Technical Report No. 45

Global Priority Species of Economically Important Rattan

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CGIAR
RESEARCH PROGRAM ON
Forests, Trees and Agroforestry

INBAR
INTERNATIONAL BAMBOO AND RATTAN ORGANIZATION

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About this technical report

This research was conducted by INBAR, as part of the Consortium of International Agriculture Research Centers (CGIAR) Research Program on Forests, Trees and Agroforestry (FTA). The FTA is the world's largest research development programme intended to enhance the role of forests, trees and agroforestry in both sustainable development and food security as well as to address climate change. The Center for International Forestry Research (CIFOR) leads FTA in partnership with Bioversity International, Tropical Agricultural Research and Higher Education Center (CATIE), French Agricultural Research Centre for International Development (CIRAD), INBAR, World Agroforestry Centre (ICRAF) and Tropenbos International (TBI). The FTA's work is supported by the CGIAR Trust Fund. To learn more, please visit http://www.cgiar/org/ funders.

Citation

Li Yanxia and Rene Kaam (eds.) (2022) Global Priority Species of Economically Important Rattan. INBAR technical report no. 45. International Bamboo and Rattan Ogranization. Beijing, China.

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ISBN: 978-92-95123-97-7

Acknowledgements

We are extremely grateful to the following rattan experts for all their comments and helpful suggestions: Dr Asyraf Mansor, Dr Nadine Brigitte Ruppert (Malaysia), Mr Khou Eang Hourt (Cambodia), Dr Willie P. Abasolo (Philippines), Dr Tam Le Viet, Dr Dong Le Van, Dr Nguyễn Quốc Dựng (Vietnam), Dr Emmanuel Ebanyenl (Ghana), Dr Krisdianto Sugiyanto (Indonesia), Dr Bansa Thammavong, Mrs Bouavanh Phachomphonh (Laos), Dr C.L. Chowdhary, Dr Ishwar Chandra Dutta (Nepal), Dr Li Rong-sheng (China) and Dr William J. Baker (Kew). Thanks to Gayathri Unnikrishnan (India) for compiling the scientific data and Dr Ramamoorthy Sasi (India) for preparing the species distribution maps. The photographs provided by Dr Andrew Henderson (New York Botanic Garden, USA), Dr Selim Mehmud (India) and Dr Li Rong-sheng (Chinese Academy of Forestry, China) are gratefully acknowledged. Finally, we would like to thank those at INBAR for all their support and commitment to producing this report.

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Introduction

The various rattan species are spiny climbing palms belonging to the subfamily Calamoideae (Arecaceae). They are considered one of the most important non-timber forest products (NTFPs) used in the furniture and handicraft industry due to their economic value and unique properties, including strength, lightness, durability, appearance and flexibility. The rattan genera include *Calamus* (411 species), *Eremospatha* (11 species), *Korthalsia* (28 species), *Laccosperma* (6 species), *Myrialepis* (1 species), *Oncocalamus* (5 species), *Plectocomia* (15 species) and *Plectocomiopsis* (6 species), among which *Eremospatha, Laccosperma* and *Oncocalamus* are restricted to Africa, whereas the other genera are distributed throughout the Asia-Pacific region (except for one African species of *Calamus*) (Vorontsova et al., 2016; Henderson, 2020).

Rattan makes a crucial contribution to local livelihoods. In fact, it is estimated that more than 700 million people trade in or use rattan worldwide (Sastry, 2000). Moreover, rattan and its products contribute over USD 6.5 billion in trade per annual (Wan Ariffin et al., 2018). Trade statistics concerning bamboo and rattan products show that China is the world's largest producer, with an industry valued at USD 39 billion (INBAR, 2018). Most of the economically important species of rattans are widely traded and, apart from the wild resources, some species are cultivated alongside other timber trees and crops.

The majority of the rattan resource base is exploited from natural forests where management has been largely absent or ineffective. As rattans make a substantial contribution to the livelihood and economic status of local communities in many countries worldwide, it is vital to establish rattan plantations in order to ensure sustainable availability and sufficient economic returns. Although approximately 483 species of rattans have been identified globally, only a small proportion are used for commercial purposes. Despite this, several underutilised rattan species have the potential for development as plantation crops. In terms of the manufacture of furniture and handicraft items, the choice of species varies on the basis of the diameter classes, strength and flexibility as well as from country to country. In light of this, the identification of priority species suitable to each country for prioritising research on various aspects as well as for raising large-scale plantations is essential.

1. Background

In 1994, the INBAR and the International Board for Plant Genetic Resources (IBPGR) begun an exercise to select the priority bamboo and rattan species for further research. The resultant document was published in 1994 (Williams and Rao, 1994) and included background details, criteria for selection and other ecological parameters. This document was revised in 1998, with traditionally used species from many countries being included in the revised version (Rao et al., 1998). The criteria for the selection of priority species included utilisation aspects (relative and potential importance to countries and regions in terms of use), cultivation potential, products and processing, germplasm and genetic resources, and suitability for cultivation in various agro-ecological zones. In addition to the major 18 individual species, several complex of closely related, taxonomically poorly understood species representing sections such as *Calamus* sect. *Podocephalus* and relatives of *Calamus palustris* and *Calamus hollrungii* were included in the species priority list.

2. Need for revision

Resolving the taxonomic and nomenclatural problems related to rattan is quite difficult given the high morphological variation and widespread taxa across different countries that are often treated as separate species or varieties. Still, there have been several nomenclature changes over the last five years based on recent molecular phylogenetic evidence and taxonomic revision (Henderson and Floda, 2014; Baker, 2015a; Henderson, 2020). As rattans are not cultivated in large-scale plantations by farmers in the same way as bamboos, a proper understanding of the correct species identification, silviculture techniques, agro-ecological suitability for cultivation, diseases, pests and properties of the cane is important in relation to popularising cultivation and, therefore, improving the resource base. The propagation of rattans is mainly based on seeds. The large-scale

planting of commercially important species requires sufficient planting materials, while the establishment of seed orchards for seed production is important when it comes to supplying sufficient planting materials. However, the dioecy in rattan limits its breeding and cultivation. Hence, the understanding of sex ratio of commercially important rattan species would contribute towards better management of natural strands and establishment of seed orchards. Rather than popularising all rattans, the species that are widely used, have maximum economic potential and are associated with wide usage, especially in the furniture and handicraft industry, should be given priority, meaning that focused research on various aspects of these species is urgently needed.

3. Process of revision

Against this background, the existing priority list (Rao et al., 1998) has been revised through consultation with experts from various countries (Bangladesh, Cambodia, Cameroon, China, Ghana, Indonesia, India, Laos, Malaysia, Nepal, Nigeria, Philippines, Thailand and Vietnam). The initial list was compiled and circulated to INBAR Rattan Task Force members for further evaluation and comment before the final list was prepared. The taxonomic nomenclature of the species was updated as per Sunderland (2012), Henderson and Floda (2014), Baker (2015a, 2015b) and Henderson (2020). The information concerning the species description, common names, synonyms, geographical distribution and conservation status was compiled using various literature (Beccari, 1908; Dransfield, 1992, 1997; De Zoysa and Vivekanandan, 1994; Evans et al., 2001; Eang Hourt, 2008; Henderson, 2009; Baja-Lapis, 2010; Dowe, 2010; Renuka and Sreekumar, 2012; Sunderland, 2012; Vorontsova et al., 2016; Quattrocchi, 2017; Henderson and Peters, 2018; Henderson and Nguyen, 2019; Henderson, 2020). The agro-ecological and cultivation details of each species were also recorded from the available literature. Moreover, photographs were collected and maps were prepared based on the distribution data obtained from the primary and secondary (De Zoysa and Vivekanandan, 1994; Evans et al., 2001; Eang Hourt, 2008; Henderson, 2009; Baja-Lapis, 2010; Dowe, 2010; Sunderland, 2012; Henderson, 2020) Global Positioning System (GPS) points.

4. Criteria for the selection of species

The criteria used for the selection of priority species include the following:

Utilisation potential:

- The relative and potential importance to countries in terms of current and expanded usage.
- Species associated with the maximum range of uses, especially the value of the end-use potential (furniture frames, furniture seats, walking sticks, umbrella handles, sporting goods, handicrafts/novelty items, baskets).
- Potential uses for maximum contribution to rural industry.

Agro-ecological potential:

- Suitability for different agro-ecological zones.
- Suitability for use in special habitats (e.g. degraded lands and mountainous areas).

Economic potential:

- Suitability for improving the economic potential and dependency with regard to livelihood improvement.

Cultivation potential:

- Knowledge concerning the degree of domestication and commercialisation.
- Potential for the generation of knowledge.

Germplasm and genetic resources:

- Degree of genetic erosion of the resource base.
- Need for genetic resource conservation programmes.

5. Priority rattans

Based on recommendations from rattan experts, the following 40 species are selected as priority species:

Calamus acanthospathus Griff.
Calamus andamanicus Kurz
Calamus applanatus (A.J. Hend. & N.Q. Dung) A.J. Hend.
Calamus aruensis Becc.
Calamus caesius Blume
Calamus deerratus G. Mann & H. Wendl.
Calamus egregius Burret
Calamus erinaceus (Becc.) Becc.
Calamus flagellum Griff. ex Walp.
Calamus gracilis Roxb.
Calamus inermis T. Anderson
Calamus latifolius Roxb.
Calamus leptospadix Griff.
Calamus longisetus Griff.
Calamus manan Miq.
Calamus melanochaetes (Blume) Miq.
Calamus moseleyanus Becc.
Calamus nagbettai R.R. Fernandez & Dey
Calamus ornatus Blume
Calamus ovoideus Thwaites ex Trimen
Calamus peregrinus Furtado
Calamus poilanei Conrard
Calamus rhabdocladus Burret
Calamus rheedei Griff.
Calamus rudentum Lour.
Calamus tenuis Roxb.
Calamus tetradactyloides Burret
Calamus tetradactylus Hance
Calamus thwaitesii Becc.
Calamus trachycoleus Becc.
Calamus viminalis Willd.
Calamus walkeri Hance
Calamus warburgii K. Schum.
Calamus zeylanicus Becc.
Calamus zollingeri Becc.
Eremospatha dransfieldii Sunderl.

Eremospatha macrocarpa (G. Mann & H. Wendl.) H. Wendl.

Korthalsia laciniosa (Griff.) Mart

Laccosperma secundiflorum (P. Beauv.) Küntze

Plectocomiopsis geminiflora (Griff.) Becc.

The value of these species' utilisation, their degree of domestication, related agro-ecological parameters, need for genetic conservation and other research improvements are shown in Table 1.

All of the economically and commercially important species (e.g. *C. andamanicus, C. manan* and *C. caesius*) have been retained in the revised list. *C. applanatus, C. flagellum, C. gracilis, C. leptospadix, C. melanochaetes, C. poilanei*, *C. peregrinus, C. rhabdocladus, C. rudentum, C. walkeri, Eremospatha dransfieldii, E. macrocarpa, L. secundiflorum* and *Plectocomiopsis geminiflora* have been included as new additions, as these species are associated with high utilisation and cultivation potential in certain countries. There have also been certain nomenclature changes when compared with the previous priority list, for example, *C. palustris* is now treated as a synonym of *C. latifolius* and, similarly, important species such as *C. platyacanthus*, *C. nambariensis* and *C. wailong* are treated as synonyms of C. *inermis.* As per the recent treatment (Henderson, 2020), three different species, namely *C. foxworthyi, C. merrillii* and *C. zollingeri*, are treated as the following subspecies *C. zollingeri* subsp. *zollingeri*, *C. zollingeri* subsp. *foxworthyi* and *C. zollingeri* subsp. *merrillii.* Species such as *C. zieckii* and *C. vitiensis* in the existing priority list (Rao et al., 1998) were excluded as they are evaluated as medium-quality canes that are not commonly used in the furniture industry.

Table 1. Priority rattan species of global and regional importance.

Sl. No	Taxa	Value				Agro-ecological Properties				Genetic Resources	
		DC	EP	RI	D	NS	C	H	Alt	TL	FR
1	*Calamus acanthospathus*	L	M	H	W	S	s	ru	++	H	H
2	*Calamus andamanicus*	L	H	H	W	S	h	ru	+	H	H
3	*Calamus applanatus*	L	M	M	W	C	h	rd	+	H	H
4	*Calamus aruensis*	L	M	H	W	S	s	rd	+	NA	H
5	*Calamus caesius*	S	H	H	D	C	h	ru	+	M	M
6	*Calamus deerratus*	S, L	H	H	D	C	h	rd, sh	+	L	H
7	*Calamus egregius*	S	M	H	SD	C	h	ru	+++	H	M
8	*Calamus erinaceus*	L	M	M	W	C	h	rd, sh	+	NA	H
9	*Calamus flagellum*	L	H	H	SD	C	h, s	ru	++	NA	H
11	*Calamus gracilis*	S	H	H	SD	C	h, s	ru	++(+++)	H	H
10	*Calamus inermis*	L	H	H	W	S, C	h, s	ru	+++	H	H
12	*Calamus latifolius*	L	H	M	W	S, C	h, s	rd	++	NA	H
13	*Calamus leptospadix*	S	M	H	W	C	s	ru	++	M	H
14	*Calamus longisetus*	L	H	H	SD	C	h	rd	++	M	M
15	*Calamus manan*	L	H	H	D	S	h	ru	+++	M	H
16	*Calamus melanochaetes*	L	M	M	W	C	h, s	rd	++(+++)	NA	H
17	*Calamus moseleyanus*	L	H	H	D	S, C	h	ru, rd	++	NA	M
18	*Calamus nagbettai*	L	H	H	W	C	h	ru	+++	H	H
19	*Calamus ornatus*	L	H	H	D	C, S	h	ru	++	M	M
20	*Calamus ovoideus*	L	H	H	W	C	h	ru	+	H	H
21	*Calamus poilanei*	L	H	H	SD	S	h	ru	++	H	H
22	*Calamus peregrinus*	L	H	H	D	S, C	h	ru, rd	+	NA	H
23	*Calamus rhabdocladus*	L	M	M	W	C	h, s	rd	++	L	H
24	*Calamus rheedei*	S	M	H	W	C	h	ru	++	H	H
25	*Calamus rudentum*	L	H	H	W	C	h	rd	++	NA	H
26	*Calamus tenuis*	S	H	H	D	C	h, s	sh, f	+	L	M
27	*Calamus tetradactyloides*	S	M	M	SD	C	h, s	ru	++	NA	H
28	*Calamus tetradactylus*	S	H	H	D	C	h	rd	++	L	M
29	*Calamus thwaitesii*	L	H	H	W	C	h	ru, rd	+	L	M
30	*Calamus trachycoleus*	S	H	H	D	C	h	rd, f	+	M	M
31	*Calamus viminalis*	L	M	H	D	C	h, s	d	+	L	M
32	*Calamus walkeri*	L, S	M	M	W	C	h	rd	+	NA	H
33	*Calamus warburgii*	L	H	H	SD	C	h	ru	+	NA	H
34	*Calamus zeylanicus*	L	H	H	W	C	h	ru	++	H	H
35	*Calamus zollingeri*	L	H	H	D	C	h	ru	++	NA	H
36	*Eremospatha dransfieldii*	L	M	M	W	C	h	rd	+	L	H
37	*Eremospatha macrocarpa*	S	H	M	D	C	h	rd	+	L	H
38	*Korthalsia laciniosa*	L	H	H	W	C	h	ru	++	M	H
39	*Laccosperma secundiflorum*	L	H	H	W	C	h	ru	++	L	H
40	*Plectocomiopsis geminiflora*	L	H	H	W	C	h	ru	++	L	H

Key Values

Utilization potential:

Diameter class (DC):

Large-diameter rattan: Unsplit cane measuring from 18–40 mm or above = (L)
Small-diameter rattan: Unsplit cane measuring below 18 mm = (S)

End-use potential (EP): High (H), Medium (M)

Potential for rural industries (RI): High (H), Medium (M).

Domestication (D): Wild = W, Semi-domesticated = SD, Domesticated = D

Agro-ecological properties:

Nature of stem (NS): Solitary = (S), Clustering = (C)

Climate (C): Humid tropics = (h), Sub-tropics = (s)

Habitat (H): Rainforests undisturbed areas = (ru), Rainforests with disturbed areas = (rd), Drylands, Scrub forests = (d), Swampy habitats = (sh), Flood plains = (f)

Altitudinal range (Alt): 0–500 m = (+), 500–1000 m = (++), Above 1000 m = (+++)

Genetic resources:

Threat level (TL): High = (H), Medium = (M), Low = (L), Needs evaluation = (NA)

Further research importance (FR): High = (H), Medium = (M)

Notes on priority rattans

1. *Calamus acanthospathus* Griff.

Synonyms:

Calamus feanus Becc.
Calamus feanus var. *medogensis* S.J. Pei & S.Y. Chen.
Calamus montanus T. Anderson.
Calamus yunnanensis S.J. Pei & S.Y. Chen.
Calamus yunnanensis var. *densiflorus* S.J. Pei & S.Y. Chen.
Calamus yunnanensis var. *intermedius* S.J. Pei & S.Y. Chen.
Palmijuncus acanthospathus (Griff.) Kuntze.
Palmijuncus montanus (T. Anderson) Kuntze.

Common names:

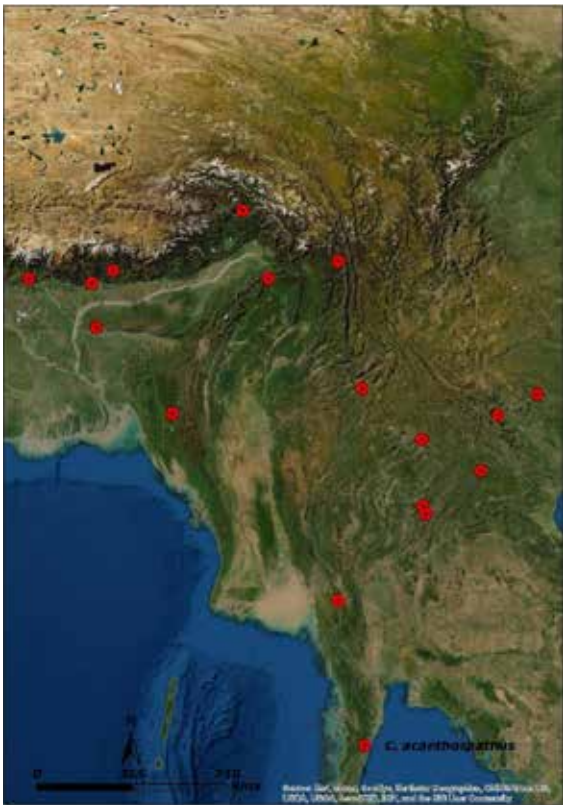
Bhutan: gauri bet, gauribet, gren, krath, minji, munzi, pukka bet, rhu, rue, tzim; **China:** yun nan, sheng teng; **India:** esong, gouri bet, hunphop, jatibet, leetingkhang, panbi, rhu, rue, thatch; **Laos:** blong eur, bong er, bong eur, wain hom; **Nepal:** gauri bent, gauri bet, gouri bet, pukka bet; **Philippines:** belala, kegiskis, tuvu.

Description:

Solitary rattan, rarely clustered, climbing, up to 25 m long, 1.5–3 cm in diameter without leaf sheath. Leaf sheath green with brown hairs, sparsely to densely arranged brown spines; leaf cirrus absent; ocreas present; knees present; well-developed flagella; petiole very short or absent. Fruit yellowish brown, ovoid, 1.9 × 1.3 cm, grooved scales; one seed per fruit.

Geographical distribution:

Bhutan, China, India, Laos, Myanmar, Tibet, Thailand and Vietnam.



Ecological requirements:

C. acanthospathus is found in lowland and montane rainforest areas with altitudes ranging from 800–2300 m (Laos, 1800 m; Thailand, 1500–1700 m; South Yunnan, 1600 m). In Nepal, it grows well in moist areas with slightly acidic soil (5.2 pH) where the N: P: K ratio = 0.08%: 7.3 kg/ha: 374 kg/ha and the organic matter content = 1.67% (Chowdhary and Paudel, 2008). The associated species are those of the evergreen forest, mainly *Albizia procera*, *Albizia lebbeck*, *Castanopsis hystrix*, *Schima wallichii*, *Syzigium cumini*, *Trewia nudiflora*, *Terminalia* spp., *Bombax* spp., *Bauhinia vahlii* and *Clerodendron* spp.

Cultivation:

Propagated by seed. For cultivation, this species requires organic-rich soil, sufficient water and low to medium light (Evans et al., 2002). There are small trial plantations in South Yunnan.

Uses:

This is an excellent small-diameter rattan that is commonly used for making furniture, baskets, sticks, scaffolding for houses and household goods (Chowdhary and Paudel, 2008; Renuka and Sreekumar, 2012). Its other uses include walking sticks, polo mallets, umbrella handles, ropes and cables for suspension bridges, crafts and twine. In Bhutan, split cane is used by yak herders throughout the mountains to weave horse packs. It has anti-inflammatory, astringent and anti-diarrheal properties (Quattrocchi, 2017).

Conservation status:

It is mainly harvested from the wild, is moderately available and is threatened by habitat destruction due to the conversion of land for agriculture and logging purposes. It is a weakly suckering rattan, which produces only one or two additional stems, and poor regeneration was noted after harvesting. In India (Sikkim), the population declined severely due to harvesting over 100 years ago (Anderson, 1869).

Research needs:

Large scale production of superior planting materials, suitability for cultivation, physical and anatomical parameters of the stem need to be studied. A thorough understanding of the current population status is urgently required to assist with planning conservation measures.

