Revision of the rattan genus *Daemonorops* (Palmae: Calamoideae) in Sulawesi using a phenetic analysis approach

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ABSTRACT. A phenetic analysis based on 27 morphometric characters of seven species of *Daemonorops* in Sulawesi recovered two groups with a similarity coefficient value of 0.51. Group A consists of *D. takanensis* and *D. lamprolepis* with a similarity coefficient value of 0.58. Group B is divided into subgroup B1 and subgroup B2, with a similarity coefficient value of 0.59. Group B1 consists of *D. macroptera, D. mogeana* and *D. robusta.* Group B2 consists of *D. riedeliana* and *D. sarasinorum*. An identification key to species and their descriptions are presented.

Keywords. Calamoideae, *Daemonorops*, Palmae, phonetic analysis, rattans, Sulawesi

Introduction

The palm flora of Sulawesi is distinctive and combines elements in common with Sunda, Sahul, the Philippines, and the Papua New Guinea. In the case of *Daemonorops*, all seven species recognised are endemic to the island and their affinities are not yet clear – whether with Sunda, Philippines or East Malesia. The genus *Daemonorops* itself is not well collected and poorly represented further east. Until recently, five species of *Daemonorops* were recorded for Sulawesi. As a result of recent fieldwork, a further two species have been recognised and described (Rustiami 2009). The purpose of this study to investigate morphological variation within *Daemonorops* in Sulawesi using a phenetic analysis of morphological data taken from herbarium specimens. This is done as a precursor to a treatment of the genus for Flora Malesiana.

The genus *Daemonorops* was described by Blume (1830), based on a single species which he named *Daemonorops melanochaetes* Blume. *Daemonorops* with more than 120 species is the second largest rattan genus after *Calamus*. It belongs to the subtribe *Calaminae,* tribe *Calameae* of the palm subfamily *Calamoideae*. Beccari (1911) divided *Daemonorops* into two sections based on the structure of the inflorescence*,* i.e., section *Cymbospatha* and section *Piptospatha*. Basically, the former have concave boat-shaped bracts which are at anthesis completely enclosed

by the prophyll (the first bract) and splitting longitudinally to expose the flowers. In contrast, the bracts of the species in the latter section split to the base and only the lower part is enclosed by the prophyll. Of the 84 species identified, Beccari placed 32 species in the former section and 52 species in the latter. According to Furtado (1953) the bracts of section *Piptospatha* usually fall at anthesis and occasionally only the prophyll remains.

The name *Daemonorops* is derived from the Greek language combining two words *daemon* (devil) and *rops* (bush or shrub). This name reflects the fearsome appearance of the plant with its very robust leaf sheaths densely armed with long, blackish brown or cream-coloured spines (Dransfield et al. 2008).

Material and methods

Field work was carried out in several areas of Sulawesi to collect herbarium material. Herbarium specimen preparation followed the standard procedure of Dransfield (1986). Data or information recorded from the field include location; general habitat; altitude; association with other plant; vernacular name(s); uses; habit (solitary vs. clustered); stem attributes (height, diameter with/without leaf sheath, internode length, colour); characteristics of the leaves (length, leaflet arrangement, number of leaflets, length and width of leaflets); inflorescence characteristics (length, number of rachilla, colour); flower attributes (colour, scented/not scented); and fruit and seed characteristics (length and width, colour).

Field work data was combined with herbarium data for each taxon to obtain a more comprehensive set of morphological data. Morphological studies were carried out with specimens in several herbaria: Herbarium Bogoriense (BO), the Kew Herbarium (K) and the Leiden Herbarium (L).

A total of 300 herbarium specimens were studied following Vogel (1987) and Rifai (1976), using comparative morphological data as the main source of evidence in developing the species concept (Dransfield 1999).

Twenty seven morphometric characters were chosen (Table 1). These were scored using two simple states (absent – 0: present – 1). The data processing was carried out using the NT-Sys program 2.1 (Rohlf 1997). The descriptions of each species and identification key for *Daemonorops* were constructed based on the characters and character-states recorded.

Results and discussion

Fig. 1 shows the result of the phenetic analysis, in which seven species of *Daemonorops* are differentiated morphologically based on twenty seven characters. The specimens are clearly divisible into two groups (A and B) with a coefficient similarity value of 0.51. This value means that these two groups only have morphological similarity of around 51%. Group A consists of *D. takanensis* and *D. lamprolepis* where these two

Table 1. Morphometric characters used in the analysis.

