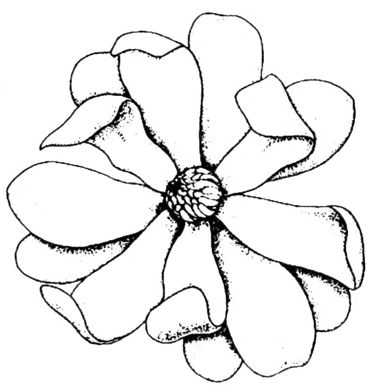

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CONTENTS

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Rhaphidophora tenuis (Araceae: Monstereae) Resurrected

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Abstract

Rhaphidophora tenuis Engl., a species considered synonymous with the widespread and variable *R. korthalsii* Hassk. in the most recent revision of Bornean species is resurrected as an endemic to Sarawak and Brunei. A full description of *R. tenuis* is presented together with a modification to the most recent published key to *Rhaphidophora* in Borneo and photographs. This reinstatement takes to 15 the number of *Rhaphidophora* species recognized for Borneo.

Introduction

In the revision of *Rhaphidophora* for Borneo Boyce (2001) treated *Rhaphidophora korthalsii* Hassk. as a polymorphic species. Since that publication, the author has been able to undertake extended and on-going fieldwork in Sarawak which has revealed that at least one element of Bornean *R. korthalsii* sensu Boyce 2001 is a morphologically stable taxon with a suite of characters consistently separating it from *R. korthalsii s. s.* In particular the smaller stature, slender leaflets and solitary, slender inflorescence, and most strikingly in the form of the leaves in the juvenile shingling plant which are ovate and spreading in *R. korthalsii s. s.* (Plate 1 c & d), but strongly falcate-lanceolate and ascending in the segregate taxon. Such plants match incontrovertibly *R. tenuis* Engl. based on Beccari collections from Matang, Kuching Division.

Rhaphidophora tenuis Engl.

Rhaphidophora tenuis Engl., Bot. Jahrb. Syst. 1 (1881) 181; Beccari, Malesia 1 (1882) 271–272; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 53. –Type: Malaysia, Sarawak, Kuching Division, Matang, *Beccari PB 1977*

(lecto, FI; isolecto, B; selected by Boyce, 1999).
Rhaphidophora korthalsii var. angustiloba Ridl. ex Engl. & K. Krause in Engler, Pflanzenr. 37 (IV.23B) (1908) 49. – Type: Malaysia, Sarawak, Kuching Division, Matang, Jul 1903, *Ridley s.n.* (lecto, SING; selected by Boyce, 1999). **Plate 1 (a & b).**

Moderate slender heterophyllous liana to 5 m; ***seedling stage*** a non-skototropic shingling juvenile shoot; ***pre-adult plants*** never forming terrestrial colonies; ***adult shoot architecture*** comprised of elongated, clinging, physiognomically unbranched, moderately leafy fertile stems; ***stems*** smooth, medium green, with sparse prophyll, cataphyll and petiolar sheath fibre, especially at the stem tips, internodes to 11 x 2 cm, separated by prominent oblique leaf scars, older stems subwoody; ***flagellate foraging stems*** absent; ***clasping roots*** densely arising from the nodes and internodes, prominently pubescent; ***feeding roots*** abundant, adherent and free, very robust, densely ramentose-scaly; ***leaves*** distichous; *cataphylls* and *prophylls* membranous, soon drying and degrading to intricately reticulate fibres, these only very slowly falling; *petiole* shallowly grooved, upper part ± terete, (1–) 9–65 x 0.2–1.5 cm, smooth, apical and basal genicula prominent; *petiolar sheath* prominent, membranous, strongly to slightly unequal on one side, extending almost to or reaching the apical geniculum, of ± short-duration, soon degrading into persistent netted fibres, these eventually falling leaving a prominent, slightly corky scar; *shingling lamina* entire, ascending falcate-lanceolate, 5–11x 3.5–6 cm, base slightly cordate, *pre-adult* and *adult lamina* spreading, entire, pinnatipartite to pinnatisect, 10–30 x 14–45 cm, broadly oblong-elliptic to oblong lanceolate, slightly oblique, subcoriaceous, base truncate and very briefly decurrent, apex acute to acuminate, individual pinnae 1–2 cm wide, perforated basally adjacent to the midrib, thus appearing stilted; *midrib* very prominently raised abaxially, slightly sunken adaxially; *primary venation* pinnate, raised abaxially, somewhat impressed adaxially, 2–4 primary veins per pinna; *interprimaries* sub-parallel to primaries, slightly raised abaxially, slightly impressed adaxially; *secondary venation* strongly reticulate, slightly raised; *tertiary venation* invisible; ***inflorescence*** solitary subtended by a membranous prophyll and one or more cataphylls, these swiftly degrading to netted fibres; *peduncle* slightly laterally compressed to terete, 6–26 x 1–1.5 cm; *spathe* narrowly canoe-shaped, stoutly beaked, 10–15 x 3–3.5 cm, stiffly fleshy, dull yellow, gaping at female anthesis and then caducous leaving a large straight scar at the base of the spadix; *spadix* cylindrical, sessile, inserted ± level on peduncle, 9–13 x 1–1.5 cm, dirty white; *stylar region* well developed, mostly rhombohexagonal, 1.5–2 x c. 2 mm, very slightly conical; *stigmas* slightly elliptic, mostly longitudinally oriented, c. 0.3–0.5 x 0.2–0.4 mm; *anthers* barely exserted at male anthesis; *infructescence*

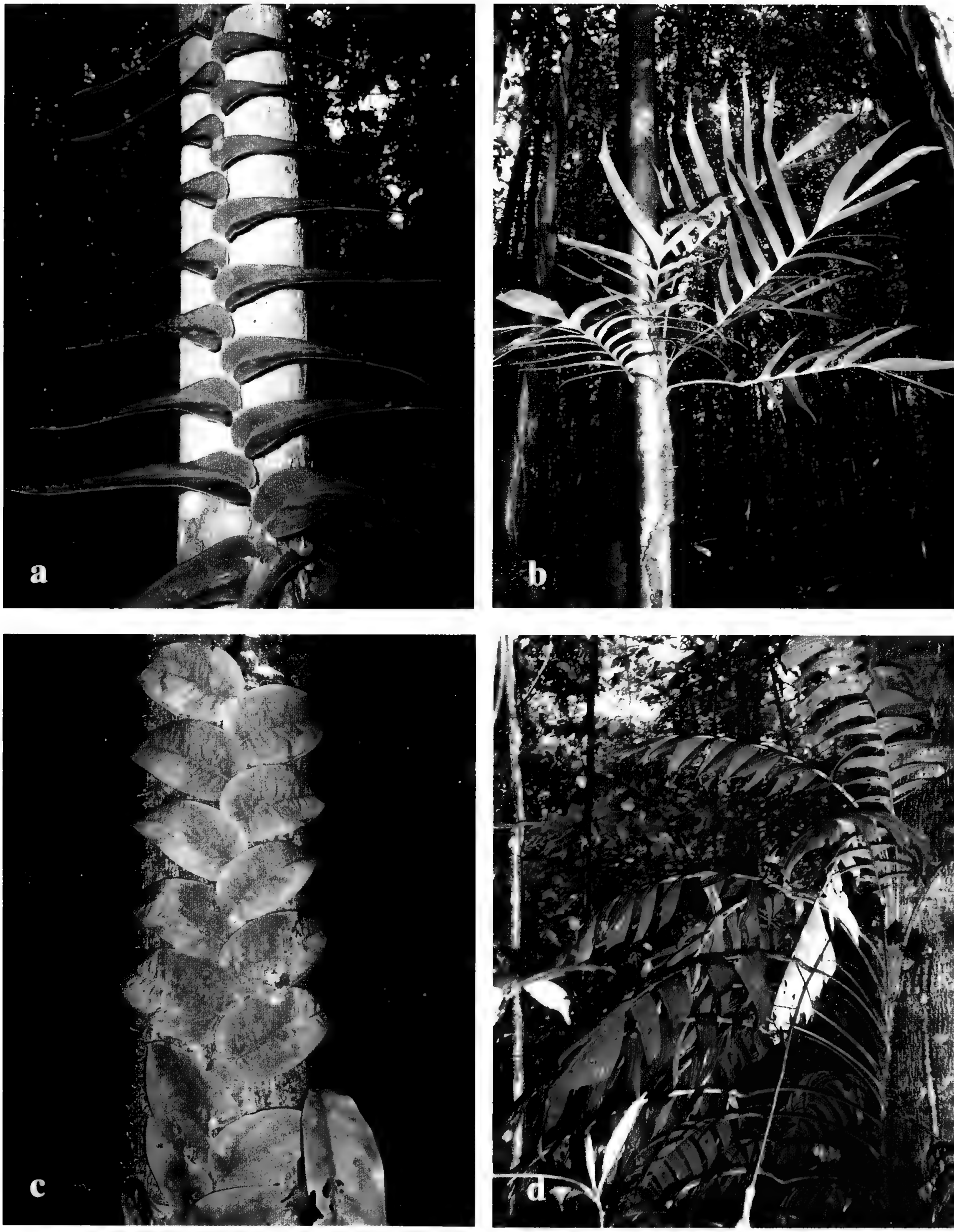

Plate 1. ***Rhaphidophora tenuis*** Engl.

a. Juvenile shingling stage showing diagnostic ascending falcate-lanceolate leaves.
b. Adult plant showing narrow pinnae.

Rhaphidophora korthalsii **Hassk.**
c. Juvenile shingling stage with ovate, spreading and overlapping leaves.
d. Adult plant showing broad pinnae.

14–18 x 2– 3cm, dark green ripening to dull orange, stylar tissue abscissing to reveal pale orange ovary cavity pulp.

Distribution: Sarawak, Brunei. Endemic.
Habitat: Primary to disturbed secondary lowland and hill forest, on trees and rocks on a variety of substrates including limestone. 20–650 m altitude.

Other specimens examined: SARAWAK. Kuching Division: Three miles from Kuching, *Haviland & Hose 3605* (K); Semengoh F.R., 6 miles west of Kuching, *Nicolson 1252* (US); Padawan, Subang, 7 Dec 2004, *M.Gibernau AR-837* (SAR); Bau, Kampung Segong, 26 Jun 2005, *Jeland ak Kisai & A. Shafreena AR-1262* (SAR); Padawan, Gunung Braang, 2 May 2001, *C.Lee AR-68.1* (SAR). Samarahan Division: Tebedu, mile 15, *Mohtar et al. S 49245* (K, SAR, US); Serian, G. Penrissen; *Paie S 16001* (K, LE, SAR). Bintulu Division: Eastern ridge of Bt. Kans, Bintulu district, *Hirano & Hotta 1432* (KYO); Sg. Ma'au, Dataran Tinggi Merurong, Tubau, *Othman et al. S 49050* (K, SAR); Bukit Sarang, Ulu Kakus, 02° 39' 21.08"; 100° 02' 61.09", *R.Kiew, Julia anak Sang & S.Lee* AR-729 (SAR). BRUNEI DARUSSALAM. Belait: Ulu Ingei, Bt. Batu Patam, lower slopes near Sg. Ingei, *Boyce 312* (BRUN, K).

Rhaphidophora tenuis can be fitted into the key to Bornean *Rhaphidophora* (Boyce 2001) as follows:

1a. Mature leaf lamina pinnately divided 2

1b. Mature leaf lamina entire, without or without perforations, but never pinnately divided 3

2a. Plants always associated with sandy or rocky forest streams. Flowering plants usually rheophytic, rarely low-climbing on trees beside torrential streams .... **R. beccarii**

2b. Plants not specifically associated with watercourses.

3a. Juvenile shingling stage falcate-lanceolate non-overlapping ascending leaves; adult plants with leaf pinnae no more than 2 cm wide and frequently much less; inflorescences solitary; spadix slender, not exceeding 13 cm long .... **R. tenuis**

3b. Juvenile shingling stage with ovate, overlapping spreading leaves; adult plants with leaf pinnae exceeding 3 cm wide; inflorescences several together; spadix stout, up to 25 cm long .... **R. korthalsii**

3a = 4a, etc., as in Boyce (2001)

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Boyce, P.C. 2001. The genus *Rhaphidophora* Hassk. (Araceae-Monsteroideae-Monstereae) in Borneo. *Gardens' Bulletin Singapore* **53**: 19–74.

Studies on Schismatoglottidae (Araceae) of Borneo I: A trio of new *Schismatoglottis* from Sarawak

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Abstract

Three new species of *Schismatoglottis* - *Schismatoglottis jelandii* P.C.Boyce & S.Y. Wong, *Schismatoglottis jepomii* P.C.Boyce & S.Y. Wong and *Schismatoglottis maelii* P.C.Boyce S.Y. Wong - from Sarawak are described and included in the amendments to the key to Bornean *Schismatoglottis* published by Hay & Yuzammi (2000). All are illustrated.

Introduction

Recent revisions and publications on tropical Asian *Schismatoglottis* (Hay & Yuzammi, 2000; Hay, 2002; Hay & Herscovitch, 2003) have greatly facilitated accurate naming of Bornean *Schismatoglottis* and provided an excellent platform from which to describe further novelties without the concern that obfuscated species names are being overlooked. Despite a 100% increase in the number of Bornean *Schismatoglottis* in the past five years resulting from these publications, on-going fieldwork in Sarawak has revealed that there is still a considerable number of *Schismatoglottis* species awaiting formal description. Three are described here.

1. Schismatoglottis jelandii P.C.Boyce & S.Y. Wong, *sp. nov.*

Schismatoglottidem asperatam Engl. *simulans sed folii lamina stenophylla at inflorescentia gemini differt.* –**Typus**: Malaysia. Sarawak, Bintulu Division, Bintulu, Bukit Satiam, 02° 59' 33.0"N; 112° 56' 01.4"E, 12 Aug 2004, *P.C.Boyce & Jeland ak Kisai AR-636* (holo, SAR). **Plate 1.**

Facultative rheophytic ***herb*** to *c.* 30 cm tall, solitary or forming small clumps.

Stem condensed, erect, to *c.* 1 cm diam., pleionanthic; internodes obscured by overlapping leaf bases, not conspicuous. ***Leaves*** several together (*c.* 10 per plant); petiole D-shaped in cross-section, 2–4(–7) cm long, *c.*1/3 the length of the lamina, sheathing in the lower 1/3–2/3, asperulate, narrowly crispulate-alate on each side on the adaxial face; petiolar sheath adnate to petiole for the greater part, then free-auriculate at the top for *c.* 1 cm, broad and subparallel, the margins inrolled; blade narrowly obovate, thinly subsucculent, 15–21(–26) x 2–4(–5) cm, lustrous deep green adaxially variegated with two longitudinal zones of diffuse greenish white blotches, matt pale brownish yellow-green abaxially, the base slightly obliquely truncate, the tip attenuate and apiculate for *c.* 2 mm; midrib not prominent adaxially, prominently raised abaxially; primary lateral veins *c.* 9 on each side, alternating with slightly to considerably lesser interprimaries, diverging at c. 30°; secondary conspicuously tessellate (abaxially); tertiary venation not visible. ***Inflorescences*** two together, subtended by one narrow prophyll and one broad cataphyll; peduncle short, not exserted from leaf bases. *Spathe* 5.5–7.5 cm long, subcylindric, tapering distally, weakly rounded-truncate basally; lower spathe 1.5–2.5 cm long, ovoid, flushed pale pink, hardly differentiated from the limb by a barely perceptible constriction corresponding with the upper part of the fertile male zone; limb 3.5–6 cm long, narrowly ovate-lanceolate, dirty white flushed and slightly veined pale pink, spreading at onset of female anthesis then crumbling-deliquescent at late male anthesis. *Spadix* sessile, somewhat shorter than the spathe, to 5.5 cm long; female zone 0.6–1 cm long, with oblique to very shortly adnate (to spathe) insertion, 0.4 cm diam. at base, weakly conoid; pistils crowded, oblong-barrel-shaped, *c.*1 mm tall, 0.75 mm diam.; stigma sessile, discoid, weakly umbonate, papillate, fractionally wider than ovary and ± contiguous with neighbouring stigmas; interpistillar staminodes few, claviform, scattered among the pistils, slightly taller than the pistils, *c.*0.5mm diam.; sterile interstice 3–8 mm long, slightly wider with top of female and base of male zones, 4–5 whorls of irregularly polygonal staminodes *c.* 0.5 mm diam., separated from the female zone by a row of more slender staminodes; male zone *c.* 0.8 mm long, cylindric, fractionally wider at the junction of the appendix; stamens orange (even before anthesis) crowded, truncate with the thick connective slightly elevated above the thecae, more or less rectangular from above; pollen extruded in short strands; appendix pale pink, about one and a half the length of the rest of the spadix, widest *c.* half way up, then gradually tapering to a rather narrow blunt tip, 2.5–3.5 cm long, 4–6 mm diam.; staminodes of appendix more or less flat-topped, irregularly polygonal, 0.75–1mm diam., densely crowded (fresh). *Fruiting spathe* not observed.

Plate 1. ***Schismatoglottis jelandii***
a. Holotype plants in habitat; **b.** Inflorescence at female anthesis. Note orange stamens; **c.** Inflorescence at male anthesis, spathe beginning to deliquesce prior to being shed.

Distribution: Sarawak, Bintulu Division. Known only from the type locality. *Habitat*: Facultative rheophyte on stream banks on sandstone-derived clays in slightly seasonally dry lowland secondary forest at 18 m altitude.

Notes: *Schismatoglottis jelandii* falls within the *Schismatoglottis asperata* group (see Hay & Yuzammi 2000: 54) by the pleionanthic shoot, fully attached persistent leaf sheath and the spathe limb opening more or less wide and then crumbling-deliquescent. It is most similar to *S. asperata* Engl. from which it differs most notably in the stenophyllous habit, the conspicuously tessellate secondary venation (visible on the abaxial surface of the lamina) and in always producing pairs of inflorescences. Additionally the stamens are orange prior to and after anthesis *vs.* white prior and orange at and after anthesis in *S. asperata*.

The type locality is subjected to periodic inundation and while the plants of *S. jelandii* are probably not regularly buffeted by flood waters it does seem likely that during particularly heavy rainfall they are at least temporarily in the flood water flow. It seems reasonable to speculate that the stenophyllous habit is adaptive for this.

Hay & Yuzammi (2000) adopted a broad circumscription for *S. asperata* with the caveat that, 'Possibly it will transpire on further field study that more than one taxon has been included here, but at present there is insufficient evidence on which to base a split'. Extensive and focused fieldwork since has revealed that *S. asperata* is widespread and indeed variable but that there exists a considerable number of localized morphologically distinct taxa, frequently adapted to a specific substrate (shale in particular) and/or ecological niche and that these do, indeed, warrant taxonomic recognition.

Schismatoglottis jelandii can be fitted into the key to Bornean *Schismatoglottis* (Hay & Yuzammi 2000) as follows:

31a. Appendix subcylindric 32

b. Appendix conic-ellipsoid to broadly conic-ovoid 34

32a. Petiole conspicuously and thickly longitudinally ridged; stigmas minute, punctate, sterile interstice absent (or reduced to a whorl of incompletely abortive stamens); Southern Sarawak .... **27. S. nervosa**

b. Petiole finely longitudinally ridged and/or asperous; stigmas button-like to discoid; sterile interstice well-defined 33

33a. Petiole not ridged; appendix about two thirds of the length of the spadix; 34

b. Petiole finely longitudinally ridged; appendix about or less than one third of the length of the spadix; Sarawak, ?W. Kalimantan ..... **25. S. latevaginata**

34a. Plant with broad leaves and not associated exclusively with riverine habitats; secondary venation obscure; inflorescences solitary; stamens white prior to anthesis, then turning orange. Widespread in NW Borneo .... **14. S. asperata**

b. Plant stenophyllous, only associated with riverine habitats (facultative rheophytic); secondary venation conspicuously tessellate; inflorescences paired; stamens orange prior to and after anthesis. Bornean endemic. .... **S. jelandii**

34a in key = 35a, etc.

Etymology: *Schismatoglottis jelandii* is named for Jeland ak Kisai in recognition of his considerable field skills and excellent company.

2. Schismatoglottis jepomii P.C.Boyce & S.Y. Wong, *sp. nov.*

Ab aliis speciebus sect. tecturatae lamina spathae caducosenti differt. – **Typus**: Malaysia. Sarawak, Kuching Division, Lundu, Kampung Rayu, Sungai Rayu, 01° 36' 42.6"N; 110° 08' 59.8"E, 30 m asl, 30 August 2005, *PC..Boyce, Jeland ak Kisai, Jepom ak Tisai & Mael ak Late AR-1341* (holo, SAR; iso, SING). **Plate 2.**

Facultative rheophytic ***herb*** to *c.* 45 cm tall, forming large clumps. ***Stem*** condensed, epigeal, pleionanthic, *c.* 8–10 mm diam., to *c.* 6 cm long (usually less); foliage ***leaves*** many together, each subtended by submembranous, later papery linear dark brown (when dry) cataphylls to 5 cm long; petiole 10–14 cm long, slender, terete, sheathing only at very base; sheath very shortly and truncately ligular; leaf blades spreading to erect, lanceolate, somewhat brittle-coriaceous, glossy mid- to dark green adaxially, concolorous or frequently with irregular jagged or cloudy paler green or creamy grey blotched along the midrib, abaxially paler, the base cuneate, the tip long-acuminate and terminating in a 2–5 mm long tubular mucro, 8–25 x 1–5 cm; venation more or less obscure adaxially; midrib flattened-raised adaxially, usually drying with a more or less conspicuous narrow central channel adaxially, abaxially prominent; primary lateral veins, *c.* 14 on each side of midrib, alternating with scarcely lesser interprimaries and diverging at *c.* 35°; secondary venation more-or-less obscure forming a weak reticulum, tertiary venation not visible. ***Inflorescences*** (solitary to) clustered in groups of up to four, smelling pungently of acetic acid; peduncle moderately robust, much shorter than the petiole *c.* 2 cm long and hardly emerging from the subtending cataphyll. *Spathe* white, *c.* 9 cm long; lower spathe ovoid basally becoming slender cylindrical above, *c.* 5 cm long; limb elongate-ovate, gaping at female anthesis then crumbling and falling, distinctly incurved ventrally, *c.* 4 cm long, apically stiffly mucronate for *c.* 3 mm, soon crumbling-caducous. *Spadix* sessile, stout, lower part cylindrical, distally weakly elongate-clavate, *c.* 4 (lower part) to 6 mm (upper part) diam., ventrally curved, slightly shorter than the spathe, *c.* 7 cm long; female zone *c.* 5 mm long, slightly conical, obliquely inserted but otherwise entirely free from the spathe; pistils crowded; ovary squat-oblong, *c.* 0.75 mm diam.; style distinct, *c.* 0.5 mm long; stigma minutely papillate, as wide as the style; interpistillar staminodes scattered throughout the zone, clavate, *c.* 0.5 mm diam.; male and female zones contiguous; male zone *c.* 2.5 cm long, cylindric; stamens truncate, partly confluent apical pores; appendix sub-cylindric, *c.* 3.7 cm long, weakly elongate-clavate, blunt-tipped, composed of columnar trapezoid to triangular staminodes. *Fruiting spathe* with the lower part broadly ovoid.

Distribution: Sarawak, Kuching and Sri Aman Divisions.
Habitat: Facultative rheophyte in deep sandy-loam along stream banks in lowland secondary forest. 100 m altitude.

Notes: *Schismatoglottis jepomii* belongs to the *Schismatoglottis tecturata* group (see Hay & Yuzammi 2000: 162) based on shoot arrangement (pleionanthic with the leaf sheath very short and fully attached; foliage leaves alternating with cataphylls) but differs from the two species hitherto comprising this group (*S. tecturata* (Schott) Engl. and *S. petri* A.Hay) by the spathe limb crumbling and shedding before male anthesis. *Schismatoglottis jepomii* differs from *S. tecturata* in the considerably larger size of the inflorescence and the scattered interpistillar staminodes (arranged in a single ring at the base of the female zone in *S. tecturata*). From *S. petri* the truncate connective is immediately diagnostic.

Schismatoglottis jepomii can be fitted into the key to Bornean *Schismatoglottis* (Hay & Yuzammi 2000) as follows:

Plate 2. *Schismatoglottis jepomii.*
a. Holotype plants in habitat; **b.** Inflorescence at female anthesis. Note spathe already partially shed; **c.** Inflorescence emerging from prophyll.

22a. Connective not or hardly elevated; appendix cylindrical or only weakly elongate-clavate, more or less isodimatric with top of male zone 23

b. Connective much elevated above the thecae; appendix clavate-cylindric, distinctly thicker than male zone; Brunei .... **87. S. petri**

23a. Spathe persistent into anthesis, later marcescent; appendix cylindric, more or less isodiametric with top of male zone; Borneo and Riau Archipelago .... **88. S. tecturat**

b. Spathe caducous prior to male anthesis; appendix weakly elongate-clavate; Western Sarawak .... **S. jepomii**

23a in key = 25a, etc.

Etymology: *Schismatoglottis jepomii* is named for Jepom ak Tisai, the most recent member of the Malesiana Tropicals field staff, who has an excellent pair of forest eyes and is a splendid company.

