ferocious ants, which make specimen collection unpleasant.



Daemonorops sabut Beccari – 1, sheathed stem and basal part of leaf; 2, leaf-sheath showing ant-galleries; 3, middle portion of leaf; 4, basal part of leaf; 5, upper part of leaf with cirrus; 6, part of infructescence; 7, fruit.

Ecology *D. sabut* is very characteristic of alluvial or freshwater swamp, mostly in lowlands, but also up to 400 m altitude.

Agronomy *D. sabut* is propagated by seed. It has been cultivated by villagers in Sarawak. No information is available on husbandry, yield and handling after harvest. Harvesting is as for medium- and large-diameter canes like *Calamus ornatus* Blume.

Genetic resources and breeding No germplasm collections have been established so far.

Prospects Since the cane of *D. sabut* is very useful in basketry work and the plant clusters, it is worthwhile to take this rattan into cultivation.

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No 35. Forest Department, Kuala Lumpur. p. 32.

J.P. Mogea

Korthalsia Blume

Rumphia 2: 166 (1843).
PALMAE
$2n = 32$ (*Korthalsia laciniosa, K. rostrata*)

Major species and synonyms

- *Korthalsia cheb* Becc., Malesia 2: 67 (1884);
- *Korthalsia echinometra* Becc., Malesia 2: 66 (1884);
- *Korthalsia flagellaris* Miq., J. Bot. Néerl. 15 (1861);
- *Korthalsia laciniosa* Griff. ex Mart., Hist. Nat. Palm. 3 (2nd ed.): 211 (1845), synonym: *Korthalsia grandis* Ridley (1902);
- *Korthalsia rigida* Blume, Rumphia 2: 167 (1843);
- *Korthalsia robusta* Blume, Rumphia 2: 170 (1843), synonym: *Korthalsia macrocarpa* Becc. (1918);
- *Korthalsia rostrata* Blume, Rumphia 2: 168 (1843), synonym: *Korthalsia scaphigera* Griff. ex Mart. (1845).

Vernacular names

- *Korthalsia* spp. (in general, in trade): Malaysia: rotan merah.
- *Korthalsia cheb*: Malaysia: keb, wee jematang tengan.
- *Korthalsia echinometra*: Indonesia: uwi hurang, rotan meiya. Malaysia: rotan dahan, rotan semut, rotan udang.
- *Korthalsia flagellaris*: Malaysia: rotan dahan.
- *Korthalsia laciniosa*: Malaysia: rotan dahan.
- *Korthalsia rigida*: Malaysia: rotan dahan.
- *Korthalsia robusta*: Malaysia: rotan asas, lasas.
- *Korthalsia rostrata*: Malaysia: rotan semut, rotan udang.

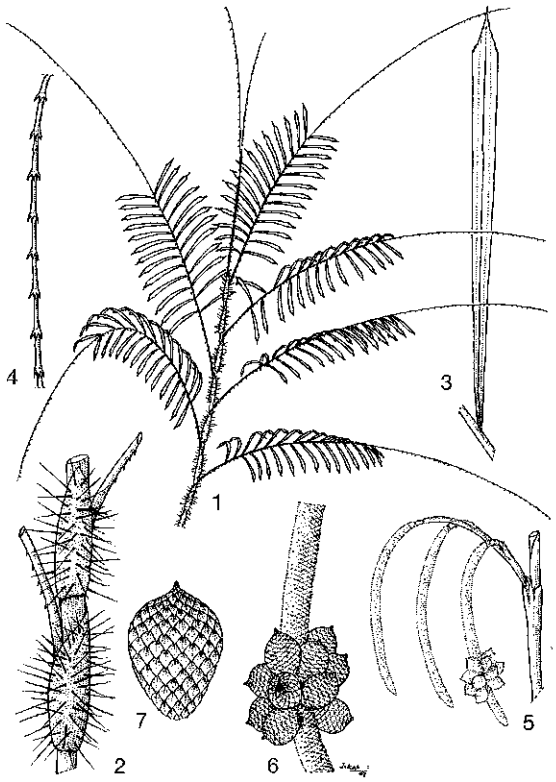
Origin and geographic distribution *Korthalsia* is a genus of about 26 species, widely distributed in South-East Asia from Burma and the Andaman and Nicobar Islands, Indo-China southwards and eastwards to New Guinea with greatest diversity in Sumatra, Peninsular Malaysia and Borneo.

- *Korthalsia cheb* is endemic to Borneo where it is widespread but nowhere common. It is occasionally cultivated near longhouses in Sarawak.
- *Korthalisa echinometra* is a conspicuous and abundant rattan in Sumatra, Peninsular Malaysia and Borneo; it is occasionally cultivated near longhouses in Sarawak.
- *Korthalsia flagellaris* is widespread in Peninsular Malaysia, southern Thailand, Sumatra and Borneo where it occurs exclusively in lowland peat-swamp forest.
- *Korthalsia laciniosa* is one of the most widespread species, occurring from Indo-China and the Andaman and Nicobar Islands to Peninsular Malaysia, Sumatra and Java, and the Philippines, but not Borneo.
- *Korthalsia rigida* is widespread occurring from southern Thailand and Peninsular Malaysia to Borneo, Sumatra and Palawan.
- *Korthalsia robusta* is confined to Sumatra, Borneo and Palawan.

Uses The most important use of *Korthalsia* species is as a source of very durable cane for weaving strong baskets. Some species such as *K. echinometra* are highly sought after for their canes because they are a preferred constituent of particular types of baskets. Occasionally, because of the dull reddish colour they are used mixed with canes of contrasting colour such as those of *Calamus caesius* Blume. In addition to their use in basketry, canes of *Korthalsia* spp. are incorporated into cheap furniture, some of which is exported and they are widely used for cordage, particularly in situations demanding great durability.
The fruit of some species is eaten but there is little flesh.

Properties Cane diameter varies from very slender (6 mm) to moderately robust (40 mm or more). Internode length varies from about 10 cm to over 40 cm. The cane surface is dull and reddish-brown and its internal structure shows great evenness of texture. The inner epidermis of the leaf-sheaths is not easily separable from the cane surface and the nodes are frequently scarred on one side by the remains of axillary buds or branches. These factors detract from the overall marketability of the canes, which are otherwise very durable and not unattractive.

Description Slender to moderately robust, high-climbing, hapaxanthic, hermaphroditic rattans, usually densely clustering and also frequently branching high in the canopy to produce large aerial entanglements. Leaf varying from scarcely 40 cm to more than 3 m long; leaf-sheath lacking a knee and always terminating in an ocrea; the leaf-sheath and ocrea variously



Korthalsia echinometra Beccari – 1, habit of a stem with leaves; 2, part of sheathed stem with two ocreas; 3, leaflet; 4, detail of cirrus; 5, part of infructescence; 6, part of rachilla in fruit; 7, fruit.

armed with sparse to dense spines; ocrea tightly sheathing, loosely expanded and net-like, greatly swollen and ant-infested or diverging from the sheathed stem with margins inrolled and ant-infested; petiole absent to well-developed; cirrus well-developed; leaflets usually rather few in number, lanceolate to diamond-shaped with the upper margins jagged (praemorse), leaflet undersurface often covered with indumentum and leaf-base stalked. Inflorescences produced simultaneously from the topmost nodes, branching to 3 orders, death of the stem following flowering and fruiting; rachillae cylindrical, usually densely tomentose, the flowers embedded in the tomentum. Fruit spherical to ovoid, covered with vertical rows of flat scales with fimbriate margins; mesocarp fleshy; sarcotesta absent; endosperm homogenous or ruminate. Seedling-leaf bifid or entire.

- *Korthalsia cheb*: stem without leaf-sheaths c. 20 mm in diameter, with sheaths 30 mm in diameter; ocrea to 25 cm × 4.5 cm, inflated, usually filled with ants. Leaflets diamond-shaped.
- *Korthalsia echinometra*: stem without leaf-sheaths to 20 mm in diameter, with sheaths to 30 mm in diameter; ocrea to 10 cm × 5 cm, very spiny, inflated and filled with ants. Leaflets lanceolate.
- *Korthalsia flagellaris*: stem without leaf-sheaths to 25 mm or more in diameter, with sheaths to 40 mm or more; ocrea tightly sheathing, tattering with age. Leaflets lanceolate with conspicuous long stalks, rusty indumentose on the undersurface.
- *Korthalsia laciniosa*: stem without leaf-sheaths to 35 mm in diameter, with sheaths to 40 mm or more; ocrea net-like, tightly sheathing, spiny. Leaflets diamond-shaped.
- *Korthalsia rigida*: very variable. Stem without leaf-sheaths 6–20 mm in diameter, with sheaths to 30 mm in diameter; ocrea usually short, tightly sheathing, sometimes tattering, very sparsely spiny. Leaflets diamond-shaped.
- *Korthalsia robusta*: stem without leaf-sheaths to 25 mm in diameter, with sheaths to 35 mm in diameter; ocrea elongate, to 25 cm long, diverging from the sheathed stem, spiny, the margins inrolling to form a chamber, usually occupied by ants. Leaflets diamond-shaped.
- *Korthalsia rostrata*: stem without leaf-sheaths 6–9 mm in diameter, with sheaths 8–15 mm in diameter; ocrea rounded, to 4 cm long, inflated and usually ant-infested. Leaflets diamond-shaped.

Growth and development There is little information on growth and development. Clustering and aerial branching behaviour is unusual in this genus and would repay further study. It is not known whether aerial branch production is in any way related to the onset of flowering and hence termination of individual stem growth.

Other botanical information Many species of *Korthalsia* have close association with ants that make their nests within the swollen ocreas. The ant–rattan relationship also seems to involve the presence of scale insects that are husbanded by the ants for honey dew on young rattan tissue. Ants occupying the ocreas of some species are extremely aggressive and in *K. robusta* and *K. hispida* Becc. are also noisy, producing an alarm call when disturbed by banging their mandibles against the dry ocreas.

Ecology Most species of *Korthalsia* are wide-

spread and quite tolerant of disturbance, often being the most well represented rattan genus in logged-over forest. This wide dispersal may be correlated with the hapaxanthic behaviour of production of large numbers of fruit simultaneously. *K. flagellaris* is confined to peat-swamp forest; *K. concolor* Burret is restricted to forest developed on ultramafic rock in Sabah. Most species occur in the lowlands, but *K. laciniosa* has been recorded as high as 1100 m above sea-level in Peninsular Malaysia.

Agronomy Propagation is from seed. Only *K. cheb* and *K. echinometra* have been recorded as being cultivated by villagers, on a small scale, in western Sarawak. Supplies from the wild seem otherwise to be sufficient for local basket-making throughout much of the range of the genus. Harvesting is similar to harvesting of other similar-sized species.

Genetic resources and breeding Several species are cultivated in botanical gardens and arboreta throughout the South-East Asian region.

Prospects As there is great demand for the canes of *Korthalsia* spp. for local basket-making, it seems likely that local cultivation may continue and perhaps expand, especially where the wild resource is in short supply. It is unlikely, however, that there will ever be any commercial planting of these rather poor quality canes, no matter how durable and sought after they may be at the village level.

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J. Dransfield & J.P. Mogea

3 Minor rattans

Calamus albus Pers.

PALMAE

Vernacular names Indonesia: rotan putih, ue puti, uwe ahun tain (Ambon).

Distribution Moluccas (Ambon).

Uses Possibly the cane is used locally for making furniture for domestic use.

Observations Habit unknown. Stem with leaf-sheaths 47 mm in diameter, leaf-sheaths in upper portion of stem scarcely spiny. Leaves cirrate. Rumphius named it *Palmijuncus albus*; he also presented a habit drawing. According to Heyne, *C. albus* is conspecific with *C. rudentum* Roxb. In fact, the proper identity of *C. albus* requires further taxonomic study. The form of the inflorescence is similar to the group of *C. minahassae* Becc.

Selected sources 4, 27, 47.

Calamus andamanicus Kurz

PALMAE

Vernacular names Andaman Islands: chowdah, charab. Nicobars: nat.

Distribution Andaman and Nicobar Islands.

Uses An excellent large-diameter cane, harvested for the furniture industry. Leaves used for thatch.

Observations Very robust clustering rattan. Stem to great heights, 25–30 mm in diameter without leaf-sheaths, with sheaths 80–100 mm in diameter. Leaf very large, cirrate; leaf-sheaths fiercely armed. Found in lowland rain forest. Because of its growth form and fine quality cane, *C. andamanicus* could have potential as a silvicultural crop in South-East Asia.

Selected sources 4.

Calamus aruensis Becc.

PALMAE

Vernacular names Several names are recorded on herbarium sheets, but it is not known how reliable these are.

Distribution Aru Islands, New Guinea, Queensland (Australia).

Uses The cane is of excellent quality

Observations Sparsely clumped robust rattan. Stem without leaf-sheaths 10–20 mm in diameter, with sheaths 20–45 mm in diameter. Leaves cirrate, with few broad leaflets; leaf-sheaths unarmed. Fruit rounded, 8–12 mm in diameter. *C. aruensis* occurs in lowland rain forest, and is closely related to *C. hollrungii* Becc. and *C. subinermis* Becc.

Selected sources 4, 30, 31.

Calamus arugda Becc.

PALMAE

Vernacular names Philippines: arugda (Ibanag).

Distribution The Philippines (Cagayan, northern Luzon).