1	Leaf sheath indumentum	15	Leaflets arranged regularly
2	Leaf sheath surface scales	16	Leaflets arranged subdistantly
3	Leaf sheath armed with short easily removed spines	17	Leaflets arranged distantly
4	Leaf sheath armed with brittle unequal, solitary spines	18	Transverse veinlets present
5	Leaf sheath armed with hair like spines	19	Corolla same size as the calyx
6	Leaf sheath armed with long, strongly attached spines	20	Corolla longer than the calyx
7	Leaf sheath armed with large, irregularly seriate spines	21	Fruit spherical
8	Ocrea present	22	Fruit subglobose
9	Leaf sheath armed with short, scattered, seriate spines	23	Fruit ellipsoid
10	Direction of spines on leaf sheath horizontal	24	Seed surface smooth
11	Direction of spines pointing upward	25	Seed surface reticulate
12	Knee armature present	26	Endosperm slightly ruminate
13	Leaf sheath mouth spiny	27	Endosperm deeply ruminate
14	Petiole with indumentum		

species have a coefficient similarity value of 0.58. Group B divided into two sub-groups, B1 and B2, with a coefficient similarity value of 0.59. From the phenogram we can see that *D. macroptera* and *D. mogeana* have a morphological similarity of around 81%. Those two species are close to *D. robusta*, with 67.4% similarity. In the other group we can see that *D. riedeliana* and *D. sarasinorum* have a similarity of around 77.4%.

Daemonorops mogeana, *D. macroptera* and *D. robusta* clustered in one group. This is because they have some similarities in their leaf sheath armature and leaflet arrangement. However they do differ in their general morphological appearance.

The stem of *Daemonorops* is covered by tightly sheathing, densely spiny, leaf sheaths. The diameter of the stem with the leaf sheaths can vary from a few mm to over 10 cm. Leaves consist of a tubular sheathing base, the leaf sheath, which arises from the node on the stem; at its upper end, the sheath narrows into the petiole that continues into the rachis or leaflet-bearing portion of the leaf. Although a petiole is usually present, it is sometimes very short or absent. In many species, the rachis is extended beyond the terminal leaflets into a barbed whip (cirrus) which acts as a

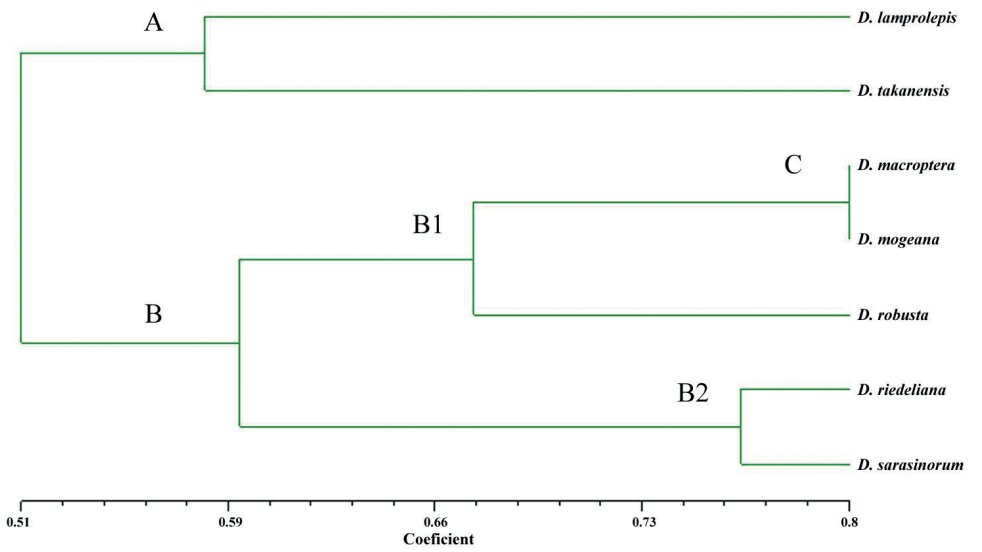

Fig. 1. Phenogram of morphological similarity among *Daemonorops* spp. from Sulawesi.

climbing organ (Dransfield & Manokaran 1994). Spine arrangement on the leaf sheath is remarkably diverse and frequently of diagnostic importance. Just below the petiole or leaf rachis, there is a marked swelling known as the knee. This character is also of some diagnostic importance, because some of the *Daemonorops* species do not have very obvious knees or the knee is only slightly developed.

As with most rattans, *Daemonorops* are dioecious, that is, female and male flowers are borne on different plants. The main axis bears a basal bract or prophyll, which may be short and tubular, or large. Branches are borne in the axils of subsequent bracts. The branches in turn bear bracts, the lowermost of which is usually empty, subsequent bracts subtending branches, and so on. The ultimate flower-bearing branches are termed partial inflorescences. On each female flower, there is a bracteole which immediately surrounding the flower, known as an involucre and an outer bract known as the involucrophore. Flowers are borne in dyads with two bracteoles in the female and in the male flowers are solitary with one bracteole.

Taxonomic treatment

Daemonorops Blume in J.A. & J.H. Schultes, Syst. Veg. 7(2): 1333 (1830).