Other specimens examined: SARAWAK: Kuching Division: Bau, Segong, 12 Feb 2004, *Jepom ak Tisai AR-222* (SAR); Bau, Rieng Opui, 26 May 2004, *Jeland ak Kisai AR-402* (SAR); Bau, Singai, Batu Taring, 19 Jun 2004, *Jeland ak Kisai & Jepom ak Tisai AR-465* (SAR); Bau, Rieng Opui, 1 May 2005, *Jeland ak Kisai AR-1184* (SAR). Sri Aman Division: Lubok Antu, Batang Ai, Nanga Sumpa, Sungai Delok, 01° 11' 40.8"N; 112° 04' 04.2"E, 28 Jul 2004, *P.Boyce, Jeland ak Kisai & Kachong AR-558* (SAR).

3. Schismatoglottis maelii P.C.Boyce & S.Y. Wong, *sp. nov.*
Ab aliis speciebus sect. multiflorae foliius profunde corrugatis differt. – **Typus**: Malaysia. Sarawak, Kuching Division, Bau, Segong, Ulu Sungai Adis, Sungai Bronand, 50 m asl, 4 May 2004, *Jeland ak Kisai & Jepom ak Tisai AR-47* (holo, SAR). **Plate 3.**

Lithophytic ***herb*** to *c.* 50 cm tall. ***Stem*** condensed, erect to creeping, *c.* 2–2.5 cm thick, with internodes to *c.* 0.5 cm long, pleionanthic. ***Leaves*** to *c.* 15 together; petiole 15–25 cm long, terete, mid-green, sheathing only at the extreme base, the wings of the sheath extended into a bicarinate narrowly lanceolate free ligular portion to 13–18 cm long, drying dark brown; lamina oblong, deflexed at insertion on petiole and held subpendent, 14–25 x 5–15 cm, deep lustrous green adaxially, abaxially almost the same, the base obtuse and slightly decurrent, the tip acute and with a tubular mucro up to 8 mm long; midrib very prominent-rounded abaxially, adaxially impressed

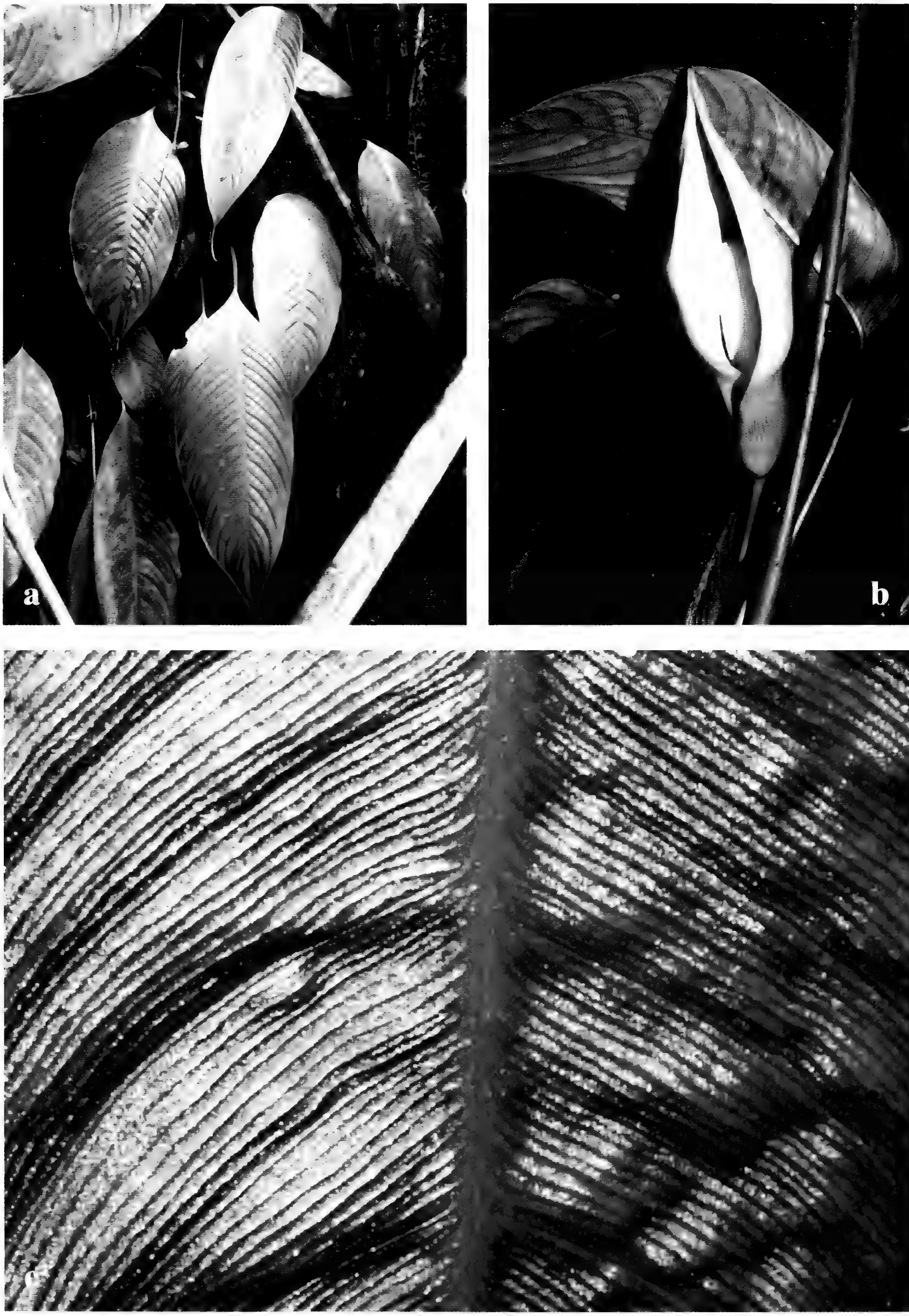

Plate 3. ***Schismatoglottis maelii***
a. Holotype plants in habitat; **b.** Inflorescence at female anthesis; **c.** Leaf lamina, adaxial surface to show diagnostic venation.

to semi-flush with the lamina, with 5–28 primary lateral veins on each side, irregularly alternating with the prominent interprimary veins and diverging at 60–70°; secondary venation very prominently deep green-transparent abaxially, impressed adaxially, arising from the midrib and from the bases of the primary veins; tertiary venation obscure, all primary and secondary veins impressed adaxially and giving the lamina a prominently finely corrugated texture. ***Inflorescences*** 1–4 together, nodding, subtended by lanceolate cataphylls resembling the ligular leaf sheaths, strongly fragrant of crushed raspberries at anthesis; peduncle to 7 cm long, terete, pale green, not exceeding the cataphylls, deflexed at the junction of the lower spathe and long-decurrent on the spathe (corresponding to the female zone). ***Spathe*** 7.5–8 cm long; lower spathe c. 2 cm long, green, differentiated from the limb by a pronounced constriction level with the top of the interstice; limb 5.5–6 cm long, pale green with darker green veining, apex mucronate for c. 3 mm, interior sticky at female anthesis when conspicuously inflated, then crumbling-caducous at male anthesis. Spadix to 4.5 cm long, subcylindric; female zone c. 1.8 cm long, adnate to the spathe in the lower 2/3, the free part slightly conoid, apically 6.5 mm diam.; pistils numerous and crowded, subcylindric, c. 0.4 mm diam.; stigma sessile, about the diameter of the ovary, button-like, papillate; interpistillar staminodes very few among the pistils, otherwise confined to a single row along the spathe/spadix adnation and a further incomplete row at the junction of the female zone and the interstice, overtopping the pistils, elongate mushroom-shaped, round-topped; sterile interstice 6 mm long, white, somewhat obconoid, distally 6 mm diam.; staminodes of interstice crowded, irregularly polygonal, the lower most resembling the interpistillar staminodes, the upper more flattened, 0.5–1 mm diam., flat-topped; male zone 2 cm long, cylindrical, basally isodiametric with top of interstice, tapering to a blunt point in the upper half; stamens rather dense, somewhat irregularly rectangular with the connective wide and raised and the pores small on the narrower edges of the connective, 0.7–10 mm across; appendix, c. 1 cm long, blunt-conic, composed of densely packed trapezoid to triangular irregular staminodes, the apex slightly depressed. Fruiting spathe mid-green, narrowly urceolate, up to 3 cm long.

Distribution: Sarawak, known only from the vicinity of Bau, Kuching Division.

Habitat: Lithophytic on thin layers of humus and in shallow litter pockets on sandstone boulders and cliffs, 60 – 100 m altitude.

Notes: *Schismatoglottis maelii* belongs to the *Schismatoglottis multiflora* group (see Hay & Yuzammi 2000: 84) by reason of the pleionanthic shoots, free-ligular leaf sheath, and the inflorescence held subhorizontal by the bent peduncle and caducous spathe limb. It may immediately be distinguished from all other species in the group by the prominently raised striate veins, and from most species by the curiously brilliant green leaves.

Schismatoglottis maelii is most similar to *S. mayoana* Bogner & M.Hotta in possessing a sterile appendix with large staminodes and a sterile interstice but is readily differentiated by the markedly corrugated adaxial venation, smaller spadix (up to 4.5 cm in *S. maelii vs.* 8 cm in *S. mayoana*) and different inflorescence odour. The freshly opened inflorescences smell strongly of crushed raspberries in notable contrast to all other *Schismatoglottis* so far sampled, including species probably most closely related to *S. maelii*, e.g., *S. nicolsonii* A.Hay, *S. mayoana*, etc., in which the newly opened inflorescence emits a pungent smell reminiscent of acetic acid.

Schismatoglottis maelii can be fitted into the key to Bornean *Schismatoglottis* (Hay & Yuzammi 2000) as follows:

15a. Secondary venation very fine and dense – 2 veins per mm; thecae of stamens each with two pores 16

b. Secondary venation density various but 1.5 veins or fewer per mm; thecae of stamens each with one pore 1*

16a. Spadix with a short sterile interstice of sterile stamens between the fertile zones; appendical staminodes large, ca. 1 mm across 17

b. Spadix with fertile zone contiguous; staminodes small, ca. 0.3 mm across; Bako, Sarawak .... **42. S. nicolsonii**

17a. Spadix usually ca. 8 cm long; leaves smooth adaxially; Matang, Sarawak .... **39. S. mayoana**

b. Spadix ca. 4.5 cm long, leaves corrugate adaxially; Bau, Sarawak .... **S. maelii**

17a in key = 18a, etc.

Etymology: *Schismatoglottsis maelii* is named for Mael ak Late, who is responsible for the construction and maintenance of the Malesiana Tropicals nurseries, and lately an occasional but valued member of our field team.

Other specimens seen: SARAWAK: Kuching Division: Bau, Kampung Jugan, Sungai Merah, 27 Apr 2004, *Jeland ak Kisai AR-32* (SAR) & 6 May 2004, *P.Boyce & Jeland ak Kisai AR-55* (SAR); Bau, Segong, Ulu Sungai Adis, 2 Jun 2004, *Jepom ak Tisai AR-427* (SAR) & 5 Jun 2004, *Jeland ak Kisai & Jepom ak Tisai AR-437* (SAR); Bau, Segong, Gunung Moi, 28 Feb 2005, *Jeland ak Kisai AR-1008* (SAR).

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Rhaphidophora crassifolia Hook.f. (Araceae: Monstereae): a new record for Sarawak and notes on the *Rhaphidophora* 'Hongkongensis' group in Borneo

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Abstract

Rhaphidophora crassifolia Hook.f., a species hitherto known only from Peninsular Malaysia and southern Thailand is recorded as new for Sarawak and takes to 16 the number of species of *Rhaphidophora* for Borneo, of which five are endemic. A species description and photographs together with a new key to the *Rhaphidophora* species in Borneo is given.

Introduction

Revision work on *Rhaphidophora* (Boyce, 2001, 2005, 2006) in Borneo has established that there are 16 species (excluding that described here), of which five are endemic.

The most speciose group in Borneo with four species is the 'Hongkongensis' Group defined by shingling, non-skototropic seedling and shingling juvenile shoots, pre-adult and adult plants with climbing stems square to rectangular in cross-section, simple, often coriaceous leaf laminae, a petiolar sheath extending beyond the leaf base by short to rather long ligules and the sheath soon falling to leave a horseshoe shaped scar around the top of the apical geniculum. All species flower on free lateral shoots that are either angular or more-or-less terete in cross-section. Species in the 'Hongkongensis' Group are often lofty climbers and are frequently very inadequately collected.

Key to Adult Flowering *Rhaphidophora* in Borneo

1a. Mature leaf lamina pinnately divided 2

1b. Mature leaf lamina entire, with or without perforations, but never pinnately divided 3

2a. Plants always associated with sandy or rocky forest streams. Flowering plants usually rheophytic, rarely low-climbing on trees beside torrential streams .... **R. beccarii**

2b. Plants not specifically associated with watercourses.

3a. Juvenile shingling stage with falcate-lanceolate non-overlapping ascending leaves; adult plants with leaf pinnae no more than 2 cm wide and frequently much less; inflorescences solitary; spadix slender, not exceeding 13 cm long .... **R. tenuis**

3b. Juvenile shingling stage with ovate, overlapping spreading leaves; adult plants with leaf pinnae exceeding 3 cm wide; inflorescences several together; spadix stout, up to 25 cm long .... **R. korthalsii**

4a. Geniculum and abaxial surface of lamina pubescent 5

4b. Geniculum and abaxial surface of lamina glabrous 4

5a. Plants flowering on clinging stems. Leaves of mature plants extensively perforated, active shoot tips with black mucilage .... **R. foraminifera**

5b. Plants flowering on free lateral stems. Leaves of mature plants lacking or with only with scattered perforations; active shoot tips lacking black mucilage.. **R. puberula**

6a. Leaves always shingling, even in flowering individuals; leaf laminae stiffly coriaceous, broadly oblong-ovate-elliptic, 8–48 x 6.5–20.5 cm, bright green, slightly to markedly glaucous, base truncate-cordate to broadly cuneate. Flowering on clinging shoots.. **R. latevaginata**

6b. Leaves spreading in adult and flowering individuals; leaf laminae variously coloured but never glaucous. Flowering on free or clinging shoots 7

7a. Stems scabrid to asperous. Spathe exterior minutely puberulent .... **R. lobbii**

7b. Stems smooth. Spathe (where known) exterior glabrous 8

8a. Abaxial surface of lamina glaucous. Peduncle up to 18 cm long .... **R. typha**

8b. Abaxial surface of lamina never glaucous. Peduncle not exceeding 10 cm long 9

9a. Clinging stems square or rectangular in cross-section; tips of active stems with netted prophyll, cataphyll and petiolar sheath fibre..........**R. elliptifolia**

9b. Clinging stems various shapes in cross-section, including square or rectangular; tips of active stems without fibre 10

10a. Spadix stipitate; leaf lamina very thickly coriaceous ....**R. conocephala**

10b. Spadix sessile; leaf lamina variously textured but if thickly coriaceous then spadix sessile 11

11a. Inflorescences two, three or more together, each subtended by a prominent chartaceous prophyll and one or more chartaceous cataphyll; leaf lamina oblong-lanceolate or oblong-elliptic, entire to slightly perforated, glabrous .... **R. megasperma**

11b. Inflorescences almost always solitary, never subtended by prominent chartaceous prophylls and cataphylls; leaf lamina variously shaped but never perforated 12

12a. Clinging stems rectangular in cross-section 13

12b. Clinging stems more-or-less terete in cross-section 15

13a. Leaf lamina thickly coriaceous to almost fleshy, margins slightly reflexed, this becoming greatly accentuated in dried material. Clinging stems twisting to produce complex ridges .... **R. crassifolia**

13b. Leaf lamina thinly coriaceous, margins flat, leaf drying pale straw-coloured. Clinging stems not twisting 14

14a. Leaf lamina lanceolate-elliptic to falcate-lanceolate, 4.5–32 x 1.75–8.5 cm. Spadix weakly clavate-cylindrical, 3–6 cm long .... **R. sylvestris**

14b. LEAF LAMINA, NARROWLY ELLIPTIC TO NARROWLY ELLIPTIC-OBLONG, 20–29 X 4.5–7 cm. Spadix cylindrical, 8–14 cm long .... **R. elliptica**

15a. Leaf lamina narrowly falcate-elliptic to falcate-lanceolate or falcate-oblanceolate, 2.5–16 x 1.2–3 cm, drying uniformly pale straw-coloured. Spadix slender cylindrical, 2.5–7 cm long .... **R. minor**

15b. Leaf lamina subfalcate-lanceolate or oblong-elliptic, oblique, 10–19.5 x 2.5–6.5 cm, drying very dark brown. Spadix cylindrical-obtuse, 3–10 x 1 cm (fruiting specimen only) .... **R. cylindrosperma**

Rhaphidophora crassifolia Hook.f.

Rhaphidophora crassifolia Hook.f., Fl. Brit. Ind. 6 (1893) 543; Ridl., Mat. Fl. Malay Penins. 3 (1907) 42; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 22, Fig. 5; Ridl., Fl. Malay Penins. 5 (1925) 122– **Type**: Malaysia, Perak, Batang Padang District, Batang Padang, Aug 1884, *Kunstler 8111* (holo, K).

Large, occasionally very large, moderately robust, semi-pachycaul homeophyllous liane to 10 m; ***seedling stage*** a non-skototropic shingling shoot; ***pre-adult plants*** rarely forming small terrestrial colonies of appressed shingling shoots; ***adult shoot*** architecture comprised of greatly elongated, clinging, physiognomically monopodial, leafy, non-flowering stems and short to moderately elaborated, free, sympodial, densely leafy, flowering stems; ***stems*** smooth, climbing stems rectangular in cross section, the angles winged, the surfaces between sulcate, the stem twisting to produce a complex series of ridges and channels, free stems more or less terete to weakly four-angled in cross section, often branching extensively, growing to considerable lengths and then pendent under their own weight, green, later dull brown, without prophyll, cataphyll and petiolar sheath fibre but active apices coated with clear mucilage, internodes to 10 x 2 cm on adherent shoots, usually shorter and less stout on free shoots, separated by prominent slightly oblique leaf scars, older stems woody; ***flagellate foraging stems*** absent; ***clasping roots*** densely arising from the nodes and internodes of clinging stems, densely pubescent; ***feeding roots*** rather rare, adherent, pubescent; ***leaves*** weakly spiralled on adherent and proximal portions of free shoots, densely distichous distally on flowering shoots; cataphylls and prophylls membranous, very quickly drying and falling; *petiole* shallowly canaliculate to grooved adaxially, 4–7 x 0.2–0.3 cm, smooth, with a slight apical and somewhat prominent basal geniculum; petiolar sheath prominent, extending to and encircling the apical geniculum, very swiftly drying and falling to leave a continuous scar from the petiole base, around the top of the apical geniculum and back to the base; lamina entire, falcate-elliptic-lanceolate to falcate-oblong or falcate-oblanceolate, 2.5–35 x 1–10 cm, thickly coriaceous to almost fleshy, upper surfaces glossy, lower surfaces matte, base sub-ovate to acute or briefly decurrent, apex sub-acute with a prominent apiculate tubule, margins slightly reflexed, this becoming greatly accentuated in dried material; mid-rib barely raised abaxially, slightly sunken adaxially; primary venation pinnate, slightly raised abaxially and adaxially; *interprimaries* parallel to primaries, very slightly raised abaxially and adaxially; *secondary* and *tertiary venation* ± invisible in fresh material, barely visible in dried specimens; ***inflorescence*** solitary, subtended by a fully developed foliage leaf; *peduncle* compressed-cylindric-clavate, 1.7–2.5 x 0.2–0.3 cm; *spathe* cigar-shaped, stoutly short-beaked, 4–6.5 x 1–1.7 cm, thickly fleshy, dull green to dull yellow, swiftly falling at female receptivity; *spadix* cylindrical, sessile, inserted level on peduncle, 3.5–6 x 0.5–1.3 cm, dirty white; *stylar* region rather well developed, mostly rhombo-hexagonal, 0.8–1 x c. 1 mm, truncate; *stigma* punctiform, c. 0.3 mm diam.; *anthers* barely exserted at anthesis, pollen extruded from between ovaries; ***infructescence*** not observed.

Distribution: Peninsular Malaysia (Negri Sembilan, Perak, Selangor), southern peninsular Thailand (Narathiwat), Borneo (Sarawak: Miri).

Habitat: Primary lowland rainforest, dry *Dryobalanops* forest, peatswamp forest, wet evergreen forest, frequently but not exclusively associated with Karst limestone. 10–90 m altitude.

Notes: The remarkably thick leaves and complex patterns of ridges and channels (Plate 1) resulting from the twisting of the stems immediately distinguish *R. crassifolia* from the two most similar species in Sarawak, *R. elliptica* Ridl. and *R. elliptifolia* Merr. *Rhaphidophora crassifolia* may be further distinguished from *R. elliptifolia* by the lack of fibrous remains on the tips of the active shoots and from *R. elliptica* by the smaller (3.5–6) spadix (8–14 cm long in *R. elliptica*).

Other specimens examined: SARAWAK: Miri, Niah Suai, Niah National Park, trail to Great Cave, 03° 49' 21.7"; 113° 45'44.1", *P.C.Boyce, Jeland ak Kisai & Jepom ak Tisai* AR-1464 (SAR). PENINSULAR MALAYSIA: Perak: Padang, Batang Padang, *Kunstler ('Dr King's Collector') 8111* (K, holo); *Wray 2260* (SING); Selangor: Genting Sempah 22 mile, Ulu Gombak F.R., *Stone 5738* (KLU); Batu Cave ravine, *Nicolson 1148* (US); Negeri Sembilan, Pasoh F.R., *La Frankie 2185* (KEP); Johore, Pengkalan Raja, Pontian, *Ngadiman SFN 36774* (B, BO, L, K, P, SING); Sg Kayu Ara, Mawai - Jemaluang road, *Corner SFN 29318* (KEP, K, SING). THAILAND: PEN72. Narathiwat, Budho-Phadee N.P., Nam Tok Chatwarin, 6°06'N, 101°50'E, *Boyce 1226* (BKF, K).

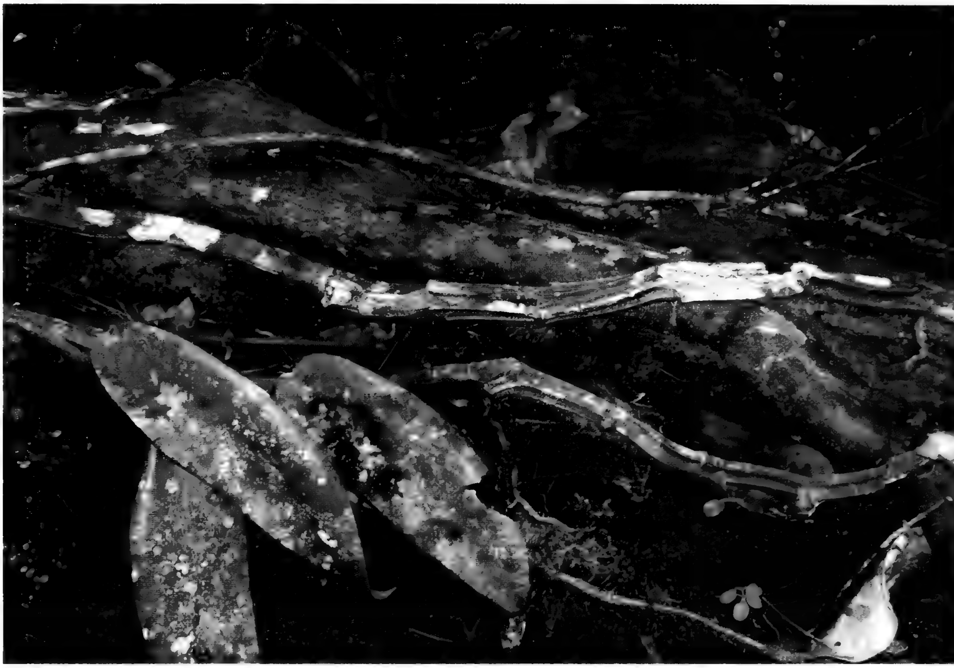

Plate 1. ***Rhaphidophora crassifolia*** **Hook.f.** Note the ridges along the twisted stem and coriaceous leaf.

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A review of entire-leaved *Tacca* (Dioscoreaceae) in Sarawak, Borneo

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Abstract

A review of entire-leaved *Tacca* in Sarawak is presented; four species are recognized. *Tacca borneensis* Ridl. is resurrected and problems concerning the interpretation of *T. integrifolia sensu* Drenth are reviewed. The first complete description of *T. bibracteata* Drenth is published. One new species, *T. reducta* P.C.Boyce & S.Julia, is proposed. Significant floral and fruiting morphologies are highlighted and a key to all *Tacca* species (entire and palmate/dracontioid-leaved) in Sarawak is provided. All entire-leaved species in Sarawak are illustrated.

Introduction

The most recent complete revision of *Tacca* J.R. & G.Forst (including *Schizocapsa* Hance) was by Drenth (1972), with regional accounts for Flora Malesiana (Drenth, 1976) and Flora of China (Ling, 1985; Ding *et al.*, 2000). All these accounts follow Drenth (1972) in treating *T. integrifolia* Ker Gawl as a widespread and highly polymorphic species.

Drenth (1972, 1976) recognizes two entire-leaved *Tacca* species for Sarawak, viz. *Tacca bibracteata* Drenth and *T. integrifolia*, in addition to two compound-leaved species: *T. leontopetaloides* (L.) Kuntze & *T. palmata* Blume. As is inevitably the situation with wholly herbarium-based monocot, family accounts, subsequent fieldwork has revealed considerable problems interpreting names and a far too broad circumscription of species. In particular there are considerable problems with the circumscription of *T. integrifolia*, which, far from being a highly variable species, in Sarawak, divides incontrovertibly into three morphologically and, in one instance, an ecologically – limestone –, a distinct species.