C. acanthospathus - Habit, leaf sheath, infructescence @ Selim Mehmud.

2. *Calamus andamanicus* Kurz

Synonyms:

Calamus semierectus Renuka & Vijayak.

Palmijuncus andamanicus (Kurz) Kuntze.

Common names:

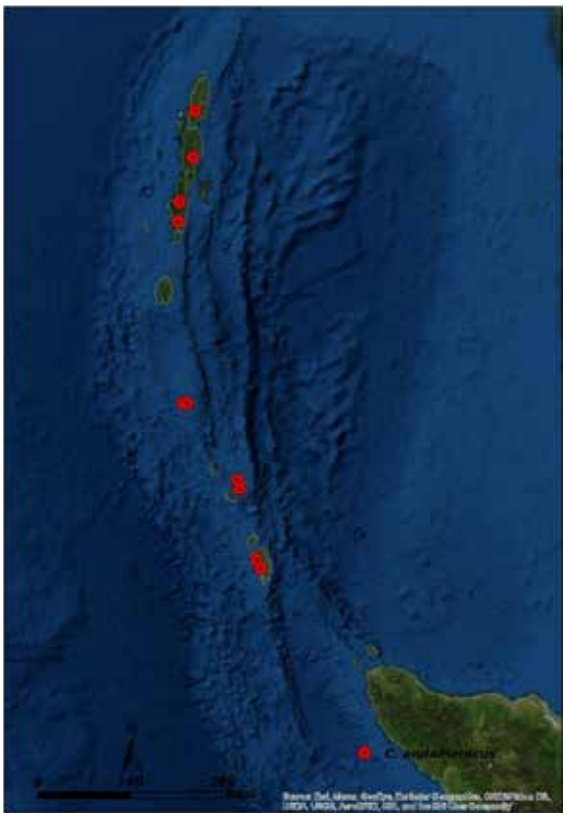
India: charab, chowdah, hokneak, mofabet, mota bet, mota beth, nat, otaang, ottang, thaing kyein.

Description:

Solitary large-diameter rattan, climbing, up to 24 m or more in length, 4.5–5 cm in diameter without leaf sheath, straw-yellow colour when exposed; leaf sheath ranges from slightly pale yellow to reddish-brown colour, thick woody appearance with minute bristle-like black spines, arranged in comb-like narrow crests, easily detached; knees present; indistinct ocrea; very robust petiole; cirrate leaves; ellipsoid fruit, 1.5 × 0.9 cm in diameter, scales arranged in 17 vertical rows, brown with a dark-brown border, slightly channelled.

Geographical distribution:

India (Andaman & Nicobar Islands).



Ecological requirements:

Distributed in lowland rainforest areas at an elevation of 20 m (1–50 m). The main associated species are *Pterocarpus dalbergioides*, *Canarium euphyllum*, *Dipterocarpus grandifloras, Dipterocarpus gracilis*, *Syzygium samarangense*, *Artocarpus gomezianus*, *Caryota mitis* and *Garcinia andamanica.*

Cultivation:

No plantations; only natural populations. The experimental trials in Kerala exhibit good growth; however, large evergreen trees such as *Pterocarpus dalbergioides* are required to provide climbing support.

Uses:

C. andamanicus is extensively used in the furniture industry for the production of chairs, tables, beds, cane bridges, tops, wickerwork, baskets and containers, furniture frames, walking sticks, polo mallets, umbrella handles and more. The leaves are used as a thatching material as well as for weave mats. When cut, the stem yields a fair amount of good water, which the Great Andamanese drink in the forest to quench thirst (Awasthi, 1991; Chakrabarty and Balakrishnan, 2003). The Shomben tribe of the Great Nicobar Islands uses this rattan to make folklore artifacts (Sharief and Panda, 2021; Senthilkumar et al., 2014). Young leaves are used by tribal communities in making stews, soups, pickles, chutneys and curries (Singh et al., 2013). The fruit is also edible (Tigga and Sreekumar, 1996). Moreover, this rattan exhibits anti-inflammatory, astringent and anti-diarrheal properties, and it is used to treat skin diseases.

Conservation status:

As this is a solitary species, the extraction of cane prior to flowering age drastically affects the natural regeneration and, therefore, for *in situ* conservation the identification of top-priority sites is urgent.

Research needs:

There is an urgent need for mapping the existing population, understanding population genetic structure and development of molecular markers for gender identification at the seedlings stage. It is also important that the samples representing different islands to allow for population characterisation in terms of the variation in size, quality and apparent ecological requirements. Large-scale production of high-quality planting material via tissue culture techniques and immediate restoration programmes are also needed.

C. andamanicus - Habit, leaf sheath, fruit @ VB Sreekumar.

3. *Calamus applanatus* (A.J. Hend. & N.Q. Dung) A.J. Hend.

Synonym:

Daemonorops applanata A.J. Hend. & N.Q. Dung.

Common names:

None recorded.

Description:

Clustering rattan, climbing, up to 20 m long, 2.2–3.6 cm in diameter without leaf sheath; leaf sheath spines dense, flattened, prominent ocreas, not spiny, flagella absent, cirrate leaves, globose fruit, 1.5 × 1.2 cm, yellow-brown colour; scales deeply channelled; one-seeded.

Geographical distribution:

Vietnam (central and southern parts).

Ecological requirements:

Found in lowland rainforest area, often persisting in disturbed places, at an elevation of 299 m (20–790 m). This species is adaptable to different types of habitats.

Cultivation:

Unknown.

Uses:

Basketry, furniture industry.

Conservation status:

Unknown.

Research needs:

Very little is currently known about the basic biology of this rattan.

4. *Calamus aruensis* Becc.

Synonyms:

Calamus hollrungii Becc.

Calamus latisectus Burret.

Common names:

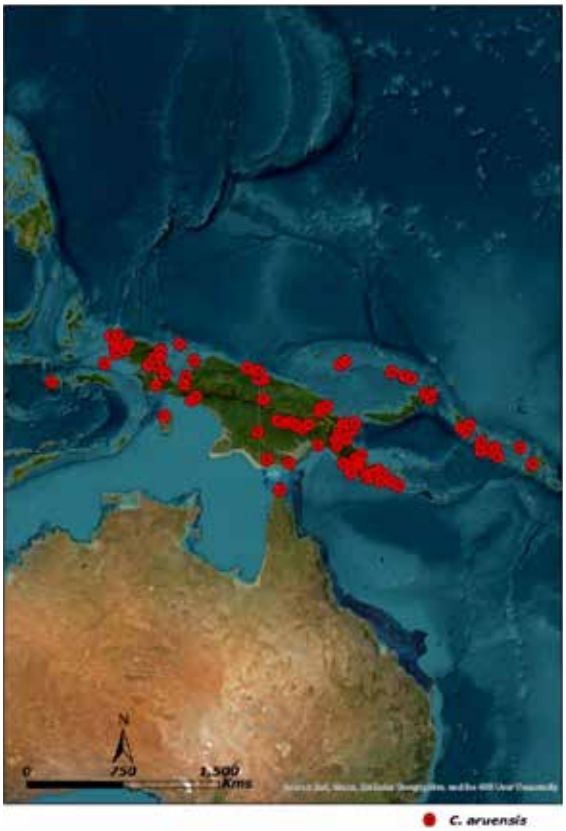
General names: bamaga waitawhile, Daintree lawyer cane, Lockerbie scrub waitawhile, Papuan white rattan; **New Ireland:** kalaua, kalawa, kuanua, magu, ni; **Papua New Guinea:** akalane, apo gui, bu, busep, dou, futepa, kanda, kaunor, kerowa, kou, kuminang, meya senga, minge, mumuni, proway, sate, sauwe, sehp, sel, sough, tek niali, to mur, to puot, tub, uawa jawa, wap, wampwang, war, wil dow, yapl; **Solomon Islands:** haikeletau, kalitau, karakara, obai, pata, pelo, piol, potonai, siku, suak, suaq, tikulu.

Description:

Robust, solitary, rarely clustered rattan, climbing, up to 50 m long, 3.5–5 cm in diameter, 16–39 cm internodes; leaf sheath spines range from short to elongated, narrowly triangular, horizontal or curved, scattered, yellowish-brown or dark-brown colour; short ocrea; flagella absent; cirrate leaves, globose fruit, 1.1 × 1.2 cm; yellowish-brown colour; fruit scales channelled longitudinally; one seed per fruit.

Geographical distribution:

Australia (Lockerbie Scrub and Jardine River catchment, northern Cape York Peninsula), New Guinea (including Bougainville Island) and Solomon Islands.



Ecological requirements:

Found in lowland or montane rainforest and secondary forest areas, or in littoral forest, swamp forest and seasonally dry monsoon forest areas, as small groups; most frequently found in lowland forest areas below 500 m.

Cultivation:

This species is easily available and, therefore, represents a promising target species for commercial exploitation in New Guinea (Baker et al., 2003).

Uses:

High-quality, medium-diameter rattan; limited use in the furniture industry; other uses include cordage for pulling heavy objects and building bridges, split cane for tying house timbers and cirrus for catching eels. The leaves are used as wrapping for sago and in the walls of houses. The young shoots are edible (Baker et al., 2003). It is also used for the treatment of diarrhoea, abdominal pain, constipation and loss of appetite (Quattrocchi, 2017).

Conservation status:

Unknown.

Research needs:

Very little is currently known about the basic biology of this rattan.

5. *Calamus caesius* Blume

Synonyms:

Calamus glaucescens Blume.
Calamus tapa Becc.
Palmijuncus caesius (Blume) Kuntze.
Palmijuncus glaucescens Kuntze.
Rotang caesius (Blume) Bail.

Common names:

General names: rattan segah, rotan sego; **Borneo:** sega, seka, sokag, uwei sigi, uwey seka; **Indonesia**: rotan sega, rotan sego, rotan taman, sega, sego aer, uwe sokaq, wey seka; **Kalimantan**: lakeu linau, rotan segah, rotan taman, sega, segah, sokaq, uäy säkäk, uwe sokaq, uwei, uwei sigi; **Malaysia**: rotan sega, rottan latong, sega; **Philippines**: seeka, sega, seka, sika, sikasika; **Sabah**: sege, sogoh, **Sarawak**: leutik, sega, uwai seka, wee sega, wi buru, wi jalai, wi letik, wi sega seluai; **Sumatra**: rotan sego, sego aer; **Thailand**: ka tae sa tong, ro tae sa kong, ro tan se ka, takathong, wa tae sa ko, wai ta kha thong, wai ta khla thong, wai takra thong, wai tha ka tong.

Description:

Densely clustering moderate-sized rattan, climbing, 60–100 m long; internodes up to 50 cm, highly polished cane surface; 0.7-1.8 cm diameter, dull-green colour, well-developed spines, brownish colour, triangular, often pointing downwards; prominent knees; short ocrea; cirrate leaves; ellipsoid fruit, 1.5 × 1 cm, yellow or pale-yellow colour; greenish-white fruit scales; one seed per fruit.

Geographical distribution:

Borneo, Peninsular Malaysia, Peninsular Thailand, Philippines, Sumatra (including Billiton Island). This species has also been introduced to China and the islands of Upolu, Western Samoa in the South Pacific for cultivation purposes.

Ecological requirements:

Grows in lowland rainforest areas, found in moist and rich alluvial soils, wide altitudinal range stretching from sea level up to 800 m (Weidelt,1996). Most frequently found in lowland areas on alluvial flats, riverbanks, freshwater swamp forests or the margins of peat swamp forests. High morphological variations among populations have been noted in Borneo, where this species was found in drier areas up to 800 m above sea level (Dransfield and Manokaran, 1993). This species can tolerate permanently wet and waterlogged or temporarily flooded soils (Borchard et al., 2018); young seedlings can even withstand severe flooding (Van der Maesen and Somaatmadja, 1989). In the initial growth phases, especially during the first few years of the establishment phase, sufficient light is required (Wong and Manokaran, 1985). Dransfield (1979) noted that *C. caesius* naturally grows on a wide variety of sites, ranging from peat-swamp forests to lowland or hill dipterocarps forests, although its growth

performance varies from site to site depending on the site quality. The major factor affecting growth is the level of equilibrium between the light required for photosynthesis and the protective shade (Nasi and Monteuuis, 1992). Optimum light and soil moisture regimes also play a key role. Growth was found to be superior when thinning canopy had been conducted prior to planting and in a poorly drained habitat (Manokaran, 1982a, 1982b).

Cultivation:

This species has a long tradition of small-scale cultivation in Borneo, where it is planted during the fallow period of the shifting cultivation cycle and harvested when the forest is felled for rice-planting. Dayak farmers in Indonesia plant rattan seeds or seedlings in their newly created agricultural fields (or ladang) alongside upland rice and other food crops such as maize, cassava and banana. In this way, the young rattan plants are protected in the ladang and, when farmers shift to a new plot 1–2 years later, the rattan is left to grow up with the secondary forest vegetation, thereby creating a 'kebun rotan' or 'rattan garden'.

Plantations of domestic, commercial and experimental production *C. caesius* have been available in different countries of Southeast Asia (Borchard et al., 2018) since the late 1970s (Dransfield, 1979). According to Manokaran (1982b), *C. caesius* can grow by as much as 5–6 m/year for the first five years of planting at near optimum conditions (with a thinned canopy and poorly drained soil). The average growth rate recorded for this species is 4–5 m/year; however, in exceptional cases, has been reported to be 7 m or more. The clump establishment of this species is rapid and, after five or six years, 20–50 or more aerial stems have been noted, depending on the growing conditions and provenance. Bacilieri and Appanah (1999) reported the high heritability of morphological traits in *C. caesius*, including the growth rate and the number of stems formed per clump. Two types of suckers are produced by *C. caesius,* one with lanceolate leaflets and one with vestigial leaflets, and there is no correlation between the canopy opening and the number or kind of suckers produced (Lee, 1998). This species can be intercropped with rubber trees, bungor (*Lagerstroemia* sp.) and fruit trees to provide shade and support.

The seedlings may be affected by leaf spot diseases caused by *Curuvularia, Collectotrichum, Phomopsis* and *Pestalotiopsis* species, which cause severely infected leaves to dry up. This can be controlled by applying fungicides at ten-day intervals. Leaf blight caused by *Collectotrichum gloeosporioides* is another major concern in this species. In the field, the tender young shoots are prone to attack by rats, squirrels, porcupines and weevils. Elephants pull out the seedlings or feed on shoots, whereas wild boars uproot the seedlings as they forage for roots and worms (Dransfield and Manokaran, 1993).

This species is mainly collected from Malaysia, Indonesia and the Philippines. In East Kalimantan, it is cultivated as part of the traditional swidden agricultural system and is a major source of internationally traded rattan raw material. In this system, farmers plant rattan seeds, wildings or seedlings in newly created agricultural fields (or ladang*)* where the average size of the rattan gardens is 1.4 ha and the density of the rattan clumps ranges from approximately 50 per ha to 350 per ha, with a mean of around 170 per ha (Garcia-Fernandez, 2001).

The yield of this species per ha per year is highly variable figures, ranging from 0.8 tons per ha (processed cane) in the case of eight-year-old plantations (Alloysius, 1999) to 1.5–3 tons per ha per year (Dransfield and Manokaran, 1993).

Uses:

C. caesius is one of the most demanding small-diameter species that is extensively used in the furniture and handicraft industries (Kadir, 2000). It has a pale-golden colour when cured, and it has the ability to split well (Weinstock,1983), which is why it is one of the preferred species for fine weaving. It is also used for cordage, house construction, sewing of 'atap' (thatch) and all types of binding and weaving in the furniture industry, in addition to being known for making the finest baskets (Blažková and Jeníček, 2006). It is a major source of cane for splitting and coring to make 'chair-cane' and coring for furniture construction in the international market (Van der Maesen and Somaatmadja, 1989). The famous 'tatami' mats or rattan carpets are mainly made from this species. Conelly (1985) investigated the profitability and economic potential of this species on Palawan Island in the Philippines. The Dayak people in East Kalimantan, Indonesia, use this rattan for the preparation of floor mats (lampit) and all-

purpose baskets (anjat or berangka) (Mulyoutami et al., 2009). In Indonesia, around 44,500 tons of sega rattan (*C. caesius*) are produced annually (Data Consult Inc, 1993).

Conservation status:

The harvesting of canes prior to flowering and fruiting severely affects the regeneration of wild populations.

Research needs:

C. caesius is a rattan with great morphological variability, suggesting that the collection of provenances to sample the wide variation in size, quality and apparent ecological requirements is a priority need. The Sabha Foundation in Malaysia has conducted some preliminary provenance trials. This species has immense international trade potential, meaning that, as a resilient and durable cane, standardisation of post-harvest processing technologies, identification of optimum harvesting age and resource enhancement through plantation is important. This is an ideal species for cultivation as a smallholder crop, although the prospects of cultivation in village orchards, marginal lands and buffer zones have yet to be studied.

C. caesius- Leaf sheath @ Andrew Henderson.

6. *Calamus deerratus* G. Mann & H. Wendl.

Synonyms:

Calamus akimensis Becc.
Calamus barteri Drude.
Calamus falabensis Becc.
Calamus heudelotii Becc. & Drude.
Calamus laurentii De Wild.
Calamus leprieurii Becc.
Calamus perrottetii Becc.
Calamus schweinfurthii Becc.
Eremospatha deerrata (G. Mann & H. Wendl.) T. Durand & Schinz.
Palmijuncus deerratus (G. Mann & H. Wendl.) Kuntze.

Common names:

Benin: akete, dekun wéwé; **Cameroon:** ndié, nding, penja; **Central African Republic:** bioh; **Congo:** babio, ikonga, kpude, lekwe, mandakele, mukolo; **Gambia:** tambo; **Ghana:** ayeka, ayeke, ayeké, demere, demmere, keteku, néné; **Guinea:** tãbi, tâbi, tambo, tembi; **Guinea Bissau:** batanor, batanou, bugál, ecapate, mantampadesera, nzing, quitite, quito, quito tambin, skote, tamben, tambin, tambô, tambo, tembi; **Ivory Coast:** ailémlé, gapapa; **Liberia:** kpa kala; **Nigeria:** apié, bwálàm, ekweoji, erogbo, erugbo, iye; **Senegal:** bu kètao, bu ketav, e kapat, fu fiaf, ka kèt, ka tay, ke hiya, kékiya, ki tia, ki tid, kintem, mantampa da sera, ratlan, tãbi, tambem, tambi, tambo; **Sierra Leone:** kangamese, lumboinyolando, ragbet, tamba, tambe, tambi, tambuna; **Uganda:** bilekwe.

Description:

Clustered, slender-to-moderate rattan, climbing, up to 20 m long, stem diameter without leaf sheath of 1.0–2.8 cm, 8–20 cm long internodes, leaf sheaths variously armed, spines usually long, triangular, dark-brown or black colour, flattened at base, mature sheaths with brown or grey indumentum; ocrea present and usually conspicuous; flagella well developed; ellipsoid fruit, at maturity 1.5 × 1 cm with a short beak up to 2 mm, with 17–20 vertical rows of scales; one seed per fruit, ellipsoid.

Geographical distribution:

Angola, Benin, Burkina, Gambia, Ghana, Guinea-Bissau, Guinea, Ivory Coast, Liberia, Nigeria, Niger, Senegal, Sierra Leone, Central African Republic, Cameroon, Congo, Equatorial Guinea, Gabon, Zaire, Sudan, Uganda and Zambia.

Ecological requirements:

Calamus deerratus is the most widely distributed rattan species in Africa. It is found in lowland rainforest areas, usually with a strong preference for swamp and riverine forests (Ainslie, 1926; Foggie, 1941; Ahn, 1961, Sunderland, 2012) at <500 m. Also reported at higher altitude regions of

East Africa at >1500 m elevation and is rather less common in areas with high rainfall. This species mostly prefers the drier gallery forest found in the transition zones between the Sudanian savanna woodland to the north of the Guineo-Congolian forest formation and the Zambezian savanna woodland to the south (Sunderland, 2012). It typically grows under the forest canopy, although it is also found in open areas as dense thickets. It can grow in both permanently and seasonally inundated forests or swamps (Sunderland et al., 2008). The highest population density for this species was noted in natural conditions in the climber category (2325 per ha) (Olajide and Udofia, 2008).

Cultivation:

This species can be propagated by seed. In Benin, flowering and fruiting have been reported for *C. deerratus* in December. The seed germinates better when the sarcotesta has been removed, whereas soaking the seeds in concentrated sulphuric acid or ethyl alcohol is detrimental (Sunderland, 2011). In Ghana, this species has been successfully propagated using rhizomes, with approximately 20% sprouting. It is mostly harvested from the wild, meaning that traditional management practices are not recorded for this species.

Uses:

C. deerratus has a wide range of traditional uses other than furniture, construction and weaving baskets (Sunderland, 2007; Sunderland, 2011), including tying fencing poles and scaffolding during house construction. This species is locally traded in West Africa, East Africa and Southern Africa (Zambia and Zimbabwe). The mature stems are used for making walking sticks and musical instruments. In Ghana and Nigeria, it is used locally for the construction of houses (Abbiw, 1990) and fences, whereas in Zambia and Uganda, in the absence of large-diameter stems, rattan furniture frames are made of two or three stems of this species joined together. Similarly, both whole and split stems are used for a wide range of products, such as baskets, chair seats, bowstrings and fish traps and weirs, and they are also used for tying house frames, rafters, thatch, fences and traditional suspension bridges (Omagor, 1999; Sunderland, 2011). In Equatorial Guinea, split stems are used in the fabrication of temporary market baskets. The leaves are used for thatching, and the palm heart is eaten. Macerated, grilled leaves are used for the preparation of a medicinal decoction that helps to reduce weight loss as well as to treat oedema caused by vitamin deficiencies (Quattrocchi, 2017).