Solitary or clustering rattans, acaulescent to high-climbing hapaxanthic (then always very short-stemmed) or pleonanthic, dioecious. Sheaths usually heavily armed with spines, the spines frequently highly organised. Flagellum absent. Knee frequently present. Leaves ecirrate in acaulescent species or longly cirrate. Leaflets variously arranged. Inflorescence male and female superficially similar, but within the genus of

two basic types: one with all bracts enclosed within the outermost bract or prophyll, splitting along their length to expose the flowers (section *Cymbospatha*) or the other with bracts splitting along their entire length to leave no tubular portion and frequently falling (section *Piptospatha*). Bracts variously armed. Partial inflorescences longer than the subtending bract in section *Piptospatha*; bracteoles and "involucres" inconspicuous. Male rachilla bearing male solitary flowers, male flowers small, cup-shaped; calyx with three small lobes; corolla split to the base into 3 petals; stamen 6, slightly epipetalous; pistillode minute. Sterile male flower found with each female flower, as the fertile male, but stamens with empty anthers. Female rachilla bearing many flowers in dyads consists of one female flower and one sterile male flower. Female flower with calyx truncate or shallowly 3-lobed; corolla with 3 petals; gynoecium with 3 stigmas and with 3 loculi. Sterile flower smaller or at least more slender than the female ones, with well-formed calyx and corolla and 6 sterile stamens and an abortive ovary. Fruit variously shaped, tipped with stigmatic remains and covered with reflexed scales. Seed only one, covered by thin to thick, sweet or sour sarcotesta. Endosperm deeply ruminate. Embryo basal.

Distribution. Based on Dransfield et al. (2008), the geographical distribution of *Daemonorops* is more restricted than *Calamus*. The centre of distribution of both are similar, from China, India to New Guinea, specifically Sumatra, Malaya, Borneo and Malay Peninsula. *Daemonorops* does not occur in Africa, Himalaya, Peninsular India, Sri Lanka and Australia.

Habitat. Rather disturbed primary forest, on alluvial soil near rivers, flat to gently sloping terrain, ridge tops, lowland forest, and steep hill slopes in primary forest on volcanic soils.

Uses. One species is recorded to have sweet, edible young shoot (Mogea 1991).

Key to *Daemonorops* species in Sulawesi

1a. Leaf sheath covered with rusty-brown coloured indumentum and armed with short, up to 10 mm long, easily detached spines ..... *D. takanensis*
1b. Leaf sheath without indumentum and armed with long, more than 15 mm long, strongly attached spines 2

2a. Leaf sheath armed with brittle, unequal, solitary (or groups of) spines 3
2b. Leaf sheath strongly armed with large, irregularly seriate spines 5

3a. Leaf sheath armed with solitary, black, brittle spines; ocrea present .... *D. lamprolepis*
3b. Leaf sheath armed with solitary (or groups of) black spines; ocrea absent 4

4a. Leaf sheath densely armed with very long, solitary, hair-like spines .... *D. sarasinorum*
4b. Leaf sheath armed with short, scattered, seriate, needle-like spines .... *D. riedeliana*

5a. Leaf sheath armed with oblique spines joined at their bases; fruit spherical, endosperm deeply ruminate ..... *D. robusta*
5b. Leaf sheath armed with upright spines that are solitary or joined at their bases; fruit subglobose to ellipsoid, endosperm slightly to deeply ruminate 6

6a. Leaf sheath densely armed with solitary, furfuraceous spines; fruit ellipsoid, endosperm deeply ruminate ..... *D. macroptera*
6b. Leaf sheath densely armed with greyish spines in groups of 3's to 5's; fruit subglobose, endosperm slightly ruminate ..... *D. mogeana*

1. *Daemonorops lamprolepis* Becc., Rec. Bot Surv. Ind. 2: 223 (1902). TYPE: South East Sulawesi, Kendari, July 1874, *Beccari s.n.* (holo BO).