Characters of Taxonomic Significance

During our studies the following characters have proven to be of diagnostic value:

Involucral bracts

Outer and inner pair: heteromorphic or homeomorphic.
Outer pair position: lateral or dorso-ventral.
Outer pair position: lateral, lateral-ascending or dorso-ventral.

Perianth

Lobes of inner and outer perianth ± equal in size or dissimilar.
Perianth lobes soon marcescent or persistent into fruiting.

Tacca on Sandstone and Shale in Sarawak

Tacca integrifolia Ker Gawl & *T. borneensis* Ridl.

Sarawak has two non-limestone associated *Tacca* species with large involucral bracts. One has heteromorphic bracts and is discussed in detail later in this paper. The other, with homeomorphic bracts and a truncate, oblique leaf base equates to *T. borneensis* Ridl., and although treated as a synonym of *T. integrifolia* by Drenth (1972), is distinct and is here resurrected from *T. integrifolia sensu* Drenth.

***Tacca borneensis* Ridl.**, J. Straits Branch Roy. Asiat. Soc., 49(1): 45 (1907). Type: Malaysia, Sarawak, Kuching Division, Matang, Aug 1905, *Ridley* s.n. (holo, SING!). **Plate 1a.**

Moderate to robust terrestrial ***herb*** to 1.2 m. tall. ***Stem*** rhizomatous, hypogeal, creeping with the active apex ascending, up to 3.5 cm thick, clothed with persistent leaf bases and frequently rooting through these. ***Leaves*** 5 – 15 together; petioles ascending, up to 41 cm long, c. 12 mm diam, sub-terete- in overall cross-section, pronounced deeply canaliculate, sharply 2-keeled on the dorsal side, mid-green, stained deep purple-brown at the base; petiolar sheath c. $^{1}/_{6}$ – $^{1}/_{5}$ length of petiole, hyaline; lamina ascending to recurved, oblong-lanceolate to oblong, 23 – 65 x 10 – 24 cm, base oblique, broadly

Plate 1a. *Tacca borneensis*. Note the large homeomorphic involucral bracts. **1b.** *Tacca integrifolia*. W Sarawak form. **1b.** *Tacca integrifolia* NE Sarawak form. Note the rather fleshy inner involucral bracts.

ovate to unequally weakly cordate, apex acuminate, margins smooth, lamina glossy mid-to deep green, paler and less glossy abaxially; mid-rib strongly raised abaxially, sunken adaxially, primary lateral veins 7 - 9 per side, prominent abaxially, sunken adaxially, interprimary lateral veins less prominent than primaries, secondary veins forming a tessellate network with a variably pronounced interprimary collecting vein running through the middle of each trans-interprimary area. ***Inflorescence*** solitary to up to 5 at different developmental stages per plant; peduncle sub-erect to decumbent and apically ascending at anthesis, 3 – 5 angled or weakly 3 – 5 winged, up to 45 cm long, mid-green to more-or-less wholly stained purple-brown; involucral bracts homeomorphic; outer pair dorso-ventrally positioned, ovate-triangular, basally briefly clawed, 5.5 – 7.5 x 6 – 9 cm, velvety very deep purple-black, rarely pale purple with deep purple veining, claw paler, occasionally almost white; inner pair laterally positioned, ovate to broadly ovate, clawed basally, 5 – 10 x 5.5 – 12 cm, deep lustrous purple-black, claw paler to almost white; filiform bracts 10 – 25 or more per inflorescence, 12 – 15 cm long, deep purple. ***Flowers*** 5 – 25 (– 30) per inflorescence; pedicel triangular in cross-section, 2.5 – 4 cm long, dark purple, initially erect, later in anthesis pendent; gynoecium obpyramidal, c. 1.5 cm long x c. 1.3 cm wide at apex, 6-ribbed, purple with the ribs darker, perianth inserted annularly onto top of gynoecium; outer perianth lobes rounded, c. 10 x 9 mm, reflexing at anthesis, velvety deep purple; inner perianth lobes ovate, c. 10 x 10 mm, deep velvety purple. ***Infructescence*** prostrate by twisting of the peduncle base, many-fruited, involucral bracts marcescent well prior to fruit maturation; fruits obpyramidal, c. 3.5 x 1.5 cm, semi-glossy deep purple. *Seeds* weakly laterally compressed-reniform, c. 3.5 x 1.5 – 2 mm, pale brown.

Distribution: Sarawak. Endemic, based on known herbarium collections, but most likely occurring also in Kalimantan Barat.

Habitat: Old or disturbed secondary lowland forest on sandstones, very rarely on limestone, but then never on exposed rocks. 40 – 450 m altitude.

Other specimens examined: SARAWAK. Kuching Division: Padawan, Kampung Belimbing, 28 Nov 2003, *P.C.Boyce & Jeland ak Kisai* TA-5 (SAR); Bau, Kampung Jugan, 26 Mar 2004, *P.C.Boyce & Jeland ak Kisai*, TA-7 (SAR); Padawan, Kampung Sadir, 2 Feb 2006, *P.C.Boyce & Simon Kutuh ak Paru* TA-34 (SAR); Bau, Plaman Kaman, 26 Sep 2000, *K.G.Pearce et al.* SBC 21 (SBC); Bau, Bukit Kho Z San, Km 1 ½ Bau – Kuching road, 20 Dec 1994, *Rantai Jawa et al.* S70124 (SAR); Padawan, Gunung Merubong, Ulu Sungai Sluba, 18 Sep 1987, *Yii Puan Ching* S.51396 (K, L, SAR). Samarahan

Division: Serian, Gunung Ampungan, 21 Nov 2003, *P.C.Boyce & Jeland ak Kisai* TA-4 (SAR); Serian, Tebedu, Kampung Saan, 4 Oct 2004, *P.C.Boyce & Simon Kutuh ak Paru* TA-13 (SAR); Serian, Pichin, Bung Biringan, 28 Oct 2004, *P.C.Boyce & Simon Kutuh ak Paru* TA-15 (SAR); Serian, Pichin, Utak Ogong (Ogong Amang Ramping), 5 Jan 2005, *P.C.Boyce & Simon Kutuh ak Paru* TA-18 (SAR). Sri Aman Division: near Sungai Kuap, Ulu Sungai Engkari, 21 Mar 1974, *P.Chai* S34090 (L, K, MO, SAR, USA). Kapit Division: Rejang, *G.D.Haviland* 936 (SAR). Miri Division: Baram, *J.Hewitt* 593 (SAR). Bintulu Division: tau Range, Sungai Mayeng, 2 Jun 1956, *J.W.Purseglove P.5300* (SAR).

Notes: The oblique, broadly ovate to unequally weakly cordate leaf bases immediately distinguish *T. borneensis* from all other entire-leaved Sarawakian *Tacca* in which the leaf bases are acute and decurrent. The large ovate homeomorphic involucral bracts of *T. borneensis* are diagnostic.

Resurrection of *T. borneensis* in Sarawak delimits a non-limestone associated *Tacca* with large heteromorphic involucral bracts. For the present, with the caveat that there appears to be at least two taxa involved (one in W Sarawak and the other in NE Sarawak), and that these require further field study to ascertain their appropriate status, we are maintaining this heteromorphic bracted plant as a single taxon for which the earliest name applicable name is *T. integrifolia*.

Tacca integrifolia **Ker Gawl**, Bot. Mag., 35, t.1488 (1812). Type: 'East Indies', (holo, K!; iso, L!). **Plate 1b, c.**

Slender to moderately robust terrestrial ***herb*** to 75 cm tall. ***Stem*** rhizomatous, hypogeal, creeping with the active apex ascending (W Sarawak) or epigeal (NE Sarawak), up to 2 cm thick, clothed with persistent leaf bases and frequently rooting through these. ***Leaves*** 5 – 15 together, petioles ascending, up to 41 cm long, c. 12 mm diam, D-shaped in overall cross-section, canaliculate, 2-keeled on the dorsal side, pale to mid-green sometimes stained purple at the base; petiolar sheath c. $^{1}/_{5}$ length of petiole, hyaline; lamina thinly to rather thickly coriaceous, ascending, lanceolate, 11 – 45 x 5 – 12 cm, base acute, decurrent, c. 5 cm along petiole, apex acute to acuminate, margins smooth, lamina pale to mid-green, weakly glossy adaxially, paler and less glossy abaxially; mid-rib prominently raised abaxially, sunken adaxially, primary lateral veins 3 – 5 per side, slightly sunken adaxially, interprimary lateral veins slightly less prominent than primaries, secondary veins forming a very obscure network with an obscure interprimary collecting vein running through the middle of each trans-interprimary tessellate area. ***Inflorescence*** solitary; peduncle erect, weakly 3 angled, up to 75 cm tall but usually less, especially in plants from NE Sarawak, pale green stained deep purple especially near the base; involucral bracts heteromorphic: outer pair dorso-ventrally positioned, narrowly ovate, 2.5–3.5 cm x 10–22 mm, deep purple-black to pale lavender purple, rarely white with lilac veining; inner pair laterally positioned but ascending and ultimately sub-erect at anthesis, spathulate, 3.5 –9 x 2–6 cm, deep purple-black to pale lavender purple, rarely white with lilac veining; filiform bracts 8–15 per inflorescence, 12–19cm long, pale to mid- or deep purple basally, fading to at the tip. ***Flowers*** 7–14 per inflorescence; pedicel triangular in cross-section, 2–4cm long, pale to mid-purple, initially erect, later in anthesis reflexing, thence pendent; gynoecium widely obpyramidal, c. 1 cm long x c. 1 cm wide at apex, 6-ribbed, greenish-purple to dark purple, the ribs darker purple, perianth inserted annularly onto top of gynoecium. Outer perianth lobes oblong, rounded 10–17 x 5–7 mm, reflexing at anthesis, dark purple; inner perianth lobes oblong, 12–17 x 6–9 mm, deep velvety purple on both surfaces. ***Infructescence*** declinate by twisting of the peduncle base, few to many-fruited, involucral bracts marcescent well-prior to fruit maturation; fruit obpyramidal, deep glossy brown-purple c. 3 x 1.5 cm, dull purple. ***Seeds*** weakly laterally compressed-reniform, c. 3.5 x 1.5 –2 mm, pale brown.

Distribution: Following the taxonomic interpretation used here, the distribution is southern Peninsular Thailand, Peninsular Malaysia, Singapore and N Borneo.

Habitat: Old or disturbed secondary lowland forest on sandstones. Very occasionally associated with limestone formation but never on exposed limestone rock, 40–420 m altitude.

Other specimens examined: SARAWAK. Kuching Division: Bau, Tanjung Durian, 14 Nov 2003, *P.C.Boyce* TA-3 (SAR); Bau, Serikin, *P.C.Boyce* TA-37 (SAR); Kuching, Dec 1906, *J.Hewitt* 592 (SAR); Matang, Sungai Rayu, 27 Mar 1987, *Bernard Lee Meng Hock* S.53351 (K, SAR); 10th Mile Landeh Road, Engkabang Plantation, 26 Feb 1974 *S. Laijanai* S.33648 (SAR, USA). Samarahan Division: Serian, Pichin, Kampung Kakang, Sungai Sisang, 14 Jan 2005, *P.C.Boyce & Simon Kutuh ak Paru* TA-19 (SAR); Serian, Pichin, Ampan Pichin, 25 May 2005, *P.C.Boyce & Simon Kutuh ak Paru* TA-36 (SAR). Sarikei Division: Sungai Lepong, 01° 57' 12.9"; 111° 30' 34.9", 8 Dec 2005, *P.C.Boyce, Jeland ak Kisai, Jepom ak Tisai, Mael ak Late & Wong Sin Yeng* TA-33 (SAR).

Bintulu Division: Bukit Satiam, 02° 59' 26.1"; 112° 55' 54.4", 11 Aug 2004, *P.C.Boyce & Jeland ak Kisai* TA-10 (SAR). Miri Division: Baram, Sept. 1891, *C.Hose 1357* (*G.D.Haviland* 949) (SAR); Marudi, Sungai Slat basin, Sungai Palutan, 2° 50' 32"; 114° 59' 12", *S.P.Lim & Banyeng L.* S.90414 (SAR, KEP).

Notes: Drenth (1972) took a very broad view of the circumscription of *T. integrifolia*, synonymizing 10 taxa described from as far apart as NE India to NE Borneo. The present paper is not intended as a critical revision of all the names so treated, but observation of *Tacca* in Sarawak coupled with knowledge of the level of endemism in ever-wet Sunda of other herbaceous monocots (notably Araceae and Zingiberaceae) are pertinent in suggesting that *T. integrifolia sensu* Drenth is a grossly heteromorphic assemblage.

A brief discussion of the taxa treated as synonymous with *T. integrifolia* by Drenth (1972) is insightful. Six names attributed to the synonymy of *T. integrifolia* (*Tacca aspera* Roxb., *T. choudhuriana* Deb., *T. integrifolia* var. *pseudolevis* Limpr, and *T. laevis* Roxb. [including var. *angustibracteata* Limpr. and var. *latibracteata* Limpr.]) are based on types originating from NE India and Bangladesh, and one (*T. integrifolia* var. *pseudolevis* Limpr.) on a type from NW Myanmar. Given the fact that in families, e.g., Araceae and Zingiberaceae – with pronounced bipolar diversity, and endemism in ever-wet Sunda and Indo-China, and tropical and subtropical trans-Himalaya – there are no shared indigenous species between Borneo and the Indo-Himalaya, it is unlikely that *Tacca* from these areas are synonymous with species present in Borneo.

There are three distinct entire-leaved *Tacca* species in Peninsular Malaysia and Singapore, one with heteromorphic and two with homeomorphic involucral bracts. The earliest available name for the heteromorphic bracted species is *T. integrifolia*, and for the homeomorphic bracted, *T. cristata* Jack and *T. chantrieri* André. More fieldwork is required to ascertain whether additional taxa require recognition, to clarify the presence, or otherwise, of *T. chantrieri,* and to further its status *vis à vis* other published names for Thailand and Indo-China. In particular *T. minor* Ridl. (treated as one of nine synonyms of *T. chantrieri* by Drenth in 1972) requires field investigation to clarify its status.

Four names (*T. sumatrana* [incl. var. *ovalifolia* Limpr.]) and (*T. lancifolia* [including var. *laeviformis* Limpr.]) originate from Sumatera and Java respectively. None of the types of these names is in a sufficient state of preservation to place them without question in any one of the known taxa for these islands. More fieldwork is required.

The spathulate and ascending inner involucral bracts are diagnostic for *T. integrifolia* as interpreted here. Inflorescence colour is variable with the involucral bracts and perianth ranging from deep glossy purple through to pale lavender to lilac-flushed white. The 'white' form is in cultivation under the illegitimate name '*T. nivea*'.

Plants from NE Sarawak differ from those in NW Sarawak by an epigeal stem, distinctly more leathery leaf, shorter peduncle, and somewhat fleshy, glossy, deep purple inner involucral bracts (Plate 1c). More fieldwork is required to investigate the taxonomic significance of these characters.

Tacca bibracteata Drenth

The type description of *T. bibracteata* (Drenth, 1972) was based on only three herbarium specimens and lacking details of the stem and ripe fruits. The first author has had the opportunity to collect and bring *T. bibracteata* into cultivation and we are now able to furnish a more detailed description.

***Tacca bibracteata* Drenth**, Blumea, 20(2): 395 (1972 publ. 1973) & in Fl. Mal. Series 1, 7(4): 814, Fig.7 a – c (1976). Type: Malaysia, Sarawak, Kapit Division, Belaga, Long Kapa, Bukit Dulit, *Synge* 1335 (holo, K!; iso, L!). **Plate 2 a, b.**

Moderate terrestrial ***herb*** to 40 cm tall. ***Stem*** rhizomatous, ascending and ultimately epigeal, c. 2 cm thick, clothed with persistent leaf bases. ***Leaves*** c. 6–8 together, petioles ascending, 5–19 cm long, c. 2–5 mm diam, D-shaped in overall cross-section, sharply sulcate-canaliculate, bluntly keeled on the dorsal side, pale to mid-green; petiolar sheath c. ¼ – ½ length of petiole (3.5–9.5 cm long), hyaline and shortly (c. 2mm) ligulate; ligule dolabriform-acute, margins minutely erose; lamina ascending to somewhat spreading, oblong-lanceolate,16–27 x 7–10.5 cm, base acute, apex shortly acuminate, margins smooth, lamina deep glossy green adaxially, paler and less glossy abaxially; mid-rib strongly pronounced abaxially and sunken adaxially; primary lateral veins c. 4 per side, very pronounced abaxially, all arising from the basal half of the mid-rib, interprimary lateral veins absent, secondary veins forming a rather obscure untidy reti-tesellate network and with a weak interprimary collecting vein running through. ***Inflorescence*** solitary; peduncle ± terete, 20 –31 cm tall, pale green lightly to heavily dark purple-mottled, intensifying

Plate 2a. *Tacca bibracteata.* Note the inner involucral bracts nearly indistinguishable from the filiform bracts, the inflorescence giving the impression of only two involucral bracts. **2b**. Close up of flowers.

towards the base; involucral bracts strongly heteromorphic; outer pair dorso-ventrally positioned, ovate, c. 3 x 2 cm, briefly decurrent basally and fused to form a short pocket, mid-green with the primary veins and apical portion stained purple; inner pair laterally positioned, filiform, up to 10.5–14 cm x c. 2 mm, basally mid-purple fading to pale yellow-green at the tips; filiform bracts 8 - 13 per inflorescence, very variable in length with c. 2.5–14 cm lengths in one inflorescence, pale green. ***Flowers*** up to 10 but usually fewer (5 or less) per inflorescence; pedicel triangular in cross-section, 1–3.5 cm long, pale greenish purple; gynoecium obpyramidal, c. 1.5 cm long, strongly 6-ribbed, pale greenish-purple with the ribs dull purple, perianth inserted annularly onto top of gynoecium; outer perianth lobes broadly ovate, 7–12 x 5–14 mm, reflexing at anthesis green purple-stained abaxially, deep velvety purple adaxially; inner perianth lobes ovate, tip notched, 10 x 5 mm, bright green abaxially, deep velvety purple adaxially. ***Infructescence*** declinate by twisting of the peduncle base, almost always solitary fruited, fruit subtended by the persistent outer involucral bracts, ovary obpyramidal, deep c. 2.5 x 1.5 cm, dull purple, topped by the persistent outer and basal half of the inner perianth lobes. ***Seeds*** not observed.

Distribution: NE Sarawak. Endemic.
Habitat: Old or disturbed secondary lowland forest on shales, 30–100 m altitude.

Other specimens examined: SARAWAK. Kapit Division: Pelagus, Jeram Pelagus, 02° 11' 59"; 113° 04' 01", 1 Dec 2004, *Jeland ak Kisai* TA-16 (SAR) & 02° 11' 35.7"; 113° 03' 30.08", 15 Mar 2005 *P.C.Boyce, Jeland ak Kisai & Jepom ak Tisai* TA-21 (SAR); Belaga, Long Kapa, Bukit Dulit, *Richards* 1569 (K). Bintulu Division, Sebauh, Kampung Tubau, Sungai Tubau, *P.Ashton* S.18369 (K, L, SAR, SING); Bintulu, Bukit Satiam, 02° 59' 26.1"; 112° 55' 54.4", 11 Aug 2004, *P.C.Boyce & Jeland ak Kisai* TA-11 (SAR). Limbang Division, Tg. Long Amok, Sungai Ensungei, Ulu Medamit, 19 Sep 1980, *R. George et al.* S.42879 (L, K, KEP, SAN, SAR).

Notes: The epithet *bibracteata* is misleading. The inflorescence of *T. bibracteata* has four involucral bracts, as indeed realized and noted by Drenth (1972, 1976). The outer pair is dorso-ventrally positioned and conspicuous, while the inner pair is laterally positioned, filamentous and in the absence of close examination of fresh material easily mistaken for filiform bracts.

The outer perianth and basal parts of the inner perianth are persistent into fruit maturity. This character is shared with *T. reducta* from which *T.*

bibracteata is readily separable by the strongly heteromorphic involucral bracts and a preference for shales; *T. reducta* is limestone associated.

Tacca on Limestone in Sarawak

Fieldwork on the limestone formations of W Sarawak (Bau, Padawan and Serian) has revealed that the common limestone-associated *Tacca* does not have a published name. It is here formally described.

Tacca reducta **P.C. Boyce & S. Julia,** *sp. nov.*

Ab omnibus speciebus Tacca borneensibus combinatio bractiorum involucralis idem et valde minoribus et in habitu calcicola differt. – TYPUS: Malaysia, Sarawak, Kuching Division, Bau, Kuching – Bau road, Gunung Serambu, 1 Sep 1976, *P.J. Martin* S.37798 (holo, SAR). **Plate 3 a –c.**

Slender to moderately robust terrestrial ***herb*** to 50 cm tall. ***Stem*** rhizomatous, hypogeal, creeping with the active apex ascending, c. 1.5 cm thick, clothed with persistent leaf bases and frequently rooting through these. ***Leaves*** 7–10 together; petioles ascending, up to 11 cm long, c. 5 mm diam, D-shaped in overall cross-section, shallowly to rather pronounced canaliculate, sharply 2-keeled on the dorsal side, mid-green variously speckled and stained deep purple-brown notably at the base and along the dorsal keels; petiolar sheath c. $^{1}/_{5}$ length of petiole, hyaline; lamina ascending to recurved, lanceolate, 23–30 x 5–9 cm, base acute, decurrent c. 3 cm along petiole, apex acute to acuminate, margins smooth to very slightly crenulate-dentate, lamina mid-green, slightly glossy adaxially, paler and less glossy abaxially; mid-rib strongly subterete to raised abaxially, sunken adaxially, primary lateral veins 3–5 per side, slightly sunken adaxially, interprimary lateral veins much less prominent than primaries, secondary veins forming a rather prominent tessellate network with a obscure interprimary collecting vein running through the middle of each trans-interprimary tessellate area. ***Inflorescence*** solitary to 3 at different developmental stages per plant; peduncle terete to weakly 3–5 angled, up to 20 cm tall, pale green more-or-less wholly stained and speckled deep purple-brown; involucral bract homeomorphic: outer pair dorso-ventrally positioned, linear-triangular to linear ovate, 2.5–3.5 cm x 5–7 mm, slightly lustrous very deep purple-black; inner pair laterally positioned, linear-triangular to linear ovate, 3.5–4 cm x 0.5–10 mm, deep lustrous purple-black; filiform bracts c. 8 per inflorescence, very variable in length with 12–15 cm long, deep purple basally, fading to pale green at the tip. ***Flowers*** 2–4 (-5) per inflorescence; pedicel triangular in cross-section, 1.5–2 cm long, mid-purple, initially erect, later in anthesis reflexing, thence pendent; gynoecium broadly obpyramidal, c. 1 cm long x c. 1 cm wide at apex, strongly 6-ribbed, dull greenish-purple with the ribs darker purple, perianth inserted annularly onto top of gynoecium; outer perianth lobes oblong, rounded with a brief acumen, c. 12 x 7 mm, reflexing at anthesis, purple with a darker purple reticulations, deep velvety purple adaxially; inner perianth lobes ovate, 15 x 10 mm, deep velvety purple on both surfaces. ***Infructescence*** declinate by twisting of the peduncle base, few- fruited, involucral bracts marcescent well-prior to fruit maturation; fruit obpyramidal, deep slightly glossy purple c. 2.5 x 1.5 cm, dull purple, topped by the persistent whole outer perianth and basal half of the inner perianth lobes. *Seeds* weakly laterally compressed-reniform, c. 3.5 x 1.5–2 mm, pale brown.

Distribution: W Sarawak. Based on known herbarium collections, it is an endemic, but probably (based on plants observed for sale at border markets) also occurring on limestone in Kalimantan Barat.

Habitat: Primary to disturbed secondary lowland forest on limestone, 35–220 m altitude.

Other specimens examined: SARAWAK. Kuching Division: Bau, Seburan, 6 Aug 1961, *J.A.R.Anderson* S.2411 (SAR); Bau, Seburan, 31 Oct 1964, *J.A.R.Anderson* S.26854 (SAR); Bau, south of Bukit Seburan, 30 Apr 1966, *J.A.R.Anderson* S.25140 (SAR); Bau, Seburan, gully between Seburan and Bukit Krian, 15 Jul 1964, *J.A.R.Anderson & N.G.Bisset* S.20261 (SAR); Bau, Gunung Juita, 01° 23' 48.7"; 110° 08' 07.2", 28 Oct 2005, *P.C.Boyce, Jeland ak Kisai, Angeline anak Simon & Wong Sin Yeng* (SAR); Padawan, Kampung Danu, Gunung Temuang, Sungai Abang, 01° 15' 38.6"; 110° 15' 31.4", 16 Feb 2006, *P.C.Boyce, Jeland ak Kisai & Wong Sin Yeng* TA-38 (SAR); Bau, Kampung Bogag, Gunung Tibugai, 01° 21' 31.1"; 110° 03' 48.7", 31 Mar 2005, *P.C.Boyce, R.Kneer & Jeland ak Kisai* TA-22 (SAR); Serian, Kampung Selabi, Sungai Mawang, 2 Feb 2006, *P.C.Boyce & Simon Kutuh ak Paru* TA-35 (SAR); Bau, Gunung Poing, 13 May 2002, *Malcom D. et al.* SBC 1548 (SAR, SBC); Padawan, Bukit Manok, mile 38 old Padawan road, 2 Sep 1979, *J.P.Mamit* S41074 (L, SAR, USA); Bau, Jambusan, Gunung Batu, 20 Feb 2002, *K.Meekiong et al.* SBC 1681 (SAR, SBC);); Bau, Jambusan, Gunung Jebong, 6 Mar 2002, *K.Meekiong et al.* SBC 1965 (SBC); Bau, Krokong, Gunung Tabai, 12 March 2002, *J.S.Steven et al.* SBC 1995 (SAR, SBC). Samarahan Division: Serian, Pichin, Umon Murut, Tiab Belanting, 01° 08' 03.7"; 110° 27' 00.3", 28 Jun 2005, *P.C.Boyce, Jeland ak Kisai & A.Shafreena* TA-24 (SAR); Samarahan, Kuap, Pangkalan Kuap, 01° 26' 16.7"; 110° 22' 18.9", 25 Oct 2004, *P.C.Boyce, Jeland ak Kisai, Angeline anak Simon & Wong Sin*

Plate 3a. *Tacca reducta*. Note the stellate arrangement of the small homeomorphic involucral bracts. **3b.** close up of flowers. **3c.** Nearly ripe fruit. Note the persistent perianth.