Conservation status:

C. deerratus is not considered a threatened species according to the International Union for Conservation of Nature (IUCN) criteria. However, selective logging activities and overexploitation throughout many forest areas of West and Central Africa have detrimental effects on its population. According to Sunderland (2012) conservation status of this species is assigned as ‘Least concern (LC)’ category.

Research needs:

Although *C. deerratus* is considered inferior to other African rattan species in terms of its quality and physical parameters, it contributes to various household needs and a wide range of construction and weaving applications. There is growing interest of this rattan in Africa on account of its importance in the livelihoods of rural as well as urban people (Sunderland, 2011).

7. *Calamus egregius* Burret

Synonyms:

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

Common names:

China: duan ye sheng teng, duanye shengteng, liteng.

Description:

Clustering, moderate-sized rattan, climbing, up to 50 m long, stem diameter without leaf sheath 1.0–1.5 cm; yellowish-green colour leaf sheaths with brown hairs, with scattered, brownish, flattened and well-developed triangular spines, pointing downwards; conspicuous knees; flagella absent; cirrate leaves; brown fruit, ovoid, 2 × 1.6 cm, covered in 20 vertical rows of pale brown scales with dark margins; one seed per fruit.

Geographical distribution:

Southern China (Guangdong, Guangxi and Hainan) in lowland or montane rainforest areas.

Ecological requirements:

C. egregius generally prefers montane rainforest areas between 600 m and 1000 m in altitude. This species grows well in rich and moist soil, and it requires adequate light for optimum growth. It cannot adapt to full sunlight. In fact, overhead shade should be manipulated at approximately six-monthly intervals for the first 2–3 years of a young plant's life to ensure it receives sufficient light to grow vigorously. In China, the ideal growth conditions identified for this species include lateritic red soil, laterite soil and mountainous yellow-brown soil with an average annual temperature ranging from 19–25 °C. The ideal annual precipitation is between 1400 mm and 2800 mm, and the ideal average monthly temperature is 16 °C (Zeng et al., 2000). Approximately 40–50 % light penetration is generally considered to be ideal for promoting stem growth. In Jianfengling, Hainan Island, *C. egregius* is associated with *Lithocarpus* spp., *Cryptocarya* spp., *Dacrydium pierei, Podocarpus imbricatus, Madhuca hainanensis, Beilschmiedia* spp., *Nephelium topengii, Livistona saribus* and *Quercus* spp. (Xu et al., 1999).

Cultivation:

C. egregius is a weak suckering rattan, with two or three suckers reported per clump. It has great potential for development as a cultivated crop, both within and outside its native range. The mature, cleaned seeds are sown in sand beds and the seedlings are potted after the first leaf has emerged. The potted seedlings should be kept in partial shade for 10–12 months before planting (Dransfield and Manokaran, 1993). This species can be intercropped under trees, including *Gmelina hainanensis, Tectona grandis, Dalbergia odorifera, Adenanthera pavonina, Chukrasia tabularis, Homalium hainanense, Casuarina equisetifolia* and *Acacia* sp. Moreover, rubber plantations and artificial shelter forests are also common sites for rattan planting. Zeng et al. (2000) found that the most suitable areas for the cultivation of *C. egregius* in China are Huanan, Diannan and Qionghei.

The fruit begins to mature in October and ends in December. The fruit is propagated by seed. Collected mature seeds should be cleaned immediately after collection and then sown in sand beds, which germinate in 50–60 days. They should be transplanted to pots as the first leaf emerges. Seedlings are usually kept in partial shade for 10–12 months, and they can then be interplanted into secondary forests, artificial plantation forests and agroforestry systems. The mother stems in a clump should be harvested 10–12 years after planting. Morphologically, *C. egregius* is closely related to *C. simplicifolius*. Plantations of this species are found in Hainan and Guangdong in China. The growth rate reported for this species is 0.8 m/year (Sunderland and Dransfield, 2002) or 1.2–2.0 m/year (Dransfield and Manokaran, 1993).

Uses:

C. egregius provides a high-quality small-to-medium diameter cane with a creamy yellow colour and a glossy outer surface. It is widely used for binding and weaving material in the furniture industry as well as for house construction. The palm hearts are eaten (Henderson, 2009). Additionally, the young shoots are cooked and eaten as vegetables.

Conservation status:

This species is treated as 'Vulnerable A2c ver 3.1' according to the IUCN criteria (China Plant Specialist Group, 2004). The annual output of the canes from natural forests has drastically declined, mainly due to habitat loss and overexploitation.

Research needs:

As an excellent small-to-medium diameter rattan, this species has great potential to be introduced as a cultivated crop, which means that proper agronomy practices need to be developed. There is currently no information available on the current stock in natural forests, production and trade. A thorough understanding of the existing distribution pattern, population status, genetic diversity patterns and germplasm collection is essential. Similarly, the physical and mechanical properties of the cane need to be investigated.

C. egregius - Habit @ Li Rongsheng.

8. *Calamus erinaceus* (Becc.) Becc.

Synonyms:

Calamus aquatilis Ridl.

Daemonorops erinacea Becc.

Common names:

General name: Malayan mangrove rattan; **Cambodia:** phdao aeng, phdao toek prei; **Malaysia:** air, rotan air, rotan ayer, rotan bakau, rotan bakau, air, rotan batu; **Sarawak:** wi tibu; **Thailand:** wai phang ka.

Description:

Robust clustering rattan that tends to form thickets, climbing, up to 15 m long, diameter without sheaths of 2–3.5 cm, leaf sheath has orange-yellow to yellowish-green colour when fresh, very densely armed with slender grey-brown spines; flagella absent; cirrate leaf to 4.5 m long; globose fruit, relatively small, 1 cm in diameter, covered in 12 vertical rows of straw-coloured scales; rounded seed.

Notes:

C. erinaceus is a widely distributed and morphologically variable species that is found in several different areas. There are two recognised subspecies (Henderson, 2020): *C. erinaceus* subsp. *erinaceus* is distributed in lowland rainforest areas, often near the sea on the landward side of mangroves in Cambodia, Peninsular Thailand, Peninsular Malaysia, Singapore, Sumatra (including Bangka Island), Borneo and the Philippines (Palawan), whereas *C. erinaceus* subsp. *daemonoropoides* is only distributed in the Philippines (Luzon, Mindanao) in lowland rainforest areas.

Geographical distribution:

Borneo, Cambodia, Philippines, Malaya and Sumatera Thailand.

Ecological requirements:

The important habitats of *C. erinaceus* include estuaries, rivers, mudflats, seagrass beds, coastal sand bars and mangrove forests (Pillai and Piai, 2003), and it is among the total species of riparian vegetation (Jamal et al., 2017). *C. erinaceus* grows well in areas in which the annual daytime temperatures are within the range of 24–32 °C, although it is able to tolerate 20–37 °C, and it prefers a mean annual rainfall in the range of 2,500–4,000 mm. The preferred pH is in the range of 6.8–7.2, although it can tolerate 6.5–7.5, and 40–50 % light penetration is generally considered to be ideal for promoting stem growth.

Cultivation:

Propagation is by seed. A sufficient representation of both male and female plants should be ensured to maintain the sex ratio (Fern, 1997).

Uses:

Produces medium- to low-quality coarse cane. In Laos, the shoots are considered a delicacy and over half the species growing there are said to be cooked and eaten as vegetables.

Conservation status:

The conservation status of this species has yet to be updated.

Research needs:

Further knowledge of the basic biology of this species, including the cultivation practices, provenance trails, as well as the physical and mechanical properties of the cane is essential.

C. erinaceus - Habit @ Andrew Henderson.

9. *Calamus flagellum* Griff. ex Walp.

Synonyms:

Calamus jenkinsianus Griff.
Calamus flagellum var. *karinensis* Becc.
Calamus karinensis (Becc.) S.J. Pei & S.Y. Chen.
Calamus flagellum var. *furvifuraceus* S.J. Pei & S.Y. Chen.
Palmijuncus flagellum (Griff. ex Walp.) Kuntze.

Common names:

General name: monkey dung cane; **Bhutan**: rabi bet, reem, rheem, rhim, soka, tangtangma; **China**: chang bian teng; **India**: hoodoom bet, lee, leekhet, nagagola bet, putli bet, putti, bet, rabi bet, raidang, raidangbet, ramang, reem, resin; **Laos**: blong poul, bong poul, wai katok, wai kha nyai, wai, khanyai, wai lao, wai leum, wai long, wai mon, wai namleuang, wai, thabong, wai thoon; **Myanmar**: myauk chi kyein; **Nepal**: rabi bet; **Vietnam**: may nuoc da.

Description:

Clustered stems, climbing, up to 30 m long, 4.5–5 cm in diameter; leaf sheath is greenish-yellow colour with dark brown hairs, with densely arranged, black, brownish or yellowish flattened spines; flagella well developed, heavily armed; fibrous ocreas; inconspicuous knees; yellowish or brownish fruit, ovoid, 2.7–3 × 1.8–2.2 cm, deeply channelled longitudinally; one seed per fruit.

Geographical distribution:

Bangladesh, China (southern), India (north eastern part), Laos (northern), Myanmar (northern part), Thailand (northern), Tibet and Vietnam (north and central parts).

Ecological requirements:

Seen in lowland or montane rainforest areas at an elevation of 730 m (100–1,500 m). It grows in primary or secondary rainforests and is also found in subtropical broadleaved forests.

Cultivation:

Flowering has been reported in March, April and October, and the fruiting period is April–May. Propagation is by seed. There is no information on any other cultivation practices of *C. flagellum*.

Uses:

This medium-quality cane is used in the furniture and handicraft industries. The young shoots are eaten. The seeds are used as betel nut. The tender young shoots are eaten for stomach problems, removal of worms, dysentery, cold and coughing. It is rich in vitamin B complex. The canes are used for the preparation of fences, crafts, rope, mats and baskets. The leaves are used for roofing thatch.

Conservation status:

Overexploitation has resulted in the decline of natural populations.

Research needs:

C. flagellum is a potentially important species that could be promoted for cultivation in homesteads to provide edible shoots. Advanced processing technology for edible shoots to allow for storage in the form of powder needs to be standardised.

C. flagellum - Habit, leaf sheath @ VB Sreekumar, fruits @ Selim Mehmud.

10. *Calamus gracilis* Roxb.

Synonyms:

Calamus hainanensis C.C. Chang & L.G. Xu ex Miau Ru–huai.

Palmijuncus gracilis (Roxb.) Kuntze.

Common names:

General name: chicken egg cane; **Bangladesh:** mapuri bet; **China:** wai nan, hai nan sheng teng, xi jing sheng teng; **India:** chulibet, mapoori bet, mapuri bent, tsjera tsjurel, yoyee; **Laos:** wai hom, wai soum, wai tairtair; **Myanmar:** kyetu kyein; Thailand: wai hom, wai sam bai to; **Vietnam:** meuy saang, meuytheum.

Description:

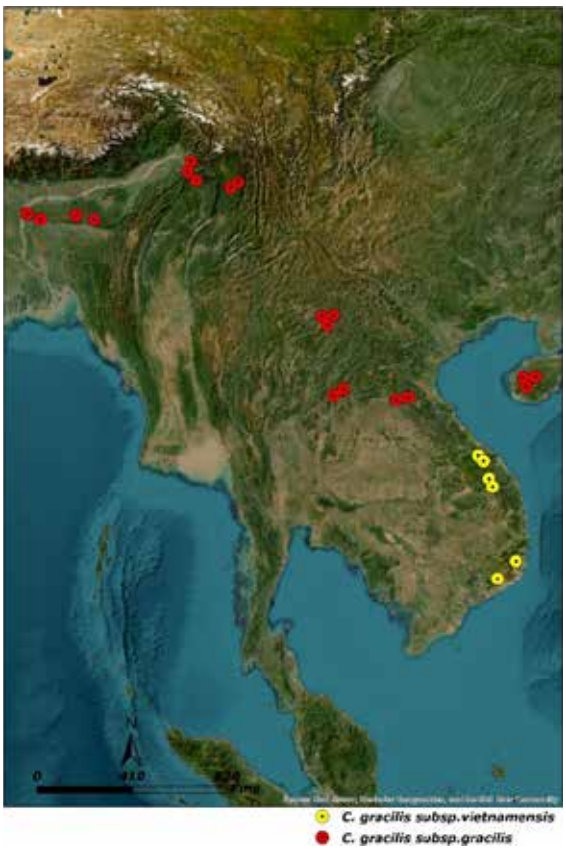
Clustered stems, rarely solitary, climbing, up to 30 m long, up to 2 cm in diameter; green leaf sheaths with mottled dark-brown and whitish hairs, short spines are scattered, black-tipped, sometimes upward-pointing; short ocreas; knees present; well-developed flagella; orange or red-brown fruit, ovoid to ellipsoid, 2 × 1 cm, stalked, grooved scales; one seed per fruit.

Notes:

Two subspecies are recognised (Henderson & Nguyen, 2018): *C. gracilis* subsp. *gracilis* and subsp. *vietnamensis* A. J. Hend. & N.Q. Dung.

Geographical distribution:

Bangladesh, China (Hainan, Yunnan), India (northeastern), Laos, Myanmar (northern) and Vietnam.



Ecological requirements:

Lowland or montane rainforests; an elevation of 800–1500 m.

Cultivation:

This species is common in Hainan Island and Xishuangbanna, Yunnan Province.

Uses:

The cane is high quality, very flexible and widely traded. It is used for handicrafts, making furniture, ballast baskets and seats. The cane can be split very fine. It is also used for various ceremonial, ritual and worship-related purposes. The young shoots are edible (Quattrocchi, 2017).

Conservation status:

This species is threatened by overexploitation and habitat loss. Renuka and Sreekumar (2012) noted that the Indian population in particular has declined considerably due to various levels of threats.

Research needs:

Little information is available about the basic biology of this species.

C. gracilis* subsp. *gracilis- Habit, leaf sheath, mature fruits @ Selim Mehmud.

11. *Calamus inermis* T. Anderson

Synonyms:

Calamus banlingensis Cheng Y. Yang, Zheng H. Yang & J. Lu.
Calamus distichus var. *shangsiensis* S.J. Pei & S.Y. Chen.
Calamus doriaei Becc.
Calamus giganteus var. *robustus* S.J. Pei & S.Y. Chen.
Calamus inermis var. *menghaiensis* San Y. Chen, S.J. Pei & K.L. Wang.
Calamus palustris var. *amplissimus* Becc.
Calamus palustris var. *longistachys* S.J. Pei & S.Y. Chen.
Calamus polydesmus Becc.
Calamus platyacanthus Warb. ex Becc.
Calamus platyacanthus var. *longicarpus* San Y. Chen & K.L. Wang.
Calamus platyacanthus var. *mediostachys* S.J. Pei & S.Y. Chen.
Calamus khasianus Becc.
Calamus multinervis var. *menglaensis* San Y. Chen, S.J. Pei & K.L. Wang.
Calamus nambariensis Becc.
Calamus nambariensis var. *alpinus* S.J. Pei & S.Y. Chen.
Calamus nambariensis var. *furfuraceus* S.J. Pei & S.Y. Chen.
Calamus nambariensis var. *menglongensis* S.J. Pei & S.Y. Chen.
Calamus nambariensis var. *xishuangbannaensis* S.J. Pei & S.Y. Chen.
Calamus nambariensis var. *yingjiangensis* S.J. Pei & S.Y. Chen.
Calamus obovoideus S.J. Pei & S.Y. Chen.
Calamus simplicifolius C.F. Wei.
Calamus wailong S.J. Pei & S.Y. Chen.
Palmijuncus inermis (T. Anderson) Kuntze.

Common names:

General name: mountain cane, partridge rattan, striped rattan; **China:** banla shengteng, changsui shengteng, dateng, nan ba sheng teng, wailing, gaodi shengteng, kuanci shengteng, kuanci teng, menglong shengteng, nan ba sheng teng, nanbashengteng, wailong, yingjiang shengteng, zhongsui, shengteng; **India:** hoka bhet, korak bet, leenan, rong, takat, takit; **Laos:** ka taeng kor dai, kateng blor, kateng koday, kloong, wai khairt, wai, khor, wai kieo, wai lai, wai leuang, wai namhang, wai namleuang, wai nokkhor, wai namba, wai niew, wai niuw, wai nok khor, wai nokkhor, wai nokkor, wai nokor, wai noun, wai nuan, wai nwan, wai nwn, wai tiu khaeng; **Myanmar:** Kadin, taung kyein; **Thailand:** wai dateng, wai hin; **Vietnam:** may song, song, song mat, song meut.

Description:

Solitary or clustered stems, climbing, up to 35 m long, diameter without sheath of 3 cm; green, yellowish or reddish-brown leaf sheath, with a distinct knee below the petiole, spines brownish, well-developed, triangular, often pointing downwards, swollen at the base distally; short ocreas, membranous, not spiny; flagella absent; cirrate leaves; ellipsoid fruit, 3 × 2.2 cm, white or yellow; fruit scales channelled longitudinally; one seed per fruit.

Notes:

According to Henderson (2009, 2020), *C. inermis* is a widespread and morphologically variable species. Moreover, it is treated as a polymorphic species with chaotic infraspecific variation. The economically important species representing different countries, namely *C. khasianus* (India), *C. nambariensis* (India, Laos, Myanmar, Thailand, Vietnam) *C. obovoideus* (China, Laos), *C. platyacanthus* (China, Laos), *C. simplicifolius* (China) and *C. wailong* (China, Laos, Thailand) are morphologically difficult to separate and so treated as synonyms of *C. inermis* (Henderson, 2020).

Geographical distribution:

Bhutan, China (southern), India (northeastern), Laos, Myanmar, Thailand (northern) and Vietnam.

Ecological requirements:

C. inermis is found in lowland or montane rainforest areas with elevations ranging from 100–2,000 m. In Nepal, it is localised in the mixed forests and lower hills, and it is mostly found in the middle hills in well-drained areas associated with evergreen tree species on the southern aspect of slightly steep sloped land at altitudes of 600–850 m (Chowdhary and Paudel, 2008). This species prefers black humus soil, although it can also grow in rocky patches. Generally, it prefers to grow in the upper canopy of trees that hang downwards. A study of the soils at Dhorbarahi in Tanahun (Nepal), where the species grows well, found that it likes neutral soil with a pH of approximately 7 with 3.5 % organic matter and an N: P: K ratio of 0.18 %: 120 kg/ha: 307 kg/ha. The associated tree species are *Schima wallichii* and *Castanopsis indica* (Chowdhary and Paudel, 2008).

Cultivation:

Normally, seed germination starts 50–60 days after sowing, the germination period continues after 120 days and the primary leaf develop 2–3 months later. After three years of planting, the first stem may exceed 1 m long and around 1–2 suckers in a clump that may appear from very short horizontal rhizomes. Three to four years after establishment, the stem grows at rates exceeding 3.0–3.5 m/ year under suitable climatic conditions. In a ten-year-old clump, a clump may represent around 12 aerial stems. Flowering begins in the fifth year after planting, whereas the phenological cycle differs slightly from place to place, although flowering generally occurs from February to March and ends in June when fruiting begins. The maturation of the fruit starts in late October, peaks in November and ends in early December, with it taking around 6–8 months for the fruit to mature (Rao and Ramanatha Rao, 1996). Plantations for cane production have been reported in Vietnam (Vu and Le, 1996). Although seedlings require the support of pre-existing tree crops and forest canopy, they still require adequate sunlight for healthy and fast growth (Dransfield and Manokaran, 1993). It has been estimated that, 10–11 years after establishment, the plantation is ready for the initial harvest, which will have an estimated yield of approximately 3.5 t/ha. It is also estimated that, within a 25-year management period, canes may be harvested five times in a rotation of five years, providing a total yield of approximately 11.5 t/ha.

Uses:

It is a robust, high-quality and widely traded cane with a medium diameter. It is suitable for all types of binding, weaving and furniture making. When abundant, it is also widely used locally for cordage, house construction

and the finest basket ware. The strong and flexible cane is used for handicrafts, bookshelves, binding, cradles, raft wrapping, furniture frames, sticks, alpenstocks and basketry. The young shoots are edible. It is used in the treatment of malaria (Wangpan and Tangjang, 2020). Due to being a robust cane, it can be used for police batons and for making furniture. In some areas, it is used as rope for binding purposes. The use of this species for making small local-level furniture for household items is common. This species is also used for ceremonial and ritual purposes, with the leaves used in poojas, at the time of marriage or in house-warming ceremonies (Quattrocchi, 2017).

Conservation status:

This species is threatened by overexploitation and habitat loss.

Research needs:

The morphological and population variability throughout this species' geographical range need to be studied. Provenance trials, germplasm collections and plantation technologies also need to be developed.

C. inermis – Habit, infructescence @ Selim Mehmud, leaf sheath spine variation @ VB Sreekumar.

12. *Calamus latifolius* Roxb.

Synonyms:

Calamus dumetorum Ridl.
Calamus gregisectus Burret.
Calamus kerrianus Becc.
Calamus latifolius var. *marmoratus* Becc.
Calamus loeiensis Hodel.
Calamus macracanthus T. Anderson.
Calamus palustris Griff.
Calamus palustris var. *cochinchinensis* Becc.
Calamus palustris var. *malaccensis* Becc.