Clustering rattan. Sheathed stem up to 2 cm in diam., stem without sheath up to 1 cm in diam. Leaf sheaths green, covered with collar spines with jointed bases, scarcely up to 3 cm long, sheath surface smooth with caducuous reddish-blackish scaly indumentum, leaf sheath mouth armed as the rest of sheath; knee present, very conspicuous, armed as the rest of sheath; ocrea present, papery, small, to 5 mm high. Leaves to 3 m long including petiole 30 cm long, armed adaxially with short, erect, scattered spines to 2 mm long, abaxially armed with erect, very rarely solitary spines, up to 1 mm long; rachis unarmed, or armed only slightly proximally; cirrus up to 80 cm long, armed with regularly arranged groups of grapnel-like spines, leaflets mostly arranged regularly, 30 on each side of the rachis, stiff, horizontal; leaflets lanceolate, papery, acuminate, up to 30 cm long, 2 cm wide, armed with scattered reddish, short bristles along the main nerve on lower surface, transverse veinlets conspicuous. Female inflorescences pendulous to 37 cm long, peduncle 10–15 cm long, armed distally with groups of spines; prophyll papery, erect, 25 cm long, 3 cm wide, ellipsoid oblong, armed with scattered spines, some spines in groups of 2's; partial inflorescences up to 4, each inflorescence bearing up to 8 partial inflorescences; rachilla covered with chocolate scurf; involucre pendulous, flat, just above the involucrophore, 5 mm long; involucrophore short, papery, 2 mm long. Female flowers 6 mm long, ovoid, acute; calyx very short; the corolla several times longer than the calyx, ventricose at the base. Male inflorescence and male flowers unknown. Young fruits ovoid to ellipsoidal, 15 × 10 mm, covered by 8–9 vertical rows of encrusted scales. Seed ovoid, 10 × 7 mm, boldly tubercled and coarsely pitted. Endosperm ruminate.

Distribution. Donggala, Central Sulawesi and Kendari, South East Sulawesi.

Habitat and ecology. Disturbed primary forest.

Vernacular names. Rotan mapis (Donggala language), *lasero epe* or *lita* (Tobelo language).

Notes. This is the only species of *Daemonorops* from Sulawesi which has an ocrea. This ocrea is papery, small, to 5 mm high.

Specimens examined: **Central Sulawesi**: Northern central part, on the coast of South West of Donggala, 11 May 1975, *W. Meijer 10086*, fruiting (BO). Mountain Sojo, November 1913, *Rachmat 705*, fruiting (BO). **South Sulawesi**: Maliki, Desoe, 02 Jun 1933, *H.N. Reppie 18*, sterile (BO). Wadjo, *Heyne 2581*, *Heyne 2587*, sterile (BO); *Heyne 2615*, fruiting (BO); Boni, *Heyne 2599*, young fruit (BO); *Heyne 2595*, *Heyne 2604*, fruiting (BO); *Heyne 12*, dead female inflorescence (BO).

2. *Daemonorops takanensis* Rustiami, Reinwardtia 13(1): 25–30 (2009). TYPE: Indonesia, South Sulawesi, Kab. Mamuju, District Kaluku, Dusun Roa, Rantai Village, Kaluak, Bukit Takane-kane, 200 m alt., 06 February 1993, *Padmi Kramadibrata 28*, fruiting specimen (holo BO).

Slender, clustering rattan, climbing to 20 m. Sheathed stem 2 cm in diam., without sheaths 1.5 cm in diam., internodes 20–30 cm long; leaf sheath dark green, covered with conspicuously rusty brown-coloured indumentum and armed with numerous very brittle, thinly laminar, unequal, up to 1 cm long or even shorter, solitary, scattered, easily to detached, brown spines, with small bulbous bases; leaf sheath mouth densely armed with similar spines; knee present and conspicuous, 10 mm long, 20 mm wide, moderately armed. Leaves 3.5 m long including petiole and cirrus; petiole to 20 cm long, 10 mm wide and 8 mm thick at base, flat adaxially, rounded abaxially, with acute edges, covered slightly with rusty brown indumentum, as on sheath, armed with numerous short triangular spines; rachis up to 1.8 m long, armed with very short, erect, slender, triangular claws, that become ternate near the apex and 5-nate and half-whorled on the cirrus; cirrus to 150 cm long; leaflets numerous, 55 pairs on each side of rachis, regularly arranged, linear-lanceolate, acuminate, armed with bristles to 5 mm long along the midrib of both surfaces; transverse veinlets minute; basal leaflets 34 cm long and 8 mm broad, middle leaflets 35 cm long and 1 cm broad, apical leaflets to 20 cm long and 8 mm broad. Male and female inflorescences not known. Infructescence pendulous, up to 50 cm long, consisting of 4 partial infructescences, 5 cm apart; peduncle 10 cm long; partial infructescence to 8 cm long bearing 10 partial inflorescences. Fruit ellipsoid with a short conical beak, pale, covered with 15 vertical rows of scales, 15 mm long and 10 mm broad. Seed one, ellipsoid. Endosperm deeply ruminate.

Distribution. Known from the type locality only.

Habitat and ecology. Disturbed primary forest on hill slope.

Uses. Not recorded.

Vernacular name. *Rotan api*.

Notes. This species can be recognised easily by its dark green leaf sheath, covered with conspicuously rusty brown-coloured indumentum and armed with numerous very brittle, thinly laminar, unequal, up to 1 cm long or even shorter, solitary, scattered, easily to detached, brown spines, with small bulbous bases. So far this species is only known from the type locality, Bukit Takane-kane.