Uses Entire canes are used in handicrafts, furniture, baskets, etc., and sold locally or exported abroad.

Observations A moderate to robust rattan. Stem without leaf-sheaths 30 mm in diameter, with sheaths to 40 mm in diameter. Leaves cirrate; leaflets elliptical-lanceolate, closely set. Fruit with prominent beak. Endemic to the Philippines and found in primary forest at low altitude.

Selected sources 2, 3, 8, 11, 22, 23, 26, 37, 38, 39, 45.

Calamus axillaris Becc.

PALMAE

Vernacular names Indonesia and Malaysia: rotan sega air.

Distribution Sumatra, Borneo and Peninsular Malaysia. In Peninsular Malaysia, it is a rather rare species found only in the states of Pahang, Perak, Johor.

Uses Small-diameter cane suitable for making baskets, fish traps and for tying.

Observations A clustering, moderate-sized, high-climbing rattan with stem diameter without leaf-sheaths to 13 mm, not more than 25 mm in diameter with sheaths. Resembles *C. caesius* Bl. (rotan sega) but lacking the whitish colour on the under surface of the leaflets. Locally abundant on river banks and in freshwater swamps in the lowlands.

Selected sources 14, 35, 40, 46.

Calamus bacularis Becc.

PALMAE

Vernacular names Malaysia: wi tulang (Iban, Sarawak), wi babut (Bidayuh, Sarawak), kokop (Penan, Sarawak).

Distribution Borneo, endemic to Sarawak.

Uses The cane is used for making walking-sticks.

Observations A solitary short-stemmed rattan rarely growing beyond 2 m height. A very localized palm only known from the 1st Division of Sarawak, inhabiting hill slopes and ridge tops in hill dipterocarp forest at an altitude up to 600 m.

Selected sources 18, 21, 43, 44.

Calamus bicolor Becc.

PALMAE

Vernacular names Philippines: lasi, rasi, sambonotan (Bagobo).

Distribution The Philippines (on Mount Apo, Davao).

Uses Ornamental; the young plant forms a rosette that is attractive because of the two distinct colours of the leaflets, dark green above, grey below.

Observations Stem without leaf-sheaths 15–20 mm in diameter, with sheaths to 40 mm in diameter. Leaves cirrate; leaf-sheaths densely covered with hair-like, elastic, brownish spines; leaflets green above and chalky white below. Endemic to the Philippines in primary forest at 1200–1800 m altitude.

Selected sources 2, 3, 8, 11, 22, 23, 26, 37, 38, 39, 45.

Calamus blumei Becc.

PALMAE

Vernacular names Malaysia: coo (= coon) cemee (= cemees), rotan tukas (Perak), rotan riman (Sabah). Thailand: wai kaepung (Surattani), wai kunun (Trang).

Distribution Thailand (Surattani, Trang), Peninsular Malaysia, Sumatra and Borneo.

Uses Good quality cane, but rarely sufficiently abundant to be commercially significant; in Sarawak the cane is used for making baskets and mats.

Observations Clustering climber to 20 m tall. Stem 8–12 mm in diameter without leaf-sheaths, with sheaths to 20 mm in diameter. Flagellum to 1.5 m long. Leaflets diamond-shaped. Found in lowland and hill rain forest up to 800 m altitude. Although *C. blumei* is quite widespread, populations are small and rather rare. Easily recognized by its diamond-shaped leaflets, but not to be confused with *Korthalsia* and *Ceratolobus* species. Species of *Calamus* with diamond-shaped leaflets are still poorly known taxonomically, mainly because specimens are inadequate.

Selected sources 4, 14, 18.

Calamus boniensis Becc. ex Heyne

PALMAE

Vernacular names Indonesia: tomani (southern Sulawesi).

Distribution Sulawesi (southern).

Uses Probably sold together with other small-diameter rattans in the area such as rotan runti (*C. leptostachys* Becc. ex Heyne) or rotan jermasi (*C. leiocaulis* Becc. ex Heyne), or with both.

Observations Incompletely known rattan. Heyne reported that the cane is 5–8 mm in diameter based on collection number 21/573/II in the Ethnobotanical Museum – Herbarium Bogoriense. Only a minimal description has been published so far.

Selected sources 27.

Calamus burckianus Becc.

PALMAE

Vernacular names Indonesia: howe belukbuk (western Java).

Distribution Java and Bali.

Uses The cane is used for broom handles. In Bali, a traditional coconut grater is made from the petioles.

Observations Clustering, robust rattan to 25 m tall. Stem to 40 mm in diameter without leaf-sheaths. Leaves cirrate, to 6 m long including the 2 m long cirrus; leaflets pendulous. Found on slopes in the lowlands and up to 600 m altitude.

Selected sources 4, 12.

Calamus castaneus Becc.

PALMAE

Vernacular names Malaysia: rotan cucor. Thailand: wai-chakkao, wai-khao.

Distribution Southern Thailand, northern Sumatra and Peninsular Malaysia.

Uses The leaves are used for making thatch ('atap'). The immature fruits are used as cough medicine in traditional medicine in Peninsular Malaysia.

Observations A clustering undergrowth palm showing no tendency to climb, without flagellum or cirrus. Leaf-sheaths with grey yellowish-based spines; leaflets with dirty grey indumentum below. One of the most common palms in Peninsular Malaysia from near sea-level to 800 m altitude.

Selected sources 14, 19, 28, 35.

Calamus ciliaris Blume

PALMAE

Vernacular names Indonesia: hoe cacing (Sundanese), palem paris (horticultural).

Distribution Found only in western Java and in one small area in western Sumatra.

Uses The slender cane is used locally in weaving and binding. The seedlings are sold as ornamentals.

Observations A slender solitary or clustering rattan to 10 m tall. Stem without leaf-sheaths 4–10 mm in diameter, with sheaths 5–15 mm in diameter. *C. ciliaris* is commonly found in lower montane forest, but it is also found occasionally in lowland forest.

Selected sources 4.

Calamus conirostris Becc.

PALMAE

Vernacular names Indonesia: rotan dago kancil, rotan dalem buku. Malaysia: rotan kerai, rotan sabut (Temuan), mai lepe, wee ligur (Kayan).

Distribution Widespread in Borneo, local in Sumatra, and rare in Peninsular Malaysia.

Uses The cane is not of good quality and is rarely used. In Brunei the fruit is eaten.

Observations Clustering, moderate-sized, dioecious rattan. Stem rather short, rarely to 10 m long; without leaf-sheaths to 10 mm in diameter; with sheaths to 35 mm in diameter; flagellate. This rattan is mostly found on steep slopes of hill dipterocarp forest.

Selected sources 4, 14, 18.

Calamus cumingianus Becc.

PALMAE

Vernacular names Philippines: douung-douung (Manobo).

Distribution The Philippines (Tayabas, Agusan).

Uses Entire canes can be made into handicrafts, furniture and baskets.

Observations Moderate-sized rattan. Stem without leaf-sheaths to 20 mm in diameter, with sheaths to 30 mm in diameter. Flagellum present. Leaves ecirrate; leaflets arranged in groups of 2–4, oblong-oblanceolate to subspathulate. Fruit rounded with very short beak. Endemic to the Philippines in primary forest at low and medium altitudes.

Selected sources 2, 3, 8, 11, 22, 23, 26, 37, 38, 39, 45.

Calamus densiflorus Becc.

PALMAE

Vernacular names Malaysia: rotan kerai, rotan pahit. Thailand: keerah.

Distribution Peninsular Malaysia, Singapore and Thailand.

Uses One of the species commonly traded as rotan kerai. The canes are used for making fur-

niture and baskets.

Observations A clustering, moderate-sized, high-climbing rattan with stem diameter without leaf-sheaths to 22 mm, with sheaths to 40 mm in diameter. Leaves ecirrate, with a long flagellum to 3 m; leaf-sheaths with knee, covered with dense broad dull-coloured thorns. Commonly found in the lowlands especially on river banks, on hills up to about 600 m altitude, avoiding freshwater and peat-swamp forests.

Selected sources 6, 14, 35.

Calamus didymocarpus Warb. ex Becc.

PALMAE.

Vernacular names Indonesia: nue waatang, tohiti siombo (central Sulawesi), lauro sura (southern Sulawesi).

Distribution Widespread in Sulawesi.

Uses The cane is inferior but sold locally for making furniture.

Observations Solitary-growing rattan. Stem to 15 m long, without leaf-sheaths to 30 mm in diameter, with sheaths to 44 mm in diameter. Leaves cirrate, to 4 m long; cirrus to 2 m long. The bracts of the partial inflorescences spiny, unlike other species related to *C. minahassae* Becc. Found in lowland forests, near streams, on clay soils, up to 1100 m altitude.

Selected sources 4.

Calamus diepenhorstii Miq.

PALMAE

Vernacular names Indonesia (except Sulawesi): rotan batu, rotan sega batu. Malaysia: rotan koman, rotan kerai hitam (Peninsular Malaysia), wi batu (Iban), rotan putih (Sabah). Philippines: abuan. Thailand: wai-khom.

Distribution Widely distributed throughout the region, from Thailand to Peninsular Malaysia, Sumatra, Borneo and the Philippines.

Uses The canes are used for tying thatch, for cordage and basketry. Other minor uses include making fish traps and noose traps.

Observations A clustering, high climbing rattan to about 20 m. Stems slender, rarely more than 15 mm in diameter without leaf-sheaths, to 25 mm in diameter with sheaths. Leaf-sheath covered with shiny black laminar spines with hairy margins. Three varieties are recognized: var. *diepenhorstii,* widespread, var. *major* J. Dransf., endemic to Sabah and var. *exulans* Becc. confined to Palawan in the Philippines. Usually found on ridges and slopes in lowland and hill dipterocarp forests.

Selected sources 14, 18, 20, 22, 29, 35, 46.

Calamus dimorphacanthus Becc. var. dimorphacanthus

PALMAE

Distribution The Philippines (Benguet, La Union, Laguna, Panay).

Uses The canes are used for baskets, bags, for tying, etc. for home industries.

Observations Slender rattan. Stem without leaf-sheaths to 10 mm in diameter, with sheaths to 15 mm in diameter. Leaves cirrate; leaf-sheaths densely armed with needle-like spines; leaflets narrowly linear and with ciliate margins. Fruit ovoid. Endemic to the Philippines in forest up to 1700 m altitude.

Selected sources 2, 3, 8, 11, 22, 23, 26, 39.

Calamus discolor Becc.

PALMAE

Vernacular names Philippines: hamlis, kumaboy (Tagalog), ubanon (Cebu Bisaya).

Distribution The Philippines (Laguna, Tayabas, Sorsogon (Luzon)).

Uses Rosettes of young plants are used as potplants for decoration (e.g. dish gardens) and the canes are used for binding. The moderate to large size plants produce superior canes used for tying or binding.

Observations Slender rattan. Stem without leaf-sheaths to 12 mm in diameter, with sheaths to 20 mm in diameter. Leaves cirrate; leaf-sheaths flagellate; leaflets numerous, long, sharply-clawed, green above, greyish below. Fruit small, ellipsoid. Endemic to the Philippines; usually in primary forest at low and medium altitudes.

Selected sources 2, 3, 8, 11, 22, 23, 26, 39.

Calamus elmerianus Becc.

PALMAE

Vernacular names Philippines: sababai (Manobo), samanid (Bagobo).

Distribution The Philippines (Tayabas, Dinagat, Agusan, Davao).

Uses The canes are used for furniture, handicrafts, and home industries.

Observations Slender rattan. Stem without leaf-sheaths to 15 mm in diameter, with sheaths to 25 mm in diameter. Leaves cirrate; petiole short. Fruit globose with cylindrical beak. Endemic to the Philippines. Usually found in primary forest, sometimes at low altitude, more often in mossy forest at 1300–1800 m.

Selected sources 2, 3, 8, 11, 22, 23, 26, 37, 38, 39, 45.

Calamus erioacanthus Becc.

PALMAE

Vernacular names Malaysia: wi buluh (Sarawak).

Distribution Found only in the 1st and 2nd Divisions of Sarawak, occurring from 50–800 m altitude.

Uses The cane is of good quality.

Observations Clustering, moderate-sized rattan. Stems to 10 m or more. Stem without leaf-sheaths 7–10 mm in diameter, with sheaths to 18 mm in diameter. Leaves cirrate; leaf-sheaths possess short vestigial flagella and a conspicuous ocrea. In lowland and hill dipterocarp forest. Occasionally occurring in longhouse orchards where it is harvested.

Selected sources 21.

Calamus flabellatus Becc.

PALMAE

Vernacular names Indonesia: rotan lilin, rotan berman. Malaysia: rotan batu, wi takong (Iban, Sarawak), wi tautuk (Bidayuh, Sarawak).

Distribution Widespread in Borneo. Local in Peninsular Malaysia and Sumatra.

Uses The canes are used for tying, binding and weaving.

Observations A clustering, high-climbing, small-diameter rattan. Stem without leaf-sheaths to 3 mm in diameter, with sheaths to 5 mm in diameter. The whole plant appearing dull green, with ecirrate leaves with few (1–4) pairs of leaflets, the lowermost pair reflexed across the stem. Locally common in lowland dipterocarp forests, rarely cultivated in Sarawak.

Selected sources 20, 21, 29, 43, 44.

Calamus gibbsianus Becc.

PALMAE

Vernacular names Malaysia: silau-silau (Sabah).