Common names:

Cambodia: kantrong, kbang, phdao chhveang, phdao kontong, rong, tauonh; **China:** dianyue, shengteng, zhesheng; **India:** dunda beth, malai bet, wai; **Laos:** ray tae, re tair, wai hangnou, wai hom, wai kanebouang, wai karn buang, wai khairt, wai kieo, wai kiyow, wai leuang, wai nam hang, wai namhang, wai namleuang, wai sard, wai savang, wai tiu khaeng, wai tiukeng, wai xart; **Malaysia:** rotan buku hitam, rotan kembong, rotan manau, langkawi, rotan pasir, rotan sega badak, rotan sega beruang, rotan teling, sega; **Myanmar**: nagata, yamahtarkyein, yamata; **Thailand:** ko khae, sa kro ai, waai khring, wai khring, wai kring, wai ling, wai plawk, wai pok, wai sai kai, wai saikai, wai tiukeng; **Vietnam:** meuy tao.

Description:

Stems clustered or sometimes solitary, climbing, up to 30 m long, 5 cm in diameter; leaf sheaths are green with whitish or brownish hairs, with spines scattered or sometimes in partial rows, brownish, triangular, well-developed, long, pointing downwards with a swollen base, often black-tipped; ocreas present; knees present and prominent; flagella absent; cirrate leaves, up to 2 m long; ellipsoid to ovoid fruit, 1.2 × 1 cm, yellowish, with a pronounced projection at the tip, fruit scales not grooved; one seed per fruit.

Notes:

According to Henderson (2020), it is a morphologically highly variable species.

Geographical distribution:

Bangladesh, Cambodia, India (eastern and northeastern parts and the Andaman Islands), Laos, Peninsular Malaysia, Myanmar, Nepal, Thailand and Vietnam.

Ecological requirements:

In Cambodia and South Vietnam, it occurs in semi-dense forests, whereas in India, it occurs in moist lower hill forest communities up to 1000 m, mostly near freshwater swamps.

Generally, this species grows well in moist sandy loam soils and performs well in shade. It is found on the hill slopes of evergreen forests in the middle hills. Intercropping is possible under this rattan and other crops (Abdul and Raja, 2001). Usually, it prefers soil with a high percentage of organic matter (6.48%) and slightly acidic soil with a pH of 6.3 is ideal. In Nepal, *C. latifolius* is associated with sub-tropical tree species, especially *Schima wallichii* and *Castanopsis indica* (Chowdhary and Paudel, 2008). It is an ideal species for cultivation in old rubber plantations.

Cultivation:

This species has a high cultivation potential. It is propagated by seeds that are sufficiently available. In each fruit bunch, there are 500–1000 fruit. The seeds begin germination six weeks after sowing. This species can be planted under the stands of *Pinus caribaea,* in the secondary forest or in old rubber plantations. If sufficient light is available, it produces 5–15 stems per clump.

Uses:

This species is an excellent large-diameter cane similar to *C. manan*. The mature canes are strong, glossy yellowish-green in colour and are resilient, durable and flexible also. It is used for making furniture frames and household utensils. It is also used for making mats (Sharief et al., 2005), baskets (Doko), winnow (Nanglo), scaffolding, walking sticks, lathis, sticks and ropes. In India (Arunachal Pradesh, Manipur, Meghalaya), the stems and fruit are sold in markets and eaten raw. Moreover, they are widely used for making rough baskets, walking sticks and furniture frames, while the split canes are used for weaving chair bottoms. The leaves are used for thatching, and the tender shoots are eaten.

Conservation status:

In Bangladesh, it is regarded as under threat from illicit felling, overharvesting and intentional fire hazards during the dry season. In India, it is highly threatened due to overexploitation.

Research needs:

The mature canes are mainly extracted from natural forests and are dwindling at an alarming rate due to overexploitation and the destruction of natural forests. An assessment of the population's genetic structuring using robust molecular markers is necessary to identify better genotypes and also to plan conservation strategies. Similarly, seed stand and germplasm collection with regard to important populations is essential. Very little information is available about the growth strategies and optimum harvesting age of this species.

C. latifolius- Leaf sheath, leaves, fruit @ VB Sreekumar.

13. *Calamus leptospadix* Griff.

Synonym:

Palmijuncus leptospadix (Griff.) Kuntze.

Common names:

Bhutan: dangre bet, kukhre bet, lat, tangtangma, titipi; **India:** dangri bet, dhangre bet, dhangri bet, jatibet, jouting, lat, lejai bet, lejaibet, lithit, mugri bet, phekori, rab bet, rabi bet, rani, ronti, ruida, runti, teland, yaireemanbi, **Nepal:** dangre bet, dangri bet.

Description:

Clustered stems, climbing, up to 5 m long, diameter without sheath of 0.8–1 cm; leaf sheaths are green with greyish-brown hairs, with scattered to densely arranged, brownish, flattened, 15–20 mm long, subulate, half-whorled spines; ocreas present, densely bristled; knees present; flagella present; cirrus absent; globose fruit, 1 × 0.8 cm, brownish-pink, fruit scales channelled longitudinally; one seed per fruit.

Geographical distribution:

Bangladesh, Bhutan, India (northeastern), Myanmar (northern) and Nepal.

Ecological requirements:

Calamus leptospadix is mostly found on damp river plains. It forms big thickets and becomes a cluster-forming, high climber when it grows in moist valleys among tall trees (Basu, 1992). In Nepal, it is found in swampy areas near permanent water sources in the moist deciduous Sal forest. This species prefers to grow in soil with a pH of 6.9, an organic matter content of 1.5 % and an N: P: K ratio of 0.6 %: 49.2 kg/ha: 240 kg/ha. The associated tree species are *Shorea robusta*, *Trewia nudiflora*, *Syzygium cumuni* and *Terminalia* spp. (Chowdhary and Paudel, 2008).

Cultivation:

Not currently cultivated; harvested from wild resources.

Uses:

Being a thin and delicate cane, it mainly used for making rough baskets, rims of baskets and mats; however, the split canes are durable and so used for making chair bottoms. It is also used for making ropes, local baskets (Doko), sticks, etc. (Chowdhary and Paudel, 2008). The tender young shoots are bitter, but the mature fruit is eaten. The tender leaves are crushed into the form of a paste that is applied to treat poisonous bites.

Conservation status:

Overexploitation and shifting cultivation practices threaten habitats; urgent conservation measures are required.

Research needs:

It is important to understand the genetic variability and the prospectus for large-scale cultivation. It is also necessary to conduct provenance trials.

***Calamus leptospadix* Griff.**- Habit, leaf sheath, fruits @ Selim Mehmud.

14. *Calamus longisetus* Griff.

Synonyms:

Calamus tigrinus Kurz.

Palmijuncus longisetus (Griff.) Kuntze.

Palmijuncus trigrinus (Kurz) Kuntze.

Common names:

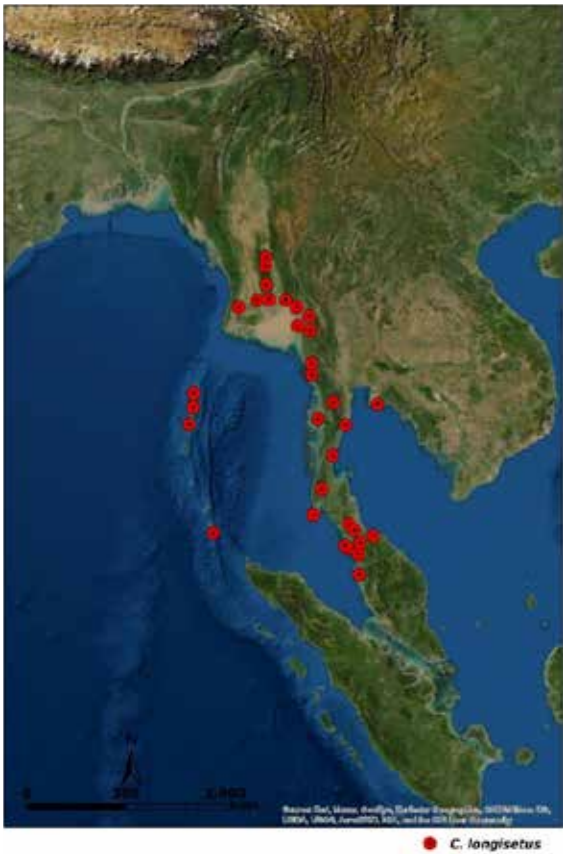
Bangladesh: bodom bet, udom bet; **India**: am, jungli bet, jungli kyein, umdah, undah; **Laos**: wai katok, wai leum; **Myanmar**: jungli kyein, khabaungkyein, leme, letmekyein, tharbaung; **Sri Lanka**: waiwel; **Thailand**: waai kam phuan, waigumpuon, wai kam phuan, waikamphuan, wai takha.

Description:

Very robust clustering rattan, climbing, up to 50 m long, with sheath 10 cm in diameter; leaf sheaths are green with brownish hairs, with two kinds of spines, one large, flat, straight, triangular, usually black or brown in colour, the other shorter, needle-like, black, densely arranged; ocrea present and inconspicuous; knees present; flagella present; fruit ellipsoid, 3 × 2 cm, scales are dark brown with paler brown, lacerated fringes with prominent, flat, brown hairs; one seed per fruit.

Geographical distribution:

Bangladesh, India (Andaman and Nicobar Islands), Myanmar (southern), Thailand (southeast and western part) and Malaysia (northern peninsular areas) (Dransfield, 1979).



Ecological requirements:

Found in lowland rainforest areas, persisting in disturbed areas, at an elevation of 100 m (20–700 m). In the Andaman Islands, found in disturbed secondary forests associated with *Tetrameles nudiflora*, *Dipterocarpus* spp., *Terminalia* spp., *Sterculia* spp. and *Pterygota alata*.

Cultivation:

A species with high cultivation potential. The few plants brought to mainland India show that this species grows well in Kerala. Propagation is by seed. Cleaned seeds should be placed for germination as early as possible. Seed longevity can be extended for approximately eight months if the seeds can be stored in polythene bags with sawdust as the medium. The optimum temperature for storage is 4 °C. The yield of *C. longisetus* at 13-, 14- and 15-year-old plantations when intercropped in *Azadirachta excelsa* with fertiliser application demonstrated an average length of 17.77 m, 19.34 m and 23.68 m, respectively. The average cane diameter was 3.5 cm with 55% commercial length (Kuldilok and Satitviboon, 1999). The total productivity at the 13-, 14- and 15-year-old plantations was 1,028.65 m per rai[1], 1,113.87 m per rai and 1,357.35 m per rai, respectively. Kuldilok (2000)

[1] One Rai is a unit of measurement equivalent to 0.16 hectares commonly used in Thailand.

reported that the commercial length at the age of 8, 9 and 10 years was 78.00 m per rai, 189.01 m per rai and 456.33 m per rai, respectively.

Uses:

As a large-diameter, very-strong and good-quality cane, it is an important raw material for the furniture industry, where it is used for the preparation of rough baskets, furniture frames, chairs, etc. The leaves are used for thatching, and the fruit is eaten (Henderson, 2009).

Conservation status:

The species is not covered by the IUCN criteria. However, the wild stock is declining at an alarming rate due to overexploitation.

Research needs:

There is currently no specific collection available that represents the considerable variation of *C. longisetus* in the wild. Similarly, the physical and mechanical properties of the cane also need to be studied.

***Calamus longisetus* Griff.** - Habit, leaf sheath, female flower, fruit @ VB Sreekumar.

15. *Calamus manan* Miq.

Synonyms:

Calamus giganteus Becc.

Palmijuncus manan (Miq.) Kuntze.

Rotang manan (Miq.) Baill.

Common names:

General name: rotan manau; **Borneo:** ngenau; **Indonesia:** manau, uwe ngono; **Kalimantan:** manau, ngono, uwe ngono, uwei manau, uwei marau; **Malaysia:** coonk serpeek, manau, manau tikus, rotan, rotan manau, rotan manau telor, rotan manau telur; **Sumatra:** manau gajah; **Thailand:** ro tae ma nao, waai kho dam, waibubo, wai kho dam.

Description:

Massive, solitary, high-climbing rattan, up to 100 m long, stem without sheath is 8 cm in diameter, internodes to 40 cm long; leaf sheaths are dull grey-green with white waxy hairs, with scattered or grouped, black, flattened, triangular, long spines; knees present and conspicuous; armed; inconspicuous ocrea; flagella absent; cirrate leaves; globose fruit, 2.8 × 2 cm, brownish-yellow or straw-coloured; one-seeded.

Geographical distribution:

Borneo (South Kalimantan), Malaysia, Sumatra, Thailand and Java.

Ecological requirements:

Usually confined to hill dipterocarp forests. It is rarely found in lowland dipterocarp forests, and then mainly near steep slopes. It is most abundant at elevations between 600 m and 1,000 m, with a total range between 50 m and 1,000 m. This species is suitable for light (sandy), medium (loamy) and heavy (clay) soils, and it prefers well-drained soil. The suitable pH for the species includes acidic, neutral and basic (alkaline) soils. It can also grow in the semi-shade (light woodland) or no shade, and it prefers moist soil. Weidelt (1996) reported that *C. manan* prefers moist and rich alluvial soils or the lower slopes of hills.

Cultivation:

Mature fruit is available in May and can be propagated by seed. Seeds start germination in 3–15 weeks. In nursery conditions, the germination percentage is 74%, whereas in laboratory conditions, it is 76 %. The germination period varies from 3–9 weeks (Mohammed and Rahman, 1990). This species requires adequate light for optimal growth (Manokaran, 1977). Here, the growth of *C. manan* with a canopy opening of more than 1.8 m was better than that with smaller canopy openings, which indicates that light is a crucial factor during initial establishment (Mohammad, 1984). This species can tolerate a fairly broad range of forest growing conditions and does not appear to have very specific microhabitat requirements. The rattan planted in natural forests exhibits very slow growth, with canes ranging

from 0.05–23.51 m and reaching 3.14 m on average (Noor and Rasali, 1987). Studies conducted in Malaysia reported a growth rate of 0.3–3.0 m/yr for *C. manan* intercropped with rubber trees (Blazkova and Jenicek, 2006). This species, along with *C. palustris*, is currently being cultivated in different planting systems, including intercropping with rubber and acacia trees and planting in logged-over forests (Nur Supardi and Aminuddin, 1992). Broadbent et al. (1982) noted that *C. manan* is often cultivated under mature rubber plantations, which need a high input of fertiliser to produce a satisfactory growth rate. As with other rattan species, identification of the sex during the seedling stage of *C. manan* is quite difficult for cultivation and breeding purposes, with it taking 5.5 years to identify the gender of *C. manan* by means of inflorescences (Choong and Wickneswari, 2016). In Peninsular Malaysia, this species represents the oldest trial of rattan planting on a 0.6 ha plot in Sungai Buloh Forest Reserve, Selangor, in 1966. Later, in 1972, *C. manan* was planted under a 17-year-old trial plot of *Pinus caribaea* in Trenggun Forest Reserve, Kuala Lipis, Pahang. Subsequent to this, the intercropping of *C. manan*, *C. scipionum* and *C. palustris* was performed with rubber trees and oil palm.

Uses:

A large-diameter cane with excellent quality, it is locally known as 'rotan manau'. The mature cane is durable, very hard, superior in terms of its mechanical properties, very strong and very flexible. In Indonesia, the two best species of rattan used for producing good furniture are locally known as manau rattan (*C. manan*) and sega rattan (*C. caesius*). It is estimated that around 47,440 tons of manau rattan and 44,500 tons of sega rattan are produced annually in Indonesia (Data Consult Inc, 1993). The stem of this species is of sufficiently high quality to be used in various types of handicraft products and furniture. The rattan fruit is often traded by communities around the forest, especially the Dayak tribes in East Kalimantan, and it is eaten row (Salusu et al., 2018). *C. manan* is also used as a medicinal plant for treating fever by ethnic groups throughout Sumatra, which is based on heredity (Adi et al., 2020). In Cirebon, Indonesia, *C. manan* is used in the furniture and webbing rattan industries (Effendi and Rostiwati, 2014), and the fruit of *C. manan* has high antioxidant and antibacterial activity (Salusu et al., 2021). In West Malaysia, *C. manan* fruit is used for food, medicine and stem used for making handle of 'adze' locally known as "se'uk" (Ave, 1988). It is used as an ornamental species in home gardens in Perak, Malaysia (Ramli et al., 2021). The stem of *C. manan* is used by the Talang Mamak tribe of Indragiri Hulu Regency, Indonesia, as a handicraft material.

Conservation status:

Although this species is found over a wide geographical range, overexploitation and harvesting prior to flowering and fruiting in many areas have resulted in severe population depletion, which led to it being designated 'Vulnerable' by the World Conservation Monitoring Centre (WCMC) in 1997. Habitat destruction and degradation are also considered reasons for the observed population decline.

Research needs:

The identification and molecular characterisation of existing populations, development of provenance trials, germplasm collection and standardisation of tissue culture techniques for large-scale production of high-quality planting materials are all suggested as important priorities for this rattan. In Peninsular Malaysia, seeds have been collected and planted in four locations, and studies concerning the growth performance of these trials are also required. As the wild stock of this species is rapidly declining, the feasibility of growing it in rubber plantations and the analysis of its productivity represent other priority areas.

16. *Calamus melanochaetes* (Blume) Miq.

Synonyms:

Acanthophoenix grandis André.
Calamus acanthopis Griff.
Calamus angustifolius Griff.
Calamus aureus (Renuka & Vijayak.) W.J.Baker.
Calamus binnendijkii (Becc.) W.J.Baker.
Calamus fissus (Blume) Miq.
Calamus grandis Griff.
Calamus hygrophilus Griff.
Calamus intermedius Griff.
Calamus jenkinsianus Griff.
Calamus kurzianus (Hook.f. ex Becc.) W.J.Baker.
Calamus lewisianus Griff.
Calamus luteus W.J.Baker.
Calamus manii (Becc.) W.J.Baker.
Calamus margaritae Hance.
Calamus monticola Griff.
Calamus nutantiflorus Griff.
Calamus pachyrostris (Becc.) W.J.Baker.
Calamus palembanicus (Blume) Miq.
Calamus rarispinosus (Renuka & Vijayak.) W.J.Baker.
Calamus sepal (Becc.) W.J.Baker.
Calamus singalanus (Becc.) W.J.Baker.
Calamus stenophyllus (Becc.) W.J.Baker.
Calamus treubianus (Becc.) W.J.Baker.
Calamus trichrous (Miq.) Miq.
Calamus wrightmyoensis (Renuka & Vijayak.) W.J.Baker.
Daemonorops aciculata Ridl.
Daemonorops angustifolia (Griff.) Mart.
Daemonorops angustispatha Furtado.
Daemonorops aruensis Becc.
Daemonorops aurea Renuka & Vijayak.
Daemonorops bakauensis Becc.
Daemonorops binnendijkii Becc.
Daemonorops carcharodon Ridl.
Daemonorops cinnamomea Schaedtler.
Daemonorops curtisii Furtado.
Daemonorops fissa Blume.
Daemonorops fissa var. *cinnamomea* Becc.

Daemonorops grandis (Griff.) Mart.
Daemonorops grandis var. *megacarpus* Furtado.
Daemonorops hallieriana Becc.
Daemonorops hygrophila (Griff.) Mart.
Daemonorops imbellis Becc.
Daemonorops intermedia (Griff.) Mart.
Daemonorops javanica Furtado.
Daemonorops jenkinsiana (Griff.) Mart.
Daemonorops jenkinsiana var. *tenasserimica* Becc.
Daemonorops kiahii Furtado.
Daemonorops kirtong Griff.
Daemonorops kurziana Hook.f. ex Becc.
Daemonorops laciniata Furtado.
Daemonorops lewisiana (Griff.) Mart.
Daemonorops malaccensis Mart.
Daemonorops manii Becc.
Daemonorops melanochaetes Blume.
Daemonorops margaritae (Hance) Becc.
Daemonorops melanochaetes var. *depressiglobus* Teijsm. & Binn. ex Becc.
Daemonorops melanochaetes var. *macrocarpus* Becc.
Daemonorops melanochaetes var. *macrocymbus* Becc.
Daemonorops melanochaetes var. *microcarpus* Teijsm. & Binn. ex Becc.
Daemonorops melanochaetes var. *padangensis* Becc.
Daemonorops monticola (Griff.) Mart.
Daemonorops nurii Furtado.
Daemonorops nutantiflora (Griff.) Mart.
Daemonorops ornata W.Bull.
Daemonorops pachyrostris Becc.
Daemonorops palembanica Blume.
Daemonorops pierreana Becc.
Daemonorops pseudosepal Becc.
Daemonorops rarispinosa Renuka & Vijayak.
Daemonorops schmidtiana Becc.
Daemonorops scortechinii Becc.
Daemonorops sepal Becc.
Daemonorops singalana Becc.
Daemonorops stenophylla Becc.
Daemonorops tabacina Becc.
Daemonorops treubiana Becc.
Daemonorops trichroa Miq.
Daemonorops wrightmyoensis Renuka & Vijayak.
Palmijuncus fissus (Blume) Kuntze.

Palmijuncus grandis (Griff.) Kuntze.
Palmijuncus hygrophilus (Griff.) Kuntze.
Palmijuncus intermedius (Griff.) Kuntze.
Palmijuncus jenkinsianus (Griff.) Kuntze.
Palmijuncus lewisianus (Griff.) Kuntze.
Palmijuncus malaccensis (Mart.) Kuntze.
Palmijuncus margaritae (Hance) Kuntze.
Palmijuncus monticola (Griff.) Kuntze.
Palmijuncus nutantiflorus (Griff.) Kuntze.
Palmijuncus palembanicus (Blume) Kuntze.
Palmijuncus trichrous (Miq.) Kuntze.
Rotang palembanicus (Blume) Baill.