Specimens examined: **South Sulawesi**: Kab. Mamuju, District Kaluku, Dusun Roa, Rantai Village, Kaluak, Bukit Takane-kane, 200 m alt., 06 Feb 1993, *Padmi Kramadibrata 028*, fruiting specimen (BO).

3. *Daemonorops macroptera* (Miq.) Becc., Rec. Bot. Surv. Ind. 2:223 (1902); *Calamus macropterus* Miq., Verh. Kon. Akad. Wetensch., Afd. Natuurk. 11 (5): 19 (1868); *Palmijuncus macropterus* (Miq.) Kuntze, Revis. Gen. Pl. 2: 733 (1891). TYPE: North Sulawesi, Manado, Minahasa, *Riedel IGF s.n.* (holo BO; iso L).

Clustering robust rattan, up to 40 m tall. Leaf with sheaths up to 3 cm in diam., without sheaths to 2 cm in diam., sheaths covered with basally joined robust spines, up to 5 cm long, leaf sheath mouth armed as the rest of the sheath; knee present conspicuously, armed as the rest of the sheath. Leaves up to 6 m long including petiole to 40 cm, armed with groups of robust spines, to 2 cm long, on both surfaces; rachis armed with scattered, solitary spines up to 1 cm long; cirrus more than 2 m long, armed with regularly arranged groups of very robust grapnel-like spines, blackish at the tip; leaflets mostly arranged regularly, slightly irregular apically, 70 on each side of the rachis, stiff, horizontal; leaflets lanceolate, papery, acute, up to 55 cm long, 3 cm wide, armed with scattered, reddish, short bristles along the main nerve on lower surface, up to 1 cm long, short bristles along the leaflets margin; transverse veinlets very minute, and sharp. Male inflorescence pendulous, up to 85 cm long including peduncle 25–30 cm long, peduncle straight and rigid, flattened, densely armed with flat, irregular, erect, spreading, 1–2 cm long spines; the outer bract is narrowly lanceolate before flowering; after flowering it is coriaceous, gradually narrow to acuminate, covered with furfuraceous indumentum; rachilla about 40 cm long, with 5 small partial inflorescences. Male flower small, 4–5 mm long; calyx very small, deeply 3-dentate. Female inflorescence elongate, rather slender, pendulous up to 65 cm long, bearing 6–7 partial inflorescences; secondary spatha short, acute or acuminate, up to 8 cm long, covered with rusty indumentum. Female flower unknown. Infructescence pendulous,

to 60 cm long, peduncle up to 15 cm long, armed distally with groups of robust spines; peduncular bracts leathery, erect 25 cm long, 3 cm wide, ellipsoid oblong, covered by rusty indumentum, armed with solitary spines up to 2 cm long, partial inflorescences 5 each, bearing up to 9 partial inflorescences; involucre pendulous, flat, just above the involucrophore, 5 mm long; involucrophore short, papery, 2 mm long. Fruits obovoid, 15 × 15 cm, covered by 7 vertical rows of encrusted scales. Seed ovoid, 10 × 10 mm, smooth surfaces.

Distribution. North and Central Sulawesi.

Habitat and ecology. Rather disturbed primary forest, on alluvial soil near river, terrain flat to gently sloping.

Vernacular name. Rotan batang, *angah*.

Notes. This rattan, based on Vogel's field record, produces a white gummy exudate from the cut stem and the immature fruit is green. It is found at low elevations along river terraces (field note of *Musser* T10).

Specimens examined: **North Sulawesi**: Manado, *Miquel s.n.*, fruiting (BO, L). **Central Sulawesi**: Sopu Valley, c. 80 km SSE of Palu, 1000 m alt., 2 May 1979, *E.F. de Vogel 5171*, fruiting (BO); 22 May 1979, *E.F. de Vogel 5508*, fruiting (BO); 26 Apr 1979, 1000 m asl., *E.F. de Vogel 5055*, fruiting (BO, K); Mountain Rorokatimbu, 13 May 1979, *E.F. de Vogel 5326*, fruiting (BO, K); Poso, Lore Utara, Gn. Pada Esa, 11 Sep 2010, 1525 m asl., *Himmah Rustiami, Dewi, M. Amir, Hamzah & Ato HR 447*, fruiting material, Mt. Petulu, Kulawi, 18 Feb 1986, 700 m asl, *Anggana & Yusuf Dali 62*, sterile (K); Sungei Tolewonu, 30 km South of Kuala Navusu, between 1974–1976, *G.G. Musser T10* (K). **South East Sulawesi**: Tongoa, 730 m asl., 4 Mar 1981, *J.Th. Johansson, H. Nybom & S. Riebe 169* (K).