Distribution Borneo; confined to montane forest on Mount Kinabalu; elsewhere known only from one collection from the Kelabit Highlands in Sarawak.

Uses The canes are used locally for general tying and weaving.

Observations Slender clustering rattan. Stem to 8 m long. Stem without leaf-sheaths 4–10 mm in diameter, with sheaths 6–30 mm in diameter; flagellate in climbing forms. *C. gibbsianus* is only found in montane forest at 1400–3000 m altitude.

Selected sources 4, 18.

Calamus grandifolius Becc.

PALMAE

Vernacular names Philippines: saba-ong (Tagalog).

Distribution The Philippines (Laguna, Tayabas).

Uses The cane is used for making furniture.

Observations Robust high-climbing rattan. Stem without leaf-sheaths to 22 mm in diameter, with sheaths to 40 mm in diameter. Leaves large, cirrate; leaf-sheaths armed with slender, blackish spines; leaflets broad-lanceolate. Fruit globose, to 20 mm in diameter. Endemic to the Philippines.

Selected sources 2, 3, 8, 11, 22, 23, 26, 38, 39, 45.

Calamus halconensis (Becc.) Baja-Lapis var. dimorphacanthus Becc.

PALMAE

Synonyms *Calamus halconensis* Becc.

Vernacular names Philippines: lambutan (Tagalog).

Distribution The Philippines (Laguna, Mindoro).

Uses Canes are used in making 'bent wood' chair frames, as cables for ferry boats, for hauling logs, standing-rigging on small sailing vessels, and sometimes to support short suspension bridges. Split canes are used for making mats, hats, baskets, chairs, various types of fish traps,

and the bottoms and backs of cane-bottomed chairs.

Observations Moderate-sized rattan. Stem without leaf-sheaths to 20 mm in diameter, with sheaths to 30 mm in diameter. Leaves cirrate; leaf-sheaths armed with comb-like, stiff spines; leaflets numerous, narrow-lanceolate. Fruit ovoid to subovoid and with prominent beak. Endemic to the Philippines. Found in primary forest at 450–1500 altitude.

Selected sources 2, 3, 8, 11, 22, 23, 26, 39, 48.

Calamus heteroideus Bl.

PALMAE

Vernacular names Indonesia: howe cacing, rotan cacing (western Java) (this local name is also applied to *C. javensis* Bl., *C. unifarius* H. Wendl. and *C. viminalis* Willd.).

Distribution Sumatra (northern Lampung), Java.

Uses The cane is used incidentally as cordage.

Observations Clustering slender rattan, up to 3 m tall, forming thickets. Stem 6 mm in diameter without leaf-sheaths, with sheaths to 10 mm in diameter. Flagellum 1 m long. Included in this species is var. *pallens* (Bl.) Becc. *C. heteroideus* is included in the synonymy with *C. reinwardtii* Bl. in the 'Flora of Java', but it is distinct. Found in hill and montane forests to 1250 m altitude.

Selected sources 1, 4.

Calamus hispidulus Becc.

PALMAE

Vernacular names Indonesia: rotan bulu.

Distribution Confined to Borneo, widespread throughout the island.

Uses The cane is locally used for weaving.

Observations Slender solitary or clustering rattan. Stem climbing to 10 m; stem without leaf-sheaths to 9 mm in diameter, with sheaths to 10–26 mm in diameter. This rattan is found in a wide range of habitats from heath forest, lowland forest, to hill dipterocarp forest.

Selected sources 4.

Calamus hollrungii Becc.

PALMAE

Distribution New Guinea, Solomon Islands, Queensland (Australia).

Uses Excellent medium- to large-diameter cane, much collected for furniture manufacture. The potential of *C. hollrungii* for cultivation is worth investigating.

Observations Robust, usually single-stemmed rattan. Stem without leaf-sheaths 9–20 mm in diameter, with sheaths 20–40 mm in diameter. Leaf-sheaths sparsely armed with short spines; petiole densely spiny on upper surface. Fruit rounded, 8–12 mm in diameter. *C. hollrungii* occurs in lowland rain forest, and is closely related to *C. subinermis* Becc. and *C. aruensis* Becc.

Selected sources 4, 30, 31.

Calamus inops Becc. ex Heyne

PALMAE

Vernacular names Indonesia: rotan tohiti (but this name is applied more consistently to species of larger diameter).

Distribution Found only in the central and southern part of Sulawesi.

Uses The cane has a small to medium diameter. The actual use of this rattan is not known, though often incorrectly cited as rotan tohiti of commerce.

Observations Moderately robust, solitary rattan. Stem climbing to 10 m; stem without leaf-sheaths to 20 mm in diameter, with sheaths to 25 mm in diameter. Found in lowland forest.

Selected sources 27, 36.

Calamus insignis Becc.

PALMAE

Vernacular names Malaysia: rotan batu. Thailand: wai-hin.

Distribution Sumatra, Peninsular Malaysia, Singapore and Thailand.

Uses Split canes are used in making fine basketware. Also used for cordage by the Temuan of Peninsular Malaysia. The spiny leaf-sheaths have been used for grating tapioca and rubbing the seeds off maize cobs.

Observations A clustering, high-climbing rattan, with slender stem, diameter to 7 mm

without leaf-sheaths, with sheaths to 15 mm in diameter. Stem colour pale green and glossy. Commonly found in lowland and hill dipterocarp forests. Three varieties have been distinguished: var. *insignis*, var. *longispinosus* J. Dransf. and var. *robustus* J. Dransf.

Selected sources 19, 35, 46.

Calamus koordersianus Becc.

PALMAE

Vernacular names Indonesia: rotan boga (central Sulawesi).

Distribution Sulawesi.

Uses The cane is locally used in making basket frames.

Observations Clustering, sometimes solitary rattan. Stem 4 mm in diameter without leaf-sheaths, with sheaths to 18 mm in diameter. Leaves cirrate, 2.8 m long; flagellum up to 2.5 m long; knee conspicuous. Fruit with 3 seeds. Found in lowlands to 500 m altitude.

Selected sources 4.

Calamus laevigatus Mart.

PALMAE

Vernacular names Malaysia: rotan tunggal (Selangor), wae saput (Sabah), wi sugi (Sarawak) (all the local names are used for *C. laevigatus* var. *laevigatus*). The local name 'rotan semampun' is also used for *C. praetermissus* J. Dransf.

Distribution Peninsular Malaysia, Sumatra and Borneo.

Uses Cane extensively collected as a small-diameter cane, it is said to be of as good quality as rotan sega (*C. caesius* Bl.). In Padawan (Sarawak) it is cultivated by Bidayuh people.

Observations Solitary, moderate-sized rattan to 30 m tall. Stem without leaf-sheaths 8–10 mm in diameter. Leaves cirrate; lowermost leaflets swept back across the stem. In *C. laevigatus* three varieties are distinguished, i.e. var. *laevigatus*, var. *serpentinus* J. Dransf. and var. *mucronatus* (Becc.) J. Dransf.; var. *laevigatus* is widespread from Peninsular Malaysia and Sumatra to Borneo and grows in lowland and hill rain forests up to 900 m altitude, avoiding peat-swamp forests and extreme ridgetop soils; var. *mucronatus* is widespread in Borneo; var. *serpentinus* is confined to ultrabasic rock soils up to 500 m altitude in Sabah.

Selected sources 4, 14, 16, 18, 32.

Calamus leiocaulis Becc. ex Heyne

PALMAE

Vernacular names Indonesia: rotan jermasi, jarmasi (Sulawesi). In the rattan trade it is wrongly named 'jermasin', which appears to be the shortened name of Banjarmasin, the capital of South Kalimantan, one of the centres of rattan production.

Distribution Sulawesi (Central and South-East).

Uses Cane extensively used in making furniture, locally and for export; excellent quality small-diameter cane but cheaper than that of *C. caesius* Bl.

Observations Sparsely clustering rattan, slender, to 42 m tall. Stem to 4 mm in diameter without leaf-sheaths, with sheaths to 10 mm in diameter. Found in lowland primary forest on rather wet soils up to 50 m altitude. Very poorly known botanically.

Selected sources 27, 41.

Calamus leptostachys Becc. ex Heyne

PALMAE

Vernacular names Indonesia: ronti, runti (Sulawesi), teland (south), matakito (Buton). The cane is often wrongly called 'tohiti' or 'jermasi'.

Distribution Sulawesi.

Uses Excellent small-diameter cane for furniture and handicraft, used extensively locally as well as exported.

Observations Clustering or solitary rattan. Stem to 60 m long, without leaf-sheaths 15 mm in diameter, with sheaths 28 mm in diameter. Leaves cirrate, to 3 m long with cirrus; knee conspicuous. Found in lowland primary forest up to 200 m altitude.

Selected sources 27, 36, 41.

Calamus longisetus Griff.

PALMAE

Vernacular names Burma: leme. Thailand: wai-kamphuan.

Distribution Bangladesh, Burma, Thailand,

northern Peninsular Malaysia, Andaman and Nicobar Islands.

Uses Rather coarse cane, harvested in Thailand for the furniture industry. Leaves used for thatch and the fruit is eaten in the Andaman Islands.

Observations Very robust clustering, erect to high-climbing rattan, with stems reaching about 10–15 m tall. Stem without leaf-sheaths 25–50 mm in diameter, with sheaths 80–100 mm in diameter. Leaf with clustered leaflets; leaf-sheaths very densely armed with black spines with pale yellow bases; flagellate. Occurring in dry evergreen to monsoonal forest at altitudes up to 300 m.

Selected sources 4, 33, 34.

Calamus longispathus Ridley

PALMAE

Vernacular names Malaysia: rotan kunyung.

Distribution Endemic to Peninsular Malaysia and confined to the states of Perak, Pahang, Selangor, Terengganu, Melaka and Johor.

Uses The young leaves are occasionally used as cigarette paper by the aborigines of Peninsular Malaysia. The fruits are of medicinal value.

Observations A clustering, thicket-forming and low climbing rattan. Stem diameter 15–20 mm, without leaf-sheaths, with sheaths to 35 mm in diameter. Leaf subcirrate to 3 m long. Confined to ridgetops in hill forest.

Selected sources 14, 35.

Calamus luridus Becc.

PALMAE

Vernacular names Indonesia: huwi pantis (Sumatra). Malaysia: rotan kerai.

Distribution Sumatra, Peninsular Malaysia and Thailand.

Uses The cane is split and used for tying and binding.

Observations A slender, clustering rattan climbing to 15 m tall. Most parts turn dark on drying. Leaf ecirrate; petiole length, width and number of leaflets very variable. It is found in a wide range of habitats from the lowlands to lower montane forests at altitudes of 1400 m.

Selected sources 14, 35, 46.

Calamus manillensis (Mart.) H. Wendl.

PALMAE

Vernacular names Philippines: bayabong (Manobo), litoko (Ifugao), lintokan (Bagobo).

Distribution The Philippines (Nueva Viscaya, Tayabas, Sorsogon, Dinagat, Agusan, Davao, Surigao).

Uses Fruit edible and a delicacy among the Ifugaos in Mountain Province, Luzon. Canes are of inferior quality compared to those of *C. merrillii* Becc.; they are used for tying and other purposes but not for furniture.

Observations Large, robust, solitary rattan. Stem without leaf-sheaths to 30 mm in diameter, with sheaths to 50 mm in diameter. Leaves to 3 m long, cirrate; leaf-sheaths armed with numerous scattered short spines; leaflets lanceolate. Fruit globose, light cream, with 3 seeds. Endemic to the Philippines in primary forest between 600 and 1000 altitude.

Selected sources 2, 3, 8, 11, 22, 23, 26, 38, 39, 42, 45.

Calamus marginatus (Bl.) Mart.

PALMAE

Vernacular names Indonesia: rotan besi (Palembang), rotan manau padi (Bangka), rotan pehekan (southern Kalimantan). Malaysia: wi tedong, wi natahari, uwau paya (Sarawak), rotan bembangin (Sandakan).

Distribution Sumatra and Borneo.

Uses The cane is coarse and poor in appearance; however, it is quite durable and hence is used in making the framework of carrying baskets. In Sarawak it is also used for making walking-sticks.

Observations Solitary, rarely clustering, climber to 15 m tall or more. Stem to 18 mm in diameter without leaf-sheaths, with sheaths to 35 mm in diameter. Leaves cirrate; flagellum 5 m long. *C. marginatus* is very variable. Populations in montane forests seem to have consistently longer spines, with specialized erect spines around the leaf-sheath mouth. In Sabah widespread, occurring on wetlands, heath forest and river banks, up to 1800 m altitude in primary montane forest.

Selected sources 4, 10, 18, 25, 32.

Calamus mattanensis Becc.

PALMAE

Vernacular names Indonesia: rotan maran (Kalimantan). Malaysia: wi lantak patong (Iban, Sarawak), wei saput (Penan, Sarawak).

Distribution Borneo (Sarawak and Kalimantan).

Uses The canes are occasionally used for making coarse baskets.

Observations A solitary or clustering, moderately climbing rattan. Stems rarely more than 10 mm in diameter, without leaf-sheaths, with sheaths to 18 mm in diameter. Inflorescence short with recurved rachillae. *C. mattanensis* occurs in a wide range of habitats from swamps to ridgetops up to 800 m altitude.

Selected sources 18, 21, 43, 44.

Calamus megaphyllus Becc.

PALMAE

Vernacular names Philippines: banakbo (Manobo).