Common names:

General name: nypa rattan; **China:** huang teng shu; **Indonesia:** hoe seel, howe seel, rotan legi, rotan lelo, sekei udang; **Java:** hoe seel, hoë selang, hooëh selan, hooëh sellang, hooy, penjalin manis, rottan selang, seel, seël; **Malaysia:** getah, rotan getah; **Thailand:** wai jark.

Description:

Clustered stems, rarely solitary, forming thickets, climbing, sometimes non-climbing, up to 30 m long and 7 cm in diameter; brownish-green leaf sheath with light brown hairs, with densely arranged, black, slender to stout, triangular, long spines; short ocreas, membranous, not spiny; knees present and conspicuous; cirrate leaves; globose to ellipsoid fruit, 2 × 1.7 cm diameter, brown, brownish, reddish-brown, red-brownish, brown–pink, orange, light orange, yellow-orange or pale yellow colour, fruit scales deeply channelled longitudinally.

Notes:

Morphologically variable size in terms of the sheath spine size and arrangement, width and spacing of the leaflets, arrangements of spines in different morphological parts of leaflets, colour of the fruit and shape of the seeds (Henderson, 2020). Several important species, such as *D. angustifolia, D. fissa, D. grandis, D. jenkinsiana, D. kurziana, D. lewisiana* and *D. manii* are treated as synonyms of *C. melanochaetes*. There are several identified morphotypes, including the *jenkinsiana* morphotype, *tenasserimica* morphotype, *singalana* morphotype, *manii* morphotype, *grandis* morphotype and *angustifolia* morphotype, details concerning which are given below.

***Jenkinsiana* morphotype**: The specimens have shorter, narrower and closely spaced leaflets. They are found in geographical areas in southern China (including Hainan), Vietnam, Cambodia, Thailand and Myanmar and extending into northeastern India and Bangladesh. They tend to be found in coastal areas and low- to medium-elevation areas.

***Northern* morphotype:** The specimens have relatively few, wider and more distantly spaced leaflets. They are found in north-central Vietnam, northern and central Laos, and northern and central Thailand.

***Jenkinsiana* morphotype:** The specimens represent *D. aurea, D. kurziana, D. manii, D. rarispinosa* and *D. wrightmyoensis* in the Andaman Islands and are distinguished by their sheath spine size and arrangement as well as other morphological features.

Geographical distribution:

Northeastern India, Andaman Islands, Myanmar, Thailand, Laos, Vietnam, southern China, Cambodia, the Philippines (Palawan), Peninsular Malaysia, Singapore, Sumatra, Java, Borneo, Sumbawa, Flores, Wetar and the Aru Islands. The species has also been reported in Bihar and Orissa in India (Haines, 1922), Bangladesh (Alam, 1990)

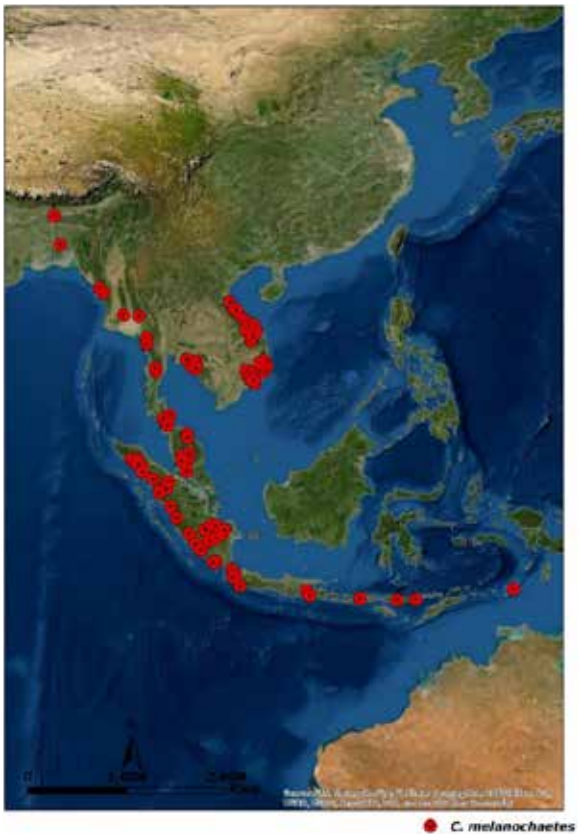
and East Timor (Kalima et al., 2019).

Ecological requirements:

Species are characteristic of alluvial or freshwater swamps, mostly in lowlands, up to an altitude of 1200 m; more frequent in disturbed areas.

Cultivation:

This species can be cultivated in alluvial soil near rivers, on flat to slight slopes, ridge tops and lowland forests, and it also thrives in degraded areas. The eco-physiological requirements for optimal growth of *D. margaritae* have shown that a temperature of 20–32 °C, 1500 mm annual rainfall with over 80% relative humidity, 30–50 % shade (Dransfield and Manokaran, 1993). The species grows well in fertile and damp soil with a medium to high amount of humus content (2.5–4.5 %) and a pH of 4.5–6.5. Seedlings require more sunlight than other plants for optimum growth (Dransfield and Manokaran, 1993). An 8- to 10-year-old clump may already consist of over 30 aerial stems. It has been estimated that the yield of the initial harvest could be approximately 9.9 t/ha 10–11 years after establishment and, in the subsequent years, re-harvesting may be performed four times in a rotation of five years (Dransfield and Manokaran, 1993).



Uses:

Provides cane used in furniture making and leaves used for thatching. It is used for all types of weaving and basket ware. The split cane is used for weaving handbags. The seeds are used for making necklaces, while the fresh shoots are collected as a vegetable (Dransfield and Manokaran, 1993).

Conservation status:

The exact conservation status is not recorded; sufficient quantities are available in the wild stock.

Research needs:

As a morphologically highly variable species, understanding the population's genetic variability, identifying superior genotypes and assessing species boundaries using DNA barcodes are essential.

C. melanochaetes- Habit @ Andrew Henderson. Leaf sheath with fruit @ VB Sreekumar.

17. *Calamus moseleyanus* Becc.

Synonyms:

Calamus grandifolius Becc.
Calamus jenningsianus Becc.
Calamus mindorensis Becc.
Calamus multinervis Becc.
Calamus reyesianus Becc.
Calamus spinifolius Becc.
Calamus subinermis Wendl. ex Becc.
Calamus viridissimus Becc.

Common names:

Philippines: bugtong, tumalin, tumaram, sarani; **Sulawesi:** bopaloa, hoa, powaloa, rotan hoa, rotan siumbo, tohiti tannage.

Description:

Solitary or clustering robust rattan with stems climbing to 40 m or more, stem diameter without sheath of 1.8-3.0 cm, internodes up to 20 cm; stem surface smooth, yellowish, very even; dull green leaf sheaths with thin to abundant greyish indumentum, densely spiny with swollen bases; knees present; cirrate leaves; fruit globose to ellipsoid, 1.8 × 1.3 cm, pale grey or light orange, scales in 18–20 vertical rows; one seed per fruit, small, globose.

Geographical distribution:

Found throughout the Philippines (including Palawan) and northeastern Borneo (Sabah) in lowland or montane rainforest areas.

Ecological requirements:

Mostly found in the interiors of dense primary forests at elevations ranging from 200–500 m; occasionally reported at the edges of primary forests or in secondary forests (Soerianegara and Lemmens, 1993).

Cultivation:

This species can be propagated by seed. The approximate harvesting age ranges from 8–10 years after planting.

Uses:

The unsplit stems are around 15–25 mm in diameter and are mainly used for making furniture. When split, they are made into baskets and cordage or used as tying material to thatch houses.

Conservation:

The exact conservation status of this species has yet to be assessed.

Research needs:

C. moseleyanus is an extremely morphologically variable species (Henderson, 2020). There are several forms available based on the local variation. The economically important species such as *C. mindorensis* is a synonym of *C. moseleyanus* which is found in Laguna and Quezon Provinces in Luzon, Mindoro, and Agusan, in addition to in Misamis Oriental and Bukidnon Provinces in Mindanao, Philippines. The collection and characterisation of all the morphological variants based on molecular markers should be prioritised.

18. *Calamus nagbettai* R. R. Fernandez & Dey

Synonyms:

Nil.

Common names:

India: nag bet, nagbetha, nag betta, naga betha, nagabetha.

Description:

Clustered stems, climbing, up to 25 m long and 10 cm in diameter; yellowish-green leaf sheaths with brown hairs, with densely arranged, grouped, dark-brown, flattened, triangular, up to 4-cm-long spines; knees present; flagella absent; cirrate leaves; ovoid fruit, 1.6 × 1 cm, brown.

Geographical distribution:

Southwestern India (Karnataka, Kerala).

Ecological requirements:

Found in wet evergreen forests up to an elevation of 1,500 m. The associated trees are *Calaophyllum polyanthum*, *Drypetes elata*, *Syzigium gardneri*, *Elaeocarpus serratus* and *Humboldtia deccurens.*

Cultivation:

Plantations are available in Karnataka, which are managed by the forest department.

Uses:

Used to make furniture and handicrafts. The stems are harvested from the wild for use in making baskets, cane furniture, etc.

Conservation status:

Highly threatened by habitat loss. Only a few mature individuals are available at ***Shendurney*** Wildlife Sanctuary. Poor regeneration. Conservation measures are urgently required.

Research needs:

As a promising rattan that is not available in sufficient qualities, the standardisation of tissue culture techniques, development of large-scale plantations and assessment of existing population structure are essential.

C. nagbettai- Habit, leaf sheath, young leaf, fruit @ VB Sreekumar

19. *Calamus ornatus* Blume

Synonyms:

Calamus aureus Reinw.
Calamus ornatus var. *celebicus* Becc.
Calamus ornatus var. *horridus* Becc.
Calamus ornatus var. *philippinensis* Becc.
Calamus ornatus var. *sumatranus* Becc.
Calamus ornatus var. *mitis* Becc.
Calamus ornatus var. *philippinensis* Becc.
Calamus ornatus var. *celebicus* Becc.
Calamus ornatus var. *pulverulentus* Fernando.
Calamus ovatus Reinw.
Palmijuncus aureus (Reinw.) Kuntze.
Palmijuncus ornatus (Bl.) Kuntze.
Rotang ornatus (Bl.) Baill.

Common names:

General name: black mountain rattan, elephant rattan, limuran palm; **Borneo:** jelayan, jelayang, kesoleg, tebongan, tebungan, uvey tebongan; **Brunei:** uwai kiton; **Indonesia:** hoe seuti, hoy seutti, jelayan, kesup, kesur, lambang, rotan buku, rotan buku dalam, rotan kesup, rotan lambang, rotan lambing, rotang kassur, rotang suttie, selian, seuti, wey tabongen; **Java:** hoe seuti, hooy seutti, hooy suttie, hoy seutti, penjaling retung, rotan latun, rotang suttie, seuti; **Kalimantan:** jelayan, sidong; **Malaysia:** coonk bantak, dok, mantang, rotan dok, rotan kembong, rotan manau kelesek, rotan kumbang, rotan kumbong, rotan manau kelichek, rotan mantang, rotan pujare, rotan saga badak, rotan sega, rotan sega badak, rotang suga butak, sek batang, we maliang; **Philippines:** alimuran, borangan, borongan, gamngan, kalape, kalapi, limuran, quwen, rimoran; **Sabah:** bontai, kowiten kusai, kowiton, lesun, losun, losun gobup, mangkawayan; **Sarawak:** we maliang, wi jalayan, wi maliang, wei maraw; **Sulawesi:** lambing; **Sumatra:** rotan besi; **Thailand:** waai chaang, waichang, wai chang yai, wai khao dam, waikhaodom.

Description:

Clustered or, more rarely, solitary stems, climbing, up to 60 m long and 8 cm in diameter; leaf sheath spines stout, pointing downwards; knees present; minute ocrea; well-developed flagella present; leaf cirrus absent; fruit ellipsoid, red, chestnut-coloured, brown or dark brown, 3 × 2 cm; one-seeded.

Notes:

According to Henderson (2020), this is a widespread and morphologically variable species. There exists wide variation within the leaf sheath spines, which can range from not spiny to scarcely spiny, densely spiny or spines arranged in horizontal rows. The fruit from all geographical areas is fairly consistent and, in this context, the separation of subspecific categories is not justifiable. All of the varieties are treated as synonyms of *C. ornatus*.

Geographical distribution:

Peninsular Thailand, Peninsular Malaysia, Singapore, Sumatra, Java, Borneo, Philippines (including Palawan) and Sulawesi.

Ecological requirements:

It prefers lowland rainforests or secondary forests at low elevations. It is able to grow in the lower light conditions of mature forests with well-established canopies (Powling, 2004). This species has not been seen at altitudes above 1250 m (Stiegel et al., 2011).

Cultivation:

It is a commercially important rattan that is propagated by seed and requires light gaps for growth and development. Cultivation trials of *C. ornatus* var. *philippinensis* were begun in Quezon, the Philippines, in 1977. In the early 1990s, 500 ha of *C. ornatus* var. *philippinensis* were planted under *Endospermum peltatum* (a matchwood tree plantation) in Mindanao (Dransfield and Manokaran, 1993). In Mindanao, the Philippines, a plantation with an area of 280 ha of this species is available, which was the Ecosystems Research & Development Bureau (ERDB). The published data concerning the inventory of rattan standing stock of this species show the annual allowable cut to be 606.39 tons per year (ITTO and MoF, 2008).

Uses:

Large-diameter rattan that, other than furniture, is used for making walking sticks, handles for umbrellas, axes and parangs, and flooring. The mature fruit of *C. ornatus* var. *philippinensis* is edible and commonly found in markets in the Philippines, Brunei and Sarawak. In Sarawak, drinking an extract prepared from the root of this species is believed to alleviate pain during childbirth.

Conservation status:

Threatened by overexploitation.

Research needs:

An exclusive collection of different varieties representing different geographical areas as well as an analysis of the physical and chemical parameters, molecular genetic diversity, selection of superior genotypes and seed stands are recommended for this species.

20. *Calamus ovoideus* Thwaites ex Trimen

Synonym:

Palmijuncus ovoideus (Thwaites ex Trimen) Kuntze.

Common names:

Sri Lanka: ma wewel, mawewel, sudu wewel, tambutuwel, tambutuwel, thambotu wel.

Description:

Clustered stems, climbing, up to 100 m long and 8 cm in diameter; brownish leaf sheaths with brown hairs, with closely spaced, densely arranged rings of dark brown, flattened spines; ocrea not well developed; knees present; flagella absent; leaves end in a cirrus, 2.5 m long; ovoid fruit, 1.6 cm × 1 cm, yellowish-green; one small seed per fruit, basally attached, ellipsoid.

Geographical distribution:

This species is restricted to the southwestern part of Sri Lanka, where it is considered an endemic species.

Ecological requirements:

Lowland or montane rainforest in wet places up to an elevation of 1,500 m. The ideal conditions include an average temperature of 27 °C, annual rainfall of 5,000 mm and relative humidity of 80–90 %. The preferred soils are mainly lateritic. It grows on well-drained slopes and is frequently found in forest gaps and other open sites. Juvenile clumps are seen as isolated, scattered individuals in the forest undergrowth, whereas mature climbers are often associated with disturbances, natural or manmade, in forest gaps, logged forests and edges of clearings (Dransfield and Manokaran, 1993).

Cultivation:

This species can be propagated by seed. Cleaned seeds must keep in moist conditions until sowing. The seedbeds can be prepared with a mixture of soil and sawdust or a similar loose mixture. The seeds start germinating 2.5–3 months after sowing, and the seedlings can be planted in the field after 10–12 months. The growth performance of this cane under pine plantations (*Pinus caribaea*) is moderate when compared with *C. zeylanicus* (Kathriarachchi et al., 2004). Observations of the growth patterns in pine plantations suggest that a sudden increase in light may trigger the climbing habitat. *C. ovoideus* flowers in April. Its fruit takes 5–6 months to mature, ripening during September and October. This species can be planted in other forest plantations (*Pinus caribae* and *Swietenia mahagoni*), other tree crop plantations (rubber) and home gardens where there are trees for support (Dransfield and Manokaran, 1993).

Uses:

Provides a high-quality, large-diameter cane used in furniture making and basketry. The cane is heavy and durable. The inner core is pale with hardly any soft pith (Dransfield and Manokaran, 1993). This species is in high demand

for furniture frames and handicraft items.

Conservation status:

Natural populations are threatened by habitat loss and overexploitation. This species is conserved in Peradeniya Botanic Gardens, Sri Lanka.

Research needs:

This excellent cane is not available in sufficient quantities to meet even local need. Information on the physio-chemical properties of the cane, data concerning its post-harvest treatment, germplasm collection, conservation of existing wild stocks and large-scale plantation trials are urgently required. The existing population is restricted to southwestern forest areas of Sri Lanka. To allow for large-scale production of high-quality planting, tissue culture techniques should be standardised after a proper selection.

21. *Calamus peregrinus* Furtado

Synonyms:

Nil.

Common names:

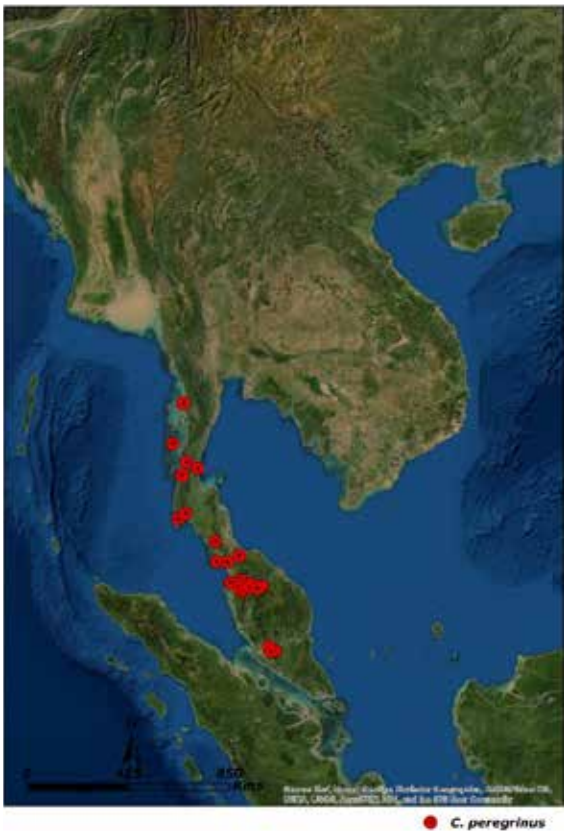
Malaysia: coonk beet, rotan, rotan jelayan; **Thailand:** nguay, wai ngouy, wai nguai.

Description:

Solitary stems, rarely clustering, climbing, up to 40 m long and 9 cm in diameter; leaf sheath marked with green and yellow in an irregular pattern, scattered or short rows of yellowish, black-tipped, triangular spines, with hairy margins; ocreas present; knees present; flagella present, up to 6 m long; leaf without cirrus; globose to obovoid fruit, up to 2 cm long and 1.6 cm in diameter, stalked, reddish-brown.

Geographical distribution:

Southern Myanmar, Peninsular Thailand and northern Peninsular Malaysia.



Ecological requirements:

This lowland rattan species is found on steep slopes and ridges in hill dipterocarp rainforests at elevations ranging from 50–500 m.

Cultivation:

Seeds start germination within three days of sowing and last up to 18 days. The mean germination value is 97.5 %. This species is suitable for areas in which the annual daytime temperatures are within the range of 22–30 °C, although it can tolerate 17–35 °C, and a mean annual rainfall in the range of 1,400–2,200 mm. Fertile medium- to light-texture soil with a pH in the range of 4–4.5 is preferred. The leaves of young plants are unable to withstand too much light. It can also grow in wet soils or areas with seasonal inundation habitats. Generally, in Thailand, this species prefers sandy-clay-loam, loamy-sand or sandy-loam with a medium to high amount of organic matter (1.8–3.9 %), a soil moisture content of 35–45 % and a potassium content of 65–90 ppm, although the phosphorus content can be low as 6–14 ppm. The preferred light intensity values range from 200–400 lux at a height of approximately 1.5 m from the forest floor, whereas on the forest floor, it varies from 100–300 lux (Vongkaluang, 1985).

Uses:

The robust canes are of good quality for furniture making. The young shoots are edible.

Conservation status:

The exact conservation status has not been identified. It might be threatened due to overexploitation.

Research needs:

Identification of gender-specific markers, germplasm conservation and population status assessment are suggested as high-priority needs.

Calamus peregrinus - Leaf sheath, fruit @ VB Sreekumar.

22. *Calamus poilanei* Conrard

Synonyms:

Nil.

Common names:

General name: white song; **Laos:** blong chang, blong thoon, blong thoun, bong toon, ga parl, gaparl, ka parl, wai khom, wai thoon, wai thoun; **Thailand:** wai kruh, wai nampung, wai thoun; **Vietnam:** song boat, song bot, u pôn.

Description:

Solitary stems, climbing, up to 150 m long and 7.5 cm in diameter; green or yellowish leaf sheaths with patches or stripes of brown hairs, with scattered, greenish, flattened, triangular spines; ocreas present; knees present; flagella present, up to 6 m long; ellipsoid fruit, 2 × 1.4 cm, brown.

Geographical distribution:

Eastern Thailand, southern Laos, and central and southern Vietnam.