Yeng TA-28 (SAR); Serian, Pichin, Bung Biringan, 28 Oct 2005, *P.C.Boyce & Simon Kutuh ak Paru* TA-14 (SAR); Serian, Pichin, Ampan Pichin, 25 May 2005, *P.C.Boyce & Simon Kutuh ak Paru* TA-23 (SAR).

Notes: The small homeomorphic black stellate involucral bracts are immediately diagnostic. Fruiting plants are recognizable by the persistent perianth, a character otherwise found only in *T. bibracteata* from NE Sarawak.

Tacca reducta bears some resemblance to W Malaysian *T. minor* Ridl. (treated by Drenth (1972) as a synonym of *T. chantrieri*) in the narrowly triangular homeomorphic involucral bracts, but is readily separable by the pronounced tessellate secondary veins.

The epithet comes from the Latin, *reductus*, reduced, in allusion to the small involucral bracts and generally few-flowered inflorescence.

Key to *Tacca* in Sarawak

1a. Mature leaf lamina palmate or dracontioid (elaborated forms of sagittate, hastate or trisect leaves in which the anterior and posterior divisions are highly dissected and subdivided) 2

1b. Mature leaf lamina entire 3

2a. Mature leaves dracontioid. Ripe fruits green, ribbed. Plants of coastal forest on almost pure sand .... **T. leontopetaloides**

2b. Mature leaves palmate. Ripe fruits red, smooth. Plants of a variety of habitats, but never in coastal forest on sand .... **T. palmata**

3a. Involucral bracts strongly heteromorphic 4

3b. Involucral bracts ± homeomorphic 5

4a. Outer involucral bracts ovate; inner filiform and not readily distinguished from filiform floral bracts (i.e., inflorescence with the appearance of only one pair of involucral bracts). Perianth persistent until fruit maturity. Plants of shale .... **T. bibracteata**

4b. Outer involucral bracts ovate; inner spathulate, ascending. Perianth marcescent early in fruit development. Plants of sandstone and (rarely) limestone .... **T. integrifolia**

5a. Involucral bracts broadly ovate. Leaf base rounded, oblique, truncate. Perianth marcescent early in fruit development. Plants of sandstone .... **T. borneensis**

5b. Involucral bracts linear-triangular to narrowly ovate-triangular. Leaf base acute, decurrent. Perianth persistent until fruit maturity. Plants of limestone .... **T. reducta**

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A New Species of Curcuma L. (Zingiberaceae) from Southeast Asia

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Abstract

Curcuma larsenii C. Maknoi & T. Jenjittikul, *sp. nov.* from Southeast Asia (Thailand, Laos and Vietnam) is described and illustrated.

Introduction

The genus *Curcuma*, established by Linnaeus in 1753, comprises approximately 100 species (Škorničková *et al.*, 2003a). In recent years, several new species have been described, for example by Sirirugsa and Newman (2000), Mood and Larsen (2002), Škorničková *et al.* (2003a, 2003b and 2004), as a result of extensive exploration in South and Southeast Asia.

While revising this genus for Flora of Thailand between 2002 and 2003, the first author found some unidentified specimens that did not match any known species. One of them was collected in Ubon Ratchathani Province, vegetatively similar to *C. gracillima*. However, it was reported by the second author in 2001 that this species was being sold in Chatuchak Market in Bangkok which was collected from the same province. This species seems to be becoming known as ornamental plants in the market. Therefore, it is described here as *Curcuma larsenii* C.Maknoi & T.Jenittkul.

Curcuma larsenii C. Maknoi & T. Jenjittikul, *sp. nov.*

Curcuma larsenii Maknoi & Jenjittikul sp nov., C. gracillimae Gagnep. characteribus vegetativis et inflorescentiae simulans, sed characteribus sequentibus differt: foliis latioribus; bracteis majoribus; apice staminodii acuto, non truncato; lobis labelli rectangularibus, apicibus truncatis, irregulariter *erosis.* – **Typus:** *C. Maknoi 496,* Ban Sanamchai, Piboon Mangsahan, Ubon Ratchathani, 26 Aug 2003 (holo, PSU; iso, AAU, BKF, QSBG). **Figure 1 and Plate 1.**

Perennial ***herb****, 25–30 cm tall. Vertical underground structure* ovoid, 2–3 cm in diameter, yellowish inside. Bladeless sheaths 2–3, 1–6.5 cm long, pale yellow, green or dull red with red veins, apex acute or with a minute beak. ***Leaves*** 2-4; sheath up to 4 cm long, glabrous; petiole furrowed, 5-7 cm long, glabrous; ligule c. 1 mm long, membranous, glabrous, truncate; blade lanceolate, 20–25 x 3–5 cm, green, sometimes with a purple midrib, glabrous on both surfaces, except for few short hairs at the tip, base attenuate, apex acute. Inflorescence terminal; peduncle green, 5–10 cm long, glabrous; spike elliptic to elliptic-oblong, 4–6 x 2.5–3 cm; fertile bracts 7–15, obovate, 15–20 x 18–25 mm, subtending cincinnus of 5–7 flowers, glabrous, green with a white margin, apex truncate, recurved; coma bracts 3–5, smaller and narrower, white or green with white stripes at apex. Bracteole broadly ovate, concave, 4.5–6.5 x 3.5–5.0 mm, white, membranous, glabrous. Flowers 20–25 mm long, exerted from the bract. Calyx funnel-shaped, 4–6 mm long, white, glabrous, apex unequally 3-lobed. Corolla tube 10–14 mm long, white, glabrous; corolla lobes 4.5–5.2 x 2.5–3 mm; dorsal one concave, white or pale yellow, apex hooded, shortly cucullate; lateral ones shallowly concave, white or pale yellow, apex obtuse. Staminodes oblong, spreading, 4.5–6.5 x 1.8–2.3 mm, creamy white to dark orange with translucent veins, red streak along margin near labellum, sparsely hairy at base, apex acute, margin eroded. Labellum broadly obovate, 5.5–6.5 x 6.0–7.5 mm, deeply divided, 2.5–3.5 mm deep, broad sinus, creamy white to dark orange with translucent veins, longitudinal red-streaked on the lower half, raised-band on either sides of sinus creamy white or yellow; lobes c. 2 mm wide, oblong, apex truncate with irregularly eroded. Filament c. 2.5 x 2 mm, white, glabrous. Anther c. 2.0 x 1.5 mm, white, pilose near the base; spurs absent; crest 1 mm long, apex shallowly emarginate. Ovary tri-loculed, oblong, c. 3 x 2.5 mm, white, glabrous; epigynous glands absent; stigma appressed cup-shaped, 0.6 mm wide, mouth serrulate. Fruits subglobose, 1 cm diam., white; seeds obovate, 3.5 mm long, brown with white aril.

Distribution: Thailand – Ubon Ratchathani; Laos and Vietnam.
Flowering period: May to October.
Ecology: In open forest in moist sandy areas.

Other specimens examined: Eastern Thailand – *Larsen 47387*, plant from Ubon Ratchathani, cultivated in Aarhus, 8 Oct 2001 (AAU!); *Ngamriabsakul 67*, Suan Pa Buntharik, Ubon Ratchathani, 5 Aug 1999

Plate 1. *Curcuma larsenii.* 1. flower – pale colour form, 2. flower – dark colour form, 3. habit; 4. habitat.

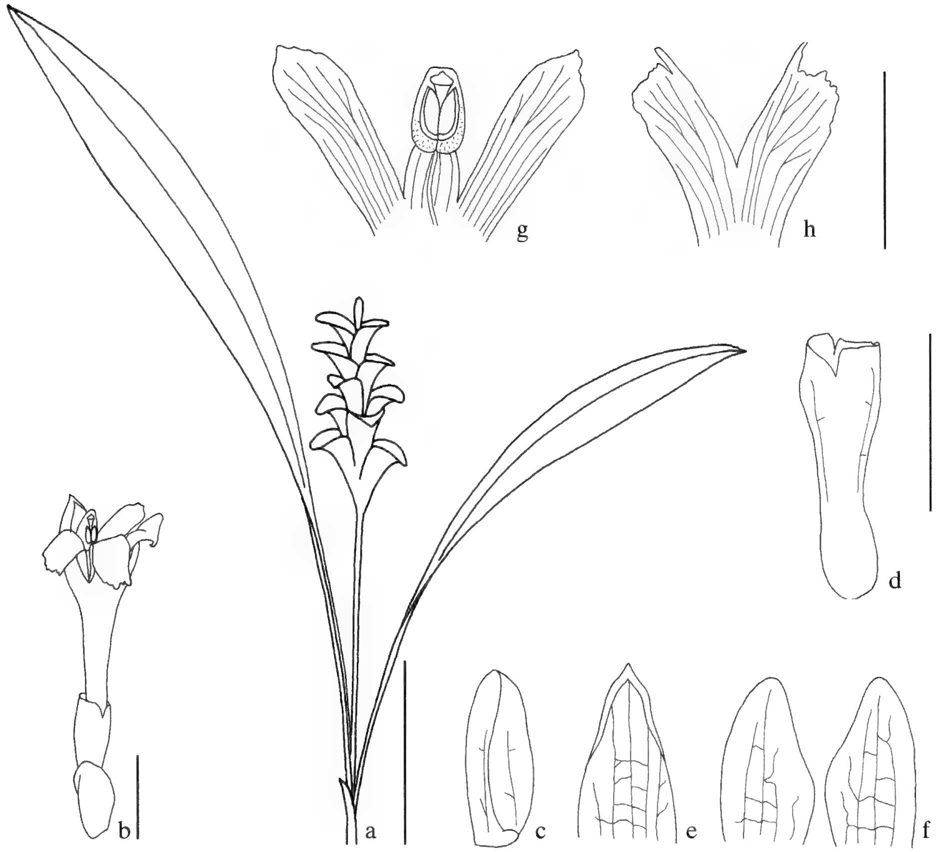

Figure 1. *Curcuma larsenii.* a) whole plant; b) flower with bracteole at base; c) bracteole; d) calyx and ovary; e) dorsal corolla lobe; f) lateral corolla lobes; g) staminodes and stamen; h) labellum (scale a = 5 cm; b – h = 5 mm). Drawings made by the first author from the type specimen.

(BKF! E!); *Tiptabiankarn 6604,* Ubon Ratchathani, 29 May 2001 (PBM!); *Laos – Maxwell 98-896*, Khong Island, E side, base to the summit of Khong Hill, Mae Khong river, Champasak, 11 Sep 1998 (CMU!); Vietnam – *Evrard 2324,* 3 Jul 1929 (P!); Madris, km 97 route to Saigon, 21 Oct 1920 (P!).

Notes: This species is similar to *Curcuma gracillima* Gagnep. in vegetative and inflorescence characteristics but differs by the following characters: leaves broader, bracts larger, staminode apex acute instead of truncate, labellum lobes rectangular, apex truncate with irregularly eroded, staminodes and labellum creamy white to orange with translucent veins, red streaks on the lower half and creamy white or yellow raised mid-band (table 1).

Table 1. Comparison of key characters of *C. larsenii* and *C. gracillima.*

Character	***C. larsenii***	***C. gracillima***
Leaf width	30-50 mm	8-12 mm
Bract size	15x20 mm	12x12 mm
Corolla tube	10 mm	5-6 mm
Staminode apex	Acute	Truncate
Staminodes and lip color	Creamy white to orange with red streaks and yellow mid-band	Violet
Labellum lobes shape	Oblong, apex truncate, margin irregular eroded	Obliquely obovate, apex acute

This species is named in honor of Professor Kai Larsen who initiated the research of Zingiberaceae in Thailand over 40 years ago.

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A hitherto overlooked field identification character for Borneo *Scaphochlamys* Baker (Zingiberaceae: Zingibereae)

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Abstract

The consistent presence of a pulvinus above the insertion at the base of the petiole of *Scaphochlamys* species has been observed in Sarawak and is here proposed as a useful field character for recognizing and separating *Scaphochlamys* Baker from its nearest allied taxa *Boesenbergia* Kuntze and *Haplochorema* K.Schum.

Introduction

The genus *Scaphochlamys* Baker was last revised for Borneo by Smith (1987) at which time taxonomically important inflorescence characters were discussed (see Table 1). Poulsen & Searle (2005) added another reproductive character, splitting of the bracteole, to those proposed by Smith (1987). In the key to genera of Hedychieae (at that time *Scaphochlamys* included in Hedychieae) (Smith, 1987), characters other then those pertaining to inflorescence or flowers received very little attention. Recent work (Kress *et al.*, 2002) has shown that Hedychieae is embedded in a newly expanded Zingibereae. The only vegetative character mentioned is well-developed stem in *Hedychium* König as compared to stem-less and tufted or shoots single-leaved (*Scaphochlamys* Baker, *Boesenbergia* Kuntze, *Haplochorema* K.Schum. and *Kaempferia* L.) (Smith, 1987).

For the present study, numerous species from three closely related genera (*Scaphochlamys*, *Boesenbergia* and *Haplochorema*) have been observed in Sarawak. The presence of a pulvinus at the base of the petiole (Plate 1) has been shown to be generically diagnostic in all the *Scaphochlamys* so far studied, which includes the six species currently recognized for Borneo and at least a further 25 unidentified and seemingly novel taxa revealed during the first author's ongoing studies in Borneo. This is a very useful character especially if plants are not in flowering at the time of collection since assigning sterile individuals to one of the three above genera is often problematic.

Despite our confidence in the diagnostic pulvinate petiole, care still needs to be exercised when examining *Boesenbergia* and *Haplochorema* since the insertion of the leaves can *appear* to be pulvinate (Plates 2 & 3). Careful comparison with the true pulvinate petiole of *Scaphochlamys* reveals that in *Scaphochlamys* the pulvinus is situated *above* the insertion of the petiole (Plate 4).

Scaphochlamys and its allied genera look very similar in the vegetative state. Thus, the presence of pulvinus will make determining these closely related taxa easier at the genus level.

Plate 1. *Scaphochlamys* sp. (*Boyce & Shafreena* ZI-157): note the pulvinate petioles.

Plate 2. *Boesenbergia pulchella* (Ridley) Merr. showing leaf insertion (*Boyce & Shafreena* ZI-860)

Plate 3. *Haplochorema magnum* R.M.Sm. showing leaf insertion (*Boyce & Shafreena* ZI-1013)

Plate 4. *Scaphochlamys polyphylla* (K. Schum.) B.L. Burtt & R.M. Sm.: note many leaves each with a pulvinate petiole (*Boyce & Shafreena* ZI-904)

A comparison of inflorescence characters among *Scaphochlamys* and allied genera (based on Smith, 1987; Poulsen & Searle, 2005) and additional characters from this study are set out in Table 1 below.

Table 1. Comparative table of inflorescence and vegetative characters of *Scaphochlamys*, *Boesenbergia* and *Haplochorema*.

Character	*Scaphochlamys*	*Boesenbergia*	*Haplochorema*
Inflorescence bract arrangement	Spiral	Distichous	Distichous
Flowering mode	Acropetalous	Basipetalous	Basipetalous
Flower arrangement	Cincinni	Solitary	Solitary
First bracteole (shape and position)	More or less keeled, arising oppositebract	Boat-shaped, arising at right angle to bract	Boat-shaped or split, arising at right angle to bract
Bracteole splitting	Split to base	Split to base	Split to $^{2}/_{3}$
Labellum	Bilobed or entire, lobes overlapping	Usually saccate, rarely bilobed, never flat	Bilobed or emarginated, flat
Base of thecae	With very short free basal spurs	Spurless	Spurless
Pulvinus	Present	Absent	Absent

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Phylogeny of the Genus *Pomatocalpa* Breda (Orchidaceae)

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Abstract

The phylogeny of the orchid genus *Pomatocalpa* has been analyzed using morphological and molecular (*matK* and ITS) data. First, 9 representative species of *Pomatocalpa*, viz. *P. armigerum* (King & Pantl.) T.Tang & F.Wang, *P. bambusarum* (King & Pantl.) Garay, *P. bhutanicum* N.P.Balakr., *P. bicolor* (Lindl.) J.J.Sm., *P. spicatum* Breda, *P. kunstleri* (Hook.f.) J.J.Sm., *P. diffusum* Breda, *P. macphersonii* (F.Muell.) T.E. Hunt and *P. tonkinense* (Gagnep.) Seidenf. and 11 neighboring genera (according to morphological features), viz. *Acampe*, *Cleisostoma*, *Micropera*, *Haraella*, *Pelathanteria*, *Robiquetia*, *Sarcoglyphis*, *Smitinandia*, *Staurochilus*, *Trichoglottis* and *Ventricularia,* were included to test the monophyly and phylogenetic position of the genus *Pomatocalpa*. This analysis was based on morphological data only, and the genera *Seidenfadenia*, *Vanda* and *Ascocentrum* were chosen as outgroups. Second, the interspecific phylogenetic relationships within *Pomatocalpa* were analyzed on the basis of *matK* and ITS sequences and morphological characters. The molecular analyses included seven species of *Pomatocalpa*, viz. *P. undulatum* (Lindl.) J.J.Sm., *P. bicolor, P. diffusum, P. kunstleri*, *P. macphersonii*, *P. maculosum* (Lindl.) J.J.Sm. and *P. spicatum*, and used *Acampe ochracea* (Lindl.) Hochr., *Ventricularia tenuicaulis* (Hook.f.) Garay and *Smitinandia micrantha* (Lindl.) Holtt. as outgroups. The morphological analysis included all 13 accepted species of *Pomatocalpa* by us and used

Acampe, *Ventricularia*, and *Smitinandia* as outgroups. Based on the results of an unpublished precursory study, the monotypic genus *Haraella* was included in the ingroup in both the morphological and molecular analyses. In addition to the separate analyses, a total evidence analysis was made, combining information from *matK*, ITS, and morphological data. *Pomatocalpa* turned out to be monophyletic, but only after exclusion of *P. armigerum* (= *Cleisostoma armigerum* King & Pantl.), *P. bambusarum* (= *Cleisostoma bambusarum* (King & Pantl.) King & Pantl.) and *P. bhutanica* (= *Cleisostoma bhutanicum* (N.P.Balakr.) S. Watthana, comb. nov.). According to *matK*, morphology, and total evidence, *Pomatocalpa* is monophyletic without *Haraella*. According to ITS data, on the other hand, *Haraella* is nested in *Pomatocalpa*. The incongruence of *matK* and ITS sequences may be because *Haraella retrocalla* is of ancient hybrid origin. When delimited according to this paper, the genus *Pomatocalpa* is probably monophyletic and is characterized by a single unique synapomorphy, i.e., the presence of a narrow longitudinal groove at the upper end of the front wall of the spur. The interspecific relationships in *Pomatocalpa* were poorly resolved.

Introduction

The orchid genus *Pomatocalpa* Breda belongs to subtribe Aeridinae, subfam. Epidendroideae, tribe Vandeae (Dressler, 1993). It contains 13 species distributed from Sri Lanka to Fiji, south to Northern Australia and north to Hainan and Taiwan (Watthana, in prep.).

A comprehensive hypothesis about the phylogeny of the genus *Pomatocalpa* is not yet available. A recent global phylogenetic analysis of subtribe Aeridinae based on DNA (*matK* and ITS sequences) contributes some information (Topik et al., 2005). In that analysis, *Pomatocalpa* is represented by *P. diffusum* and *P. kunstleri*. On this limited basis, *Pomatocalpa* appears to be monophyletic with the monotypic genus *Haraella* as a sister-group.

As a precursory work of the present study, the molecular phylogeny of the Aeridinae has been re-analyzed with additionally seven species of *Pomatocalpa* included, which were available for DNA extraction only, viz *P. undulatum* s.l. (including *P. acuminatum* (Rolfe) Schltr.), *P. bicolor*, *P. diffusum, P. kunstleri, P. macphersonii*, *P. maculosum* and *P. spicatum* (Topik and Yukawa, unpublished). However, they seem to represent almost all the variations observed in the genus. In this analysis, *Pomatocalpa* is still monophyletic according to *matK* data. In the re-analysis based on ITS data, on the other hand, *Haraella* is nested in *Pomatocalpa*.

The objectives of the present study are: 1) to test the monophyly of *Pomatocalpa* more thoroughly and to identify its phylogenetic position among closely related genera according to morphological features; 2) to resolve the interspecific phylogenetic relationships in *Pomatocalpa* based on molecular and morphological data and on total evidence.

Materials & Methods

I. Delimitation and phylogenetic position of Pomatocalpa (morphological data)

A. Sampling

Acampe, *Cleisostoma*, *Haraella*, *Micropera*, *Pelathanteria*, *Robiquetia*, *Sarcoglyphis*, *Smitinandia*, *Staurochilus*, *Trichoglottis* and *Ventricularia* were identified as the genera being morphologically most similar to *Pomatocalpa*. Thus, all of them except *Robiquetia* are placed in the same main group in Seidenfaden's (1988) comprehensive account of Thai monopodial orchid genera; additionally, certain species of *Robiquetia* and *Cleisostoma* have previously been referred to *Pomatocalpa*. Consequently, these genera were included in a phylogenetic analysis together with nine representative species of *Pomatocalpa*, viz. *P. armigerum*, *P. bambusarum*, *P. bhutanicum*, *P. bicolor*, *P. spicatum*, *P. kunstleri*, *P. diffusum*, *P. maphersonii* and *P. tonkinense*. Furthermore, *Trichoglottis lasiocarpa* was treated separately from the rest of *Trichoglottis* in the analysis, because this species was only recently transferred to the latter genus from *Pomatocalpa* (Ormerod, 1997). Unfortunately, no specimen of *Robiquetia vaupelii* (syn. *Pomatocalpa vaupelii* Ormerod & J. J. Wood) was available for this study. The genera *Seidenfadenia*, *Vanda* and *Ascocentrum* were chosen as outgroups. According to the molecular phylogenetic study of Topik et al. (2005), these three genera belong to the clade that is sister to the clade accommodating the genera of the ingroup of the present study.

The decision to include genera as terminal taxa in the ingroup was made because this practice was expected to increase the influence of ancestral character states by reducing the noise from later-evolved species-specific features (Wiens, 2000). Naturally, the best solution would have been to include all individual species of all the genera concerned. However, this would have become a major project, far beyond the scope of the present study. The only realistic alternative would be to include one or few representative species from each genus. Since none of the genera concerned have ever been thoroughly analyzed phylogenetically, a more or less random selection of "representative" species might well influence the analysis through the differences in later-evolved species-specific features. Naturally, we realize that including the genera as terminal taxa in the ingroup probably reduces the final resolution. Still we consider this practice to be the better option.

B. *Characters*

Morphological characters are usually regarded as qualitative or quantitative. However, so-called qualitative characters often have a quantitatively phenomenological base (Stevens, 1991) and can be expressed quantitatively by the systematist coding them (Baum, 1988). According to Stevens (1991), character states used in phylogenetic analysis should be discrete and based on carefully analyzed discontinuities in the variation. However, it seems that neither characters with a continuous variation pattern, nor characters with overlapping attribute values of the taxa, should be excluded a priori from phylogenetic analyses. Thiele (1993) and Ryding (1998) found such polymorphic characters to track phylogeny almost as accurately as characters with a discontinuous variation pattern. The results of Wiens (1995) suggest that polymorphic characters may contribute significant phylogenetic information, but also that they are less reliable. On this background, it was decided to include polymorphic characters in the present study.

For all genera included in the analysis, the character states were scored from: (1) the keys and descriptions in Schuiteman & de Vogel (2000), Seidenfaden (1988) and Seidenfaden & Wood (1992); (2) herbarium specimens and spirit samples deposited at C; (3) live specimens cultivated in the Botanical Garden, University of Copenhagen.

Some of the measurements are defined in Figure. 1. For this part of the study, 18 characters were scored (Table 1) and the matrix is shown in Table 2. The inflorescence type was excluded due to occasional variation within individual specimens of certain species (e.g., *Pomatocalpa bicolor*, *P. diffusum*, *P. kunstleri* and *P. spicatum*). It should also be mentioned that several floral characters were excluded because of too much variations seen in many of the terminal taxa.

The interpretation of the variation encountered in some of the accepted characters should be briefly explained.

Habit (character 1). Plants with moderately elongate stems carrying many condensed leaves (e.g., *Vanda*) were coded as "stem short". Certain species of *Pomatocalpa*, e.g. *P. diffusum*, are polymorphic. However, *P. kunstleri*, *P. macphersonii* and *P. spicatum* consistently have a short stem, while *P. bicolor* consistently has a rambling habit with an elongate stem.