Distribution The Philippines (Agusan, Davao).

Uses The cane is used for basketry and tying.

Observations Medium-sized rattan. Stem without leaf-sheaths to 22 mm in diameter, with sheaths to 35 mm in diameter. Leaves to 1 m long, cirrate; leaf-sheaths smooth or with few small spines; leaflets grouped in threes or fours. Fruit spherical, to 13 mm in diameter. Endemic to the Philippines in primary forest up to 900 m altitude.

Selected sources 2, 3, 8, 11, 22, 23, 26, 37, 38, 39, 45.

Calamus melanorhynchus Becc.

PALMAE

Vernacular names Philippines: dalimban (Bagobo).

Distribution The Philippines (Davao).

Uses Canes used in making baskets and other handicrafts.

Observations Medium-sized rattan. Stem without leaf-sheaths to 25 mm in diameter, with sheaths to 40 mm in diameter. Leaves cirrate; leaf-sheaths densely armed with flat, rigid, triangular black spines; flagellum present. leaflets numerous, linear lanceolate. Fruit globular-ovoid. Endemic to the Philippines in primary forest at about 1200 m altitude.

Selected sources 2, 3, 8, 11, 22, 23, 26, 37, 38, 39, 45.

Calamus microcarpus Becc.

PALMAE

Vernacular names Philippines: kalapit (Bikol), lambutan, tandulang-glubat (Tagalog).

Distribution The Philippines (Rizal, Laguna, Tayabas, Camarines, Sorsogon, Davao, Agusan, Lanao).

Uses Canes used in making baskets.

Observations Slender rattan. Stem without leaf-sheaths to 15 mm in diameter, with sheaths to 25 mm in diameter. Leaves cirrate; leaf-sheaths armed with comb-like spines. Fruit globose, to 7 mm in diameter, with short beak. Endemic to the Philippines in primary forest at low and medium altitudes up to 1200 m.

Selected sources 2, 3, 8, 11, 22, 23, 26, 38, 39, 45.

Calamus microsphaerion Becc.

PALMAE

Vernacular names Philippines: kulakling, labit (Tagalog).

Distribution The Philippines (Palawan, Bataan, Culion Philippines) and Sabah.

Uses Unsplit slender canes are made into baskets.

Observations Slender rattan. Stem without leaf-sheaths to 8 mm in diameter, with sheaths to 15 mm in diameter. Leaves cirrate; leaf-sheaths unarmed; leaflets grouped in twos to fours, narrowly lanceolate. Fruit very small, spherical with short beak. In primary forest at low altitude.

Selected sources 2, 3, 8, 11, 22, 23, 26, 39, 48.

Calamus minahassae Becc.

PALMAE

Vernacular names Indonesia: datu (Sulawesi), pondos alus (northern Sulawesi), rotan patani (central Sulawesi), uwe rence (southern Sulawesi).

Distribution Widespread in Sulawesi.

Uses Locally the cane is used as cordage.

Observations Solitary or clustering, slender

rattan. Stem up to 40 m long, without leaf-sheaths 4 mm in diameter, with sheaths to 12 mm in diameter. Leaves cirrate, 3.5 m long including the 1.5 m long cirrus; knee conspicuous. Found in lowland to montane forests up to 1000 m altitude.

Selected sources 4, 27.

Calamus mitis Becc.

PALMAE

Vernacular names Philippines: matkong (Ilokano), tebdas (Ivatan).

Distribution The Philippines (Batan, Babuyan Islands, Ilocoss Norte).

Uses The cane is used for basketry and tying.

Observations Slender rattan. Stem without leaf-sheaths to 10 mm in diameter, with sheaths to 15 mm in diameter. Leaves cirrate, without petiole; leaf-sheaths greenish, leathery and unarmed; leaflets numerous, close. Fruit globose, to 10 mm in diameter. Endemic to the Philippines and found in forest at low and medium altitudes.

Selected sources 2, 3, 8, 11, 22, 23, 26, 38, 39, 45.

Calamus moseleyanus Becc.

PALMAE

Vernacular names Philippines: sarani (Bagobo).

Distribution The Philippines (Mindanao, Basilan).

Uses The cane is used for making furniture.

Observations Medium-sized rattan. Stem without leaf-sheaths to 20 mm in diameter, with sheaths to 30 mm in diameter. Leaves cirrate; leaflets regularly arranged, lanceolate to narrowly elliptical-lanceolate. Endemic to the Philippines.

Selected sources 2, 3, 8, 11, 22, 23, 26, 38, 39, 45.

Calamus multinervis Becc.

PALMAE

Vernacular names Philippines: balala, ubli (Ilokano).

Distribution The Philippines (Batan, Babuyan Islands, Ilocos Norte).

Uses The cane is used for making furniture.

Observations Robust rattan. Stem without leaf-sheaths to 30 mm in diameter, with sheaths to 50 mm in diameter. Leaves large, to 2 m long, cirrate; leaflets equidistant, elongate-lanceolate. Fruit globose-ovoid, with short conical beak. Endemic to the Philippines. Found in forest at low and medium altitudes.

Selected sources 2, 3, 8, 11, 22, 23, 26, 37, 38, 39, 45.

Calamus muricatus Becc.

PALMAE

Vernacular names Indonesia: rotan melukut, rotan sakat (Kalimantan). Malaysia: wi tunjung (Iban, Sarawak), wae sawit usen (Penan, Sarawak), rotan yuk (Sabah).

Distribution Borneo.

Uses The growing point is eaten as palm cabbage and known locally as 'savit' by the Penans in Sarawak.

Observations A solitary rattan climbing to 10 m tall; stem 15 mm in diameter without leaf-sheaths, to 25 mm in diameter with sheaths. Widely distributed throughout Borneo in the lowlands and foothills in lowland mixed-dipterocarp forest.

Selected sources 21, 29, 43, 44, 46.

Calamus myriacanthus Becc.

PALMAE

Vernacular names Malaysia: wi dudok, wi tulang (Iban, Sarawak), wei dangh (Penan, Sarawak).

Distribution Endemic to Borneo. Widespread in Sarawak, Brunei and Kalimantan.

Uses The cane is made into walking-sticks, cages, frames and corners of baskets.

Observations A solitary, short-stemmed, moderate-sized rattan. Leaves ecirrate, petioles armed with large thorns. Commonly occurring in heath forest and poor soil forests in Sarawak.

Selected sources 21, 43, 44.

Calamus oxleyanus Teysm. & Binnend. ex Miq.

PALMAE

Vernacular names Indonesia: manau riang (Palembang). Malaysia: rotan minyak. Thai-

land: wai-dam.

Distribution Widespread in Peninsular Malaysia, relatively rare in Borneo. It also occurs in Sumatra and Thailand.

Uses The canes are said to be used for walking-sticks.

Observations Usually solitary and rather weakly climbing rattan. Grows on slopes and ridges in lowland and hill dipterocarp forests.

Selected sources 14, 35, 46.

Calamus paspalanthus Becc.

PALMAE

Vernacular names Malaysia: rotan sirikis (Peninsular), wi (= lempinit) singkau (= tingkau), wi lohong (Sarawak).

Distribution Peninsular Malaysia and Borneo (Sarawak, Sabah, Kalimantan).

Uses The cane is useless because adventitious roots develop at almost every node near the ground, but the seedling is decorative and hence would make an excellent ornamental. The ripe fruit is edible, used for pickles by local people in Peninsular Malaysia and Sarawak. In Sarawak, the young shoot is eaten, and the exudate from the burnt cane can be used to blacken and strengthen teeth.

Observations Solitary, moderate-sized rattan, to 20 m tall, frequently creeping along the ground and producing roots at positions about 1 cm below each node. Stem without leaf-sheaths 10–15 mm in diameter. Leaf-sheaths bearing a flagellum. Found in primary forest from the lowlands up to 1300 m altitude, widespread but not in heath forest.

Selected sources 4, 14, 18, 32.

Calamus pedicellatus Becc. ex Heyne

PALMAE

Vernacular names Indonesia: Samole (Bugis).

Distribution Found only in the south and south-east of Sulawesi.

Uses The cane is apparently of good quality and can be used for furniture.

Observations Moderately robust, solitary or clump-forming, dioecious rattan. Stem climbing to 40 m. Stem without leaf-sheaths to 10 mm in diameter, with sheaths to 40 mm in diameter. Leaf cirrate.

Selected sources 27, 36.

Calamus perakensis Becc.

PALMAE

Vernacular names Malaysia: rotan dudok.

Distribution Western Sumatra and Peninsular Malaysia.

Uses The cane is occasionally used to make walking-sticks.

Observations Three varieties are recognized, var. *perakensis*, var. *crassus* J. Dransf. and var. *niger* J. Dransf. All varieties are without leaf-sheath knee, flagellum and cirrus. Var. *perakensis*, a clustering and short-stemmed variety, is found in Peninsular Malaysia and western Sumatra; var. *crassus*, known in Malaysia as 'tekok gunung', and var. *niger* are solitary, erect and short-stemmed rattans. The large inflorescence bracts of var. *crassus* distinguish it from the other and it is endemic to Terengganu. Var. *niger* is endemic to Johor.

Selected sources 14, 35.

Calamus peregrinus Furtado

PALMAE

Vernacular names Thailand: nguay.

Distribution Peninsular Malaysia (Kedah, Perak, Kelantan, Selangor, Negri Sembilan) and Thailand.

Uses A robust cane of good quality used in the furniture industry in Thailand. In Peninsular Malaysia the use is not known with certainty, but it is probably mixed with other large canes in the trade.

Observations Solitary rattan with stout stem to 20 m tall, without sheaths about 20 mm in diameter, with sheaths to 35 mm in diameter. Leaves ecirrate, very large, 4–5 m long; knee well developed; ocrea short, blackish; flagellum to 3.5 m long. Cut surfaces exuding yellow sap. On steep slopes and ridges in hill dipterocarp forest, at altitudes up to 600 m.

Selected sources 14.

Calamus pilosellus Becc.

PALMAE

Vernacular names Indonesia: rotan lintang.

Distribution Endemic to Borneo and found throughout the island.

Uses The cane is of good appearance but is probably only used locally.

Observations Slender, clustering, dioecious rattan. Stems climbing to 10 m. Stem without leaf-sheaths to 6 mm in diameter, with sheaths to 15 mm in diameter; flagellate.

Selected sources 4, 14.

Calamus polystachys Becc.

PALMAE

Vernacular names Indonesia: wai lau cincin (Sumatra), howe gelang (western Java). Malaysia: rotan sabung, rotan sabong (Peninsular Malaysia).

Distribution Peninsular Malaysia, Sumatra and Java; doubtfully recorded for Borneo.

Uses Coarse cane used for broom handles.

Observations Tall climber, clustering to form rather dense clumps or thickets. Stem to 10–20 mm in diameter. Leaf-sheaths with green collars (which are formed by the union of the spine bases), encircling and interlocking to form tunnels which are usually ant-infested (cf. *Daemonorops sabut* Becc.). Found in lowland swampy secondary forest.

Selected sources 4, 14.

Calamus ramulosus Becc.

PALMAE

Vernacular names Philippines: panlis (Tagalog).

Distribution The Philippines (Luzon).

Uses The cane is used for making furniture.

Observations Slender rattan. Stem without leaf-sheaths to 10 mm in diameter, with sheaths up to 20 mm in diameter. Leaves to 1 m long, cirrate and without petiole; leaf-sheaths densely armed with short spines; leaflets linear, grouped in twos or threes, thin. Fruit very small, spherical, with distinct short beak. Endemic to the Philippines.

Selected sources 2, 3, 8, 11, 22, 23, 26, 37, 38, 39, 45, 48.

Calamus reyesianus Becc.

PALMAE

Vernacular names Philippines: apas, lukuan, samulid (Tagalog).

Distribution The Philippines (Laguna, Tayabas, Quezon).

Uses The cane is used for furniture and baskets for home industry, local and international commercial use. The canes are of good quality, but the diameter is smaller than those of *C. merrillii* Becc.

Observations Stem without leaf-sheaths to 18 mm in diameter, with sheaths to 30 mm in diameter. Leaves cirrate; leaf-sheaths densely armed with solitary, narrowly-linear spines; leaflets in pairs on each side of the rachis, elliptical-lanceolate. Fruit spherical, to 1.5 cm in diameter, straw-coloured, one-seeded. Endemic to the Philippines and found in forest at low and medium altitudes.

Selected sources 2, 3, 8, 11, 22, 23, 26, 38, 39, 45, 48.

Calamus rhomboideus Bl.

PALMAE

Distribution Sumatra and Java.

Uses Apparently similar to *C. blumei* Becc., possibly for making baskets and mats.

Observations Most of the characters of *C. rhomboideus* are similar to those of *C. blumei*; however, as it is not adequately represented in herbaria, it is difficult to draw any conclusions about its distinctness.

Selected sources 4, 14, 18.

Calamus rhytidomus Becc.

PALMAE

Vernacular names In Nunukan (East Kalimantan) wrongly called 'rotan sega' as apparently 'rotan sega' was the only well-known useful rattan in the area when it was introduced.

Distribution East Kalimantan, but can be expected elsewhere in Borneo; there are no representative collections from other localities so far.

Uses It is reported that the cane is used locally for binding.

Observations Solitary, climber to 10 m tall. Stem without leaf-sheaths 7 mm in diameter. Found in lowland forest.