Ecological requirements:

Lowland or montane rainforest areas. The elevation varies from place to place, for example, 300–1,350 m in Laos, 600–700 m in Thailand and 500 m in South Annam (Vietnam).

Cultivation:

There is no record of the existence of plantations or cultivation practices outside of forest areas. Nevertheless, this species has immense potential, as it is one of the most economically important rattan in Laos, dominating the export trade in raw cane and being the preferred species for use by artisans.

Uses:

One of the most economically important large-diameter rattans in Laos and Vietnam. Provides a high-quality cane with a large diameter for use in furniture making (Henderson, 2009). The shoots are edible.

Conservation status:

Highly threatened due to overexploitation, its solitary nature and the practice of harvesting stems prior to flowering and fruiting, which severely affects natural regeneration. Existing populations are declining at an alarming rate, meaning that urgent conservation measures are required. The harvesting of young shoots is another threat (Evans et al., 2001). A high risk of extinction has been reported in Laos and Vietnam (Quattrocchi, 2017).

Research needs:

Assessment of existing population status, development of *in situ* and *ex situ* conservation plans, introduction of

large-scale eco-restoration programmes and development of plantations for commercial purposes are urgently required to protect the existing resources.

C. poilanei - Habit @ Andrew Henderson.

23. *Calamus rhabdocladus* Burret

Synonyms:

Calamus pseudoscutellaris Conrard.

Calamus pseudoscutellaris var. *cylindrocarpus* Conrard.

Calamus rhabdocladus var. *globulosus* S.J. Pei & S.Y. Chen.

Common names:

China: r'sui, zhang teng; **Laos:** blong salay, bong sa lai, boon varn, bou wan, wai boun varn, wai boun yong, wai bounyong, wai bounwan, wai thabong, wai van, wai wan; **Vietnam:** may heo.

Description:

Clustered stems, climbing (sometimes erect), up to 40 m long and 6 cm in diameter with sheath; green leaf sheaths with reddish-brown hairs, with densely arranged, oblique rows of glossy, black or brown, flattened, long spines; ocreas present; knees absent; flagella present; leaf cirrus absent; globose, ellipsoid or ovoid fruit, 1.4 × 0.8 cm, reddish or yellowish; one-seeded, small, ellipsoid.

Geographical distribution:

Southern China (Fujian, Guangdong, Guangxi, Guizhou, Hainan, Yunnan), Laos and Vietnam.

Ecological requirements:

Lowland or montane rainforest areas. It grows densely in secondary forests at elevations ranging from 20–1,800 m.

Cultivation:

There is no information on cultivation practices concerning this species. It can be propagated by seed.

Uses:

Provides a medium-quality cane for use in furniture making and handicrafts. The skin is smooth with a beautiful colour, easily split and hard to bend. It is often used for making walking sticks, frames for tables and sofas. This species can also be used in the form of unsplit, unpeeled canes. The palm hearts and fruit are eaten (Henderson, 2009). While the apical buds and fruit are the edible parts (Li, 2007), the leaves are used for thatching.

Conservation status:

A widespread species that is not highly threatened.

Research needs:

A species with huge marketing potential that can be cultivated in secondary forests due to forming dense thickets. The skin is smooth with a beautiful colour, although its fibre is loose and its internodes are short. The mechanical and physical properties of the cane require investigation.

C. rhabdocladus - Habit @ Andrew Henderson.

24. *Calamus rheedei* Griff.

Synonyms:

Calamus travancoricus Bedd. ex Becc.

Daemonorops rheedei (Griff.) Mart.

Palmijuncus rheedei (Griff.) Kuntze.

Common names:

India: ari-chooral, kaattuchural, kattu chooral, kattu chural, kattutsjurel, kattuchural, kattucural, katu tsjurel, kiri betha.

Description:

Clustered stems, climbing, up to 10 m long and 1 cm in diameter; internodes up to 20 cm long; green leaf sheaths with brown hairs, with irregular, black, needle-like long spines; ocreas present; knees absent; flagella present; leaf cirrus absent; globose fruit, 1.3 × 0.9 cm, stalked, yellowish-brown colour; fruit scales channelled longitudinally; one seed per fruit, basally attached.

Geographical distribution:

Southwestern India (Kerala).

Ecological requirements:

This species is distributed in evergreen forests, often in areas in which canopy openings are present. The altitude varies from 50–100 m. It is often represented in sacred groves. The associated species include *Actinodaphne hookeri*, *Cinnamomum zeylanicum*, *Vateria indica* and *Syzygium zeylanicum.*

Cultivation:

Seeds represent the major source of planting material. This species can be cultivated under teak plantations or other agroforestry trees. It prefers high light intensity. Small-scale seed stands are available to ensure the production of seedlings for restoration programmes.

Uses:

Provides a good-quality, small-diameter cane used for basketry and furniture making. It is also used for tying and rafting furniture, for binding purposes and for making chairs, blinds, mats, wicker or basketwork, fishing implements, etc. The mature fruit is edible.

Conservation status:

Extraction of this cane from natural forests is banned by the Kerala Forest Department. It is highly threatened and associated with a poor regeneration pattern.

Research needs:

Apart from forest areas, this species is also found in sacred groves or remnant forest patches in villages. It is an ideal species for cultivation in homesteads, especially for smallholders in villages. Its colonising nature, small diameter and high-quality cane can generate regular income. As an added bonus, cultivating this species also helps to enrich the vegetation in home gardens. Standardisation of tissue culture techniques and trail plantation in different agro-climatic zones need to be achieved before introducing it to home gardens.

C. rheedei - Habit, leaf sheath, fruit @ VB Sreekumar.

25. *Calamus rudentum* Lour.

Synonyms:

Calamus albus Pers.

Palmijuncus rudentum (Lour.) Kuntze.

Rotang rudentum (Lour.) Baill.

Common names:

General name: black thorn rattan, lizard rattan, splinter residue rattan; **Cambodia:** phdao dambang, phdao doumbong; **Laos:** boon, boun, boun dam, boun khao, wai boun, wai katok, wai khee sian, wai long, wai tabong, wai thabong; **Maluku:** putih, uwa ela, uwa puti, uwa putih; **Thailand**: waai khee sian, wai khi sian, wai ky sien, wai nam dam, wai pong, wai pongg, wai tabong, wai yae, wai yea; **Vietnam:** may saong, songda.

Description:

Clustered stems, climbing, up to 75 m long and 7 cm in diameter; yellowish-green leaf sheath with brown hairs, with densely arranged rows of yellowish to black, flattened, long spines, often interspersed with shorter, needle-like spines; ocreas present; knees absent; flagella present, up to 10 m long; leaves not cirrate; globose-ellipsoid fruit, orange-brown or whitish colour, 2 × 1.5 cm, yellowish fruit scales deeply channelled longitudinally; one-seeded, large, basally attached, ellipsoid.

Geographical distribution:

This species is distributed in Southern Myanmar, Thailand, Laos, Cambodia, southern Vietnam and northern Peninsular Malaysia.

Ecological requirements:

This species is found in lowland evergreen and secondary forests, often in disturbed areas at elevations of 150–500 m. In Laos, it is found in lowland evergreen and scrub forests at 200 m, whereas in Thailand, it is seen in evergreen forests at 100–400 m elevations.

Cultivation:

Cultivation details are not available. Propagation is by seed.

Uses:

Provides high-quality, large-diameter cane used for handicrafts, bookshelves, weaving and basket weaving, beds, tables and sofas, chairs, and frames and supports for furniture. The fruit is also eaten (Henderson, 2009). Roasted shoots are eaten as part of postpartum recovery and postpartum diet, lactagogue, typically consumed with salt and sticky rice (Quattrocchi, 2017).

Conservation status:

The exact conservation status is not known. Being an economically important species that is widely traded and

facing extraction pressure may lead to the gradual diminishment of its population and regeneration status. In Vietnam, this species is highly degraded and its volume production has been reduced due to overexploitation (Binh, 2009).

Research needs:

As resources are scarce due to intensive and extensive overexploitation, the development of provenance trials, genetic improvements, raising large scale plantations and harvesting technology for this species are suggested.

C. rudentum- Habit @ Andrew Henderson.

26. *Calamus tenuis* Roxb.

Synonyms:

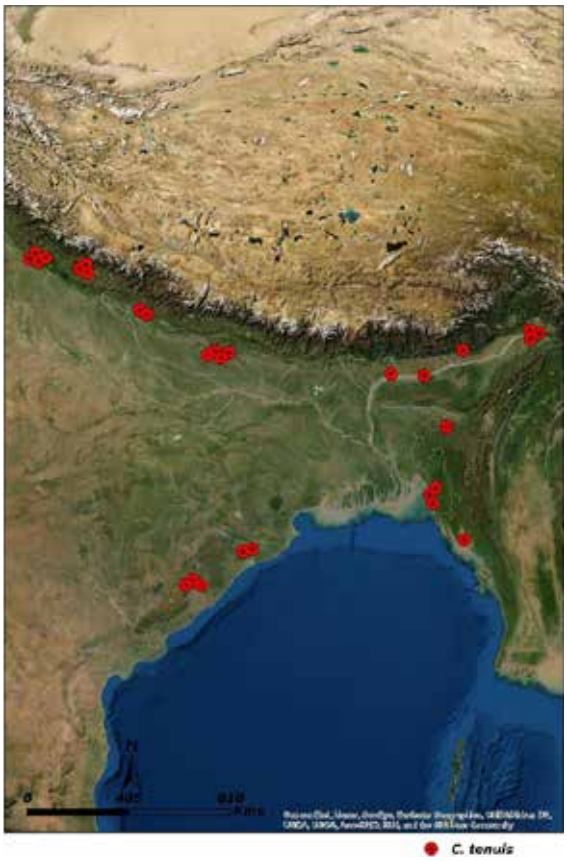
Calamus delessertianus Becc.
Calamus royleanus Griff.
Calamus heliotropium Buch.- Ham.
Palmijuncus heliotropium (Buch.- Ham.) Kuntze.
Palmijuncus royleanus (Griff.) Kuntze.
Palmijuncus tenuis (Roxb.) Kuntze.
Rotang royleanus (Griff.) Baill.

Common names:

General name: bareilly cane, water cane; **Bangladesh:** jali bet; **Bhutan:** kukhray, bet, panni bet; **India:** bandhari bet, bent, bernt, bet, chulibet, jail bet, jali bet, jalibet, jatee bet, jatee bhet, jati bet, jatibet, kashribet, may dan, pani bet, raibet, taiting, vetasa, vetra, yairee, yairi; **Java:** seel, **Laos:** nyae, nyair, wai daeng, wai khom, wai nam, wai num, wai numpueng, wai nyair, wai nyeh, yo re dark; Malaysia: rottan gelag; **Myanmar:** bareillykyein, tayelikyein, yekyein; **Nepal:** bet, pani bet; **Thailand:** wai chumphon, wai khom, wai numpueng; **Vietnam:** meuy daang.

Description:

Clustered stems, medium-sized, often forming thickets, climbing, up to 20 m long and 2.5 cm in diameter; green leaf sheaths with brownish-white hairs, often with ridges, with scattered or rows of greenish-brown or black, flattened, long spines; ocreas present, small; knees present; flagella present, up to 2.5 m long; leaf cirrus absent; globose to ellipsoid fruit, 1.6 × 1.2 cm, whitish or yellowish-brown colour; scales channelled longitudinally; one seed per fruit, basally attached, small, globose.



Geographical distribution:

Bangladesh, Bhutan, India (northern and northeastern areas such as Arunachal Pradesh, Assam, Bihar, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, Uttarakhand, Uttar Pradesh and West Bengal, and possibly farther south in Madhya Pradesh), Cambodia (also in Java and Sumatra), Laos (central), Myanmar (Kachin, Rakhine, Sagaing, Tanintharyi, Yangon), Nepal, Thailand (North, Peninsular) and Vietnam (Northern).

Ecological requirements:

C. tenuis needs to be near perennial water to grow well. In this regard, the water table, around 1–2 m from the surface, is most suitable for this species. It can also thrive in seasonally waterlogged areas. It grows well in damp places, lower hill valleys and seasonal swamp areas, and it is mostly associated with a riverine forest with altitudes of up to 300 m. In Nepal, the associated trees are *Bambax ceiba, Dalbergia sissoo, Syzygium cumini, Shorea robusta, Albizia procera, Acaica catechu, Terminalia alata, Mallotus philippinensis, Murraya*

koenigii, Flemingia spp, Dioscorea spp, Bauhinia vahillii, Clerodendron infortunatum and *Zyziphus jujuba*. In western Nepal, this species is found in black deposited loamy soil with a 1–2 m water table and a pH of 6.2–7.5 (Chowdhary and Paudel, 2008).

Cultivation:

Propagation is by seed or sucker. The seedlings are raised in nurseries and then planted at the onset of the rainy season. When planted, this species can be mixed with other crops such as peanuts (*Arachis hypogaea*). In an experimental trial of *C. tenuis*, better survival and growth performance were noted at higher altitudes under tree canopies. High-moisture areas are generally preferred. If planted in regular flooding areas, frequent floods increase shoot production (Baja-Lapis and Servaz-Audije, 2004). This species has been widely cultivated in Assam, Tripura and West Bengal in moist or damp areas and paddy fields or in the surroundings of small ponds attached to homesteads. It is an ideal species to be cultivated on the sides of ponds, floodplains, marshy lands, ditches and roadsides. It forms thickets.

Uses:

The high-quality cane is widely used for all-purpose household items, handicrafts, cottage industries, fences, rough baskets, mat screens, sticks, stools, ropes, etc. The ripened fruit is edible (Chowdhary and Paudel, 2008). The young shoots are harvested as a source of food similar to the other species such as *C. viminalis* and *C. siamensis.* In India, it is used for the treatment of diabetes mellitus, which involves the young shoots being consumed raw without salt and sugar on a daily basis for 7–10 days.

Conservation status:

Generally, this is not a threatened species due to its wide distribution and dense population in the lowland floodplains of India, Myanmar and Laos. However, it is severely threatened in Java.

Research needs:

This is a widely distributed species throughout Southeast Asia. As it is mainly used for the preparation of products based on its edible shoots, which represents one of the most promising areas for the support of rattan development, clear certification guidelines from the plantation through to product development are urgently needed. Similarly, regarding the feasibility of cultivation in different agro-ecological zones, an assessment of the socio-economic aspects of the edible shoot industry is also warranted.

C. tenuis - Habit, leaf sheath @ VB Sreekumar.

27. *Calamus tetradactyloides* Burret

Synonyms:

Calamus bachmaensis A.J. Hend., N.K. Ban & N.Q. Dung.

Calamus pulchellus Burret.

Common names:

Cambodia: hapeak, phdao changreth, phdao lpeak, saesoeng; **China:** duo ci ji teng, duoci jiteng, gaoshan jiteng; **Laos:** ka jack doy kha nae.

Description:

Clustered stems, climbing, up to 5 m long and 1 cm in diameter; greenish-brown leaf sheaths with brown hairs, with densely arranged, brown, needle-like, long spines; ocreas present; knees present; flagella present, up to 1 m long; leaf cirrus absent; sub-globose fruit, 1.5 × 1 cm, whitish; one-seeded, globose, small, basally attached.

Notes:

There are two recognised subspecies (Henderson, 2020): *C. tetradactyloides* subsp. *tetradactyloides* from China (Hainan) and *C. tetradactyloides* subsp. *bachmaensis* from central Vietnam.

Geographical distribution:

China (Hainan) and central Vietnam.

Ecological requirements:

In China, *C. tetradactyloides* subsp. *tetradactyloides* is found in lowland rainforest areas at elevations of 250–850 m, whereas in Central Vietnam, *C. tetradactyloides* subsp. *bachmaensis* has been recorded at elevations of 100–250 m. Grows well in places with annual rainfall is more than 2500 mm, mean annual temperature approximately 20 °C in moist red–yellow soil with a pH of 5.5–6.5.

Cultivation:

This species is under cultivation in Hainan Island, China, alongside other economically important rattans (Xu et al., 2000).

Uses:

It is used for the preparation of furniture, handicrafts and baskets. It is also used for weaving mats.

Conservation status:

Unknown.

Research needs:

As very little is known about the biology of this species, research should focus on various aspects like cultivation potential, physical properties of cane, and selection of superior phenotypes through provenance trails etc.

28. *Calamus tetradactylus* Hance

Synonyms:

Calamus batoensis A.J. Hend. & N.Q. Dung.
Calamus bonianus Becc.
Calamus cambojensis Becc.
Calamus crispus A.J. Hend., N.K. Ban & N.Q. Dung.
Calamus flavinervis A.J. Hend. & N.Q. Dung.
Calamus tetradactylus var. *bonianus* (Becc.) Gagnepain & Conrard.
Calamus solitarius T. Evans, Sengdala, Viengkham, Thamm. & J. Dransf.
Palmijuncus tetradactylus (Hance) Kuntze.

Common names:

General name: white rattan; **Cambodia:** phdau-dan, phdao lpeak, phdao seung, sae soeung; **China:** bai teng, baiteng, bayteng, jiteng, kai t'ang, paak t'ang; **Laos:** hang ngou, kacek doikanair, re peu, wai hakyong, wai hang noo nyai, wai hangnou, wai hangnou nyai, wai hangnounyai, wai noi, wai savang, wai thok, wai yong; **Thailand:** wai krit; **Vietnam:** cay mai, dot may, ha vay, ha way, maay neeps, maay ruootj gaf, maay tawts, may mat, may nep, may ruot ga, may tat.

Description:

Clustered stems, climbing, up to 6 m long and 1.8 cm in diameter; green leaf sheaths, without hairs, with scattered, yellowish-brown, triangular spines; ocreas present and prominent; knees present; flagella present, up to 1 m long; leaf cirrus absent; globose fruit, 1. 2 × 0.9 cm, cream-colored or yellowish; one-seeded, basally attached, small, globose.

Geographical distribution:

China, Cambodia, Hong Kong, Laos, Thailand and Vietnam.

Ecological requirements:

This species prefers lowland areas to hill slopes under 600 m in altitude, mainly in primary or secondary tropical forests, and it is also found in subtropical broadleaved forests. It flourishes in wet hollows and mountain valleys, and it is unable to withstand severe flooding (Dransfield and Manokaran, 1993). The natural population in the tropical monsoon rainforests of Jianfengling, Hainan Island, is approximately 800 clumps per ha. In general, the eco-physiological requirements include an air temperature of 20–30 °C (-20 °C or lower may damage young seedlings), more than 1300 mm of annual rainfall with a relative humidity of over 78 %, 50 % sunlight, fertile and damp soil with medium and high amounts of humus and a pH of 4.5-6.5 (Rao and Ramanatha Rao, 1996).

Cultivation:

Plantations and cultivation trials of *C. tetradactylus* are available. Seed viability is quite high. The seeds are collected

from ripe fruit, cleaned and then sown on sand seedbeds under shade. The seedbeds are covered with rice hay and watered regularly. Usually, the seeds start to germinate after 15–25 days and continue to do so for up to 65 days. The germination percentage with a moisture content of 25–35 % can reach 98 % or more (Dransfield and Manokaran, 1993). When the seedlings are approximately 10 cm high and have three leaves, they can be potted in plastic bags containing soil with humus. It takes nine months to one year in the nursery before the seedlings can be planted in the field (Baja-Lapis, 2009).

This is an ideal species for introduction into agroforestry systems, especially under fruit trees. It can also be interplanted in rubber plantations or in lowland scrubs and logged areas. Management practices such as thinning the forest canopy to optimise light penetration at 40–50 %, cleaning planting lines and enriching planting pits with organic manure to promote growth are suggested. Spacing of 1 m x 3 m, 2 m x 3 m or 1 m x 4 m is preferred, and the seedlings are planted singly or in groups of two. The development of the seedlings is rather slow. The first leaf appears after 2–3 months. After 18–30 months, the primary stem may exceed 50 cm in length and 2–3 sucker shoots may develop. Within 2–3 years of establishment, the aerial stem grows at a rate exceeding 2.0 m/year. More than 30 aerial stems can be expected in a seven-year-old clump under idle environmental conditions, with individual stems growing to a maximum length of 15 m. The inflorescence appears in March, peak flowering occurs in August and it takes around 7–8 months for the fruit to mature (Rao and Ramanatha Rao, 1996). The harvest at seven years after planting in an experimental plantation in Guangdong Province, China, showed a yield of approximately 1.2 t/ha while the second harvest in the eleventh year yielded around 1.1 t/ha. The projected yield of this species is 6 t/ha within a management period of 25 years (Dransfield and Manokaran, 1993).

Uses:

The slender, small-diameter canes are split and woven into fine baskets and trays, handicrafts and furniture. They are also used as rope for farm implements (Baja-Lapis, 2009). The stems provide a cane that is commonly used in weaving and basketry (Henderson, 2009).

Conservation status:

An exact population status assessment is required to determine the conservation status.

Research needs:

This is an excellent rattan with great potential for income generation in rural areas; however, its habitat has been largely destroyed and its population is declining. An assessment of the existing population status, prospects for the development of large-scale plantation, selection of superior genotypes, provenance trials, genetic improvement programmes, socio-economic aspects and utilisation potential is required.

C. tetradactylus- Habit, leaf sheath, leaf @ VB Sreekumar

29. *Calamus thwaitesii* Becc.

Synonym:

Calamus thwaitesii var. *canaranus* Becc.

Common names:

India: anachural, bettha, handi beettha, handi betha, handi bettha, handibet, handibetha, jeddubetha, jiddu bettha, panni chooral, pannichural, perappanakku, perappanaku thadi perambu, thadiperambu, thadiyan chooral, thadiyan chural, thadiyanchural, thatiyanchural, valiya chooral, vandi chooral, vandichural; **Sri Lanka:** kath wel, ma wewel, mawewel, periya pirambu, puwak wel, wanduru wel.