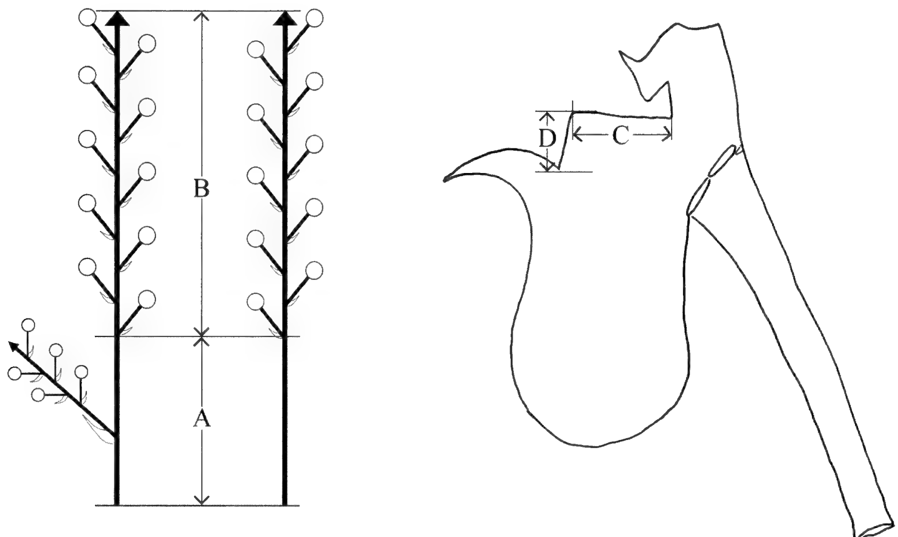

Figure 1. Definitions of selected characters. A, length of peduncle; B, length of terminal rachis shoot; C, hind edge of labellum side lobe; D, front edge of labellum side lobe.

Table 1. List of morphological characters and states used in the phylogenetic analysis of intergeneric relationships.

1. Stem elongate (0) or short (1).
2. Labellum subglabous to minutely papillose (0) or pubescent to distinctly hairy (1).
3. Mid-lobe without (0) or with ornaments (1).
4. Mid-lobe simple (0) or lobed (1).
5. Spur absent (0) or present (1).
6. Spur without (0) or with (1) a median septum.
7. Front wall of spur with (0) or without (1) a narrow longitudinal groove at its upper end.
8. Front wall of spur without (0) or with (1) a big fleshy callus at its upper end.
9. Back wall of spur without (0) or with (1) an ornament (callus or tongue).

10. Back wall ornament situated near the spur entrance (0) or down in the spur (1).
11. Back wall ornament a fleshy callus (0) or a membranous tongue (1).
12. Back wall tongue glabrous (0) or hairy (1).
13. Stipe broadly rectangular to subspathulate (0), (linear-)oblong (1) or narrowly linear (2).
14. Viscidium large and broader than long (0); large and ovate to oblong (1) or small and subglobose (2).
15. Pollinia two (0) or four (1).
16. Rostellum shorter (0) or longer (1) than the diameter of column.
17. Column not dorsally prolonged and incurved (0) or column dorsally prolonged and incurved (1).
18. Column without (0) or with (1) two horizontally protruding appendages.

Table 2. Character by taxon matrix of the analysis of intergeneric relationships. Characters as in **Table 1**. ?=unknown, -=inapplicable. Polymorphic taxa are coded with the following symbols; these are equate macros in PAUP: b = (0&1).

	5	10	15	
Seidenfadenia	00001	0000-	--100	000
Vanda	00101	00b0-	--120	000
Ascocentrum	00001	00b0-	--1b0	000
Acampe	11101	0000-	--101	000
Smitinandia	10001	0010-	--021	000
Venticularia	11101	0100-	--001	000
Trichoglottis	11bb1	0001b	1b101	000
T. lasiocarpum	01111	00011	11101	000
Staurochilus	11b1b	0001b	11101	000
Cleisostoma	bbbb1	b001b	0-bb1	b00
Pelathanteria	1bbb1	1001b	0-021	000
Micropera	1b1b1	101bb	b-111	100
Robiquetia	b0b01	000bb	b-1b0	bbb
Sarcoglyphis	100b1	100bb	b-111	000
Haraella	01000	-----	--100	000
P. bhutanicum	1?101	00010	0-101	000
P. armigerum	11101	00011	0-101	000
P. bambusarum	00101	00111	10111	111
P. bicolor	10001	01011	10101	000
P. spicatum	00001	01011	10101	000
P. kunstleri	00001	01011	10101	000
P. diffusum	b0001	01011	10101	010
P. maphersonii	00001	01011	10101	010
P. tonkinense	b0001	01011	10101	010

Labellum surface (character 2). Due to the homogeneity of the epidermis (and due to intermediary states), the condition of a densely and minutely papillose surface (e.g. *P. diffusum* and some specimens of *P. macphersonii*) was considered conceptually similar to a subglabrous surface (e.g. *P. spicatum* and *P. bicolor*). Consequently, these conditions were treated as one character state and opposed to the condition of a properly hairy surface with heterogenous epidermis (e.g. in *Acampe*, *Haraella*, *Staurochilus* and *Trichoglottis*).

Ornaments on the labellum mid-lobe (character 3). In this context, the term "ornaments" covers a range of morphologically diverse structures, such as keels, warts, or markedly thickened margins. It is uncertain to which extent these structures are homologous.

Front wall groove (character 7). Several species and genera have two small calli at the boundary between the base of the labellum mid-lobe and the upper end of the front wall of the spur. However, only in some (but not all) species traditionally assigned to *Pomatocalpa*, these calli are adjoining, elongate and extend down into the spur, thus producing a narrow longitudinal groove of varying length between them.

Front wall callus (character 8). The presence of two tiny calli at the boundary between the base of the labellum mid-lobe and the upper end of the front wall of the spur is common among the group of genera examined. However, this feature is markedly different from the presence of one big fleshy callus – a character state only observed in *Pomatocalpa bambusarum*, *Micropera* and *Smitinandia*. In the latter genus, it varies from globular (*S. micrantha*) to somewhat complanate (*S. helferi* (Hook.f.) Garay).

C. *Phylogenetic analyses*

The phylogenetic analysis based on maximum parsimony (MP) was performed using PAUP* version 4.0b10 for Microsoft Windows (Swofford, 2001). All characters were equally weighted, unordered (Fitch, 1971). The data set was analysed by the heuristic search method with bisection-reconnection (TBR) branch swapping and the MULTREES option on, saving all most parsimonious trees (MPTs). Evaluation of internal support of clades was conducted by the bootstrap analysis (Felsenstein, 1985) with 10,000 replicates with faststep searching.

Interspecific Relationships in *Pomatocalpa*

A. Molecular data

A.1. *Sampling*

For this part of the study, matK and ITS sequences could be obtained from seven species of Pomatocalpa, viz. *P. undulatum, P. bicolor, P. diffusum, P. kunstleri, P. macphersonii, P. maculosum* (Lindl.) J.J.Sm. and *P. spicatum*. Due to the results of a preliminary analysis encompassing many more taxa of subtribe Aeridinae (cf. the Introduction), *Haraella retrocalla* (Hayata) Kudo (the only species of Haraella) was included in the ingroup, while *Acampe ochracea, Smitinandia micrantha* and *Ventricularia tenuicaulis* were used as outgroups.

Material of *Pomatocalpa* was partly collected in the field in Thailand by the first author and partly obtained from living collection in the Tsukuba Botanic Garden, Japan and from Queen Sirikit Botanic Garden, Chiang Mai, Thailand. A list of voucher specimens is given in **Table 3**.

Table 3. List of species analysed in the molecular analyses.

Species	**Voucher**	**Source**
Pomatocalpa diffusum Breda	Watthana 1767 (QBG)	Thailand
P. bicolor (Lindl.) J.J. Sm.	Watthana 1821 (QBG)	Malaysia
P. maculosum (Lindl.) J.J.Sm.	Watthana 1768 (QBG)	Thailand
P. spicatum Breda	Watthana 1771 (QBG)	Thailand
P. kunstleri (Hook.f.) J.J.Sm.	TBG 145833 (TBG)	Borneo
P. undulatum (Lindl.) J.J.Sm.	Yukawa s.n. (TBG)	Taiwan
P. macphersonii (F.Muell.) Hunt	TBG 130189 (TBG)	Unknown
Acampe ochracea (Lindl.) Hochr.	TBG 130163 (TBG)	unknown
Haraella retrocalla (Hayata) Kudo	TBG 133078 (TBG)	Taiwan
Smitinandia micrantha (Lindl.) Holttum	TBG 118427 (TBG)	Vietnam
Ventricularia tenuicaulis (Hook.f.) Garay	TBG 145846 (TBG)	Thailand

A.2. *Nucleotides preparation*

The total DNA was extracted from fresh material or silica-gel dried plant tissues following the instruction of QIAGEN DNeasy Mini Plant Kit. For *matK* sequences, the amplification was performed using a primer pair, OMAT1F and trnK-2R (Topik et al. 2005). The 20-µl amplification reaction included 2 µl 10 x of Ex-Taq buffer (Takara Bio Inc.), 1.6 µl 2.5 mM of dNTPs mix, 0.5 µl each primer (10 pmol), 0.1 micro liter 5 units/µl of Ex-Taq DNA-polymerase (Takara Bio Inc.), 2 µl of template DNAs and 13.3 µl of MilliQ water. The polymerase chain reaction (PCR) profile consisted of an initial 5 min premelt at 94°C and 30 cycles of 30 s at 94°C, 30 s at 53°C, and 3 min at 72°C, followed by a final 7 min extension at 72°C.

Amplification of the ITS region was carried out using a primer pair, 17SE and 26SE (Sun et al., 1994). Total volume of PCR was 30 µl that included 15 µl GC buffer I (Takara Bio Inc.), 4.8 µl 2.5 mM of dNTPs mix, 0.5 µl of each primer (10 pmol), 0.21 µl 5 units/µl of LA Taq DNA-polymerase (Takara Bio Inc.), 2.4 µl of template DNAs and 6.59 µl of MilliQ water. The PCR profile consisted of an initial 2 min premelt at 94°C and 30 cycles of 50 s at 94°C, 1 min at 60°C, and 30 s at 72°C, followed by a final 7 min extension at 72°C. To confirm the number of amplified copies for ITS regions, we performed the single-strand conformation polymorphism (SSCP) analysis based on the method developed by Orita et al. (1989).

The PCR products were cleaned by using Montaqe PCR Centrifugal Filter Devices (Millipore Co.) and were used for auto-cycle sequencing reaction. The 10-µl auto-cycle sequencing reaction included 3 µl of Master Mix (Beckman Coulter), 1 µl primer (1.6 pmol), and 6 µl of PCR product. The reaction was incubated with 50 cycles of 20-s at 96°C, 20-s at 50°C and 4-min at 60°C.

Auto-cycle sequencing products were cleaned by adding STOP solution (2 µl 3M of NaOAc, 2 µl 100 mM of EDTA, and 1 µl 20 ng/µl of Glycogen) and 60 µl of 100 % ethanol; subsequently, they were centrifuged at 14000 rpm for 15-min at 4°C. The alcohol/salt mix was discarded, and the pellet was subjected to two washes with 200 µl 70% ethanol, each followed by centrifugation at 14000 rpm for 2-min at 4°C. Cleaned auto-cycle products were allowed to dry in the vacuum dry for 15-min. Both forward and reverse sequences were analyzed with CEQ8000 automated sequencer (Beckman Coulter), and electropherograms were edited and assembled with Genetyx-ATGC version 4.1 (Genetyx Corporation).

A.3. *Phylogenetic analyses*

DNA sequences obtained from *matK* and ITS were aligned with ClustalX and were then adjusted manually. Phylogenetic analysis and the evaluation of internal support of clades were performed by the same method as described for the morphological intergeneric analysis (see above).

B. Morphology

B.1. *Sampling*

Nearly all recently accepted species of *Pomatocalpa* by us were included in the ingroup. However, *P. armigerum*, *P. bambusarum* and *P. bhutanicum* were excluded because of the results from the analysis of the systematic position and delimitation of *Pomatocalpa* (see below). Due to considerations discussed above, also *Haraella retrocalla* was included in the ingroup, while the genera *Acampe*, *Smitinandia* and *Ventricularia* were chosen as outgroups. We preferred to use entire genera as outgroups (instead of using representative species of the same genera). This practice was expected to increase the influence from ancestral character states in the outgroup by reducing the noise from late-evolved species-specific features (Wiens, 2000).

Most of the data were obtained by examination of spirit and herbarium material from AAU, AMES, BM, C, K, L, and P. Additionally, the following publications were consulted: Seidenfaden (1988, 1992), Comber (1990), Seidenfaden and Wood (1992).

B.2. *Characters*

The choice of characters reflects the same general considerations as discussed under "Delimitation and phylogenetic position of *Pomatocalpa*" above. For this part of the study, 32 characters were scored (**Table 4**) and the matrix is shown in **Table 5**. Some of the characters are defined in **Figure 1**. Several leaf characters (morphology of the sheath, dimensions and shape of the blade, etc.) as well as the outline of the back wall tongue of the spur were excluded, mainly due to high levels of intraspecific variation. The interpretation of the variation encountered in some of the characters should be briefly explained.

Stem length (character 1). Kerr (1985) made a distinction between *Pomatocalpa* species with a compact fan-shaped habit and those with an elongate rambling habit. However, intermediary states are found in *P. diffusum*, *P. fuscum* (Lindl.) J.J.Sm. and *P. marsupiale* (Kraenzl.) J.J.Sm. Therefore, the length of stem was applied instead.

Length of peduncle in relation to rachis (character 3). This character is controversial in species with branched inflorescences. Furthermore, *P. spicatum* may produce both unbranched and branched inflorescences.

However, if the peduncle is defined to end at the point where the terminal rachis shoot starts, a ratio can be obtained that is comparable to the peduncle: rachis ratio in an unbranched inflorescence (**Figure 1**).

Hairiness of peduncle (character 4). According to Seidenfaden (1988), *P. maculosum* (subsyn. *P. linearifolium* Seidenf.) has a finely pubescent rachis. Judging from the first author's observation, it varies from minutely papillose to sparsely and finely pubescent on the rachis, but it is not pubescent on the peduncle. Only *P. kunstleri* has a finely pubescent peduncle.

Table 4. List of morphological characters and states used in the phylogenetic analysis of interspecific relationships in *Pomatocalpa*.

1. Stem up to 30 cm long (0) or more than 30 cm long (1).
2. Inflorescence erect (0) or horizontal to pendent (1).
3. Peduncle shorter than or as long as the terminal rachis shoot (0) or peduncle much longer than the terminal rachis shoot (1) – cf. **Figure 1**.
4. Peduncle glabrous to minutely papillose (0) or distinctly pubescent (1).
5. Inflorescence with less than 5 flowers (0), 5-30 flowers (1) or more than 30 flowers (2).
6. Apex of floral bract obtuse to acute (0) or acuminate to caudate (1).
7. Pedicel less than 5.0 mm long (0) 5.0-10.0 mm long (1) or more than 10.0 mm long (2).
8. Dorsal sepal up to 6.0 mm long (0) or more than 6.0 mm long (1).
9. Dorsal sepal without markings (0), (sub)bordered (1), spotted or patched (2), with two longitudinal stripes (3), with a transverse band (4) or variegated (5).
10. Lateral sepals widely spreading (0) or strongly incurved (1).
11. Petals (oblong-) obovate (0) or linear (1).
12. Petal ground colour pinkish to whitish (0) or yellowish to brownish (1).
13. Labellum glabrous to minutely papillose (0) or distinctly hairy (1).
14. Front edge of each labellum side lobe subequal to the hind edge (0) or much shorter than the hind edge (1) – cf. **Figure 1**.
15. Side lobes of labellum rounded to obtuse (0) or (sub)acute (1).
16. Mid-lobe of labellum (ob)ovate (0) or oblong to rounded (1).
17. Mid-lobe of labellum not distinctly thickened at base (0) or distinctly thickened at base (i.e. triangular in longitudinal section) (1).

18. Mid-lobe of labellum straight (0) or strongly recurved (1).
19. Abaxial angle between labellum mid-lobe and spur more than 90° (0) or up to 90° (1).
20. Spur cylindric to conical (0), pyriform to globular (1), hook-shaped (2) or spur absent (3).
21. Front wall of spur without (0) or with (1) a narrow longitudinal groove at its upper end.
22. A median callus at the base of the labellum mid-lobe absent (0) or present (1).
23. Spur not strongly recurved when dry (0) or spur strongly recurved when dry (1).
24. Back wall tongue in the spur absent (0) or present (1).
25. Back wall tongue placed near the spur apex (0) or more than 1/3 from the spur apex (1).
26. Back wall tongue truncate to obscurely emarginate (0) or distinctly bifid (1).
27. Margins of the back wall tongue only attached to the spur wall at its very base, not forming a distinct pouch (0); or margins of the back wall tongue adnate to the spur wall for a long distance, forming a pouch (1).
28. Pollinia two, porate (0) or pollinia four, entire, joined in two globular pairs (1).
29. Stipe spathulate (0) or oblong to linear (1).
30. Capsule up to 3 cm long (0) or more than 3 cm long (1).
31. Capsule distinctly stalked (0) or (sub)sessile (1).
32. Capsule glabrous to minutely papillose (0) or distinctly hairy (1).

Table 5. Character by taxon matrix of the analysis of intrageneric relationships. Characters as in **Table 1**. ? = unknown, - = inapplicable. Polymorphic taxa are coded with the following symbols; these are equate macros in PAUP: b = (0&1), d = (1&2), e = (0&2), f = (0&3).

	5	10	15	20	25	30	
Smitinandia	0b00d	b0000	000-0	10001	0000-	--100	10
Acampe	bbb0d	0b150	0111-	0bb00	0000-	--11b	10
Ventricularia	bb-00	10001	011-0	00002	0000-	--100	00
Haraella	01b00	01100	011?0	100-3	0000-	--01?	??
P. kunstleri	0b112	10bf0	10001	01b10	10011	10110	11
P. spicatum	0100d	100f1	010b0	00111	1b011	0b110	10
P. macphersonii	01001	00020	01011	01011	10011	01110	10

P. maculosum	1010d	0b020	01010	0b101	1b011	0111b	10
P. undulatum	01001	b0041	010b0	00111	bb011	10110	b0
P. bicolor	1010d	02120	01001	00111	11010	b1111	00
P. diffusum	b010d	0b010	01011	00111	1b011	bb11b	10
P. simalurense	10102	01b20	01001	00111	10110	01111	b0
P. fuscum	b0102	01020	0101b	00001	11011	b1110	10
P. marsupiale	b0102	0dbe0	01011	0b1b1	1b011	b1111	10
P. angustifolium	01001	00020	01011	00111	1b011	0b110	10
P. tokinense	01b0d	00130	10011	00110	11010	11110	10
P. floresanum	1010d	0b1?0	01001	00111	11010	b1111	10

Length of dorsal sepal (character 8). To avoid noise from expected allometry, this was the only floral size character to be included. In other words, the length of the dorsal sepal can be seen as a general measure of flower size.

Index of labellum side lobes (character 14). Nearly all *Pomatocalpa* species have labellum side lobes in which the hind edge produces a right angle to the front edge. The ratio of the lengths of the hind and front edges is informative. However, this character was coded as inapplicable for *P. undulatum* and *P. spicatum*, because the side lobes are broadly rounded in all specimens of the former and in some specimens of the latter.

Longitudinal section of labellum mid-lobe (character 17). This character was difficult to study from dried material. Therefore, it was only scored from fresh and spirit-preserved material.

A narrow longitudinal groove at upper front of the spur (character 21). In some specimens of *P. undulatum* the groove is distinct, while it is obscure in others. Consequently, the character was coded as polymorphic for this taxon.

B.3. *Phylogenetic analysis*

The phylogenetic analysis and the evaluation of internal support of clades were performed by the same methods as described for the intergeneric analysis based on morphological data (see above).

C. Total evidence

It was impossible to perform a congruency test on our data sets because of insufficient memory for simulation – probably due to the large proportion of species for which DNA data were missing. However, since all the individual clades proved to have low bootstrap support, we found it justified to combine the data sets (in case of high bootstrap support for conflicting clades, data sets should not be combined; cf. de Queiroz 1993). Thus, a total evidence analysis of all data sets was performed to get the maximum information level (Kluge 1989). *Acampe ochracea*, *Smitinandia micrantha* and *Ventricularia tenuicaulis* were used as outgroups (since the DNA sequences were derived from individual species, these species, rather than entire genera, had to be chosen). For those species of *Pomatocalpa* from which molecular data were not available, the molecular characters were coded as missing.

Results

I. Delimitation and phylogenetic position of *Pomatocalpa* (morphological data)

Of the 18 characters scored, 14 were informative. The MP analysis yielded 3704 most parsimonious trees (length = 33; consistency index (CI) = 0.58; retention index (RI) = 0.73). The strict consensus tree is shown in **Figure 2**. The consensus tree suggests that *Pomatocalpa*, as traditionally circumscribed, is non-monophyletic. Most of the *Pomatocalpa* species, however, make up a monophyletic group. Bootstrap supports for branches in the strict consensus tree were less than 50% – except for the clade of *Micropera* and *Pomatocalpa bambusarum* (55%).

II. Interspecific relationships in *Pomatocalpa*

A. *Molecular data*

The *matK* alignment had a total of 1835 sites, out of which 110 were variable and 28 were phylogenetically informative. The MP analysis yielded 9 most parsimonious trees (length = 167; CI = 0.89; RI = 0.65). The strict consensus tree and the corresponding branch supports are shown in **Figure 3**. The resolution of the *matK* tree is very low. However, the clade made up from all the *Pomatocalpa* species in the analysis has strongly bootstrap support (91%), while the clade of *Haraella* and *Pomatocalpa* is moderately supported (79%).

The ITS alignment had a total of 668 sites, out of which 69 were variable and 24 were phylogenetically informative. The MP analysis yielded 6 most parsimonious tree (length = 116; CI = 0.85; RI = 0.64). The strict consensus tree and the corresponding branch supports are shown in **Figure**

4. The ITS tree is better resolved than the *matK* tree, but all clades are weakly bootstrap supported, and *Haraella retrocalla* is nested in *Pomatocalpa*.

B. *Morphology*

Out of the 32 characters scored, 28 were informative. The MP analysis yielded 108 most parsimonious trees (length = 63; CI = 0.61; RI = 0.69). The strict consensus tree with corresponding branch supports is shown in **Figure 5**. The following relationship has moderate bootstrap support, viz. the monophyly of *Pomatocalpa* (62%), the clade consisting of *P. simalurense*, *P. bicolor* and *P. floresanum* (68%), the sister group relationship of *P. kunstleri* and *P. tonkinense* (64%) and the sister group relationship of *P. spicatum* and *P. undulatum* (51%).

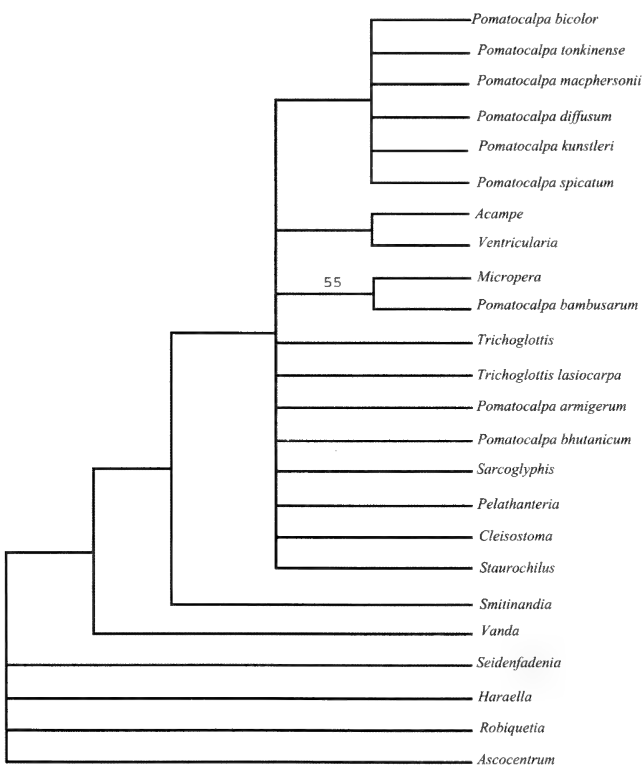

Figure 2. Strict concensus of the 3704 most parsimonious trees from the analysis of the phylogenetic position of *Pomatocalpa*, based on morphological data. Bootstrap support (if more than 50%) is indicated in percent above each branch.

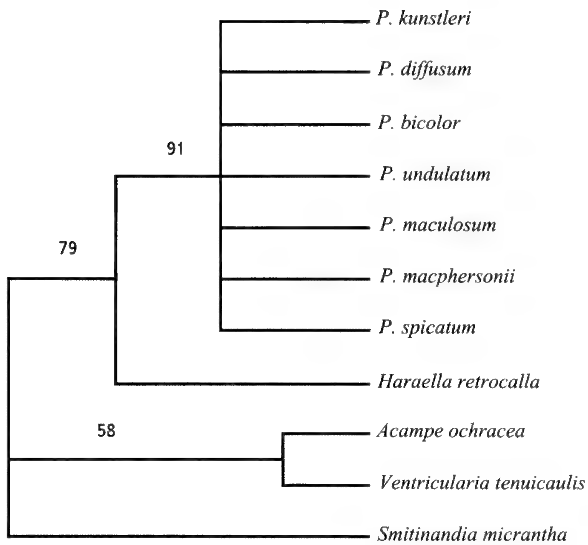

Figure 3. Strict consensus of the 9 most parsimonious trees from the analysis of the interspecific phylogenetic relationships in *Pomatocalpa*, based on *matK* data. Bootstrap support (if more than 50%) is indicated in percent above each branch.