Selected sources 4, 18.

Calamus ruvidus Becc.

PALMAE

Vernacular names Malaysia: wee lumbak (Iban, Sarawak).

Distribution Endemic to Sarawak.

Uses The cane is used for basketry and also for tying.

Observations A clustering or solitary rattan, producing small-diameter cane of good quality. Stem 15 mm in diameter without leaf-sheaths, 25 mm in diameter with sheaths. Leaf without cirrus and with very short petiole. Usually found in alluvial forest or mixed-dipterocarp forest.

Selected sources 21, 43, 44.

Calamus scabridulus Becc.

PALMAE

Vernacular names Indonesia: dara panda. Malaysia: rotan kerai, rotan kikir.

Distribution Sumatra, Kalimantan and Peninsular Malaysia.

Uses The canes are usually used as split rattan for tying or thatching, also for cordage.

Observations A clustering and high-climbing rattan to 20 m tall, stem diameter without leaf-sheaths to 12 mm, with sheaths to 30 mm in diameter. Easily recognized by the rough horizontal ridges between the spines on the leaf-sheath and knee. *C. scabridulus* is found only in peat swamp forest.

Selected sources 14, 29, 35.

Calamus sedens J. Dransf.

PALMAE

Vernacular names Malaysia: rotan dudok.

Distribution Peninsular Malaysia and southern Thailand.

Uses The cane is sometimes used for making walking-sticks.

Observations A solitary, short-stemmed rattan which commonly grows on slopes in hill dipterocarp forest. Leaves ecirrate with broad plicate leaflets. Fruit small, rounded, red-brown.

Selected sources 14, 18, 35.

Calamus semoi Becc.

PALMAE

Vernacular names Malaysia: wi tut,,wi semoi (Sarawak).

Distribution Found only in Sarawak and East Kalimantan.

Uses Produces an excellent cane; cultivated in longhouse orchards.

Observations Clustering, moderate-sized rattan. Stems to 12 mm in diameter without leaf-sheaths, with sheaths to 25 mm in diameter. Leaf cirrate; the leaf-sheath bears a short vestigial flagellum, but lacks an ocrea. In lowland dipterocarp forest on slopes, from 50–300 m altitude.

Selected sources 21.

Calamus simplex Becc.

PALMAE

Vernacular names Malaysia: rotan kerai gunung.

Distribution Endemic to Peninsular Malaysia.

Uses The cane is used for making baskets.

Observations A slender, clustering rattan that can be recognized by its very few large leaflets arranged regularly and its inflorescence branched to one order. It is found only at high altitudes between 1500–2000 m.

Selected sources 14, 35, 44.

Calamus siphonospathus Mart.

PALMAE

Vernacular names Philippines: talola (Tagalog), dagdag (Ilokano), palimanok (Pampanga).

Distribution The Philippines (Cagayan, Isabela, Pampanga, Rizal, Laguna, Tayabas, Mindoro) and Sulawesi.

Uses The cane is used for basket-making and tying.

Observations Stem without leaf-sheaths to 25 mm in diameter, with sheaths up to 40 mm in diameter. Leaves cirrate, to 1 m long, long petiolate; leaf-sheaths armed with slender, needle-like spines; leaflets linear-lanceolate, numerous, equidistant. Fruit very small, ovoid or sub-ovoid, beaked. A very variable species. In primary forest at low and medium altitudes, up to 1200 m.

Selected sources 2, 3, 8, 11, 22, 23, 26, 37, 39.

Calamus spinifolius Becc.

PALMAE

Vernacular names Philippines: kurakling (Pampanga, Tagalog).

Distribution The Philippines (Pampanga, Batan).

Uses The cane is used for basket-making and tying.

Observations Stem without leaf-sheaths to 8 mm in diameter, with sheaths to 12 mm in diameter. Leaves cirrate; leaf-sheaths armed with scattered slender, subulate spines; leaflets grouped, very spiny. Fruit spherical, to 11 mm in diameter, with short beak. Endemic to the Philippines in forest at low altitude.

Selected sources 2, 3, 8, 11, 22, 23, 26, 38, 39, 45.

Calamus symphysipus Becc.

PALMAE

Vernacular names Indonesia: rotan ombol (Sulawesi), laru (central Sulawesi), pondos embel (northern Sulawesi), uwe sangkayu-kayu (southern Sulawesi). Philippines: palanog (Luzon).

Distribution Sulawesi, Luzon, Mindanao.

Uses The cane is used for making furniture. In Indonesia it is priced the same as 'rotan tohiti' (see under *C. inops*) of the same size grade (10–19 mm). Other rattans of this grade are 'rotan lambang' (*C. ornatus* Bl. var. *celebicus* Becc.), 'rotan sabutan' (*Daemonorops robusta* Warb.) and 'tarumpu' (*Calamus* sp.).

Observations A solitary rattan. Stem to 40 m long, without leaf-sheaths 10–19 mm in diameter, with sheaths 23–40 mm in diameter; with stilt roots of 10 cm long. Leaves ecirrate to 1.75 m long; leaf-sheaths dark green with whorls of yellowish-green spines; knee conspicuous; flagellum to 8 m long; leaflets brownish underneath. Found on steep slopes in lowland forest up to 500 m altitude.

Selected sources 41.

Calamus tomentosus Becc.

PALMAE

Vernacular names Malaysia: rotan tukas, rotan tahi ayam.

Distribution Peninsular Malaysia and Borneo.

Uses The cane is used for tying and binding.

Observations A clustering rattan, climbing to 20 m tall, stem diameter without leaf-sheaths to 10 mm, with sheaths to 25 mm in diameter. Leaf-sheaths, petioles and rachis covered with white tomentum and armed with short black cone-shaped thorns; leaflets diamond-shaped. A rare species, found on steep slopes in hill forest up to 800 m altitude.

Selected sources 14, 18, 35, 44.

Calamus trispermus Becc.

PALMAE

Distribution The Philippines (Rizal province).

Uses The cane is used for making furniture.

Observations Large rattan. Stem without leaf-sheaths to 35 mm in diameter, with sheaths to 60 mm in diameter. Leaf cirrate, with broad lanceolate leaflets; leaf-sheaths covered with brownish scales. Fruit broadly obovoid, 1.3 mm in diameter, 3-seeded. Endemic to the Philippines in forest at medium altitude.

Selected sources 2, 3, 8, 11, 22, 23, 26, 38, 39, 45.

Calamus ulur Becc.

PALMAE

Distribution Peninsular Malaysia (Johor), Sumatra (Bengkulu).

Uses Split cane is used as cordage.

Observations Clustering rattan, up to 10 m tall. Leaves cirrate, to 1.75 m long including the 1 m long cirrus; leaf-sheaths with ridges less than 0.5 mm high, with vestigial flagellum. Common in swamp forest at the foot of Gunong Panti in Johor.

Selected sources 4, 14, 18.

Calamus unifarius H. Wendl.

PALMAE

Vernacular names Indonesia: wai sideken (western Sumatra), rotan patis (western Java),

rotan wuluh (eastern Java). 'Rotan cacing' is probably a wrongly applied name since this name is usually given to small-diameter canes such as *C. heteroideus* Bl., *C. melanoloma* Mart. and *C. viminalis* Willd.

Distribution Sumatra and Java.

Uses The cane is used only locally for furniture.

Observations Clustering, rather robust rattan, to 10 m tall. Stem with leaf-sheaths 30–35 mm in diameter. Leaf cirrate; cirrus about 90 cm long. Found in primary or secondary dipterocarp forest from 100–800 m altitude.

Selected sources 1, 4.

Calamus usitatus Becc.

PALMAE

Vernacular names Philippines: babuyan (Sambal), hanapas (Bikol), tandulang-parang (Tagalog).

Distribution Widespread in the Philippines and Sabah.

Uses The cane is used for baskets, furniture and handicrafts.

Observations Slender rattan. Stem without leaf-sheaths to 12 mm in diameter. Leaves ecirrate; leaf-sheaths armed with straight, slender spines and with bristles at the mouth; flagellum present; leaflets linear lanceolate. Fruit elliptical-ovoid, up to 10 mm × 6 mm, with a long beak, one-seeded. Found usually in secondary forest at low to medium altitude.

Selected sources 2, 3, 8, 11, 22, 23, 26, 39, 45.

Calamus vidalianus Becc.

PALMAE

Vernacular names Philippines: butarak (Ilokano).

Distribution The Philippines (Luzon: Nueva Ecija, Rizal, Batan, Tayabas, Camarines).

Uses The cane is used for making furniture.

Observations High-climbing moderate-sized rattan. Stem without leaf-sheaths to 15 mm in diameter, with sheaths to 25 mm in diameter. Leaves cirrate; leaf-sheaths scarcely armed; leaflets greenish or purplish-green. Fruit spherical. Endemic to the Philippines. Found in primary forest at low and medium altitudes.

Selected sources 2, 3, 8, 11, 22, 23, 26, 38, 39, 45.

Calamus viminalis Willd.

PALMAE

Vernacular names Indonesia: penjalin cacing (Bali). Cambodia: padao. Thailand: wai mon, wai som, wai sam bai taw. (Note that the local name 'penjalin cacing' or 'rotan cacing' ('cacing' = worm) in Indonesia (Sumatra and Java) is frequently used for slender canes such as *C. javensis* Bl. and *C. melanoloma* Mart.

Distribution Cambodia, Thailand, Peninsular Malaysia, Sumatra, Java and Bali.

Uses The cane is locally used for basketry and matting.

Observations Clustering rattan, forming thickets to 5 m tall. Stem without leaf-sheaths 8 mm in diameter. Leaves ecirrate; flagellum to 1.5 m long. *C. viminalis* is closely related to *C. siamensis* Becc., the conspicuous difference is mainly in the arrangement of the leaflets on the rachis: in *C. siamensis* they are regular in one plane whereas in *C. viminalis* they are irregular and fanned. Beccari described var. *andamanicus*, var. *bengalensis* and var. *faciculatus*. These varieties have not been critically reassessed. Found in the lowlands, and in Java just behind the coast in open areas and in submaritime savannah.

Selected sources 1, 4, 14.

Calamus warburgii K. Schum.

PALMAE

Distribution Indonesia: Irian Jaya (Membramo), Papua New Guinea.

Uses The cane is used locally for making the framework of baskets.

Observations Solitary rattan, stem up to 15 m tall. Stem without leaf-sheaths 38 mm in diameter, with sheaths to 70 mm in diameter. Leaves cirrate, 4.3 m long including a 1–1.5 m long cirrus. The habit and form of the inflorescence is superficially similar to that of *C. zollingeri* Becc. Found in lowlands near streams.

Selected sources 4.

Calospatha scortechinii Becc.

PALMAE

Vernacular names Malaysia: rotan demuk.

Distribution Found only in Peninsular Malaysia.

Uses The ripe fruits are eaten by Malay aborigines.

Observations A solitary, short climbing rattan. It has no cirrus or flagellum. Yellow latex exudes from cut stems and sheaths. Seeds 1–3 in each fruit. Very local in valley bottoms and lower slopes of hill dipterocarp forest.

Selected sources 14, 35.

Daemonorops angustifolia (Griff.) Mart.

PALMAE

Vernacular names Malaysia: rotan getah, rotan minyak. Thailand: wai-nam.

Distribution Widespread in Peninsular Malaysia. Also found in Thailand.

Uses The cane is used for making low quality furniture, for coring and binding. Usually traded under 'rotan air' group.

Observations A clustering, moderately robust high-climbing rattan. Produces abundant white latex when cut. Stem without leaf-sheaths to 25 mm in diameter, with sheaths to 40 mm in diameter. It can be recognized by the leaf-sheaths which are usually densely covered with brown-black spines and dark brown indumentum. It requires high light intensities for growth. Commonly found in exposed areas in lowlands especially along streams and edges of swamps. Very closely related to *D. fissa* Bl. in Borneo and *D. melanochaetes* Bl. in Indonesia and Malaysia.

Selected sources 14, 19, 28, 35.

Daemonorops calicarpa (Griff.) Mart.

PALMAE

Vernacular names Malaysia: lumpit.

Distribution Widely distributed in Peninsular Malaysia especially in the southern part. Also found in northern Sumatra.

Uses Leaves are used for thatching and the outer part of the rachis is stripped for weaving baskets.

Observations A clustering, thicket-forming, hapaxanthic, almost stemless non-climbing rattan. Usually found in lowland dipterocarp forest in valleys and on lower slopes.

Selected sources 14, 35, 40, 46.

Daemonorops clemensiana Becc.

PALMAE

Distribution The Philippines (Lanao, Mindanao).

Uses The cane is used for basket-making and tying.

Observations Slender rattan. Stem without leaf-sheaths to 10 mm in diameter, with sheaths to 20 mm in diameter. Leaves to 1.3 m long, cirrate; leaf-sheaths densely armed with scattered black, stiff, flat spines; leaflets equidistant, numerous. Fruit spherical, to 2.5 mm in diameter, one-seeded. Endemic to the Philippines.

Selected sources 2, 3, 8, 11, 22, 23, 26, 38, 39, 45.

Daemonorops crinita (Miq.) Bl.

PALMAE

Distribution Southern Sumatra (Palembang, Rawas).

Uses The cane is used for coarse basketry and cordage. Heyne records the export of canes of *D. crinita*.