Description:

Clustered stems, climbing, up to 30 m long and diameter without the sheath of 3.5 cm, internodes 45 cm long; yellow-green leaf sheaths, with dense spines arising from a raised rim-like surface, strongly flattened; ocreas absent; knees absent; flagella present, up to 9 m long; leaf cirrus absent; ovoid fruit, 2.5 × 1.5 cm, dull orange or yellowish-brown; fruit scales deeply channelled longitudinally; one seed per fruit, basally attached, ellipsoid.

Geographical distribution:

Southwestern India (Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu) and Sri Lanka.

Ecological requirements:

This species occurs in lowland evergreen forests and lower montane forests between 75 to 900 m elevation. It has also been recorded in several isolated hills in the dry zone, such as Ritigala, Gunners Quoin, Nilgala and Sigiriya. Moreover, it is found on well-drained slopes in the wet lowlands and grows in moist places in hilly locations in the intermediate lowlands. The clumps are hardy and tolerant of forest clearing. In Western Ghats, it is morphologically highly variable from place to place.

Cultivation:

Plantations are available in Kerala and Karnataka, where it is planted along with teak.

Uses:

Provides a very-strong, large-diameter cane used for furniture making, umbrella handles, walking sticks, sport equipment and basketry. Its leaves exhibit anti-inflammatory and antimicrobial activities.

Conservation status:

This species is not threatened, although the current pressure of exploitation may lead to shortages in the near future.

Research needs:

This species has high morphological variability throughout its geographical range. It is an ideal species for cultivation in teak or other forestry plantations. The selection of ideal genotypes, physical properties of the cane, identification of harvesting age, post-harvest treatment and prospects for cultivation on a commercial scale all need to be investigated.

C. thwaitesii - Habit, leaf sheath, leaf and fruit @ VB Sreekumar

30. *Calamus trachycoleus* Becc.

Synonyms:

Nil.

Common names:

Borneo: jelab, uei irit; **Indonesia:** irit, rotan irit, rotan itit, uei irit, uwe jahab; **Kalimantan:** jahab, kabon uei, taya uwei, uei irit, uwe jahab; **Sarawak:** rotan irit.

Description:

Clustered stems, climbing, up to 30.0 m long and 1.5–2 cm in diameter; tubular leaf sheaths, with a knee below the petiole, dense spines, minute, usually with longer spines present; short ocreas, membranous; flagella absent; ellipsoid fruit, 1.3 × 0.7 cm; tubular fruiting perianths; fruit scales channelled longitudinally; one-seeded.

Geographical distribution:

Borneo and introduced into Malaysia.

Ecological requirements:

This species grows best on the raised alluvial soils of floodplains subject to seasonal flooding, for example, river valleys and foothills. The seedlings, however, can survive being submerged under floodwater for over a month, provided the water is flowing. It does not occur in deep peat, and it is generally not planted by villagers in such areas in Kalimantan. *C. trachycoleus* also does not occur in areas affected by salinity or brackish water (Dransfield and Manokaran, 1993). In Borneo (Central and South Kalimantan), it occurs in lowland rainforest or disturbed forest, especially along the floodplains of rivers, at an elevation of 15 m. Dransfield and Patel (2005) reported that this species has long been introduced into and cultivated in other areas of Borneo.

Cultivation:

This species can be cultivated in seasonally flooded river banks with alluvial clay as well as in swampy margins. It has been cultivated for over 100 years, and commercial plantations (4,000–5,000 ha) are available in both Indonesia and Malaysia. According to Mindawati and Suriamiharja (1986) growth of this species was not affected by application of the NPK compound fertilizer. Propagation is by seed. The seeds begin to germinate by 3–4 weeks. Seedlings that are 2–3 cm in height can be transplanted into polybags filled with topsoil or 75% topsoil mixed with 25% sand mixed with organic manure or commercial fertilisers. When the seedlings are between 40 cm and 50 cm tall, they can be planted in the field under trees. Unlike other species, this species is not suitable for intercropping with rubber plantations or other fruit trees, as it spreads and prevents access, although abandoned rubber trees or riverine forests with trees are suitable for planting. Spacing of 2 m x 10 m, 8 m x 10 m, or 20 m x 20 m are used (Dransfield and Manokaran, 1993). Weeding 2–3 times a year for the first 2–3 years is required, as is canopy manipulation to allow sufficient light for the seedlings. In Borneo, *Lagerstroemia* species are used as support trees, as they grow evenly to a height of 10–15 m, which makes

harvesting the canes easier. This species is harvested eight years after planting and the approximate yield is 2 tons of dry cane per ha followed by 1.5–2.2 tons of dry canes/ha per year (Dransfield and Manokaran, 1993).

Uses:

The high-quality skins, splits and cores (Ariffin et al., 2001) are used in the weaving of chair seats and backs. Unsplit, it is used for furniture. The canes are light, pliable and a golden yellow in colour, and the siliceous layer gives the cane a glossy appearance after fumigation with sulphur and sun drying (Dransfield and Manokaran, 1993). It is estimated that 7,500–8,000 pieces of 6-m-long air-dried canes make a ton. The edible parts of the plant are the fruit, seeds and young shoots (Tamai et al., 2016). Villagers utilise this species as a source of food (leaves, fruit, sprouts), medicine, fuelwood, construction material and fodder. Moreover, forest-dependent communities also value for its cultural significance and aesthetics (Vallejo-Ramos et al., 2016). This species has been extensively used as a substitute for the production of rattan mats ('tatami' in Japanese or 'lampit' locally).

Conservation status:

Threatened due to overexploitation.

Research needs:

C. trachycoleus is an ideal species for cultivation by smallholders due to reasons such as its colonising nature. It is also an important substitute for *C. caesius* in terms of quality and has the ability to withstand seasonal flooding. The development of harvesting protocols, understanding genetic diversity, establishment of provenances and investigation of breeding possibilities are all required.

31. *Calamus viminalis* Willd.

Synonyms:

Calamus extensus Mart.
Calamus fasciculatus Roxb.
Calamus litoralis Blume.
Calamus pseudorotang Mart.
Calamus viminalis var. *fasciculatus* (Roxb.) Becc.
Calamus viminalis var. *fasciculatus* subvar. *andamanicus* Becc.
Calamus viminalis var. *fasciculatus* subvar. *bengalensis* Becc.
Calamus viminalis var. *fasciculatus* subvar. *cochinchinensis* Becc.
Calamus viminalis var. *fasciculatus* subvar. *pinangianus* Becc.
Palmijuncus fasciculatus (Roxb.) Kuntze.
Palmijuncus litoralis (Blume) Kuntze.
Palmijuncus pseudorotang (Mart.) Kuntze.
Palmijuncus viminalis (Willd.) Kuntze.
Rotang viminalis (Willd.) Baill.

Common names:

General names: bitter rattan palm, white thorn rattan; **Bangladesh:** bara bet; **Cambodia:** pa dao, padao, padau, phdao chhvaing krek, phdao kantel, phdao kok, phdao krek, phdao loving, phdao lving, piidau, traes sor, tresh sor; **China:** liu tiao sheng teng, mengpeng shengteng; **India:** amalavetasamu, ambuvetasa, amlavetasamu, bara bet, bet, betham, bettamu, boro bet, bura bet, cerucural, chural, cirupirappankilanku, cural, hasali bet, jati bet, jungli beth, kiring bet, kyeingkha, kyenka, naadeyi, nadeyi, niruhabbe, papatige, parambu, pepa, pepabettamu, pirambu, pirampu, purampu, totanahi, tsjerutsjurel, tsjerutsjurel, umbavelus, umbavetus, umbavetus, vetra; **Indonesia:** penjalin cacing, penjaling cacing, rotan cacing; **Java:** karokok, penjalin glatik; **Laos:** blong chang, bong chung, katengparua, ray bou, rebou, wai daeng, wai keethao, wai khee thao, wai khom, wai na, wai namhang, wai namleuang, wai nang, wai num, wai nyair, wai nyar, wai thoun, wai tiu deed, wai tiu deet, wai tiudeet, wai ton, yo re dark; **Malaysia:** rottang ayer; **Myanmar:** kyein ka, kyeinkha; **Thailand:** rotaesapo, wai dong, wai khom, wai komm, wai mon, wai nam khao, wai namhang, wai ngamkhao, wai sam bai taow, wai sambai, wai san bai taw, wai som; **Vietnam:** may, may cat, meuy seo.

Description:

Clustered stems, climbing or forming thickets, up to 35 m long and 4 cm in diameter; green leaf sheaths with a dense covering of greyish or brownish hairs, with scattered, greenish or brownish, triangular, flattened spines; ocreas present; knees present; flagella present, up to 5 m long; leaf cirrus absent; globose fruit, 1 × 0.9 cm, whitish or yellowish colour, fruit scales channelled longitudinally; one seed per fruit, basally attached, small, globose.

Geographical distribution:

Bangladesh, Bali, China (Yunnan), Cambodia, India (eastern and central parts, Andaman Islands), Java, Laos, Malaysia, Myanmar, Thailand and Vietnam.

Ecological requirements:

C. viminalis is found in lowland rainforests or deciduous forests, persisting in cleared areas and often present near

villages. It is sometimes planted. It occurs below 600 m. This species is also seen on denuded dry hill slopes associated with scrub vegetation as well as in dry village thickets.

Cultivation:

This species is suitable for dry areas and disturbed habitats. Propagation is by seed.

Uses:

The moderate-quality cane is used for handicrafts, lathis, walking sticks, furniture frames, polo mallets and umbrella handles. The medium-sized cane is used for beds, handicrafts, chair frames, bookshelves, beds, sofas, rough baskets, rubbish bins, mattresses and basket handles. It is also used to tie logs into rafts, while the split cane is used for chair seats. The young shoots are used as a vegetable and the fruit is eaten (Baja-Lapis, 2009).

Conservation status:

This is a widely distributed species and it is not threatened.

Research needs:

One of the promising species for edible shoot industry.

C. viminalis - Habit, leaf sheath, leaf and fruit @ VB Sreekumar.

32. *Calamus walkeri* Hance

Synonyms:

Calamus faberi Becc.
Calamus faberi var. *brevispicatus* (C.F. Wei) S.J. Pei & S.Y. Chen.
Calamus tonkinensis Becc.
Calamus tonkinensis var. *brevispicatus* C.F. Wei.
Palmijuncus walkeri (Hance) Kuntze.

Common names:

China: duo guo sheng teng, ku-teng, wong teng; **Laos:** wai nam, wai nyeh; **Vietnam:** may, may dang.

Description:

Clustered stems, climbing, up to 15 m long and 3 cm in diameter; green leaf sheaths with grey-brown hairs, yellowish, flattened, up to 2.5-cm-long spines; ocreas present, densely bristled; knees present; flagella present, up to 5 m long; leaf cirrus absent; ovoid fruit, 1.2 × 1 cm, yellowish, scales channelled longitudinally; one seed per fruit, basally attached, small, ellipsoid.

Geographical distribution:

Southern China and Vietnam.

Ecological requirements:

Found in lowland rainforest areas up to 700 m.

Cultivation:

Widely cultivated in Vietnam. Research efforts with regard to provenance improvement, propagation, seed source improvement and silvicultural techniques are ongoing.

Uses:

The small-diameter, high-quality cane has flexible and whitish stems, although it also has short internodes and is not preferred for making handicrafts. It is used for roping in relation to house construction as well as lines for hanging clothes. The young shoots are potentially edible (Li, 2007). The fruit can be eaten (Henderson, 2009).

Conservation status:

The conservation status of this species has yet to be assessed.

Research needs:

Not much is currently known about the basic biology of this species.

C. walkeri- Habit @ Andrew Henderson.

33. *Calamus warburgii* K. Schum.

Synonyms:

Calamus sepikensis Becc.

Common names:

General names: Claudie River lawyer vine, Iron Range wait-a-while.

Description:

Clustered stems, climbing, 20–40 m long, 3–5 cm in diameter, internodes up to 25 cm long; dark-green leaf sheath, brown to grey indumentum, densely armed with needle-like yellow-green spines, sheds easily; minute ocreas; cirrate leaves, up to 4 m long; globose fruit, 1 × 0.75 cm, fruit scales channelled longitudinally; one seed per fruit, basally attached, small, ellipsoid.

Geographical distribution:

Maluku Islands (Seram), New Guinea (including Manus Island) and Australia (Queensland).

Ecological requirements:

Found in lowland rainforest areas, swamp forests and hill slopes, often as a riparian element or small thickets, at elevations of 50–350 m.

Cultivation:

Propagation is by seed. This species is adaptable to different types of habitats.

Uses:

Used for making walking sticks and the frameworks of baskets. The fruit pulp is edible.

Conservation status:

One of the common species in New Guinea and Australia and treated as 'Vulnerable' category (Bostock and Holland, 2007).

Research needs:

Further information on the cultivation practices, existing distribution patterns and physical properties of the cane are required.

34. *Calamus zeylanicus* Becc.

Synonyms:

Nil.

Common names:

Sri Lanka: ma veval, thambotu, thambotu wel.

Description:

Clustered stems, climbing, up to 50 m long and 5 cm in diameter; copper-coloured leaf sheaths with brown hairs, with well-spaced ridges of dark brown, flattened long spines; ocreas absent; knees present; cirrate leaves; globose fruit, up to 2 cm in diameter, brownish.

Geographical distribution:

Endemic to Sri Lanka. More specifically, found in the forest areas of Sinharaja and the Kanneliya reserves.

Ecological requirements:

C. zeylanicus occurs in wet lowland forests below 1,000 m in elevation. It commonly occurs in the natural gaps in undistributed forests and moist places near streams. It is also frequently seen in distributed forests. This species is usually associated with *C. ovoideus.*

Cultivation:

This promising large-diameter rattan can be cultivated alongside timber trees.

Uses:

The good-quality, large-diameter rattan is used for furniture making, cottage industries and the preparation of baskets; however, sufficient quantities are not available (De Zoysa and Vivekanandan, 1994).

Conservation status:

This species is threatened by habitat loss and overexploitation. The existing populations are declining at an alarming rate. If illegal exploitation and habitat destruction continue, this species might become highly threatened, meaning that urgent conservation measures are required. It can be considered as 'Endangered' (De Zoysa and Vivekanandan, 1994).

Research needs:

C. zeylanicus is an excellent-quality rattan that is not currently available in sufficient quantities. Thus, seed stands, germplasm collection and standardisation of tissue culture techniques should be viewed as priorities.

35. *Calamus zollingeri* Becc.

Synonyms:

Calamus foxworthyi Becc.

Calamus merrillii Becc.

Common names:

General name: giant rattan of East Indonesia; **Indonesia:** batang, pondos batang, rotan air, rotan batang; **Sulawesi:** batang, lauro wulemea, nango wata, pendos batang, pondos batang, pondos saisagan, pondos sasiagan, rattan pece, rattan uvu momi, rotan bata, rotan batang, rotan merah, wata ape.

Description:

Clustered stems, rarely solitary, climbing, 30–50 m long, 3–6 cm in diameter, internodes up to 40 cm long; dull-green leaf sheaths, armed to varying degrees with dull-brown to black, tough, triangular spines; well-developed ocreas; flagella absent; cirrate leaves; ellipsoid fruit, 1 × 0.8 cm, blue-black or almost black, fruit scales channelled longitudinally; one seed per fruit, basally attached, small, ellipsoid.

Notes:

Henderson (2020) found there to be no significant differences in the qualitative morphological characteristics among species such as *C. zollingeri, C. foxworthyi* and *C. merrillii.* In fact, based on morphological examinations of specimens from Palawan, the rest of the Philippines, Sulawesi, the Maluku Islands and western New Guinea (Gag Island), they are treated as subspecies (subspp. *foxworthyi, merrillii, zollingeri*).

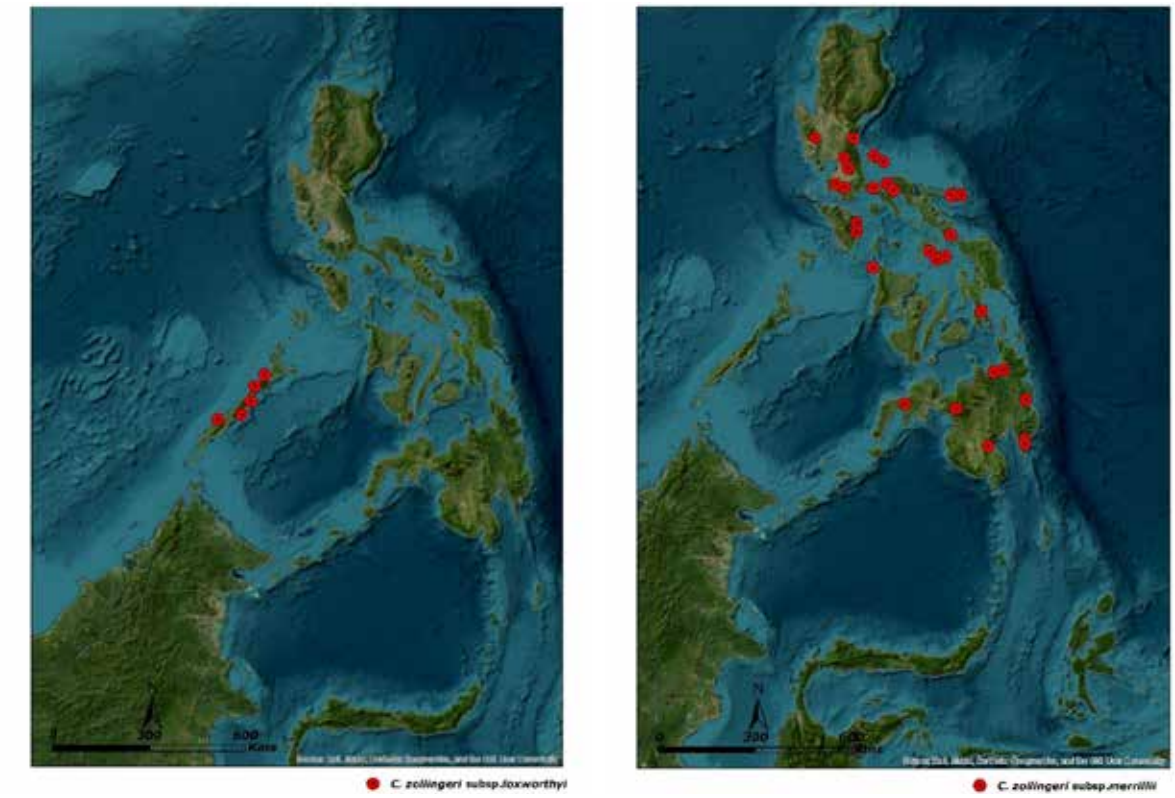
Calamus zollingeri subsp. *zollingeri* (Becc.) A. J. Hend.: Stems 20 m long; leaflets 2.2 cm wide; found in Sulawesi, Maluku Islands (Bacan, Buru, Buton, Seram) and western New Guinea (Gag Island).

Calamus zollingeri subsp. *foxworthyi* (Becc.) A.J. Hend.: Stems 40 m long; leaflets 1.5 cm wide; found in the Philippines (Palawan).

Calamus zollingeri subsp. *merrillii* (Becc.) A.J. Hend.: Stems 14 m long; leaflets 2.5 cm wide; found throughout the Philippines (except Palawan).

Geographical distribution:

Sulawesi, Maluku Islands, Philippines and western New Guinea (Gag Island)



Ecological requirements:

This species is found in the primary forests from the lowlands to altitudes of 800 m, usually near streams (Dransfield and Manokaran, 1993). *C. zollingeri* grows among timber trees such as *Canarium asperum, Celtis philippensis*, *Fagraea fragrans, Dillenia serrata, Pterospermum celebicum, Cryptocarya crassinerviopsis, Tarrietia utilis, Diospyros macrophylla* and *Dracontomelon dao*. It has been noted that the diversity of the supporting trees strongly affects the growth and number of mature canes per clump, in addition to the quality of the cane (Arifin, 2008). The other trees associated with *C. zollingeri* are *Baccaurea rasemosa*, *Celtis philippensis* and *Fagraea fragrans*.

Cultivation:

Calamus zollingeri is best propagated by seed. The seedlings are kept in the shade and generally potted in plastic bags after some weeks. They are watered regularly until they attain a height of 20–30 cm and then transplanted to the forest (allowing some light to penetrate through the canopy). It is mostly found in the interior of primary forests at low altitudes, sometimes up to 1,200 m. Occasionally, it is found at the edges of primary forests or in secondary forests (Dransfield and Manokaran, 1993). It is a fast-growing rattan that attains its full length of 15 m or more after 5–8 years and grows best in semi-open forests (Dransfield and Manokaran, 1993).

Uses:

The cane of *C. zollingeri* subsp. *zollingeri* is widely used due to its flexibility, strength and relatively uniform shape (Gautama, 2008). It is an excellent cane for use in the framework of furniture, and it is extensively used in Sulawesi. It is not used locally in the Moluccas, although it was once exported to Hong Kong and sold in a raw state in Java (Dransfield and Manokaran, 1993). The fruit is edible (Johnson, 1992). In the Philippines, entire stems are used for making 'bent wood' chair frames, as cables for ferry boats, for hauling logs, as standing-rigging on small sailing vessels and, sometimes, to support short suspension bridges. The split canes are used to make 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 parts, are used to make 'reed' furniture (Dransfield and Manokaran, 1993).