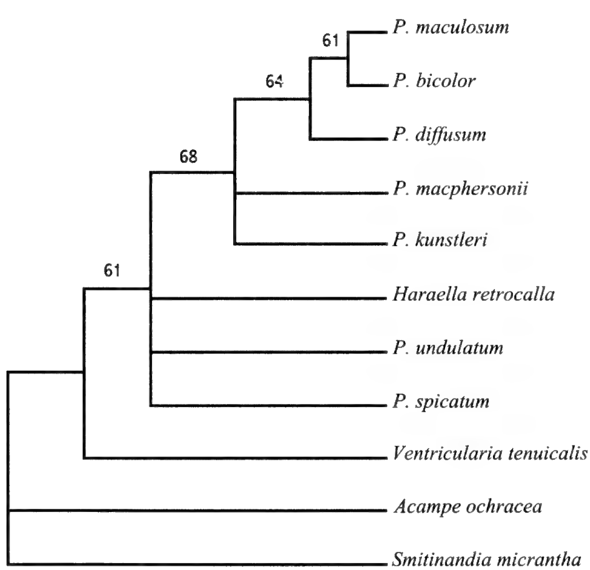

Figure 4. Strict consensus of the 6 most parsimonious trees from the analysis of the interspecific phylogenetic relationships in *Pomatocalpa*, based on ITS data. Bootstrap support (if more than 50%) is indicated in percent above each branch.

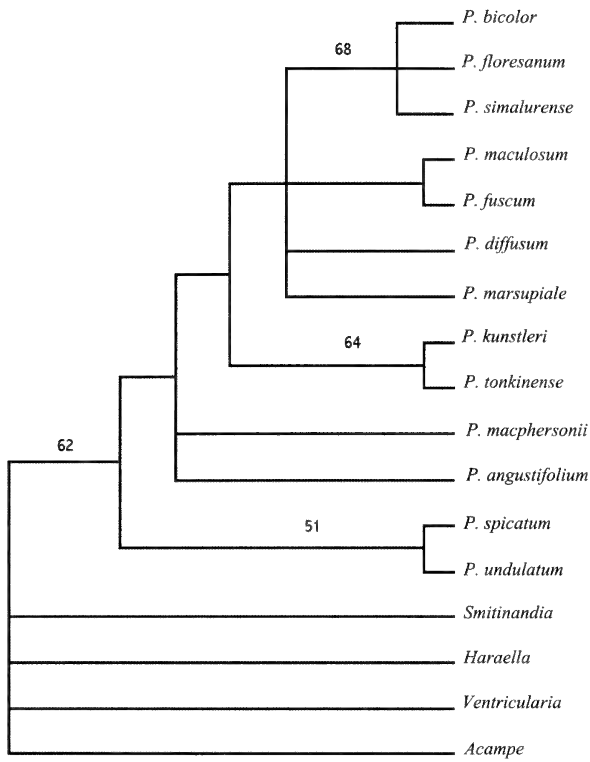

Figure 5. Strict consensus of the 108 most parsimonious trees from the analysis of the interspecific phylogenetic relationships in *Pomatocalpa*, based on morphological data. Bootstrap support (if more than 50%) is indicated in percent above each branch.

C. *Total evidence*

The data matrix of the combined molecular and morphological data sets has 2534 sites, of which 187 were variable and 82 were phylogenetically informative. The MP analysis yielded 45 most parsimonious trees (length = 365; CI = 0.81; RI = 0.60). The strict consensus tree with corresponding branch supports is shown in **Figure 6**. All analyzed *Pomatocalpa* species form a monophyletic group with 78% bootstrap support, as opposed to 62% in the morphological analysis. Also the clade consisting of this genus and its sister group, *Haraella retrocalla*, is fairly well supported (80%).

The interspecific relationships in *Pomatocalpa* are almost identical to the topology from the exclusively morphological analysis (except for the collapse of the clade containing *P. spicatum* and *P. undulatum*). The bootstrap support of the other clades within *Pomatocalpa* is slightly lower than in the morphological analysis.

Discussion

I. Phylogenetic position and achievement of monophyly of *Pomatocalpa*

The strict consensus tree from the phylogenetic analysis of representative *Pomatocalpa* species and a selection of closely related genera (**Figure 2**) indicates that *Pomatocalpa*, as traditionally circumscribed, is non-monophyletic. Thus, while most *Pomatocalpa* species make up a monophyletic group, three species are found outside this clade. *Pomatocalpa bambusarum* is sister to *Micropera*, while *P. armigerum* and *P. bhutanicum* form separate branches in the largely unresolved clade, which in addition to *Cleisostoma*, *Pelatantheria*, *Sarcoglyphis*, *Staurochilus* and *Trichoglottis*, also contains the monophyletic *Pomatocalpa* group and the *Micropera*/*Pomatocalpa bambusarum* clade. Unfortunately, we have been unable to obtain DNA data from these "misplaced" *Pomatocalpa* species. However, we tend to believe in the morphologically based phylogeny and find that *P. armigerum*, *P. bambusarum*, and *P. bhutanicum* should be removed to other genera to

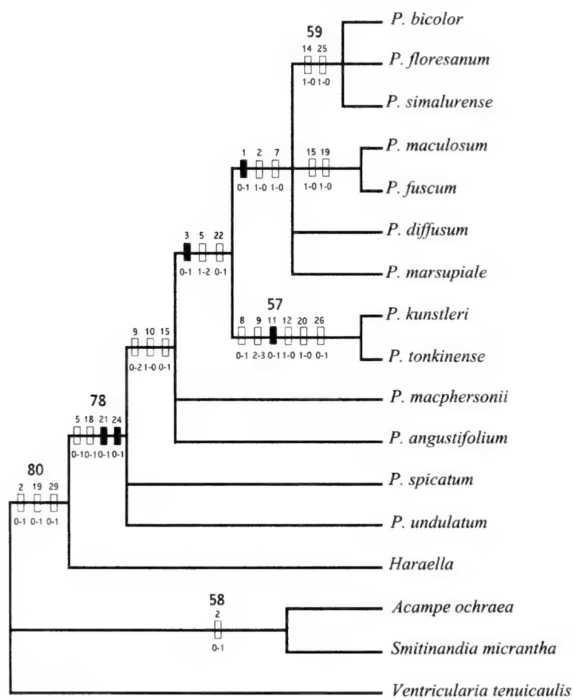

Figure 6. Strict consensus of the 45 most parsimonious trees from the analysis of the interspecific phylogenetic relationships in *Pomatocalpa*, based on total evidence (*matK*, ITS, morphology). The square boxes indicate the character numbers and character changes according to **Table 3** (black boxes: unique synapomorphies; white boxes: homoplacies). Bootstrap support (if more than 50%) is indicated in percent above each branch.

achieve monophyly of *Pomatocalpa* for the following reasons.

Pomatocalpa armigerum (King & Pantl.) T.Tang & F.Wang is probably better treated under its basionym, *Cleisostoma armigerum* King & Pantl., although its place in *Cleisostoma* is not unequivocal from the phylogenetic analysis in the present study (**Figure 2**). Just as *Pomatocalpa*, the very diverse genus *Cleisostoma* probably needs to be re-circumscribed. The back wall callus in the labellum spur of *C. armigerum* corresponds well with those of several species traditionally referred to *Cleisostoma*, e.g. *C. krabiense* (Seidenf.) Garay.

According to Pearce & Cribb (2002), Ormerod thinks that *Pomatocalpa bambusarum* (King & Pantl.) Garay might be better treated as *Cleisostoma bambusarum* (King & Pantl.) King & Pantl. According to the phylogenetic analysis in the present study (**Figure 2**), this species should rather be referred to *Micropera*. This, however, would call for a new combination. Therefore, we support the idea of tentatively referring the species to *Cleisostoma*, awaiting re-circumscription of the latter genus.

According to Pearce & Cribb (2002), Ormerod thinks that *Pomatocalpa bhutanicum* N.P.Balakr. might be better placed in *Cleisostoma*. We fully agree, admitting that its systematic position is not unequivocal from the phylogenetic analysis in the present study (**Figure 2**). The labellum shape and back wall callus in *P. bhutanicum* correspond well with those of several species traditionally referred to *Cleisostoma*. This calls for a new combination:

Cleisostoma bhutanicum (N.P.Balakr.) S.Watthana, *comb. nov.*–*Pomatocalpa bhutanicum* N.P. Balakr., J. Bombay Nat. Hist. Soc. 75: 162. 1978. – Type: Bhutan. Tashiyangtsi, 1870 m alt.; flowered in National Orchidarium, Shillong on 24 June 1965, *Balakrishnan* 41993 (holotype, CAL; isotype, ASSAM).

Likewise, judging from **Figure 2**, it seems appropriate that Ormerod (1997) transferred *Pomatocalpa lasiocarpa* to *Trichoglottis* – at least, this species clearly does not belong in *Pomatocalpa*.

When adjusted in this way, a slightly reduced, but monophyletic, *Pomatocalpa* can be readily recognized from a character state that provides a synapomorphy for the entire genus, i.e., the presence of a narrow longitudinal groove at the upper end of the front wall of the spur.

The phylogenetic relationships between *Pomatocalpa* and its neighbouring genera is very poorly resolved, and it is not unlikely that a number of the genera used as Operational Taxonomic Unit (OTUs) in the present analysis would turn out to be polyphyletic themselves, if they were analyzed with species as OTUs. The very high number of equally most parsimonious trees is undoubtedly due to many cases of polymorphism as well as missing data (cf. Wilkinson, 1995). Phylogenetic analysis of the Aeridinae, based on *matK* and ITS sequences, are somewhat incongruent with macro-morphological data (Topik *et al.*, 2005). This is hardly surprising, since the majority of currently recognized genera under the Aeridinae are mainly, or exclusively, defined by floral traits (e.g. Garay, 1972, 1974; Senghas, 1986-1990; Seidenfaden, 1988). Floral characters are frequently found to show considerably high levels of homoplasy in the Orchidaceae (e.g. Pridgeon, et al. 1997; Bateman et al. 1997, 2003). Micromorphological features, such as the surface structure of velamen, pollen and seed, as well as sequence data from other genomic regions, could be interesting supplements in future analyses.

One of the neighbouring genera is of particular interest, i.e. the monotypic *Haraella*. As mentioned above, Topik and Yukawa (unpublished) conducted a precursory study which incorporated a large number of genera of the Aeridinae. They found *Pomatocalpa* (represented by five species) to be monophyletic in a phylogenetic analysis based on *matK* sequences. However, in the analysis based on ITS sequences, *Haraella* was nested in *Pomatocalpa*, rendering the latter paraphyletic. For this reason, *Haraella retrocalla* was included in the ingroup in each analysis in the present study. While both analyses based on morphology indicated only a distant relationship between *Pomatocalpa* and *Haraella* (**Figures 2, 5**), our analyses based on molecular data corroborated the preliminary findings (**Figures 3, 4**). According to our total evidence analysis, *Haraella* is not nested in *Pomatocalpa* (**Figure 6**).

We tend to assign most weight to the total evidence analysis, because combined data sets can increase the level of information (Kluge, 1989). Consequently, we accept that *Pomatocalpa* is monophyletic without *Haraella*. Acceptance on basis of total evidence seems to be reasonable due to relatively low bootstrap values in the separate analyses (cf. de Queiroz, 1993).

Indeed, only the consensus tree based on ITS sequence data suggests that *Pomatocalpa* and *Haraella* should be lumped to achieve monophyly of the former. The conflict between the strict consensus trees based on *matK* and ITS sequences, respectively, may be because *Haraella retrocalla* is of ancient hybrid origin. This hypothesis finds some support in a forthcoming paper (Yukawa et al., in prep.) contributing further phylogenetic details on the Aeridinae. In that analysis, the Taiwanese endemic *Haraella retrocalla* is sister to a *Gastrochilus* species in the strict consensus tree based on *matK* data, while it is sister to the Taiwanese endemic *Pomatocalpa acuminatum* in the strict consensus tree based on ITS sequences. These different positions might well reflect ancient hybridization combined with maternal inheritance of cpDNA and biparental inheritance of ITS. However, the origin and phylogenetic affinities of *Haraella retrocalla* are in need of much closer scrutiny.

Even if someone finds the analysis based on ITS sequences more convincing than our other analyses, we think that transferring *Haraella* to *Pomatocalpa* would be controversial. Such an act would create a morphologically heterogenous genus that would not be recognizable as an entity outside the laboratory. Indeed, there are a number of good reasons to accept paraphyletic genera in such cases (e.g., Sosef, 1997; Brummitt, 2002, 2003; Grant, 2003). Having said this, we still think that there is fairly good support for considering *Pomatocalpa* a monophyletic genus.

II. Interspecific relationships in *Pomatocalpa*

While the interspecific relationships in *Pomatocalpa* are completely unresolved in our strict consensus tree based on *matK* sequences only (**Figure 3**), the consensus tree based exclusively on ITS data (**Figure 4**) suggests an infrageneric structure that is somewhat different from the one hypothesized by the consensus trees based on morphological data and total evidence, respectively. However, the clade containing *P. bicolor*, *P. diffusum* and *P. maculosum* is congruent with the morphological data and total evidence data.

The topology presented by the strict consensus tree based on total evidence (**Figure 6**) is almost identical to the consensus tree based on morphological data only (**Figure 5**). The only difference is that the clade containing *P. spicatum* and *P. undulatum* in the morphological tree (**Figure 5**) is found to be collapsed in the total evidence tree. The clade consisting of *P. kunstleri* and *P. tonkinense* has weak bootstrap support; "petals linear" being its only synapomorphy. The clade accommodating *P. bicolor*, *P. diffusum*, *P. floresanum*, *P. maculosum*, *P. marsupiale* and *P. simalurense* has bootstrap support less than 50%, but "stem more than 30 cm long" constitutes a synapomorphy (despite the fact that this character is variable in *P. diffusum*, *P. fuscum* and *P. marsupiale*). The clade consisting of *P. bicolor*, *P. floresanum* and *P. simalurense* also has weak bootstrap support, with no unique synapomorphic character state. *P. maculosum* is sister to *P. fuscum* with no unique synapomorphy and the bootstrap support is more than 50%.

The strict consensus trees of the various analyses do not clearly reflect distribution patterns in *Pomatocalpa*. However, the clade consisting of *P. bicolor*, *P. floresanum* and *P. simalurense* seems confined to the Malesian region (occurring in Peninsular Malaysia, Indonesia and the Philippines) apart from an uncertain collection of *P. bicolor* from "Cochinchina".

In conclusion, neither our analyses of morphological data, nor *matK* or ITS sequence provided detailed resolution of the interspecific relationships in *Pomatocalpa* (**Figures 3, 4, 5**). Variation of *matK* and ITS at species level appeared to be very low, 6.0 % and 10.3 %, respectively. The lack of resolution is probably due to a high internal conflict among the sequences collected, as can be deduced from the relatively low RI values (0.65 and 0.64, respectively). To produce a more detailed phylogeny, it would be desirable to obtain more DNA data from additional species of *Pomatocalpa* as the high amount of missing molecular characters in the total evidence analyses is undoubtedly influencing the results of this study.

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Species Composition and Biogeography of Tropical Montane Rain Forest in Southern Yunnan of China

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Abstract

The species composition, physiognomy and biogeography of tropical montane rain forest in southern Yunnan, SW China, have been studied based on data from 10 sampling plots and a complete floristic inventory. Two separate communities are recognized: a *Mastixia euonymoides-Phoebe megacalyx* forest and a *Parakmeria yunnanensis-Gymnanthes remota* forest based mainly on species composition and forest structures. The tropical montane rain forest is characterized by evergreen meso-phanerophytes and micro-phanerophytes with simple, leathery and entire mesophyllous leaves, more or less frequent woody lianas and epiphytes, abundant herbaceous phanerophytes. However, it has few buttresses or cauliflory in physiognomy. The montane rain forest has similar species diversity to the lowland seasonal rain forest in the region. This indicates that species richness is not necessarily reduced with increasing altitude. We suggest this rain forest is a type of lower montane rain forest based mainly on its physiognomy, structure and floristics, but one that occurs at a higher altitude than those in equatorial SE Asia. The montane rain forest is dominated, in terms of species richness, by Lauraceae, Euphorbiaceae, Fagaceae, Theaceae, Rubiaceae and Papilionaceae, but by Lauraceae, Magnoliaceae, Euphorbiaceae, Fagaceae, Mastixiaceae and Nyssaceae in terms of phytosociological importance. In floristic composition, a total of 623 native species in 327 genera and 115 families of seed plants were recorded from the montane rain forest, of which recognizably 'tropical' elements contributed about 78.9% at the generic level and more than 80% at the specific level. Plants of tropical Asian distribution contribute 63.7% of the total sum of species. We conclude that the montane rain forest has strong tropical Asian affinities floristically even though it occurs at the northern margin of mainland SE Asia and at a higher altitude.

Introduction

Southern Yunnan in southwestern China is exceptionally interesting to botanists because of its diversified biota and unique geological-biogeographical history. The region is the most species rich and has the largest tropical-subtropical forest cover in southern China. Geographically, the region is at a transitional zone between tropical Southeast Asia and subtropical East Asia, and is also to be at a conjunction area between the Shan-Tai fragment of Gondwanaland and the southeastern margin of the Asian continent, geologically (Fortey et al., 1998, Metcalfe, 1998). Accordingly, southern Yunnan is a key area in biogeography as well as being a global 'hot spot' for biodiversity (Myers, 1998).

The vegetation of southern Yunnan was mentioned, albeit briefly, for the first time by C.W. Wang in 1939 (Wang, 1939), but little was known until late 1950s because of poor access to the area. Many studies on the tropical forests in southern Yunnan have been done in the past, although little has been published in English (Zhu, 1992, 1993; Wu, 1987; Jin, 1997; Cao, 1996; Cao & Zhang, 1997; Zhu, 1997; Zhu et al., 1998a, 1998b, 2003, 2004; Zhu & Roos, 2004). Previous work on the forest in southern Yunnan has been restricted, largely, to the tropical rain forests at lowland sites below 900 m in elevation. The tropical montane rain forests are still poorly known (but see the descriptive works of Wu, 1987; Wang et al., 2001; Zhu et al., 2004).

Pristine montane rain forests were discovered recently at Mengsong in southern Yunnan, in the border between Myanmar and Yunnan (Wang et al., 2001). The montane rain forests occur in valleys and on some mountain slopes between 1500-1800 m and are a type of 'lower montane rain forest' according to Ashton's (2003) categorization of altitudinal forest zonation in Southeast Asia.

Montane forests and their altitudinal zonations in tropical southeastern Asia have been studied by a great many authors since Brown (1919). The more important of these include Steenis (1935, 1984), Whitmore & Burnham (1969), Whitmore (1984), Ohsawa et al. (1985), Ohsawa (1991, 1993, 1995), Kitayama (1992), Nakashizuka (1992), Pendry & Proctor (1996), Aiba & Kitayama (1999), Buot & Okitsu (1999) and Ashton (2003). It has been accepted, commonly, that there is an ecotone between the tropical lowland forest and lower montane forest with changes in physiognomic, structural and floristic attributes, occurring usually between 900-1200 m altitude. The montane rain forest in southern Yunnan occurs at much higher altitudes on the northern margin of tropical Southeast Asia. Its physiognomy, floristics and biogeography are accordingly of special interest.

Site Description

Southern Yunnan is located in the southernmost part of Mainland China (**Figure 1**). It borders Myanmar and Laos, and has a mountainous topography with the mountain ridges running in a north-south direction and becoming lower in elevation southward. Altitude ranges from 480 m at the bottom of the lowest valley in the south (Mekong River) to 2429.5 m at the top of the highest mountain in the north. The Mekong River traverses the region from northwest to southeast (Xu & Jiang, 1987).

Mengsong is an administrative district in the west of southern Yunnan occupied by Hani people, an indigenous ethnic group. It is located in the border between Myanmar and Yunnan. Topographically it is a high basin surrounded by mountains, and varies in altitude from 1557 m within the basin to 2100 m at the top of the surrounding mountains. The region has a monsoon climate. From the climatic observation at 1600 m elevation, the mean annual temperature is 16.7 °C; the extreme minimum air temperature is 1.7 °C, the maximum air temperature, 28.5 °C, and the annual temperature accumulation (the sum of daily temperature means of > 10 °C), 6083 °C. The mean annual precipitation is between 1800 and 2379 mm. More than 80% of the precipitation falls during the rainy season between May and the end of October, and the annual mean relative humility is 83.4%.

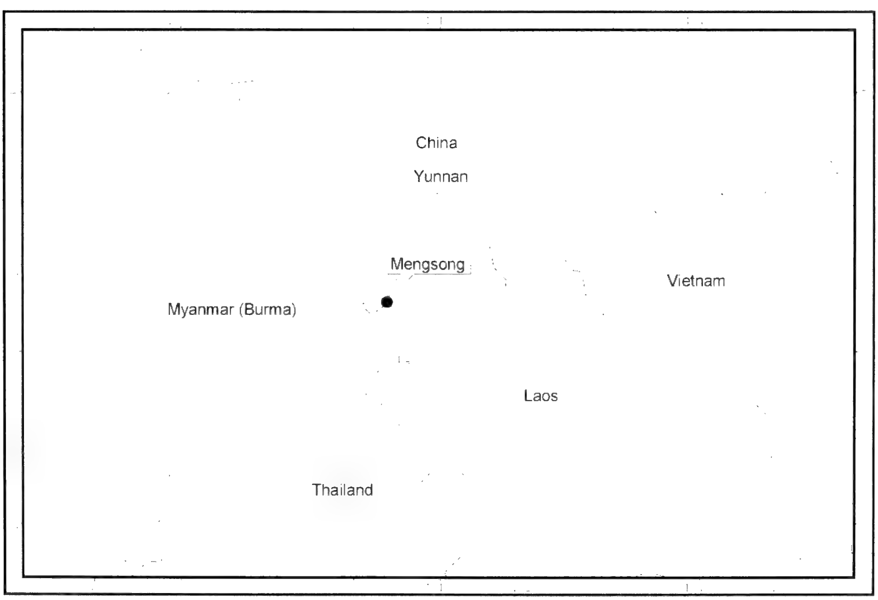


Figure 1. Map showing the location of Mengsong region in Xishuangbanna, southern Yunnan.

Methodology

The study was conducted in two stages: First, there was a general, landscape-scale, floristic inventory of the tropical montane rain forest in Mengsong, in which all plant species in the forest were recorded and specimens collected whenever possible. When habitat-related floristic variation had been identified, a systematic plot-based study was carried out. Five sampling plots, each 25 × 20 m in size, were established in each assemblage in order to characterize the floristic variation. All trees in these plots were identified and their dbh (minimum 5 cm), height, and crown cover were measured. In each plot, five 5×5 m sub-plots were established to facilitate floristic survey of the understorey. In these sub-plots, saplings, shrubs and herbaceous plants were counted. Lianas in these plots were identified and their abundance estimated. The Importance Value Index (IVI), suggested by Curtis and McIntosh (1951), was calculated. Physiognomy (life forms and leaf sizes) was analyzed using Raunkiaer's criteria (1934) as revised by Mueller-Dombois and Ellenberg (1974). Webb (1959) split off the lower end of Raunkiaer's big mesophyll class (2025 –18225 mm^2) as notophylls (2025-4500 mm^2), which is to be preferred for detailed categorization of leaf size spectrum. Nonetheless, Chinese botanists and their local audience are familiar with Raunkiaer's big mesophyll class. Accordingly we retain the big mesophyll class of Raunkiaer in this analysis.

Based on intensive floristic inventory of the forest, a more or less complete species list has been compiled, from which the floristics and geographical elements have been analyzed. Physiognomic comparisons between the montane rain forest and lowland rain forests in southern Yunnan and the equatorial tropics, and other montane rain forests in Southeast Asia have been made to demonstrate further the characteristics of the Yunnan montane rain forests. Specimens were identified and voucher material is lodged in the herbarium of Xishuangbanna Tropical Botanical Garden (HITBC). Species authorities follow the recently published and still on-going project of "Flora of China".

Results

The vegetation

Based mainly on their habitats, species composition and forest profiles, we have divided the vegetation of the montane rain forest into two distinct assemblages which we have named based on their dominant and subdominant species, *viz.*:

1 *Mastixia euonymoides- Phoebe megacalyx* forest;

2 *Parakmeria yunnanensis- Gymnanthes remota* forest.

Mastixia euonymoides- Phoebe megacalyx forest ('ME-PM')

The ME-PM forest occurs mainly in wetter montane valleys. The forest has usually two tree layers. The upper layer is up to 35 m high with a crown cover of 70-80%, and is dominated by *M. euonymoidos, Manglietia hookeri, Michelia cavaleriei* and *Nyssa wenshanensis* var. *longipedunculata*. In some sites *M. euonymoides* grew sufficiently tall as to be considered as emergents. The lower tree layer was further divided into two sub-layers in some sites. The upper sub-layer was 10-20 m high with a crown cover of 60-70%, and was dominated by *Phoebe megacalyx, Syzygium brachythyrsum* and *Dysoxylum binectariferum*. The lower sub-layer is 5-10 m high with a cover of 40-50%. The most frequently encountered species are *Ardisia thyrsiflora, Cylindrokelupha kerrii, Ostodes kuangii* and *Brassaiopsis lepidota* (see **Appended Table 1**).