Observations Clustering, slender rattan. Stem with leaf-sheaths 13 mm in diameter. Leaves cirrate; cirrus about 20 cm long. Found in lowland riverine forest.

Selected sources 5, 32.

Daemonorops curranii Becc.

PALMAE

Vernacular names Philippines: pitpit, saranoi (Tagbanva).

Distribution The Philippines (Palawan).

Uses The cane is used for basket-making and for tying.

Observations Medium-sized rattan. Stem without leaf-sheaths to 12 mm in diameter, with sheaths to 25 mm in diameter. Leaves cirrate; leaflets equidistant, papyraceous. Fruit small, spherical and with short, conical beak. Endemic to the Philippines, in forest at low altitude.

Selected sources 2, 3, 8, 11, 22, 23, 26, 38, 39, 45.

Daemonorops didymophylla Becc.

PALMAE

Vernacular names Indonesia: rotan tunggal, uwi jernang kecil (Palembang). Malaysia: rotan jergang, udat (Penan, Sarawak). Thailand: wai-khipet.

Distribution Borneo, Sumatra, Peninsular Malaysia and southern Thailand.

Uses The fruit produces red resin ('dragon's blood') used by local people (Semai) in Peninsular Malaysia as medicine. The fruits are first dried and the resin then removed by rubbing the fruit with cockle shells. The resin so collected is processed by wrapping in a cloth, dampening in hot water and then being squeezed. The cane is used as split rattan. In Sarawak, the fruits are sometimes eaten.

Observations A moderate-sized, clustering rattan with the fruit scales covered with red resin. Stem without leaf-sheaths to 12 mm in diameter, with sheaths to 30 mm in diameter. Very common in Peninsular Malaysia from almost sea-level to an altitude of 1000 m, especially common in valleys and on lower slopes of hill dipterocarp forest.

Selected sources 14, 18, 21, 24, 29, 35, 40, 43.

Daemonorops draco (Willd.) Bl.

PALMAE

Vernacular names Indonesia: rotan jernang (Sumatra). Malaysia: wi ondo (Sarawak).

Distribution Sumatra (Jambi, Bengkulu), Riau Archipelago and Borneo (Sarawak, Kalimantan).

Uses The cane appears to be of good quality. In Sumatra, 'dragon's blood' dye is extracted from the fruit scales and sold in local markets.

Observations Clustering rattan, to 15 m tall. Stem with leaf-sheaths 15 mm in diameter. Leaves cirrate to 2.5 m length. *D. draco* resembles *D. micracantha* (Griff.) Becc. Found in lowland primary dipterocarp forest.

Selected sources 5, 21.

Daemonorops elongata Bl.

PALMAE

Vernacular names Malaysia: lempinit pahetan, rotan pipit, rotan bangkorn (Sandakan).

Distribution Endemic to Borneo (Sabah, Kalimantan); not yet found in Sarawak.

Uses Leaves used locally for thatching temporary shelters.

Observations Clustering, dioecious rattan. Stem short, rarely exceeding 4 m, without leaf-sheaths 15 mm in diameter, with sheaths 25 mm in diameter. Leaves cirrate. Found in lowland dipterocarp forest. The taxon described as *D. elongata* var. *montana* Becc. ex L.S. Gibbs is conspecific with *D. longistipes* Burr.

Selected sources 5, 18, 21.

Daemonorops fissa (Miq.) Bl.

PALMAE

Vernacular names *Indonesia: rotan kotok* (East Kalimantan), rotan bejungan (Central Kalimantan). Malaysia: wi ruak ai (Sarawak), gonot pipit, rotan damp (Sandakan).

Distribution Borneo (Sarawak, Brunei, Sabah, Kalimantan).

Uses The cane is of rather poor quality, used locally only. The palm cabbage ('umbut') is eaten in East Kalimantan, Brunei and Sabah. The cane might be used for its core, in the same way as related species in Peninsular Malaysia.

Observations Clustering, robust rattan, to 30 m tall, forming thickets. Stem without leaf-sheaths 18–25 mm in diameter, with sheaths to 35 mm in diameter; white latex exuding from the cut surface. Found on disturbed sites, swampy areas, sides of streams, and is particularly frequent in secondary forest on alluvial sites; it also occurs on hills up to 800 m altitude.

Selected sources 5, 18, 21, 32.

Daemonorops grandis (Griff.) Mart.

PALMAE

Vernacular names Malaysia, Singapore: rotan sendang. Thailand: wai-chak.

Distribution Sumatra, Singapore, Peninsular Malaysia and Thailand.

Uses The leaves are used for thatch. The outer layer of the petiole and rachis are peeled and split into strips for making baskets and winnowing trays by the aborigines in Peninsular Malaysia. The rachis is also used as fishing rods.

Observations Clustering, robust rattan climbing to 20 m tall. Stem about 30 mm in diameter without leaf-sheaths, up to 50 mm in

diameter with sheaths. Commonly found on ridges and lower slopes of hill dipterocarp forest.

Selected sources 14, 19, 35.

Daemonorops hystrix (Griff.) Mart.

PALMAE

Vernacular names Indonesia: rotan sepet, uwi kalang, sintang (Palembang). Malaysia: rotan tahi landak (Peninsular Malaysia), wi duduk (Iban, Sarawak), wae dangah (Penan, Sarawak).

Distribution Sumatra, Peninsular Malaysia to Singapore, Borneo and probably Java.

Uses The cane is used to make furniture frames but is of low quality. The ripe fruits are said to be eaten by forest dwellers in Sarawak.

Observations A moderate-sized, clustering and climbing rattan, up to 10 m tall. Stem without leaf-sheaths to 13 mm in diameter, with sheaths to 15–30 mm in diameter. The leaf-sheaths are armed with huge erect spines around the sheath mouth. A very common species. Three varieties are known, var. *hystrix*, var. *minor* Becc. and var. *exulans* Becc. Usually found on lower slopes, river banks and ridge tops in lowland forest.

Selected sources 14, 18, 21, 35, 44.

Daemonorops ingens J. Dransf.

PALMAE

Vernacular names Malaysia: keplar, wi darum (Iban, Sarawak), wi seruing (Kayan, Sarawak).

Distribution Endemic to Borneo

Uses The sarcotesta of the fruit is sweet and edible. The leaves are used for thatching.

Observations A huge, solitary or clustering, stemless rattan. Leaf ecirrate, very large. It is very often confused with salak (*Salacca* spp.). The terminal leaflets consist of a single fold and this allows it to be separated from *Salacca* spp. which have compound terminal leaflets when sterile. A fairly rare species usually found on damp slopes near valley bottoms or along streams.

Selected sources 14, 18, 21, 35, 44.

Daemonorops lamprolepis Becc.

PALMAE

Vernacular names Indonesia: lapa, latea (southern Sulawesi).

Distribution Sulawesi.

Uses The cane is locally used as binding material.

Observations Very poorly known species. Leaf-sheaths bear slender spines up to 17 mm long.

Selected sources 5.

Daemonorops leptopus (Griff.) Mart.

PALMAE

Vernacular names Malaysia: rotan bacap.

Distribution Endemic to Peninsular Malaysia and Singapore.

Uses The cane is used for making baskets and for tying. The leaflets are used by local people as cigarette paper.

Observations A robust, clustering and climbing rattan to 15 m tall. Stem diameter without leaf-sheaths to 25 mm, with sheaths to 30 mm in diameter. Very common in lowland to upper hill dipterocarp forest to 1000 m altitude, especially in swampy valleys, slopes and ridge tops.

Selected sources 14, 35.

Daemonorops longispatha Becc.

PALMAE

Vernacular names Malaysia: wi tibu (Iban, Sarawak), savit payah (Penan, Sarawak).

Distribution Endemic to Borneo.

Uses The shoot is eaten as rattan cabbage ('savit') by the Penan in Sarawak. The cane is used for tying.

Observations A robust, clustering and climbing rattan. Stem 25 mm in diameter without leaf-sheaths, 50 mm in diameter with sheaths. Commonly found in coastal areas of Sabah, Sarawak, Brunei and Kalimantan.

Selected sources 18, 21, 43, 44.

Daemonorops melanochaetes Bl.

PALMAE

Vernacular names Indonesia: sekei udang (Riau), rotan lelo (Sumatra, Bengkulu), howe

seel (western Java), rotan legi (eastern Java). Malaysia: rotan getah (Peninsular).

Distribution Peninsular Malaysia, Sumatra and Java.

Uses The cabbage is edible. In Peninsular Malaysia the core of the cane is used for broom handles and coarse furniture.

Observations Clustering, moderately robust, high climber to 30 m tall. Stem 20 mm in diameter without leaf-sheaths. Leaf cirrate. Several varieties have been described, e.g. var. *depresseglobosus* Teysm. & Binnend., var. *macrocarpa* Becc., var. *macrocymbus* Becc., var. *microcarpa* Teysm. & Binnend., and var. *padangensis* Becc. However, in view of the great variability of this species, these varieties probably have little value since *D. melanochaetes* is closely related to *D. angustifolia* (Griff.) Mart. of Peninsular Malaysia and the two species are possibly not distinct. It usually occurs on dry ground near coasts, often forming thickets. It is also found in swampy lowland rain forest and alluvial flatlands up to 20 m altitude; however, in Java it occurs up to 1400 m elevation.

Selected sources 5, 12, 14.

Daemonorops micracantha (Griff.) Becc.

PALMAE

Synonyms *D. draconcella* Ridley (1902).

Vernacular names Malaysia: rotan (wi) jer(e)nang (in most localities, including Sarawak), rotan bakul (Negri Sembilan), dre sekam (Pahang), lempinit landang (Sandakan).

Distribution Peninsular Malaysia, Borneo (Sabah, Sarawak, Kalimantan).

Uses The split cane is locally used for tying; ripe fruits are sold in local markets as a source of 'dragon's blood' natural dye in Central Kalimantan and Sarawak.

Observations Clustering climber to 40 m tall or more. Stem without leaf-sheaths 12 mm in diameter, with sheaths 25 mm in diameter. Leaves cirrate to 2 m including cirrus to 80 cm long. *D. micracantha* is immediately recognized by its low ridges bearing minute black spicules interspersed with golden spines to 15 mm on the leaf-sheaths. It is found in lowland forest, near streams, and occasionally in forest transitional with heath forest, up to 500 m altitude.

Selected sources 5, 14, 18, 21, 25, 32, 35, 44.

Daemonorops oblonga (Reinw. ex Bl.) Bl.

PALMAE

Vernacular names Indonesia: rotaň pitik, rotan poprok (eastern Java).

Distribution Java.

Uses The cane is used locally for making the framework of baskets, brush handles and coarse weaving.

Observations Clustering rattan, to 12 m tall. Stem without leaf-sheaths 10–30 mm in diameter, with sheaths 17–32 mm in diameter. Leaves cirrate, 4.2 m long, including the 90 cm long cirrus. In Java it is distinguishable by its oblongoid fruits. In western Java it has been found in primary lowland dipterocarp forest up to 600 m and in eastern Java it occurs at 100 m altitude. *D. oblonga* closely resembles *D. hystrix* (Griff.) Mart.

Selected sources 1, 5, 14.

Daemonorops ochrolepis Becc.

PALMAE

Vernacular names Philippines: ditaan, palaklakanin sumulid (Tagalog).

Distribution The Philippines (Ilocos Norte, Nueva Ecija, Rizal, Laguna, Tayabas, Sorsogon, Polillo, Mindanao).

Uses The cane is used for furniture, baskets, bags, etc., for home industries and local commercial use.

Observations Large rattan. Stem without leaf-sheaths to 30 mm in diameter, with sheaths to 50 mm in diameter. Leaves cirrate; leaf-sheaths densely armed with dark brown rigid bristles; leaflets numerous, lanceolate, equidistant. Fruit spherical, to 20 mm in diameter. Endemic to the Philippines. Found in primary forest at low and medium altitudes up to 1200 m.

Selected sources 2, 3, 8, 11, 22, 23, 26, 38, 39, 45.

Daemonorops periacantha Miq.

PALMAE

Vernacular names Malaysia: wi empunoh, wi empunok (Sarawak); rotan belubu (Sabah).

Distribution Peninsular Malaysia, Singapore and Borneo. *D. periacantha* has not been

found further north than Johor state in Peninsular Malaysia.

Uses Split cane is used for sewing up fish traps; the fruits and cabbage are edible.

Observations Robust, clustering rattan, rarely more than 10 m tall. Stem without leaf-sheaths 15 mm in diameter, with sheaths 30–80 mm in diameter. Very common rattan found in lowland to hill dipterocarp forest, in swampy sites and lower slopes up to 1000 m.

Selected sources 5, 14, 18, 32.

Daemonorops propinqua Becc.

PALMAE

Vernacular names Peninsular Malaysia: rotan jernang.

Distribution Endemic to Peninsular Malaysia (Selangor, Pahang, Melaka).

Uses Reddish scales of the fruit produce 'dragon's blood' dye.

Observations Clustering rattan, forming thickets 5 m tall. Stem without leaf-sheaths 20 mm in diameter, with sheaths 40 mm in diameter. Fruit scales encrusted with 'dragon's blood' dye. Rather rare; found in lowland swamp areas at 50 m altitude. *D. brachystachys* Furt. might be merely an acaulescent form of *D. propinqua*.

Selected sources 5, 14.

Daemonorops rubra (Reinw. ex Bl.) Bl.

PALMAE

Vernacular names Indonesia: teretes (western Java).