Conservation status:

This species has the potential for regeneration in natural patches and is relatively abundant. The major threats facing it are illegal logging and forest encroachment.

Research needs:

This is an excellent large-diameter cane for use in the framework of furniture as well as a promising species for international trade; however, due to overexploitation, sufficient quantities are not available. The selection of superior genotypes, provenance trials and breeding programmes are required for this species.

C. zollingeri* subsp. *zollingeri- Habit @ Andrew Henderson.

36. *Eremospatha dransfieldii* Sunderl.

Synonyms:

Nil.

Common names:

Cameroon: penja; **Ghana:** mfia; **Sierra Leone**: balu, mbalu.

Description:

Clustering, robust, climbing rattan palm, up to 40 m long; stem without sheath has a diameter of 2.5–3 cm; internodes of 10–16 cm; sheath often profusely covered with orange-brown scale insects; knees prominent; leaves sessile, up to 3.5 m long; rachis 1.2–1.5 m long, armed along the margins with robust, reflexed, bulbous, yellow-orange spines; cirrus 1.2–1.5 m long, unarmed; up to 40 leaflets on each side of the rachis, opposite to sub-opposite, highly variable in shape.

Geographical distribution:

Sierra Leone, Côte d'Ivoire and Ghana.

Ecological requirements:

E. dransfieldii occurs in moist evergreen forests, although it is restricted to areas of high rainfall (>2000 mm) that are 100–200 meters above sea level (Sunderland, 2007, 2012; Cosiaux et al., 2017). This light-demanding species is found along forest margins, in tree-fall gaps and along roadsides, and it prefers to grow in tree-fall gaps and forest margins (Sunderland, 2007, 2012).

Cultivation:

Not recorded.

Uses:

Used for construction or structural materials (Cosiaux et al., 2017). The canes are usually longitudinally split into several ribbons, which are used to attach the frames of furniture, as ropes for thatching, for making baskets and sieves, and making traps (Ouattara et al., 2015).

Conservation status:

This is a threatened species due to habitat loss stemming from forest conversion to agriculture and the overexploitation of the stems for rattan products (Cosiaux et al., 2017). Surveys have recorded only a small number of individuals from sites such as Forêt Classée de N'zodji and Côte d›Ivoire. Moreover, no individuals have been found to remain in some places, for example, Ankasa Natural Reserve in Ghana. It is considered 'Endangered' (Cosiaux et al., 2017) based on criterion B2ab(iii) from the IUCN Red List Categories and Criteria (ver 3.1).

Research needs:

The development of germplasm collections, seed stands, silviculture techniques and species recovery programmes should be viewed as a priority.

37. *Eremospatha macrocarpa* Schaedtler

Synonyms:

Calamus macrocarpus G. Mann & H. Wendl.

Eremospatha sapinii De Wild.

Common names:

General name: small rattan palm; **Benin:** dekan, dekon, dekun, dekun vovo; **Cameroon:** melong, ndongo, nkonlo lo'o, nlo'o, nlong, nloun, ongam; **Congo:** kodi; **Equatorial Guinea:** nlong, ongam; **Gabon:** igangatsungu, kegèma, mbubi, ndètèse, nyèvila, ongam, songu, tongo; **Ghana:** mfia; **Guinea:** nlong; **Ivory Coast:** ailémlé, mfia, néné; **Liberia:** bele di bele; **Nigeria:** boru, dugwa, dugwah, egbe, ekakieri, ikan, iro, irrumka, ngkara, obong, oduana, oga, ugaa, ukan; **Sierra Leone:** balu, kavulu, kotumbalu, mbalu; **Yoruba:** egbe, ukan.

Description:

Clustered, small-diameter rattan, climbing, up to 50–75 m; stem without sheath is 0.8–1.9 cm in diameter, polished and ringed with internodes 20–30 cm long; leaf sheath sparsely to moderately covered with light-brown scale-like indumentum; cirrate leaves; fruit 2.5 × 2 cm, cylindrical, with 15–20 rows of rhomboid, rather flat, scales; one-seeded or, more rarely, two-seeded.

Geographical distribution:

West Africa (Benin, Cote d'Ivoire, Ghana, Nigeria, Senegal), Central Africa (Cameroon, Congo, Nigeria, Gabon, Equatorial Guinea), Ivory Coast, Liberia, Sierra Leone and Zaire.

Ecological requirements:

E. macrocarpa is an extremely light-demanding species that is found in gap vegetation and forest margins. This species responds particularly well to selective logging activities and is considered a common component of regrowth vegetation where it occurs (Sunderland, 2012; Sunderland et al., 2005). The population demography of this species indicates that exploitation by the local human population does not threaten populations of this rattan. It also suggests that populations achieve comparable growth rates despite clear differences in their life histories (Kouassi et al., 2008). This species prefers hydromorphic, ferralitic soil, rainfall ranging from 1,500–11,000 mm and temperatures ranging from 21–28 °C.

Cultivation:

In Cameroon, *E. macrocarpa* is ideal for short-rotation agroforestry, and annual extension growth of 3.2 m has been recorded. Propagation is by seed; however, a long germination period has been noted and the initial seed mortality is also very high. Germination trials in Cameroon have revealed germination rates of 32.5 % and a time to first emergence of 96 days.

Uses:

This is considered one of the longest and best-quality canes used in the furniture and handicraft industries. It is

mostly harvested for use in basketry (Burkill, 1995), making hammock bridges and binding house rafters. The rind is made into garden furniture and chairs (Uphof, 1959).

Conservation status:

As an important species, extraction from natural populations is not controlled, which could potentially threaten existing populations (Kouassi et al., 2008).

Research needs:

This is one of the most desired species in Africa and very little information is available about the cultivation potential, sustainable harvesting practices and post harvesting processing technology. Eventhough, the species is not threatened, the development of a conservation plan including production of quality planting material and restoration is also recommended.

38. *Korthalsia laciniosa* (Griff.) Mart

Synonyms:

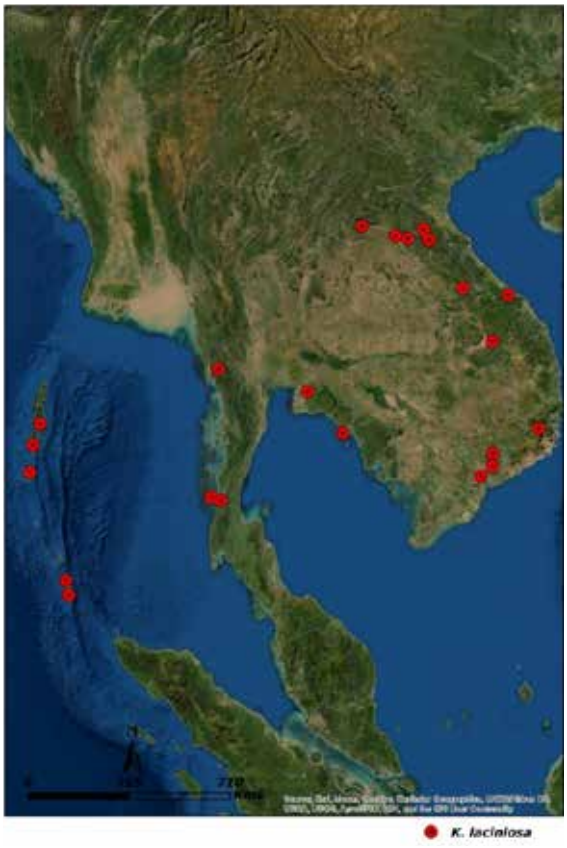
Calamosagus harinifolius Griff.
Calamosagus laciniosus Griff.
Calamosagus wallichiifolius Griff.
Korthalsia andamanensis Becc.
Korthalsia grandis Ridl.
Korthalsia scaphigera Kurz.
Korthalsia teysmannii Miq.
Korthalsia wallichiifolia (Griff.) H. Wendl.

Common names:

General names: red cane; **Cambodia:** phdao krahom, preah phdao; **India:** bagatho, bordah, lal bet, lal beth; lal kubri bet, parida, por, shamoa; **Indonesia:** rotan dahan, rotan semut, uwe lalun; **Java:** hoe ceker kidang; **Kalimantan:** uwe lalun; **Laos:** wai taleuk, wai tar lerk; **Malaysia:** dahan, danan, merah, rotan dahan, rotan hudang, rotan merah, rotan semut, rotan sumut, semut udant; **Myanmar:** kyeinni, sakankyein, wapo kyein, wapokyein, wapo kyeinni; **Philippine Islands:** danan, kapnigid, milingpiling, planug, planung, plaung, tambuanga; **Sarawak:** rotan hudang, rotan undán; **Singapore:** rotan semut, rotan sumut; **Thailand:** da nae ka yo, wai dao yai, wai sadao nam, wai sadao yai, **Vietnam:** may ra.

Description:

Clustering, medium-diameter rattan, branching above ground level, climbing, up to 75 m long, without-sheath diameter of 1.7–2 cm; green leaf sheaths with brown hairs and brown scales, scattered, black, triangular spines; knees absent; ocrea sheathing, loose and net-like, up to 20 cm long; leaf rachis up to 2 m long, with 9–11 rhomboidal leaflets per side; cirrus present; stem dying after fruiting; ovoid fruit, 2 cm × 1.5 cm, orange, red or brown.



Geographical distribution:

Cambodia, India (Andaman and Nicobar Islands), Laos (southern), Malaysia, Myanmar (Tanintharyi region), Philippines, Singapore, Thailand and Indonesia (Sumatra Islands).

Ecological requirements:

This is a high-climbing species, which means that supporting trees are required. This species has been recorded as high as 1100 m above sea level.

Cultivation:

This species is mainly collected from wild stock; cultivation is not in practice. Propagation is by seed. The flowering period is from October to November, whereas fruiting occurs from

April to May. Wild-collected or cultivated seedlings are raised to heights of 60–100 cm in earthen pots in nurseries (Baja-Lapis., 2009).

Uses:

Extensively used in the furniture and handicraft industries. It is also used to make walking sticks (Renuka and Vijayakumaran, 1995). Young *Korthalsia* seedlings are used as indoor plants and ornamental garden plants. The leaves are used in flower arrangements (Baja-Lapis, 2009).

Conservation status:

Threatened due to overexploitation.

Research needs:

There is a great demand for this species, especially for making walking sticks and umbrella handles. Insufficient representation of male and female plants (sex ratio) in forests, poor regeneration and overexploitation are the major reasons for the decline resources. The development of cultivation practices, germplasm collection, in-vitro propagation protocols and large-scale restoration programmes represent urgent needs.

Korthalsia laciniosa - Habit, leaf sheath, leaf, mature fruit @ VB Sreekumar.

39. *Laccosperma secundiflorum* (P. Beauv.) Küntze

Synonyms:

Ancistrophyllum laurentii De Wild.
Ancistrophyllum majus Burret.
Ancistrophyllum secundiflorum H. Wendl.
Calamus secundiflorus P. Beauv.
Neoancistrophyllum laurentii (De Wild.) Rauschert.
Neoancistrophyllum majus (Burret) Rauschert.
Neoancistrophyllum secundiflorum (P. Beauv.) Kuntze.
Laccosperma laurentii (De Wild.) J. Dransf.
Laccosperma majus (Burret) J. Dransf.

Common names:

General names: giant cane; **Guinea**: ekwass; **Nigeria:** ukpekpe.

Description:

Clustered, moderate to robust palm, climbing to 25–50 m, without-sheath diameter of 2–2.5 cm, with-sheath diameter of 3–3.5 cm; internodes 18–35 cm long; dark-green leaf sheath, lightly striate, moderately to sparsely armed with black-tipped, fine, triangular, upward-pointing or spreading spines, sheaths on the upper portion of the stem more sparsely armed; leaves up to 3.5 m long; ovoid fruit, 1.8–2 × 1.3–1.5 cm, with 18–22 vertical rows of scales; smooth seed, ovoid, lightly flattened on one side (Sunderland, 2012).

Geographical distribution:

Benin, Cabinda, Cameroon, Central African Republic, Gabon, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Niger, Nigeria, Senegal, Sierra Leone, Togo and Zaire.

Ecological requirements:

This species is found in high forests, commonly under a forest canopy (Sunderland, 2012) and grows well in poor drained water-logged soils. The preferred average annual rainfall is below 1600 mm. Ecological studies of the population structure, reproductive strategy and life history of this species in the Ivory Coast were undertaken by Kouassi et al. (2008, 2009).

Cultivation:

Cultivation techniques needs to be standardised. It can be propagated with seeds. However, the seed germination is slow and it will take around 100 days to germinate. The seed

mortality is high and germination rate is 19 % (Opuni-Frimpong et al., 2011). High post planting mortalities were noted in the on farm-trials in Ghana, Nigeria and Cameroon. When seedlings were planted under aged rubber trees, an annual extension growth of about 2.8 m was recorded in Cameroon (Opuni-Frimpong et al., 2011). The trials in Cameroon shows that after planting the shoot emergence from suckers was 74 days and from rhizomes was 84 days.

Uses:

The mature canes are used for the frameworks of furniture, walking sticks, baskets, fish traps, suspension bridges and drumsticks. The slender stems are used as rope. The split stems with the pith scraped out are used for basketry, fish traps and tying material. In Cote d'Ivoire, the split stems are used in the fabrication of traditional drums. The potential uses of the stem include the production of particle board and briquettes from waste material from furniture making. The leaves are used as a thatching material in Sierra Leone, Ghana and Nigeria. The apical bud (palm heart) is eaten, sometimes raw. The young shoots are eaten boiled and fried as a vegetable. The soft pith of the young shoots is also eaten. Sap from the stem is potable. In Côte d'Ivoire, women eat the boiled apical bud with the leaves of *Caesalpinia bonduc* to treat sterility-provoking stomach ache. The soft pith of the young shoots and a tea made from the young shoots are used against worms. In Cameroon, an infusion of the leaves is taken against stomach ache and dysmenorrhea, the young shoots are a remedy against fever and dysentery, and the sap is a vermifuge. In both Cameroon and Congo, the fresh stem is part of a preparation applied externally to dermatoses (Sunderland, 2012).

CONSERVATION STATUS:

This species is associated with 'Least concern' (Sunderland, 2012).

RESEARCH NEEDS:

An important species contributing to the rural livelihhod as well as international trade which dates back as far as 1920s (Opuni-Frimpong et al., 2011). Even though this species is not considered as threatened, the over exploitation may result decline in wild stocks and hence cultivation strategies need to be adopted. The mature cane is reddish brown, light to medium weight and is valued in the market owing to its stregth, durability and bending ability. However, it is susceptible to discoloration by fungi, while beetles may make holes and hence more focus on post harvesting processing technology needs to be standardized. For production of large scale planations, protocos for in-vitro propagation techniques are also needs to be developed.

40. *Plectocomiopsis geminiflora* (Griff.) Becc.

Synonyms:

Calamus geminiflorus Griff.

Calamus turbinatus Ridl.

Plectocomia geminiflora (Griff.) H. Wendl.

Common names:

General names: bitter rattan, rattan palm; **Borneo:** riwa, uvey pait, uwei pahit, uwei pait; **Brunei:** wi embalua; **Cambodia:** phdao teang oa, phdao theang, phdao thngae, teang oa; **Indonesia:** riwa, rotan rua, rotan sotong, wey pait, wey timai; **Kalimantan:** lya, peles batuq, rotan pahit, rotan sotong; **Laos**: nyang, wai daeng noy, wai deng, wai dengnoy, wai kamlao, wai kamloo, wai noo, wai nou, wai nyang; **Malaysia:** ambalua, baluak, coonk lak, ialis, moa, rotan, rotan rilang, rotang, rotang relang, rottan doengoel, wi laleh; **Myanmar:** kyein; **Sabah:** ambarua, temberuah, tomboruwah; **Sarawak:** belibih, ialis, lalis, moa, rotan pa, tambarluak, upak laleh, wi laleh, wi lalis, wi matar; **Thailand:** wai daeng, wai khi re, wai kung nam phrai, waikungnampharai.

Description:

Clustering, moderate to robust rattan, with stems of 30 m or more, forming rather dense thickets, without-sheath diameter of 3.0 cm; internodes up to 40 cm, shorter in exposed stems; dull-green leaf sheaths with persistent grey tomentum and scattered caducous reddish-brown scales, abundant scattered golden-yellow spines up to 8 mm long, spines sometimes absent from the sheaths subtending the inflorescences; knees absent; ocreas not well developed; leaf up to 3 m including the cirrus; oblate fruit, 2.5 × 3 cm, covered in up to 42 vertical rows of pale greenish to chestnut brown scales; seed 2 × 2 cm (Barfod & Dransfield, 2013).

Geographical distribution:

Borneo, Brunei, Indonesia (Sumatra Islands), Malaysia, Singapore and Thailand (Barfod and Dransfield, 2013).

Ecological requirements:

This lowland species is found in evergreen forests. It is often recorded in disturbed places or forest margins at elevations of 20–158 m.

Cultivation:

Propagation is by seed. This species is extracted from wild sources.

Uses:

The tender shoots are bitter in taste, edible and sold in village markets. The mature cane is used for handicrafts, furniture, coarse basketware and cordage (Barfod and Dransfield, 2013). The other uses include the preparation of bubu uaak, a

funnel-shaped basket trap made from cane strips.

Conservation status:

Not a threatened species; can be assigned to the **'**Least concern' category.

Research needs:

Identification of proper cultivation practices, determination of the physical and mechanical properties of the canes and the development of *ex situ* conservatories are all important research priorities.

Plectocomiopsis geminiflora- Habit @ Andrew Henderson.

Suggestions for further work

Along with bamboo, rattan has the potential to play a significant role in achieving many of the United Nations' Sustainable Development Goals, such as poverty elimination, affordable and clean energy, sustainable cities and communities, responsible consumption and production, and, above all, effective and eco-friendly solutions to adapt and mitigate climate change. However, the sustainable management of rattan resources represents a major global concern that needs to be addressed through multi-level approaches that encompass resource enhancement, processing, product development, policy and institution-related aspects in order to ensure the promotion of the rattan sector. As a consequence, the following priorities with regard to rattan research and development are proposed.

1. Resource management and assessment

Rattans are mainly harvested from wild resources and most species are overexploited. There is currently high demand for such resources coupled with uncontrolled harvesting, extraction prior to flowering and fruiting, conversion of habitats for agricultural purposes and other deforestation activities, which are leading to resource exhaustion and low regeneration. In light of this, a detailed inventory of the quantity, distribution, pattern of population variation and availability of rattans is urgently needed, which suggests the following directions for future work:

- Developing protocols for the management of existing natural strands and plantations.
- Resource assessment and estimation of the standing stock of priority species through standard inventory techniques.

2. Plantation development

While information is available on the silviculture and nursery practices of different species, knowledge regarding the suitability of species in relation to different agro-ecological parameters, growth pattern of species, selection of suitable tree coverage, timely planting activities, rotation length, method of harvesting, total cost of plantation yield/hectare and post-harvesting management practices remains scant. Better packages and practices for each priority species are required to enhance the development and management of rattan plantations, which should serve to increase the resource base and ensure sustainability. The suggested priorities in this regard include the following:

- Standardisation of tissue culture techniques and production of large-scale seedlings for operational planting.
- Development of improved harvesting techniques to avoid wastage.
- Development of packages and practices for commercial cultivation, including cost and yield.

3. Utilisation potential

There are several constraints related to the utilisation of rattans that need to be overcome. For instance, the lack of a continuous supply of raw materials is a major problem faced by the industry. In most of the countries the artisans are using the traditional processing technologies, limited skills and designs with restricted market access to their inferior products. Similarly, the knowledge of anatomy and structural features are important to 'commercialize' cane making it possible to analyse hitherto unused species for their processing potential. These constraints could be addressed in the following ways:

- Standardisation of post-harvesting technology and processing techniques.

- Identification of anatomical, mechanical and physical properties.
- Evaluation and quantification of domestic uses and marketing.
- Development of cost-effective and innovative designs.

4. Gene pool conservation

The extraction pressure on commercially important species of rattans has led to population disjunction, highly restricted gene flow and, subsequently, endangerment. The population structure (numbers, density, sex, age etc.), regeneration dynamics, and conservation status of most such species has not been assessed as per the IUCN criteria. In the case of solitary rattans, there exists an imbalance in the sex ratio in natural stands that is adversely affecting natural regeneration. Thus, the proper assessment of the pattern of genetic variation and the identification of elite genotypes are vital to the success of *in situ* (and *ex situ*) conservation efforts, which suggests the value of the following:

- Development of field gene banks, seed stands and germplasm collections.
- Assessment of genetic diversity and estimation of sex ratio using robust molecular markers.
- Germplasm collection, storage, exchange and characterisation.

5. Policy development

The growing demand for 'green products' and certified products has been leveraged as a marketing tool for linking sustainable forest management practices with environmentally conscious consumers. To further benefit from this, there exists an urgent need to develop certification standards that integrate ecological, economic and socio-cultural parameters in order to set standards for the management of resources in natural forests, plantations, agroecological gardens, etc., including the handling and sanitation of starting materials during harvest, storage and shipping. The existing national and regional policies concerning the sustainable production of rattan resources require a thorough analysis. Here, it is vital to develop rigorous policy based on accurate information about the rattan trade, future developments in the market for rattan products, production capacity in forests and planted rattan gardens, and international trade, including illegal trade. This could be accomplished in the following ways:

- Developing standards for certifying rattan cultivation and products.
- Developing national policies covering the harvesting, use, marketing and development of resources.
- Examining quarantine laws and developing ways to facilitate the exchange of propagules and germplasm.

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ISBN: 978-92-95123-97-7

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