The shrub layer is up to 1-5 m high and is dominated by juvenile trees. The most frequently seen shrub species are *Psychotria symplocifolia, Brassaiopsis fatsioides, Mycetia gracilis, Brachytome hirtellata* var. *glabrescens* and *Oxyspora vagans*.

The herbaceous layer is well developed with a cover of 50-70%. Frequent species are *Ophiorrhiziphyllom macrobotryum, Allantodia dilatata, Ctenitopsis* sp., *Microsorum dilatatum, Porandra scandens, Rhynchotechum obovatum* and *Strobilanthes* sp.

There are a few lianas, but some big woody individuals belonging to species such as *Epigynum auritum, Bousigonia angustifolia, Calamus nambariensis*, and *Gnetum montanum* are present.

Epiphytes are abundant. They include *Pothos chinensis, Neottopteris nidus, Rhaphidophora hongkongensis, Aeschynanthus bracteatus, Pholidota imbricata* and *Asplenium normale*.

Parakmeria yunnanensis- Gymnanthes remota forest (PY-GR)

The PY-GR forest occurs on shady slopes and the tops of hills. The forest is 25-30 m high with a very even canopy. It also has two tree layers. The upper layer with a crown cover of 80% is dominated by *P. yunnanensis, Nyssa* *wenshanenensis, Cinnamomum javanicum* and *Calophyllum polyanthum.* The lower layer is at 5-20 m with a cover of 70-80%, and is dominated by *G. remota, Syzygium brachythyrsum, Xanthophyllum yunnanensis* and *Wendlandia pingpiensis* (see **Appended Table 2**).

Appended Table 1. Importance Values Index (IVI) of tree species in *Mastixia euonymoides- Phoebe megacalyx* forest.

Altitude: 1650-1780 m	Height of canopy: 35 (m)			
Plot number and size: 5 (25×20) = 2500 m^2	Coverage: > 90%			
Slope degree: 10-35	No. of sp. (>5 cm dbh): 62			
	No. of stems: 263			
Species name	RA	RF	RD	IVI*
Mastixia euonymoides	0.76	1.64	23.46	25.86
Phoebe megacalyx	9.13	4.1	6.00	19.22
Syzygium brachythyrsum	9.51	4.1	3.01	16.62
Dysoxylum binectariferum	9.51	4.1	2.35	15.95
Manglietia hookeri	0.38	0.82	14.14	15.34
Michelia cavaleriei	1.9	2.46	8.73	13.09
Nyssa wenshanensis var. longipedunculata	1.52	2.46	7.12	11.10
Linociera insignis	4.94	3.28	1.66	9.88
Ardisia thyrsiflora	4.56	4.1	0.87	9.53
Cinnamomum javanicum	2.66	3.28	3.21	9.15
Helicia pyrrhobotrya	4.18	3.28	0.58	8.05
Calophyllum polyanthum	2.66	3.28	1.72	7.66
Ostodes kuangii	3.8	2.46	1.38	7.64
Xanthophyllum yunnanensis	3.42	3.28	0.88	7.58
Brassaiopsis lepidota	2.28	2.46	1.90	6.64
Cylindrokelupha kerrii	3.8	2.46	0.29	6.55
Cryptocarya rolletii	3.04	3.28	0.17	6.49
Alcimandra cathcartii	1.52	2.46	2.29	6.27
Litsea vang var. lobata	1.52	3.28	0.13	4.93
Litsea lancifolia var. pedicellata	2.28	2.46	0.12	4.86
Randia sp.	2.66	1.64	0.52	4.82

Michelia hedyosperma	1.14	1.64	1.93	4.71
Drypetes salicifolia	0.76	1.64	2.30	4.70
Hovenia acerba var. kiukiangensis	0.76	0.82	2.82	4.40
Lithocarpus hancei	0.76	0.82	2.56	4.14
Litsea verticillata	1.52	1.64	0.03	3.19
Mastixia pentandra var.chinensis	1.14	1.64	0.28	3.06
Reevesia thyrsoidea	1.14	1.64	0.26	3.04
Randia wallichii	1.14	1.64	0.25	3.03
Dimocarpus yunnanensis	0.76	1.64	0.45	2.85
Macaranga henryi	1.52	0.82	0.17	2.51
Machilus shweliensis	0.38	0.82	1.27	2.47
Alseodaphne andersonii	0.38	0.82	0.91	2.11
Litsea lancifolia	0.76	0.82	0.39	1.97
Walsura yunnanensis	0.38	0.82	0.73	1.93
Cinnamomum tamala	0.76	0.82	0.27	1.85
Elaeocarpus glabripetalus var. alata	0.38	0.82	0.61	1.81
Rhododendron moulmainensis	0.76	0.82	0.22	1.80
Alsophila costularis	0.76	0.82	0.18	1.76
Beilschmiedia roxburghiana	0.38	0.82	0.45	1.65
Alphonsea tsangyuanensis	0.38	0.82	0.43	1.63
Cyclobalanopsis chrysocalyx	0.38	0.82	0.38	1.58
Meliosma simplicifolia	0.38	0.82	0.33	1.53
Tapiscia yunnanensis	0.38	0.82	0.28	1.48
Alseodaphne pectiolaris	0.38	0.82	0.27	1.47
Eriobotrya bengalensis var. angustifolia	0.38	0.82	0.27	1.47
Gymnanthes remota	0.38	0.82	0.26	1.46
Michelia floribunda	0.38	0.82	0.19	1.39
Diospyros kaki var. sylvestris	0.38	0.82	0.18	1.38
Laurocerasus jenkinsii	0.38	0.82	0.15	1.35
Nyssa wenshanensis	0.38	0.82	0.14	1.34
Beilschmiedia linocieroidea	0.38	0.82	0.12	1.31
Ficus auriculata	0.38	0.82	0.09	1.29
Walsura robusta	0.38	0.82	0.08	1.28
Artocarpus nitidus	0.38	0.82	0.08	1.28

Lithocarpus pseudoreinwardtii	0.38	0.82	0.04	1.24
Lindera latifolia	0.38	0.82	0.03	1.23
Oxyspora vagans	0.38	0.82	0.03	1.23
Litsea garretii	0.38	0.82	0.02	1.22
Castanopsis argyrophylla	0.38	0.82	0.01	1.21
Microtropis tetragona	0.38	0.82	0.00	1.20
Gymnosphaera gigantea	0.38	0.82	0.00	1.20
Total (62 species) 263 stems	100	100	100.00	300.00

* RA: Relative abundance; RD: Relative dominance; RF: Relative frequency: IVI: Importance value index (Curtis & McIntosh, 1951)

Appended Table 2. Importance values Index (IVI) of tree species in *Parakmeria yunnanensis*- *Gymnanthes remota* forest.

Altitude: 1650-1700 m	Height of canopy: (m)			
Plot number and size: 5 (25×20) = 2500 m^2	Coverage: > 90%			
Slope degree: 5-30	No. of sp. (>5 cm dbh): 70			
	No. of stems: 293			
Species name	RA	RF	RD	IVI*
Gymnanthes remota	15.36	4.20	3.97	23.53
Parakmeria yunnanensis	1.02	2.52	11.08	14.62
Xanthophyllum yunnanensis	7.17	3.36	2.22	12.75
Syzygium brachythyrsum	7.17	3.36	1.65	12.18
Wendlandia pingpiensis	6.83	3.36	1.19	11.38
Nyssa wenshanensis	1.02	1.68	8.13	10.84
Cinnamomum javanicum	3.07	3.36	3.83	10.26
Calophyllum polyanthum	3.41	3.36	3.38	10.15
Nyssa wenshanensis var. longipedunculata	2.05	1.68	5.93	9.66
Mastixia pentandra subsp. chinensis	4.10	1.68	3.72	9.49
Cyclobalanopsis chapensis	3.42	2.52	3.29	9.23
Manglietia insignis	0.68	0.84	6.17	7.70
Acer decandrum	2.05	3.36	2.26	7.67
Ostodes kuangii	4.44	0.84	0.53	5.80
Cyclobalanopsis chrysocalyx	0.34	0.84	3.97	5.16
Machilus shweliensis	1.37	2.52	1.11	5.00

Engelhardtia spicata	0.34	0.84	3.78	4.96
Alcimandra cathcartii	0.68	1.68	2.58	4.94
Michelia floribunda	1.37	1.68	1.79	4.83
Podocarpus neriifolius	0.68	0.84	3.22	4.75
Craibiodendron stellatum	1.02	0.84	2.55	4.42
Lithocarpus gagnepainianus	1.71	0.84	1.85	4.40
Dimocarpus yunnanensis	2.05	1.68	0.55	4.28
Gomphandra tetrandra	2.73	0.84	0.69	4.26
Cinnamomum bejolghota	1.37	2.52	0.28	4.17
Lithocarpus pseudoreinwardtii	2.05	1.68	0.24	3.96
Linociera ramiflora	0.68	1.68	1.16	3.52
Castanopsis hystrix	0.34	0.84	2.24	3.43
Litsea lancifolia	0.34	0.84	2.21	3.39
Lindera metcalfiana var. dictyophylla	1.37	1.68	0.23	3.27
Castanopsis argyrophylla	0.68	0.84	1.47	2.99
Lithocarpus fohaiensis	0.34	1.68	0.90	2.92
Reevesia thyrsoidea	0.68	1.68	0.52	2.88
Ardisia thyrsiflora	1.02	1.68	0.15	2.86
Randia griffithii	0.68	1.68	0.47	2.84
Schima wallichii	0.68	0.84	1.27	2.80
Symplocos wikstroemiifolia	1.02	1.68	0.07	2.77
Dysoxylum binectariferum	1.02	1.68	0.06	2.76
Pygeum henryi	0.68	1.68	0.33	2.69
Litsea euosma	0.34	0.84	1.26	2.44
Cylindrokelupha kerrii	0.68	1.68	0.06	2.43
Eurya aurea	0.68	1.68	0.06	2.42
Linociera insignis	0.68	1.68	0.04	2.40
Eriobotrya obovata	0.68	0.84	0.84	2.37
Rhododendron moulmainensis	1.02	0.84	0.44	2.30
Acer huianum	0.34	0.84	1.03	2.21
Alangium chinensis	0.34	0.84	0.92	2.10
Elaeocarpus howii	0.34	0.84	0.77	1.95
Machilus rufipes	0.34	0.84	0.61	1.79
Ternstroemia gymnanthera	0.34	0.84	0.54	1.72

Itea macrophylla	0.68	0.84	0.16	1.68
Beilschmiedia robusta	0.34	0.84	0.39	1.57
Lithocarpus truncatus	0.34	0.84	0.38	1.56
Pittosporum kerrii	0.34	0.84	0.26	1.45
Laurocerasus jenkinsii	0.34	0.84	0.23	1.41
Helicia tsaii	0.34	0.84	0.17	1.35
Tricalysia fruticosa	0.34	0.84	0.17	1.35
Styrax grandiflora	0.34	0.84	0.16	1.34
Bruinsmia polysperma	0.34	0.84	0.15	1.33
Garcinia cowa	0.34	0.84	0.08	1.27
Eurya prunifolia	0.34	0.84	0.06	1.24
Casearia velutina	0.34	0.84	0.04	1.22
Carallia lanceaefolia	0.34	0.84	0.03	1.21
Sarcosperma griffithii	0.34	0.84	0.02	1.20
Oxyspora vagans	0.34	0.84	0.02	1.20
Platea latifolia	0.34	0.84	0.02	1.20
Cyclobalanopsis myrsinaefolia	0.34	0.84	0.01	1.20
Amoora yunnanensis	0.34	0.84	0.01	1.19
Paramichelia baillonii	0.34	0.84	0.01	1.19
Anneslea fragrans	0.34	0.84	0.01	1.19
Total (70 species) 293 stems	100.00	100.00	100.00	300.00

* See Appended Table 1.

The shrub layer is 1-5 m high with a cover of 30%-40%, and is dominated by juvenile trees. Frequent shrub species are *Euodia lepta, Fargesia plurisetosa, Lasianthus lucidus, Psychotria symplocifolia, Oxyspora vagans* and *Lasianthus inodorus*.

The herbaceous layer is usually less developed than in the preceding forest type. Frequent species are *Davallia mairesii, Pteris insignis, Ophiopogon graminifolia, Colysis pothifolia* and *Strobilanthes* sp.

Lianas are fewer but there are some big woody lianas such as *Connarus paniculatus, Celastrus monospermum, Epigeum auritum, Bousigonia angustifolia, Gnetum montanum* and *Alyxia balansae*.

Epiphytes are fewer than in the ME-PM forests.

We have analyzed the forest physiognomy based on 261 vascular species from the 10 plots of these two montane rain forest types. Both forests are dominated by phanerophytes, which make up 79.3% of all species (**Table 1**). In terms of the spectrum of leaf sizes, the plants with mesophyllous leaves contribute up to 68.2% of the total species, and 76.4% of tree species (**Table 2**). Woody plants with simple leaves contribute up to 90.6% and those with entire leaf margins, up to 76.5% (**Table 3**).

<u>The flora</u>

623 native seed plant species (including varieties) in 327 genera and 115 families of seed plants were recorded from the montane rain forest (see Appendix 3). The families with highest species richness included Lauraceae (51 species), Euphorbiaceae (36), Rubiaceae (23), Fagaceae (20), Liliaceae (20), Rosaceae (19), Araceae (18), Theaceae (17) and

Table 1. Life form spectrum of the tropical montane rain forest in southern Yunnan.

	Life form*	Number of species	%
	Megaphanerophyte	12	4.6
Trees	Mesophanerophyte	61	23.4
	Microphanerophyte	54	20.7
	(All trees)	(127)	(48.7)
Shrubs	Nanophanerophyte	22	8.4
	Herbaceous phanerophyte	24	9.2
Herbaceous	Geophyte	5	1.9
plants	Chamaephyte	25	9.6
	(All herbs)	(54)	(20.7)
Liana	Liana phanerophyte	34	13.0
Epiphyte	Epiphyte	24	9.2
Total species		261	100

* The Raunkiaer's criteria (1934) as revised by Mueller-Dombois and Ellenberg (1974): Megaphanerophyte (perennials, over 30 m high); Mesophanerophyte (perennials, 8 to 30 m high); Microphanerophyte (perennials, 2 to 8 m high); Nanophanerophyte (perennials, 0.25 to 2 m

high); Herbaceous phanerophyte (herbaceous perennials, over 0.25 m high); Chamaephytes (perennials, less than 0.25 m high above ground); Geophyte (perennials, dying back above ground).

Table 2. Leaf sizes of the tropical montane rain forest in southern Yunnan.

		Macrophyll 18226-164025 mm^2	Mesophyll 2026-18225 mm^2	Microphyll 226-2025 mm^2	Total
Trees	Number of species	1	97	29	127
	%	0.8	76.4	22.8	
Shrubs	Number of species	—	9	13	22
	%	—	40.8	59.1	
Herbs	Number of species	9	32	13	54
	%	16.7	59.2	24.1	
Lianas	Number of species	1	28	5	34
	%	3.0	82.4	14.7	
Epiphytes	Number of species	4	12	8	24
	%	16.7	50.0	33.3	
Total species	Number of species	15	198	48	261
	%	5.7	68.2	26.1	

Table 3. Leaf types, leaf textures and leaf margins of the tropical montane rain forest in southern Yunnan.

		Leaf type		Leaf texture		Leaf margin		
		S	C	P	L	E	N	
Trees	Number of species	113	14	51	76	97	30	127
	%	89.0	11.0	40.2	59.8	76.4	23.6	
Shrubs	Number of species	21	1	17	5	17	5	22
	%	95.4	4.6	77.3	22.7	77.3	22.7	
All woody plants species	Number of species	134	15	68	81	114	35	149
	%	90.6	9.4	45.6	54.4	76.5	23.5	

S: Simple; C: Compound; P: Papery; L: Leathery; E: Entire; N: non-entire.

Papilionaceae (16).

The various types of geographic distributions of seed plants from China at the generic level have been documented by Z.Y. Wu (1991). Using Wu's documentation, we have quantified the distribution types of the flora of montane forest at the generic level and these are summarized in Table 4.

Distribution described as 'tropical Asian', such as *Mastixia, Pterospermum* and *Knema*, represent up to 27.5% of total genera of the flora. 'Pantropic' distribution, such as those of *Gnetum, Piper, Lasianthus* and *Bauhinia*, contribute up to 26 %. 'Old World Tropical' distribution, such as those of *Thunbergia, Pandanus* and *Carallia* are the next most abundant. These tropical distributions (Types 2-7) compose 78.9% of the total genera. This indicates that the flora of the montane rain forest in southern Yunnan is of tropical nature and has strong tropical Asiatic affinity.

At the specific level, nine geographical elements (distribution types) were recognized from 623 seed plant species of the montane forest (see Table 4). 'Tropical Asian' elements and their subtypes contribute up to 63.7% of the total sum of species, including those of 'Indo-Malesian' distribution, such as *Garcinia cowa, Knema furfuracea* and *Gironniera subaequalis*. Others belong to 'Southern Asian' to 'Mainland Southeast Asian' distributions, such as *Alcimandra cathcartii* and *Silvianthus bracteatus*; and those of 'Mainland SE Asia' to 'SW and SE China' distributions, such as *Vaccinium exaristatum, Metadina trichotoma* and *Semecarpus reticulata*. The elements of 'Chinese Endemics' and subtypes, which were defined on available references, contribute up to 26%, including those of 'SW to SE China' distribution, such as *Lithocarpus fordianus* and *Craspedolobium schochii*; and the 'Yunnan Endemics', such as *Lithocarpus fohaiensis* and *Cryptocarya rolletii.*

<u>Comparison with the lowland rain forest in southern Yunnan and the equatorial tropical and montane rain forests in SE Asia</u>

Compared with the tropical montane rain forest in Java at similar altitude (Meijer, 1959), the montane rain forest in southern Yunnan has fewer epiphytes (**Figure 2**), but a higher proportion of woody phanerophytes.

Compared with the tropical seasonal rain forests at lower altitude in southern Yunnan (Zhu et al., 1998a) and equatorial lowland rain forests (Beard, 1946; Paijmans, 1970; Givnish, 1978; Proctor et al., 1998), the montane rain forest has fewer mega-and meso-phanerophytes and lianas, fewer plants with compound leaves, fewer plants with macrophyllous leaves, but more abundant herbaceous plants and more plants with non-entire leaf margins **(Figures 3 and 4).**

The families with highest species richness in the montane rain forest are, to some extent, similar to those in the seasonal rain forests at lower altitudes in the region, but there is greater species richness in Fagaceae, Theaceae, Liliaceae, Rosaceae and Magnoliaceae **(Figure 5).** In terms of phytosociological importance, most of the dominant families in the montane forest are also dominant families in the lowland seasonal rain forests, but Magnoliaceae, Fagaceae, Mastixiaceae, Nyssaceae and Polygalaceae are of greater importance (**Figure 6**).

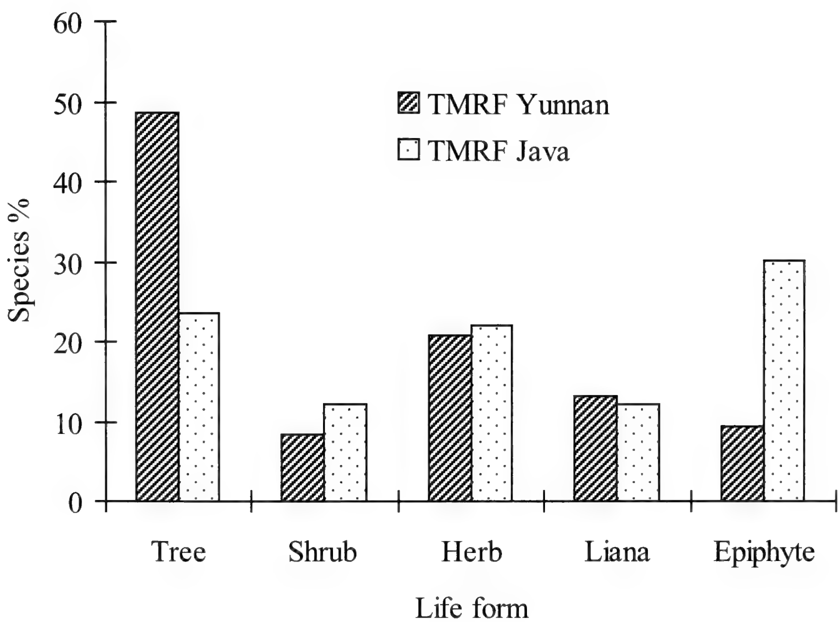


Figure 2. Comparison of life form spectra between the tropical montane rain forest of Mengsong in southern Yunnan and the tropical montane rain forest in Java, Indonesia. TMRF Java: montane rain forest at altitudes 1450-1500 m in Java (Meijer, 1959); TMRF Yunnan: tropical montane rain forest at altitudes 1500-1800 m in Mengsong, southern Yunnan.

Table 4. Geographical elements at generic and specific levels of the flora of the montane rain forest in Mengsong, southern Yunnan.

Distribution types at generic level	No. of genera	%	Distribution type at specific level	No. of species	%
1. Cosmopolitan	10	3.1	1. Cosmopolitan	12	1.9
2. Pantropics	85	26.0	2. Pantropics	7	1.1
3. Tropical Asia & Tropical America disjunct	13	4.0	3. Tropical Asia & Tropical America disjunct	2	0.3
4. Old World Tropics	30	9.2	4. Old World Tropics	4	0.6
5. Tropical Asia to Tropical Australia	16	4.9	5. Tropical Asia to Tropical Australia	10	1.6
6. Tropical Asia to Tropical Africa	24	7.3	6. Tropical Asia to Tropical Africa	11	1.8
7. Tropical Asia (Indo-Malaysia)	90	27.5	7. Tropical Asia and its subtypes	(397)	(63.7)
8. North Temperate	25	7.6	7-1. Indo-Malesia	120	19.3
9. E. Asia and N. America disjuncted	12	3.7	7-2. S Asia to Mainland SE Asia	130	20.9
10. Old World Temperate	2	0.6	7-3. Mainland SE Asia to SW and SE China	147	23.6
11. Mediterranean and W. Asia to C. Asia	2	0.6	8. Eastern Asia	18	2.9
14. E. Asia	14	4.3	9. Endemic to China and its subtypes	(162)	(26)
15. Endemic to China	4	1.2	9-1. SW to SE China	91	14.6
Total genera	327	100.0	9-2. Endemic to Yunnan	71	11.4
			Total species	623	100.0

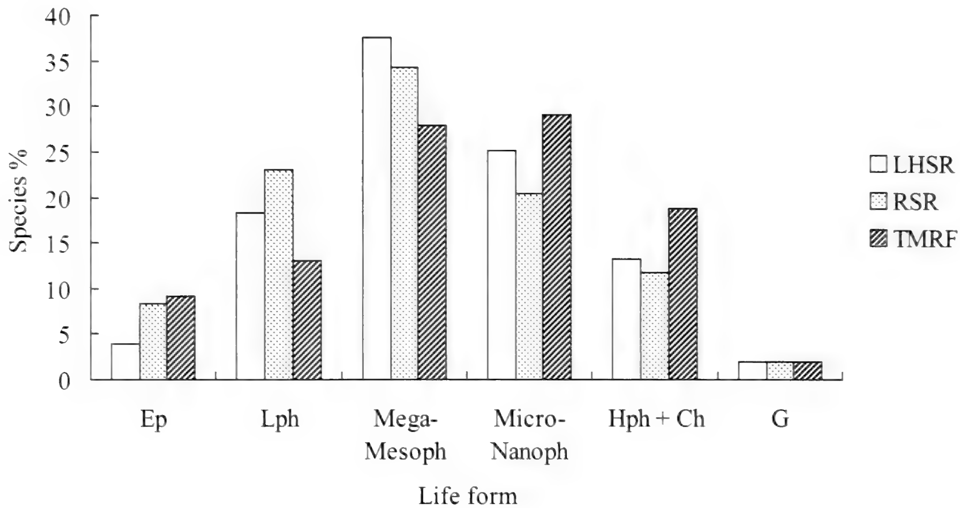


Figure 3. Comparison of life form spectra between the tropical montane rain forest in Mengsong and seasonal rain forests in southern Yunnan.
LHSR: lower hill seasonal rain forest;
RSR: ravine seasonal rain forest;
TMRF: tropical montane rain forest in Mengsong.
Ep=Epiphyte; Ch=Chamaephyte; G=Geophyte; Lph=Liana-phanerophyte
Hph=Herbaceous phanerophyte; Mega-Mesoph=Megaphanerophyte + Mesophanerophyte;
Micro-Nanoph=Microphanerophyte + Nanophanerophyte