Distribution Western Java.

Uses The fruit produces 'dragon's blood' natural dye.

Observations Clustering rattan. Stem to 10 m long, without leaf-sheaths 12 mm in diameter, with sheaths to 30 mm in diameter. Leaves cirrate, 3 m long including the 1 m long cirrus. Found in lowland primary dipterocarp forest, up to 800 m altitude.

Selected sources 1, 5.

Daemonorops ruptilis Becc.

PALMAE

Vernacular names Malaysia: wi dudok (var. *acaulescens*) (Iban, Sarawak).

Distribution Borneo. Endemic species.

Uses The ripe fruits are eaten.

Observations A clustering, robust rattan. Two varieties are recognized: var. *ruptilis* is a massive clustering variety with stems to 20 m tall, var. *acaulescens* J. Dransf. is stemless and ecirrate. The former is widespread in Brunei and Sabah; *var. acaulescens* occurs in Sabah, Brunei and Sarawak. Locally common in lowland forest.

Selected sources 18, 20, 21, 43, 44.

Daemonorops scapigera Becc.

PALMAE

Synonyms *Daemonorops lasiospatha* Furt.

Vernacular names Malaysia: wi empunok ruai (Iban, Sarawak).

Distribution Widespread in the 1st and 2nd Divisions of Sarawak, Brunei. In Peninsular Malaysia, it is confined to Johor and is considered a vulnerable species likely to become endangered. Also found in Natuna Islands in the South China Sea.

Uses The cane is used for making walking-sticks and the fruits are edible. The shoots are eaten as palm cabbage.

Observations A solitary and stemless rattan with ecirrate leaves. Occurring in a wide range from sea-level up to 1000 m altitude, being particularly common in transitional forest between dipterocarp forest and heath forest.

Selected sources 21, 35, 43, 44.

Daemonorops sparsiflora Becc.

PALMAE

Vernacular names Malaysia: wi ruah air (Iban, Sarawak), savit asaq (Penan, Sarawak).

Distribution Widespread in Sabah, Sarawak, East Kalimantan and Brunei. Endemic to Borneo.

Uses The cane is used for tying and the shoots are eaten.

Observations Slender to moderately robust, clustering, climbing rattan. Stems 8–18 mm in diameter without leaf-sheaths, to 27 mm in diameter with sheaths. Usually found on richer soils in primary and disturbed forest, in valley bottoms, on lower slopes and riverside alluvium.

Selected sources 18, 20, 21, 43, 44.

Myrialepis paradoxa (Kurz) J. Dransf.

PALMAE

Synonyms *Myrialepis scortechinii* Becc.

Vernacular names Indonesia: cekolo (Sumatra). Malaysia: rotan kertong. Thailand: waai kung (Trang).

Distribution Sumatra, Singapore, Peninsular Malaysia, Thailand, Vietnam, Cambodia and Burma.

Uses The cane is used for coarse basketry for home use.

Observations A clustering, robust, thicket-forming rattan to 40 m or more tall. Stem without leaf-sheaths to 40 mm diameter, with sheaths to 70 mm in diameter. Leaf cirrate, spines on juvenile sheaths arranged in whorls and slightly reflexed. It requires high light intensities for growth, thus it is usually found on river banks and disturbed areas.

Selected sources 14, 17, 28, 29, 35.

Plectocomiopsis geminiflora (Griff.) Becc.

PALMAE

Vernacular names Indonesia: rotan sotong (Sumatra), rotan rua. Malaysia: rotan rilang (Malay), wi laleh (Iban, Sarawak), moa (Bidayuh, Sarawak), ambalua (Kedazan, Sabah). Thailand: wai-kungnampharai.

Distribution From Borneo, Sumatra, Peninsular Malaysia to southern Thailand.

Uses The cane is used as cordage and for making coarse basketware including fish traps and chicken coops. The shoot or 'upak laleh', is eaten as palm cabbage and is commonly sold in markets in Sarawak. However, local people in Penisular Malaysia regard the cabbage as being poisonous.

Observations A clustering robust hapaxanthic rattan to 50 m tall forming rather dense thickets. Stem without leaf-sheaths to 30 mm diameter, with sheaths to 60 mm in diameter. Found abundantly in major light gaps in lowland and hill mixed dipterocarp forest.

Selected sources 14, 18, 20, 21, 29, 35, 43, 44.

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Acronyms of organizations

- FAO: Food and Agriculture Organization of the United Nations (Rome, Italy)
- FRIM: Forest Research Institute of Malaysia (Kuala Lumpur)
- IAWA: International Association of Wood Anatomists
- IDRC: International Development Research Centre (Ottawa, Canada)
- IFAR: International Fund for Agricultural Research (Washington, D.C., United States)
- RIC: Rattan Information Centre (Kepong, Malaysia)
- SAFODA: Sabah Forestry Development Authority (Sabah, Malaysia)
- UNESCO: United Nations Educational, Scientific and Cultural Organization (Paris, France)

Glossary

acanthophyll: a leaflet modified as a spine
acaulescent: appearing to be without a stem, the stem usually more or less subterranean
acuminate: ending in a narrowed, tapering point with concave sides
acute: sharp; ending in a point with straight or slightly convex sides
adjacent-ligular: type of germination in which the seedling shoot develops close to the seed
adnate: united with another part; with unlike parts fused, e.g. ovary and calyx tube
adventitious: not in the usual place, e.g. roots on stems, or buds produced in other than terminal or axillary positions on stems
androecium: the male element; the stamens as a unit of the flower
anther: the part of the stamen containing the pollen
anthesis: the time the flower is expanded, or more strictly, the time when pollination takes place
apex: the growing point of a stem or root
apical: at the point of any structure
apogeotropic: growing upwards
atap: thatch made (usually in panels) by bending palm leaflets over a lath or the leaf-rachis
auricle: an ear-like extension of the leaf-sheath, usually paired, one on each side of the petiole
axil: the upper angle between the leaf and the stem
axillary: arising from the axil
axis: the main or central line of development of a plant or organ
belukar: young secondary forest
bifid: cleft into two parts at the tip
bisexual: having both sexes present and functional in the same flower
blade: the expanded part of a leaf or petal
bract: a reduced leaf subtending a flower, flower stalk or all or part of an inflorescence
bracteole: a secondary bract on the pedicel or close under the flower
calyx: the outer envelope of the flower, consisting of sepals, free or united
cane: the bare stem of a rattan
carpel: one of the foliar units of a compound pistil or ovary; a simple pistil has only one carpel
chair-cane: finely split rattan used in weaving the backs and seats of chairs
chalaza: basal part of the ovule or seed where it is attached to the funiculus and the point at which vascular tissues enter and spread into the ovule
cirrate: bearing a cirrus
cirrus (plural *cirri*)*:* climbing organ of rattans developed from the extension of the leaf tip (cf. flagellum)
clustered: bearing more than one stem, the stems branching at the very base
connate: united or joined
core: the central part of the cane after the removal of skin, usually marketed as strips of uniform diameter
corolla: the inner envelope of the flower of free or united petals
cured rattan: green rattan that has undergone boiling, washing and scrubbing; also called 'partially processed cane'
decortication: removal of outer surface of cane
demography: the study of (plant) populations
dimorphic: of two forms, as may occur with branches, etc.
dioecious: with unisexual flowers and with the staminate and pistillate flowers on different plants (dioecy)
distal: situated farthest from the place of attachment
distichous: regularly arranged in two opposite rows on either side of the stem
ellipsoid: a solid object which is elliptical in section
elliptic(al): shaped like an ellipse
embryo: 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)
endemic: restricted to a defined geographical area and not found anywhere else

endocarp: the innermost layer of the pericarp or fruit wall

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

entire: an even margin without teeth, lobes, etc.

eophyll: the first leaf with a blade produced by a seedling

fertile (botany)*:* bearing pollen which fecundates the ovules; said of pollen-bearing anthers or of seed-bearing fruits

fertilization: union of the gametes (egg and sperm) to form a zygote

filament: thread; the stalk supporting the anther

flagellate: bearing a flagellum

flagellum: (plural *flagella*)*:* climbing organ of rattans developed from a modified inflorescence, borne on a leaf-sheath, found only in the genus *Calamus* (cf. cirrus)

fruit: the ripened ovary with adnate parts

genus (plural *genera*)*:* a grouping of species believed to be closely related to each other

geotropic: growing downwards

glabrous: devoid of hairs

glaucous: pale bluish-green, or with a whitish bloom which rubs off

green rattans: raw, freshly cut rattans which have not undergone any treatment

gynoecium: the female part or pistil of a flower, consisting, when complete, of one or more ovaries with their styles and stigmas

habitat: the kind of locality in which a plant grows

hapaxanthic: pertaining to plants in which individual stems flower once only and then die (cf. pleonanthic)

hermaphrodite: bisexual; in flowers, with stamens and pistil in the same flower

homogeneous: uniform, referring to structure of endosperm

imbricate: overlapping like tiles; in a flower bud when one sepal or petal is wholly external and one wholly internal and the others overlap at the edges only

indumentum: covering of hairs

inflorescence: the arrangement and mode of development of the flowers on the floral axis

infructescence: a ripened inflorescence in the fruiting stage

integument: covering of the seed, divisible into two layers, the outer of which becomes the sarcotesta

internode: the portion of the stem between two nodes

kerangas: Bornean heath forest developed on very poor soils at low elevations

knee: a swelling on the leaf-sheath at the base of the petiole

lamina: see blade

lanceolate: lance-shaped; much longer than broad, being widest at the base and tapering to the apex

leaflet: one part of a compound leaf

lignified: impregnated with lignin, the major chemical constituent of wood, i.e. woody

Malesia: the bio-geographical region including Malaysia, Indonesia, the Philippines, Singapore, Brunei and Papua New Guinea

mesocarp: the middle layer of the pericarp or fruit wall which is often fleshy or succulent

midrib: the main vein of a leaf which is a continuation of the petiole

monoecious: with unisexual flowers, but male and female flowers borne on the same plant

natural cane: green or cured rattan in natural form, i.e. with skin

nerve: a strand of strengthening and/or conducting tissue running through a leaf, which starts from the midrib and diverges or branches throughout the blade

node: the point on the stem or branch at which a leaf or lateral is borne

ocrea: an extension of the leaf-sheath beyond the base of the petiole

ovary: that part of the pistil, usually the enlarged base, which contains the ovules and eventually becomes the fruit

ovate: egg-shaped; a flat surface which is scarcely twice as long as broad with the widest portion below the middle

ovoid: a solid object which is egg-shaped (ovate) in section

ovule: the immature seeds in the ovary before fertilization

partial inflorescence: the first order branch of an inflorescence and the branches it carries

parenchyma: ground tissue, usually consisting of rather uniform cells

partially processed cane: see 'cured rattan'

pedicel: stalk of each individual flower of an inflorescence

peduncle: the stalk of an inflorescence or partial inflorescence

pendulous: drooping; hanging down

perianth: the floral leaves as a whole, including sepals and petals if both are present

pericarp: the wall of the ripened ovary of fruit whose layers may be fused into one, or may be more or less divisible into exocarp, mesocarp and endocarp
petal: a member of the inner series of perianth segments which are often brightly coloured
petiolate: having a petiole
petiole: the stalk of a leaf
pinnate: a compound leaf with the leaflets arranged along each side of a common rachis
pistil: the female part of a flower (gynoecium) of one or more carpels, consisting, when complete, of ovary(ies), style(s) and stigma(s)
pistillate: a unisexual flower with pistil, but no stamens
pistillode: a sterile, often reduced pistil
pleonanthic: pertaining to plants in which stems have the ability to produce inflorescences continually, and flowering is not followed by the death of the stem
polished cane: peeled cane which has undergone polishing
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
praemorse: bitten off, referring to the jagged leaflet margins of *Korthalsia* spp. and some species of *Ceratolobus*
prophyll: the first, i.e. lowermost, bract borne on an inflorescence
protandrous: stamens shedding pollen before the stigma is receptive
rachilla: an ultimate flower-bearing branch of the inflorescence
rachis: in a leaf, the axis on which the leaflets are borne; in an inflorescence, the axis which bears the first-order branches
rattan: a climbing palm belonging to the subfamily Calamoideae
recurved: bent or curved downward or backward
rhizome: an underground stem which is distinguished from the root by the presence of nodes with buds and leaves or scales
ruminate: referring to endosperm structure, penetrated by fine dark intrusions of the seed-coat
sarcotesta: the fleshy outer seed-coat
seed: the reproductive unit formed from a fertilized ovule, consisting of embryo and seed-coat and, in some case, also endosperm
sepal: a member of the outer series of perianth segments
sessile: without a stalk
sheath: a tubular structure surrounding an organ or part, as the lower part of the leaf clasping the stem in grasses
shoot: a young growing branch or twig
solitary: single-stemmed, lacking sucker shoots at the base
spine: a short stiff straight sharp-pointed hard structure
split rattan: by-products of splitting process, such as ropes and binds and cores
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 a perfect anther
stemless: referring to rattans with very short, often subterranean stems
sterile: 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)
stigma: the portion of the pistil which receives the pollen
stolon: a trailing stem usually above the ground which is capable of producing roots and shoots at its nodes
style: the part of the pistil connecting the ovary with the stigma
subcirrate: a type of leaf in which, although a true cirrus is not present, the terminal portion of the rachis bears very small, distant leaflets
subfamily: a major division of a family
subtribe: a division of a tribe
sucker: a branch formed at the base of a rattan stem
sympatric: pertaining to several species found growing at the same locality
sympodial: of a stem in which the growing point either terminates in an inflorescence or dies, growth being continued by a subtending lateral growing point
tatami: Japanese term for floor carpets or mats made of rattan skin strips strung together with strings pierced through them
tomentum: a thick covering of hairs
tribe: a division of a subfamily
ultramafic: type of rock, rich in heavy metals such as manganese and iron, usually carrying a rather distinctive flora
umbut: palm cabbage, the edible growing point
unisexual: referring to flowers of one sex, i.e.

bearing fertile stamens alone or bearing a fertile pistil alone

variety: a division of a species

vein: a strand of vascular tissue in a flat organ, such as a leaf

venation: the arrangement of the veins of a leaf

Sources of illustrations

All illustrations have been redrawn and adapted by Mrs. P. Verheij-Hayes (WAG) or Mr. Iskak Syamsudin (BO), using the following sources:

Rattan structures: Dransfield, J., 1984. The rattans of Sabah. Sabah Forest Records 13. Sabah Forest Department. Illustrated Glossary. Plate A, p. 4 (petiole bases); plate B, p. 5 (ocrea types); plate C, p. 6 (leaf types); plate G, p. 10 (rachilla types, fruit).