4. *Daemonorops mogeana* Rustiami, Reinwardtia 13(1): 25–30 (2009). TYPE: Indonesia, Central Sulawesi, Kab. Poso, District Kulawi, Dusun Moa, Mt. Malemo, 1000 m alt., 21 October 1977, *JP Mogea 1356*, fruiting specimen (holo BO; iso K, L).

Very large, robust, clustering rattan, climbing to 15 m. Sheathed stem 4 cm in diam., stem without sheaths 2 cm in diam.; internodes 20 cm long. Leaf sheaths woody, creamy-yellow, densely armed with numerous broad spines often with conspicuous bulbous bases, and arranged in groups of 3's to 5's, flat, greyish, irregularly seriate, 1–7 cm long, 5 mm wide, intermixed with smaller and ascendant spines. Leaves very large, up to 6 m long including petiole and cirrus; petiole very robust, 1 m long, 2 cm wide and 1 cm thick at base, rounded adaxially and abaxially, densely armed with, seriate or irregularly, erect, triangular, 1–3 cm long and up to 1 cm wide spines; rachis up to 3 m long, with similar triangular spines; leaflets large, 30 pairs on each

side of rachis, regularly arranged, linear-lanceolate, acuminate, armed with small bristles, 5 mm long along the mid nerve on both surfaces and the apex; transverse veinlets conspicuous; middle leaflets 40 cm long; 2 cm broad, papyraceous, green and concolorous; apical leaflets to 20 long, 1.5 cm broad; cirrus to 2 m long, armed with 4–5 hooked grapnels arranged 3 cm apart. Male and female inflorescences not known. Infructescence ascending, to about 70 cm long, with 6 erect, very slender, cupressiform, partial infructescences, 5 cm apart; the main axis cylindrical, 20 cm long, armed with dense, glaucous, seriate spines, about 1–5 cm long, with bulbous bases, and covered with blackish brown indumentum; partial infructescence about 15 cm long, bearing up to 10 unequal secondary partial infructescences. Fruit subglobose, covered with 14 vertical rows of glossy yellowish scales, 8 mm long and 4 mm broad. Seed one, globose. Endosperm slightly ruminate.

Distribution. Known from type locality only.

Habitat and ecology. This species is common in *Agathis* forest, beside streams on the slopes of G. Malemo, 1000 m alt.

Distribution. This species is only known from the type locality.

Uses. Young shoot is edible and good.

Vernacular name. Uwi manis (*umbut manis*).

Notes. This species has been identified by Maturbongs (*in scheda*) in 2001 as *Daemonorops macroptera*, to which it is morphologically similar. However, after careful examination, *D. mogeana* differs from *D. macroptera* by the leaf-sheath armature which includes very robust spines, subglobose fruit and slightly ruminate endosperm. In contrast, *D. macroptera* has gigantic, fragile, easily broken spines, and ellipsoidal fruit and deeply ruminate endosperm.

Specimen examined: **Central Sulawesi**: Kab. Poso, District Kulawi, Dusun Moa, Mt. Malemo, 1000 m alt., 21 October 1977, *J.P. Mogea 1356*, fruiting specimen (BO, K, L).

5. *Daemonorops robusta* Warb. ex Becc., Ann. Roy. Bot. Gard. (Calcutta) 12(1): 101 (1911). TYPE: Bojong, Province Minahasa, North Sulawesi, *Warburg s.n*. (Herb. Berlin, *n.v.*, probably destroyed, type specimen pictures seen in Beccari's book kept at K).

Solitary to clustering rattan, very robust, 5–7 m tall. Leaf with sheath 7 cm in diam., without sheath 2–3 cm in diam.; internodes 15–35 cm long. Leaf sheaths pale yellow-green, covered with oblique, very large black thorns with joined bases up to 5 cm long,

sheath surface with caducous glaucous black indumentum, leaf sheath mouth armed as the rest of sheath; knee present conspicuously, armed as the rest of sheath. Leaves to 4 m long including petiole to 40 cm long, armed adaxially with densely erect, long black spines to 5 cm long, abaxially armed with erect, oblique spines in groups up to 5 cm long; rachis armed with erect, solitary spines up to 5 mm long; cirrus up to 150 cm long, armed with regularly arranged groups of grapnel-like spines, blackish at the tip; leaflets lanceolate, papery, acute, 60 cm long, 2 cm wide, armed with scattered reddish, short bristles along the main nerve on the lower surface, leaflet margin armed with short spinules, reddish. Male inflorescence ascending, to 50 cm long, peduncle up to 22 cm long, armed with groups of 2–8 slightly bulbous based spines 2–20 mm long with pointed tips, more robust adaxially than abaxially; peduncular bract woody, erect to 48 cm long, 4 cm wide, lanceolate at the tip, covered by rusty brown indumentum. Female inflorescence not known. Infructescence pendulous, 50–100 cm long, peduncle 20–30 cm long, armed with spines forming rings; peduncular bracts leathery, erect, 30 cm long, 2 cm wide, ellipsoid oblong, covered by rusty indumentum, armed with scattered needle like, blackish spines; partial inflorescences 5–6, each bearing up to 8 secondary partial inflorescences; involucre pendulous, flat, just above the involucrophore, 5 mm long; involucrophore short, papery, 2 mm long. Fruits spherical, 15 × 10 cm, covered by 9 vertical rows of yellowish cream encrusted scales. Seed globular, 8 × 8 mm, seed surface reticulate, endosperm deeply ruminated.