Calamus egregius: illustration provided by the authors.

Calamus exilis: original drawing by Iskak Syamsudin.

Calamus javensis: Furtado, C.X., 1956. Palmae Malesicae 19: the genus *Calamus* in the Malay Peninsula. Gardens' Bulletin Singapore 15: 32–265, Fig. 44d, p. 182.

Calamus manan: original drawing by Iskak Syamsudin.

Calamus merrillii: redrawn and adapted from original drawing of A. Knock (K) from Madulid & Dransfield 1051 (K).

Calamus mindorensis: redrawn and adapted from original drawing of A. Knock (K) from Fernando 387 (K).

Calamus optimus: Dransfield, J., 1984. The rattans of Sabah. Sabah Forest Records 13. Sabah Forest Department. Fig. 45, p. 101.

Calamus ornatus: original drawing by Iskak Syamsudin.

Calamus ovoideus: redrawn and adapted from original drawing provided by Neela de Zoysa.

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Calamus pogonacanthus: redrawn and adapted from original drawing provided by Lesmy Tipot (FRIM) from JD 4677 (K, FRIM).

Calamus scipionum: Dransfield, J., 1979. A manual of the rattans of the Malay Peninsula. Malayan Forest Records 29. Forest Department, Ministry of Primary Industries, Malaysia. p. 204.

Calamus simplicifolius: Wei, Chao-fen, 1986. A study on the genus Calamus of China. Guihaia 6(1–2): 17–40. Plate 3, p. 38.

Calamus subinermis: Dransfield, J., 1984. The rattans of Sabah. Sabah Forest Records 13. Sabah Forest Department. Fig. 43, p. 97.

Calamus tetradactylus: illustration provided by the authors (habit, infructescence, fruit). Pei, S.J., Chen, S.Y. & Tong, S.Q., 1991. Flora reipublicae popularis Sinicae. Science Press, Beijing. Vol. 13(1). Fig. 20(1), p. 89 (leaf).

Calamus trachycoleus: original drawing by Iskak Syamsudin.

Calamus tumidus: Dransfield, J., 1979. A manual of the rattans of the Malay Peninsula. Malayan Forest Records 29. Forest Department, Ministry of Primary Industries, Malaysia. p. 146 (leaf-sheaths); p. 147 (leaf, inflorescence, fruit).

Calamus wailong: Pei, S.J., Chen, S.Y. & Tong, S.Q., 1989. New materials of Palmae from China. Acta Phytotaxonomica Sinica 27(2): 132–146. Fig. 2, p. 139.

Calamus zollingeri: original drawing by Iskak Syamsudin.

Daemonorops margaritae: Pei, S.J., Chen, S.Y. & Tong, S.Q., 1991. Flora reipublicae popularis Sinicae. Science Press, Beijing. Vol. 13(1). Fig. 16, p. 61.

Daemonorops robusta: original drawing by Iskak Syamsudin.

Daemonorops sabut: original drawing by Iskak Syamsudin.

Korthalsia echinometra: original drawing by Iskak Syamsudin.

Map of South-East Asia for Prosea: original design of R. Boekelman.

Index of scientific plant names

Page numbers printed in bold refer to main treatment.

Index of vernacular plant names

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 at 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 FRI Kepong, 52109 Kuala Lumpur, Malaysia;
- Indonesian Institute of Sciences (LIPI), Widya Graha, Jalan Gatot Subroto 10, Jakarta 12710, Indonesia;
- Institute of Ecology & Biological Resources (NCSR), Nghia do, Tu Liem, Hanoi, Vietnam;
- Papua New Guinea University of Technology (UNITECH), Private Mail Bag, Lae, Papua New Guinea;
- Philippine Council for Agriculture, Forestry and Natural Resources Research & Development (PCARRD), Los Baños, Laguna, the Philippines;
- Thailand Institute of Scientific and Technological Research (TISTR), 196 Phahonyothin Road, Bang Khen, Bangkok 10900, Thailand;
- Wageningen Agricultural University (WAU), 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 disseminaton of reports and the research results.

Implementation

The programme period has been tentatively divided into 3 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 (1991–1995): 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.

Documentation

A documentation system has been developed for information storage and retrieval called SAPRIS (South-East Asian Plant Resources Information System). It consists of 6 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.

Publication

The handbook in blue cover (hardbound) is distributed by Pudoc, the low-price edition in green cover (paperback) by Prosea only in developing countries of South-East Asia and the Pacific, the bibliographies by Prosea and the miscellaneous publications by Pudoc and Prosea.

The handbook

- No 1. Pulses. L.J.G. van der Maesen and Sadikin Somaatmadja (Editors). Pudoc, Wageningen. 1989/ESCAP CGPRT Centre, Bogor. 1990 (out of print)/Prosea, Bogor. 1992.
- No 2. Edible fruits and nuts. E.W.M. Verheij and R.E. Coronel (Editors). Pudoc, Wageningen. 1991/Prosea, Bogor. 1992.
- No 3. Dye and tannin-producing plants. R.H.M.J. Lemmens and N. Wulijarni-Soetjipto (Editors). Pudoc, Wageningen. 1991/Prosea, Bogor. 1992.
- No 4. Forages. L. 't Mannetje and R.M. Jones (Editors). Pudoc, Wageningen. 1992/Prosea, Bogor. 1992.
- No 5(1). Timber trees. Major commercial timbers. I. Soerianegara and R.H.M.J. Lemmens (Editors). Pudoc, Wageningen. 1993/Prosea, Bogor. 1994.
- No 5(2). Timber trees. Minor commerical timbers. R.H.M.J. Lemmens, I. Soerianegara and Wong Wing Chong (Editors). (expected publication date 1994/1995).
- No 6. Rattans. J. Dransfield and N. Manokaran (Editors). Pudoc, Wageningen. 1993/Prosea, Bogor. 1994.
- No 7. Bamboos. S. Dransfield and E.A. Widjaja (Editors). (expected publication date 1994).
- No 8. Vegetables. J.S. Siemonsma and Kasem Piluek (Editors). Pudoc, Wageningen. 1993/Prosea, Bogor. 1994.
- No 9. Plants mainly producing carbohydrates. F. Rumawas and M. Flach (Editors). (expected publication date 1994).
- No 10. Cereals.
- No 11. Auxiliary plants in agriculture and forestry. F.H. Ibrahim and L.J.G. van der Maesen (Editors). (expected publication date 1994).

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- Bibliography 1: Pulses. Edition 1. N. Wulijarni-Soetjipto and J.S. Siemonsma (Editors). Prosea, Bogor. 1990.
- Bibliography 2: Edible fruits and nuts. Edition 1. N. Wulijarni-Soetjipto and J.S. Siemonsma (Editors). Prosea, Bogor/Pudoc, Wageningen. 1993.
- Bibliography 3: Dye and tannin-producing plants. Edition 1. N. Wulijarni-Soetjipto and J.S. Siemonsma (Editors). Prosea, Bogor/Pudoc, Wageningen. 1991.

Miscellaneous

- A Selection. E. Westphal and P.C.M. Jansen (Editors). Pudoc, Wageningen. 1989/Prosea, Bogor. 1993.
- Basic list of species and commodity grouping. Version 1. R.H.M.J. Lemmens, P.C.M. Jansen, J.S. Siemonsma, F.M. Stavast (Editors). Prosea Project, Wageningen. 1989. (out of print).
- Basic list of species and commodity grouping. Final version. P.C.M. Jansen, R.H.M.J. Lemmens, L.P.A. Oyen, J.S. Siemonsma, F.M. Stavast and J.L.C.H. van Valkenburg (Editors). Pudoc, Wageningen. 1991/Prosea, Bogor. 1993.
- Proceedings of the First Prosea International Symposium, May 22–25,

1989. Jakarta, Indonesia. J.S. Siemonsma and N. Wulijarni-Soetjipto (Editors). Pudoc, Wageningen. 1989. (out of print).

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.

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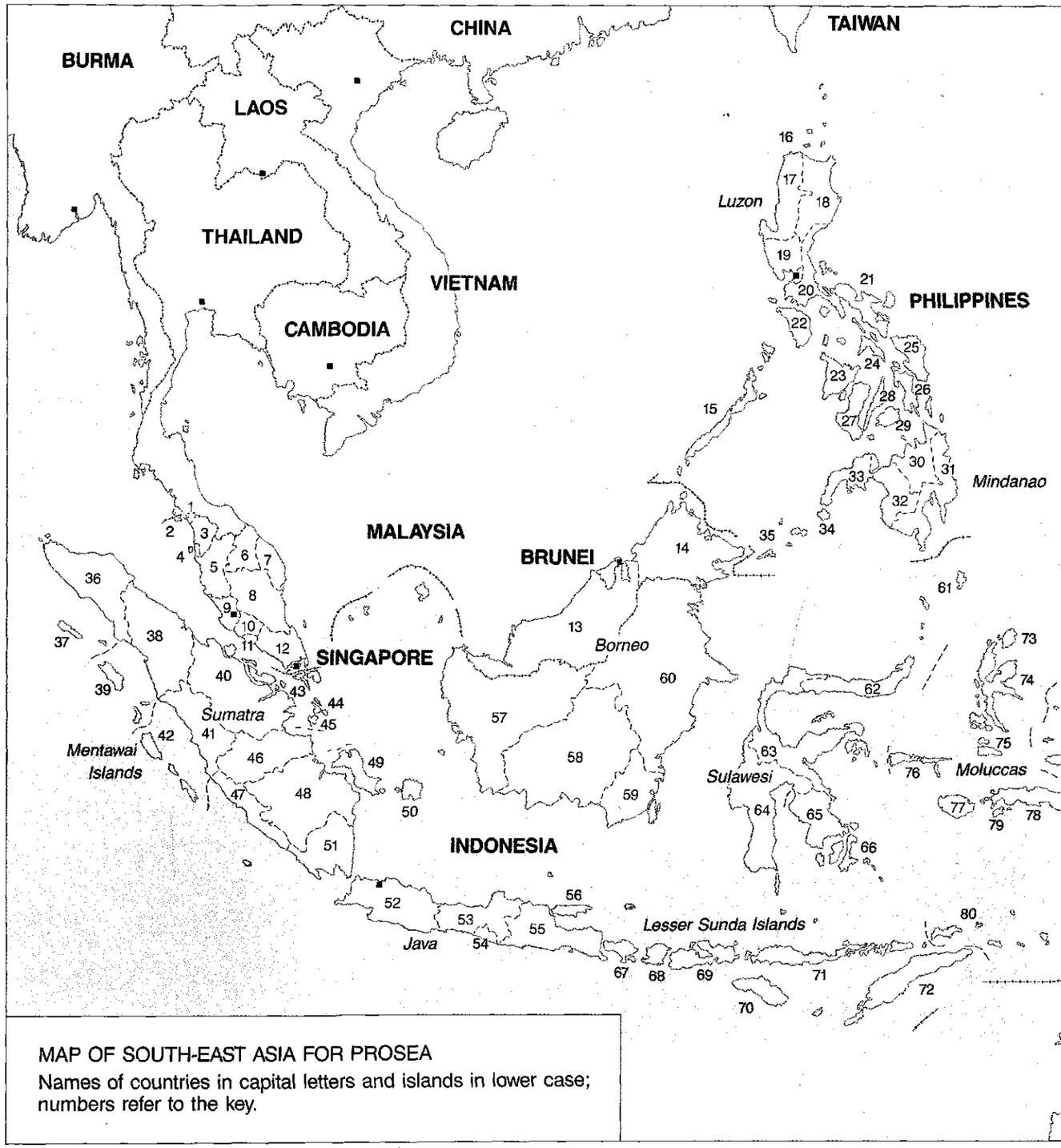

Key of islands (*i*), states (*s*), regions (*r*) and provinces (*p*).

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Kedah *s* 3
Kelantan *s* 6
Langkawi *i* 2
Melaka *s* 11
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Pahang *s* 8
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MAP OF SOUTH-EAST ASIA FOR PROSEA

Names of countries in capital letters and islands in lower case; numbers refer to the key.

1986 RB