Distribution. North Sulawesi: Bolaang Mongondow, Manado, Laelumbuan; Central Sulawesi: Toli-toli.

Habitat and ecology. Primary forest hillslopes, deep valleys, alluvial flats, lowland riverbank forest.

Vernacular names. *Lauro manu* (*toli-toli*), *pondas valukan*, *pondas rasisagan*, *pondas kuluwi* (Manado), *rotan susu* (Gorontalo language).

Notes. The mature fruit of this species has a sour sarcotesta; the young fruit is green, maturing red. Apparently related to *D macroptera* but the fruit is spherical.

Specimens examined: **North Sulawesi**: Bolaang Mongondow, Tapak Kulintang, Dumoga Bone National Park, 220 m alt., 8 Mar 1984, *J.P. Mogea JPM 5076*, young fruit (BO, K). Bolaang Mongondow, Pindol, Lolak, 50 m alt., 19 Oct 1973, *J. Dransfield & J.P. Mogea JD 3805*, mature fruit (BO); JD 3800, male flower (BO, K). Manado, Pondok Pingsang, Karoewatoe, 50 m alt., 26 Feb 1895, *Koorders KDS 18410β*, fruiting (BO, L); Laelumbulan by Paku Ure, 700 m alt., 9 Mar 1895, *Koorders KDS 18399β*, fruiting (BO, L). *Heyne 2510*, sterile (BO); Gorontalo, near Marisa, Illoheleuma, 8 Jan 1989, *Lynn Clayton 3*, fruiting (K). **Central Sulawesi**: Dako, Mountain Lakatan, Toli-toli, 750 m alt., 25 Feb 1985, *Ramlanto & Z. Fanani 530*, fruiting (BO). Malili, Toli-toli, Kawata, 200 m alt., 13 Apr 1933, *J. van Jijll de Jong 1*, young fruit (BO); Inland from Batui and Seseba on Batui river, Sinsing, 16 Oct 1989, 70–100 m asl., *Coode 5967*, fruiting (K).

6. *Daemonorops riedeliana* (Miq.) Becc., Rec. Bot. Surv. Ind. 2:226 (1902); *Calamus riedelianus* Miq., Verh. Kon. Akad. Wetensch., Afd. Natuurk. 11: 18 (1868); *Palmijuncus riedelianus* (Miq.) Kuntze, Revis. Gen. Pl. 2: 733 (1891). TYPE: North Sulawesi, Manado, Minahasa, 1895, *Riedel s.n*. (holo L).

Slender, clustering rattan, up to 10 m tall. Stem with sheaths up to 20 mm in diam., without sheaths to 6 mm in diam., internodes 8–10 cm long; leaf sheaths covered with needle-like, almost uniformly upward-pointing spines that are solitary or in groups, the spines enormous, up to 6 cm long; sheath surface smooth with corky creamy indumentum; leaf sheath mouth armed as the rest of the sheath; knee present conspicuously, armed as the rest of the sheath. Leaves to 2 m long including petiole to 15 cm, armed very densely with 5–10 mm long spines all around, lower side of rachis armed with ternate claws, upper side slightly prickly; leaflets numerous, arranged rather distantly, 38–57 pairs on each side of the rachis, arcuate, somewhat spidery; leaflets lanceolate, papery, acuminate, 25–30 cm long, 1 cm wide, armed with scattered, reddish, bristly spinules along the mid-nerve of the upper surface; young leaf covered in caducous white indumentum; transverse veinlets slender, visible on both surfaces; margins armed with rather close ciliate spines,. Male and female inflorescences not known. Fruits spherical, 13 × 13 mm, covered by 8 vertical rows of yellowish brown, dull encrusted scales. Seed irregularly globular, 10 × 8 mm, with reticulate surface.

Distribution. North and South Sulawesi.

Habitat and ecology. Disturbed primary forest, and steep hillslopes and ridge top lowland forest, on volcanic soil, 500 m asl.

Vernacular name. Angah (this name is also applied to *D. macroptera*).

Notes. It is noted by Dransfield that the seed is both astringent and sweet.

Specimens examined: **North Sulawesi**: Minahasa, Bitung, Batu Angus Nature Reserve, 500 m alt., 7 Oct 1973, *J. Dransfield & J.P. Mogea JD 3737*, fruiting (BO); Bolaang Mongondow, Pindool Lolak, 150 m alt., 18 Oct 1973, JD 3787, male flower (BO, K); Manado, 2 Mar 1895, *Koorders 18389β*, fruiting (BO, L); *A.G. Waturandang 51*, sterile (BO). **South Sulawesi**: Kabupaten Mamuju, Kec. Kaluku, Dusun Roa, Desa Dutas Kaluak, Bukit Banga, 300 m alt., 08 Feb 1993, *Padmi Kramadibrata 30*, sterile (BO).

7. *Daemonorops sarasinorum* Warb. ex Becc., Ann. Roy. Bot. Gard. (Calcutta) 12 (1): 100 (1911). TYPE: North Sulawesi, Tomohon, in the province of Minahasa, *Sarasin 1082* (Herb. Berol., *n.v.*, probably destroyed, type specimen pictures seen in Beccari's book kept in K).

Robust, clustering rattan, climbing 15–30 m long. Stem with sheath 6 cm in diam., without sheath to 4 cm in diam.; internodes generally rather short, 20 cm long. Leaf sheath very densely covered in reflexed black spines, to 4 cm long, pinkish when young; sheath surface with buff scurfy sometimes variously grey indumentum, leaf sheath mouth armed as the rest of sheath; knee present, very conspicuous, armed as the rest of sheath. Leaves 2.5–4 m long including petiole 40 cm or more, the petiole somewhat reddish, armed adaxially with short, erect, scattered spines to 4 mm long, abaxially armed with erect, solitary spines rarely up to 15 mm long; rachis unarmed or proximally only slightly armed; cirrus up to 2 m long, armed with regularly arranged groups of grapnel-like spines, blackish at the tip; leaflets mostly regularly arranged, densely crowded, 50–75 on each side of the rachis, stiff; leaflets lanceolate, papery, acuminate, 60–80 cm long, 2 cm wide, armed with scattered, reddish short bristles along the main nerve on both surfaces. Male inflorescence pendulous, up to 120 cm long, consisting of 15 rachillae, each rachilla consisting of 8 partial inflorescences; peduncular bract narrow and elongate, cupressiform with several erect, compact or appressed flowers; partial inflorescence covered with abundant furfuraceous indumentum. Male flowers short, 4 mm long, with anthers quite exserted from corolla and enclosed within spathes; calyx is very small, almost flat, corolla is longer than calyx. Female inflorescences pendulous, 60 cm long, peduncle 20 cm long, densely armed with groups of spines; peduncular bract leathery, elongate, 17 cm long, 3 cm wide, cupressiform, covered with rusty indumentum and innumerable long, narrow, scattered black spines, tubular before flowering; partial inflorescences 6, each bearing up to 11 secondary partial inflorescences; involucre pendulous, flat just above the involucrophore, 5 mm long; involucrophore short, papery, 2 mm long. Female flowers at the time of anthesis 4 mm long, exclusive of the stigmas which are exserted from the corolla and are about as long as the whole length of the female flowers (c. 8 mm); calyx very short, copular, polished (not striate), superficially 3-toothed; corolla ventricose, urceolate, strongly seriately veined, coriaceous, having 3 broadly triangular, acute teeth.

Distribution. North Sulawesi: Manado, Bitung, Kotamobagu; Central Sulawesi: Palu, Mt. Rorokatimbu.

Habitat and ecology. Montane forest, somewhat disturbed lower montane forest on steep terrain, shallow clayey soil.

Vernacular name. Pondan katunun (Manado).

Notes. Male flowers are unpleasantly ester-scented (from *JD 3862*).

Specimens examined: **North Sulawesi**: Manado, Minahasa 2 Mar 1895, *Koorders KDS 18391β*, sterile (BO); 30 Apr 1895, *Koorders KDS 18407β*, sterile (BO). Minahasa, Bitung, Batu Angus Nature Reserve, 800 m alt., 8 Oct 1973, *J. Dransfield & J.P. Mogea JD 3744*, fruiting (BO). Bolaang Mongondow, G. Ambang, Kotamobagu, 1000

m alt., 26 Oct 1973, JD 3862, male flower (BO, K); JD 3861, fruiting (BO, K). Manado, Pondok Simpang, 50 m alt., 2 Mar 1895, *Koorders KDS 18388β*, sterile (BO). **Central Sulawesi**: Mt Rorokatimbu, west slope c. 80 km SSE of Palu, 1700 m alt., *E.F. de Vogel 5484*, female flower (BO, K); 13 May 1979, c. 1º16'S 120º18'E, 1300 m alt., *E.F. de Vogel 5335*, sterile (BO, K); Mount Sadaunta, May 1976, *G.G. Musser* s.n., (K).

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