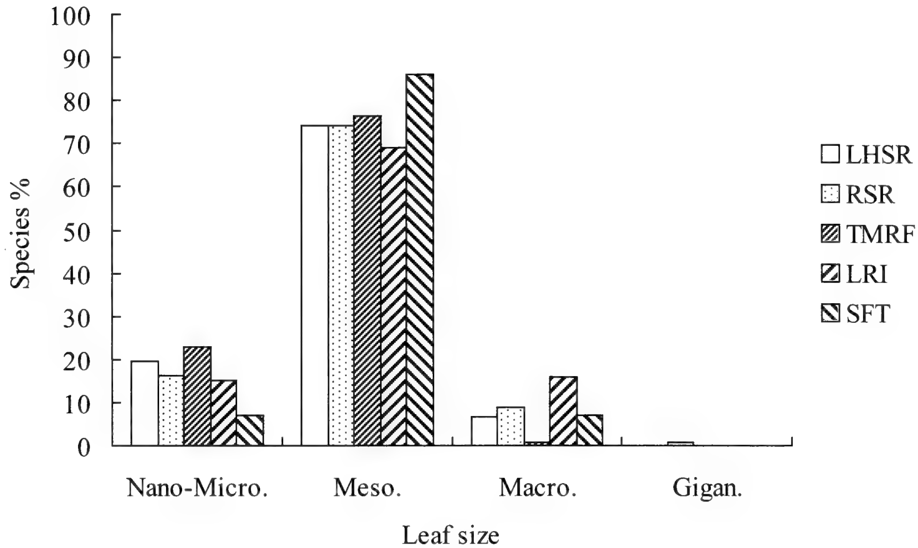
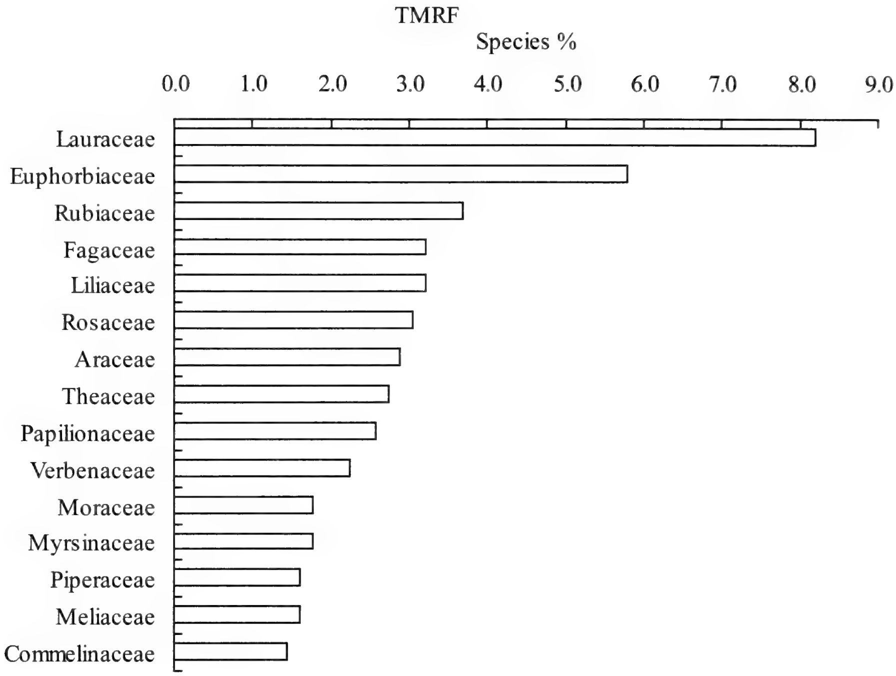
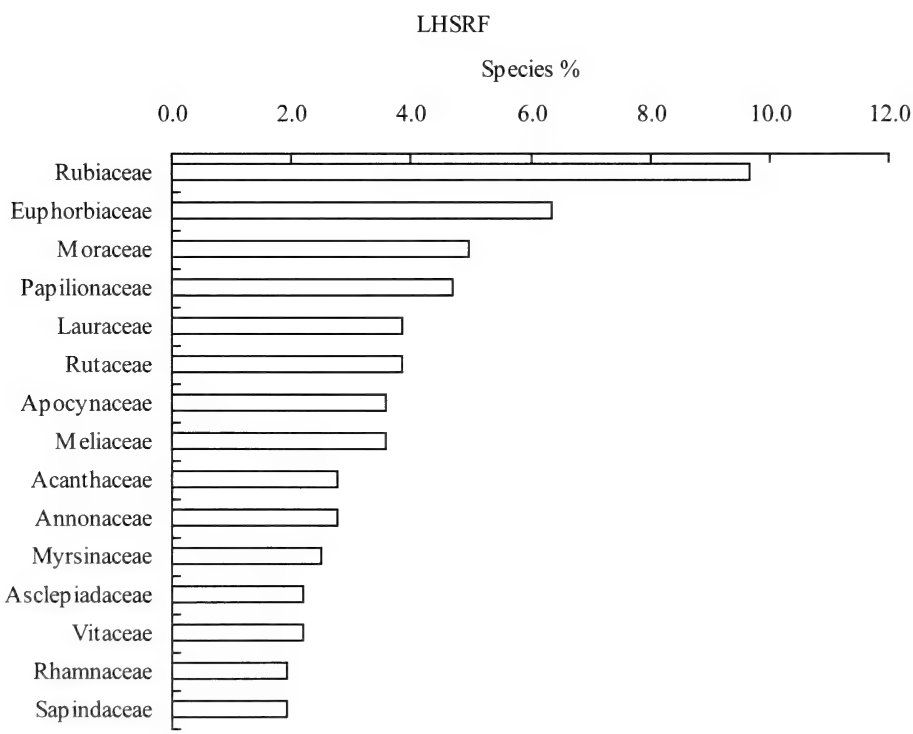


Figure 4. Comparison of leaf size spectra between the tropical montane rain forest in Mengsong and the seasonal rain forests in southern Yunnan, as well as the ones from the equatorial lowland.
LHSR: lower hill seasonal rain forest in southern Yunnan;
RSR: ravine seasonal rain forest in southern Yunnan;
TMRF: tropical montane rain forest in southern Yunnan;
LRI: lowland tropical evergreen rain forest in India[2]
SFT: evergreen tropical seasonal forest in Trinidad[1]
Nano-Micro.: Nanophyll + Microphyll; Meso.: Mesophyll; Macro.: Macrophyll; Gigan.: Gigantophyll
[1] from Beard (1946); [2] from Proctor et al. (1998)


TMRF
Species %
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
Lauraceae
Euphorbiaceae
Rubiaceae
Fagaceae
Liliaceae
Rosaceae
Araceae
Theaceae
Papilionaceae
Verbenaceae
Moraceae
Myrsinaceae
Piperaceae
Meliaceae
Commelinaceae


LHSRF
Species %
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Rubiaceae
Euphorbiaceae
Moraceae
Papilionaceae
Lauraceae
Rutaceae
Apocynaceae
Meliaceae
Acanthaceae
Annonaceae
Myrsinaceae
Asclepiadaceae
Vitaceae
Rhamnaceae
Sapindaceae

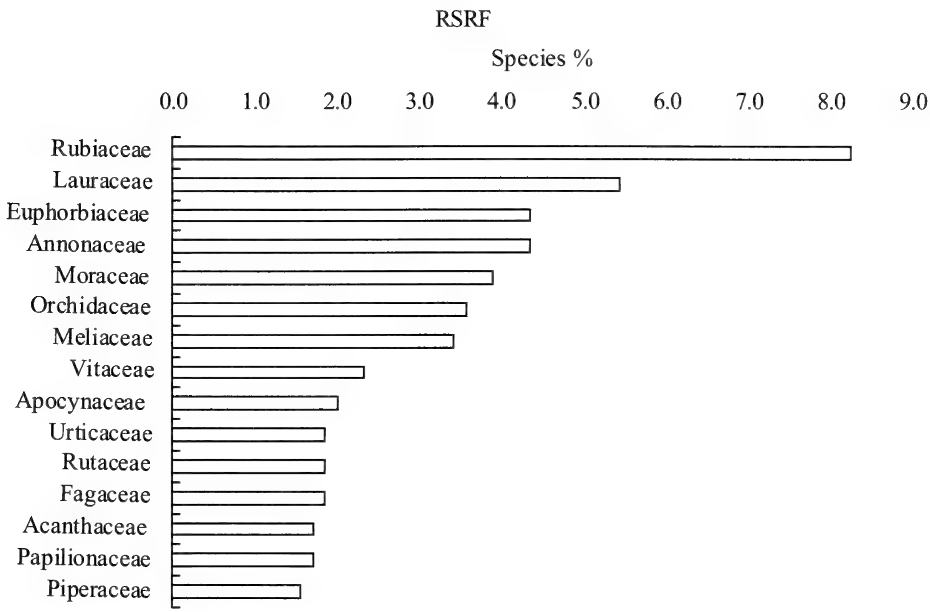
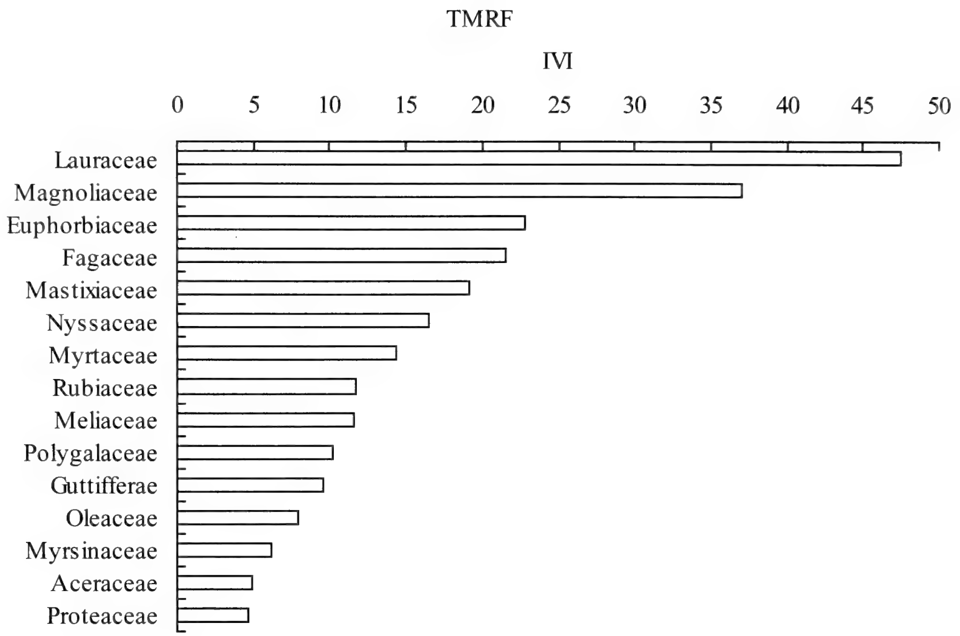
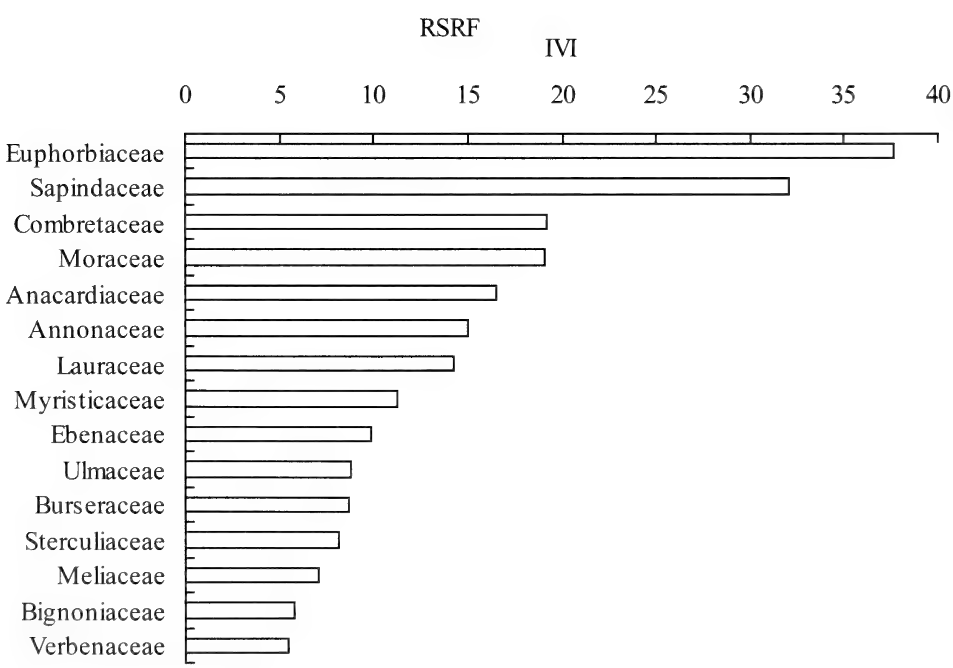


Figure 5. Comparison of abundant families with most species richness between the montane rain forest and seasonal rain forests at lower altitudes in the region.
TMRF: tropical montane rain forest in southern Yunnan;
LHSR: lower hill seasonal rain forest in southern Yunnan;
RSR: ravine seasonal rain forest in southern Yunnan.


TMRF
IVI
0
5
10
15
20
25
30
35
40
45
50
Lauraceae
Magnoliaceae
Euphorbiaceae
Fagaceae
Mastixiaceae
Nyssaceae
Myrtaceae
Rubiaceae
Meliaceae
Polygalaceae
Guttifferae
Oleaceae
Myrsinaceae
Aceraceae
Proteaceae


RSRF
IVI
0
5
10
15
20
25
30
35
40
Euphorbiaceae
Sapindaceae
Combretaceae
Moraceae
Anacardiaceae
Annonaceae
Lauraceae
Myristicaceae
Ebenaceae
Ulmaceae
Burseraceae
Sterculiaceae
Meliaceae
Bignoniaceae
Verbenaceae

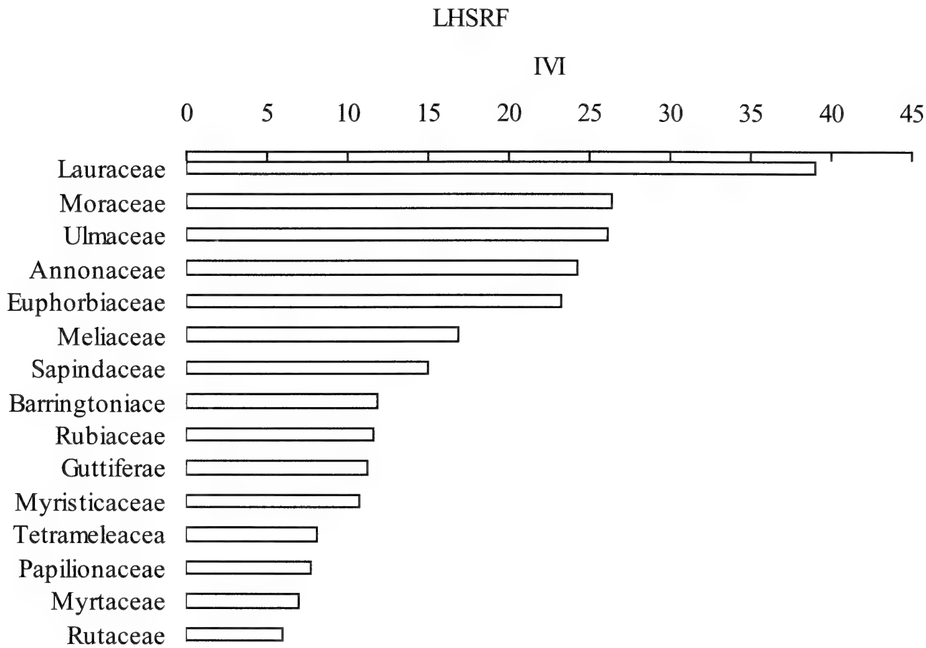


Figure 6. Comparison of families with the highest phytosociological importance between the montane rain forest and seasonal rain forests at lower altitudes in the region.
TMRF: tropical montane rain forest in southern Yunnan;
LHSR: lower hill seasonal rain forest in southern Yunnan;
RSR: ravine seasonal rain forest in southern Yunnan.

Discussion

Altitudinal zonation of tropical forest

Montane vegetation zones in tropical America have been classified by Beard (1944, 1955) into rain forest, lower montane rain forest, montane rain forest, montane thicket and elfin woodland, with increasing altitude. Similarly, Richards (1952) used the terms tropical rain forest, submontane rain forest and montane rain forest for the vegetation zonation in tropical mountains. In contrast, Grubb *et al.* (1963), Whitmore (1984, 1990) and Ashton (2003) prefer the terms of lowland rain forest, lower montane rain forest and upper montane rain forest. The tropical montane rain forest in southern Yunnan occurs at an altitude comparable with lower montane rain forest zone as defined by Grubb *et al.* (1963), Whitmore (1984, 1990) and Ashton (2003).

Equatorial lower montane rain forests are 15–33 m tall and have two tree strata, few emergent trees, few trees with buttresses and cauliflory, few big woody lianas, and fewer plants with pinnate leaves. Plants with mesophyll (Grubb *et al.*, 1963; Whitmore, 1984, 1990) or notophyll leaves (Ashton, 2003) are dominant among the woody plants, and there are abundant vascular epiphytes. Floristic zonation of forests in tropical mountains has been discussed by Ashton (2003), who stresses the laurel-oak attributes of the floras of lower montane rain forests in SE Asia.

The montane rain forest in southern Yunnan is similar to equatorial lower montane rain forests in SE Asia in physiognomy, but differs in having fewer epiphytes and more tree species with pinnate leaves (which contribute up to 11% of the sum of tree species).

The montane rain forest is dominated, in terms of species richness, by the families Lauraceae, Euphorbiaceae, Fagaceae, Rubiaceae, Papilionaceae and Theaceae. In terms of phytosociological importance the dominant families are Lauraceae, Magnoliaceae, Euphorbiaceae, Fagaceae, Mastixiaceae and Nyssaceae. The laurel-oak floristic attribute of the montane forest is overshadowed by some dominant families, such as Euphorbiaceae, Rubiaceae and Magnoliaceae, which are more commonly associated with lowland rain forests.

These differences may be due to the monsoonal climate (seasonal dryness) in southern Yunnan and the so-called "Massenerhebung", or 'mass elevation effect' (Whitmore, 1990). This may reflect the fact that these montane forests in Yunnan have characteristics more usually associated with lowland sites. The montane rain forests in Yunnan may represent a transition between lowland and lower montane forest in physiognomy and floristics, but appears closer to lower montane rain forest.

The physiognomic changes observed with increasing altitudes in southern Yunnan are similar to those in tropical America (Grubb *et al.*, 1963). Microphyllous leaves increased with increasing altitudes.

Tropical montane rain forests in Yunnan were generally classified into a subtype of tropical rain forest by Wu (1987) based on their floristic composition and physiognomy. They are most similar to the lower montane rain forest in equatorial Asia, which was included under the category of tropical rain forest by Whitmore (1990). We agree with Wu and Whitmore's classification that the montane rain forest in southern Yunnan is a type of lower montane rain forest within the broader category of tropical rain forest.

Biogeographical affinity

Floristically, the montane rain forest in southern Yunnan has strong tropical Asian affinities even though it occurs at the northern margin of mainland of Southeast Asia and at a high altitude. The tropical elements contribute about 78.9% at the generic level and more than 80 % at the specific level of its total flora. Elements with 'tropical Asian' affinities contribute 63.7% of the total sum of species.

Some species of particular biogeographical importance were encountered in these tropical montane rain forests in Yunnan. *Mastixia euonymoidos* is a dominant and the biggest tree in the montane rain forest. This species occurs only in the limited border area between Myanmar, Yunnan and Thailand, but it was widely distributed in European and America Tertiary flora, which has even been called the Mastixioidean European Flora (Mai, 1993; Eyde et al., 1990; Tiffney *et al.*, 1996). Its vicarious species, *Mastixia octandra*, occurs in mountains of central Sumatra in Indonesia (Matthew, 1976) at similar altitude (1700-1800 m alt.).

Gymnanthes remota (Euphorbiaceae), a relic and dominant species in the lower tree layer of the montane rain forest, occurs disjunctively in Mengsong in southern Yunnan and in Sumatra (Zhu *et al.*, 2000). The frequent shrub species, *Lasianthus inodorus* (Rubiaceae), which is distributed in mainland SE Asia and Sumatra, as well as Java, also occurs vicariously on Mt Kinabalu in Borneo (Zhu, 2001). It is interesting that many taxa in the montane rain forest in southern Yunnan have their vicarious species in Malesian montane forests, suggesting a special biogeographical significance for the region. Further floristic and biogeographical studies on the pristine montane rain forest in southern Yunnan are needed.

Acknowledgments

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Appendix 3. Species checklist of the montane rain forest in Mengsong, southern Yunnan.

ACANTHACEAE	*Lepidagathis incurva* Buch.-Ham. ex D. Don
ACANTHACEAE	*Mananthes patentiflora* ((Hemsl.) Bremek.
ACANTHACEAE	*Phaulopsis imbricata* (Forssk.) Sweet
ACANTHACEAE	*Phlogacanthus curviflorus* (Wall.) Nees
ACANTHACEAE	*Pseuderanthemum malaccense* (C.B. Clarke) Lindau
ACANTHACEAE	*Pteracanthus alatus* (Wall.) Bremek.
ACANTHACEAE	*Rhaphidosperma vagabunda* (R.Ben)C.Y.Wu ex Y.C.Tang
ACANTHACEAE	*Rungia pectinata* (L.)Nees
ACERACEAE	*Acer decandrum* Merr.
ACERACEAE	*Acer huianum* W.P. Fang & C.K. Hsieh
ACERACEAE	*Acer jingdongense* T.Z. Hsu
ALANGIACEAE	*Alangium barbatum* (R. Br.) Baill.
ALANGIACEAE	*Alangium chinense* (Lour.) Harms
ALANGIACEAE	*Alangium kurzii* Craib
ALISMATACEAE	*Sagittaria trifolia* L.
AMARANTHACEAE	*Achyranthes bidentata* Blume
AMARANTHACEAE	*Aerva sanguinolenta* (L.) Blume
AMARYLLIDACEAE	*Allium hookeri* Thwaites
ANACARDIACEAE	*Choerospondias axillaris* (Roxb.) B.L. Burtt & A.W. Hill
ANACARDIACEAE	*Pegia nitida* Colobr.
ANACARDIACEAE	*Rhus chinensis* Mill.
ANACARDIACEAE	*Semecarpus reticulata* Lecomte
ANACARDIACEAE	*Spondias lakonensis* var. *hirsuta* C.Y. Wu & T.L. Ming
ANACARDIACEAE	*Toxicodendron acuminatum* (DC.) C. Y. Wu. T. L. Ming

ANACARDIACEAE	*Toxicodendron succedaneum* (L.) Kuntze
ANNONACEAE	*Alphonsea boniana* Finet & Gagnep.
ANNONACEAE	*Alphonsea monogyna* Merr. & Chun
ANNONACEAE	*Alphonsea squamosa* Finet & Gagnep.
ANNONACEAE	*Alphonsea tsangyuanensis* P.T. Li
ANNONACEAE	*Fissistigma acuminatissimum* Merr.
ANNONACEAE	*Fissistigma maclurei* Merr.
ANNONACEAE	*Fissistigma polyanthum* (Hook. f. & Thomson) Merr.
ANNONACEAE	*Mitrephora maingayi* Hook. f. & Thomson
APOCYNACEAE	*Alstonia rostrata* C.E.C. Fisch.
APOCYNACEAE	*Bousigonia angustifolia* Pierre
APOCYNACEAE	*Epigynum auritum* (C.K. Schneid.) Tsiang & P.T. Li
APOCYNACEAE	*Tabernaemontana corymbosa* Roxb. ex Wall.
APOSTASIACEAE	*Apostasia odorata* Blume
AQUIFOLIACEAE	*Ilex polyneura* (Hand.-Mazz.) S.Y. Hu
AQUIFOLIACEAE	*Ilex tetramera* var. *glabra* (C.Y. Wu) T.R. Dudley
ARACEAE	*Alocasia macrorrhizos* (L.) Schott
ARACEAE	*Amorphophallus bannanensis* H. Li
ARACEAE	*Amorphophallus rivieri* Durieu ex Carrière
ARACEAE	*Amorphophallus ximengensis* H. Li
ARACEAE	*Arisaema austroyunnanense* H. Li
ARACEAE	*Arisaema inkiangense* H. Li
ARACEAE	*Colocasia esculenta* (L.) Schott
ARACEAE	*Colocasia gigantea* (Blume) Hook. f.
ARACEAE	*Gonatanthus pumilus* (D. Don) Engl. & K. Krause
ARACEAE	*Pothos chinensis* (Raf.) Merr.
ARACEAE	*Pothos scandens* L.

ARACEAE	*Remusatia hookeriana* Schott
ARACEAE	*Remusatia vivipara* (Lodd.) Schott
ARACEAE	*Rhaphidophora crassicaulis* Engl. & K. Krause
ARACEAE	*Rhaphidophora decursiva* (Roxb.) Schott
ARACEAE	*Rhaphidophora hookeri* Schott
ARACEAE	*Rhaphidophora lancifolia* Schott
ARACEAE	*Rhaphidophora megaphylla* H. Li
ARALIACEAE	*Aralia armata* (Wall.) Seem.
ARALIACEAE	*Brassaiopsis producta* (Dunn) C.B. Shang
ARALIACEAE	*Macropanax dispermus* (Blume) Kuntze
ARALIACEAE	*Macropanax undulatus* var. *simplex* H.L. Li
ARALIACEAE	*Schefflera chapana* Harms
ARALIACEAE	*Schefflera octophylla* (Lour.) Harms
ARALIACEAE	*Tupidanthus calyptratus* Hook. & Thomson
ARISTOLOCHIACEAE	*Aristolochia cathcartii* Hook. f.
ARISTOLOCHIACEAE	*Aristolochia fangchi* Y.C. Wu ex L.D. Chow & S.M. Hwang
ARISTOLOCHIACEAE	*Aristolochia tagala* Cham.
ASCLEPIADACEAE	*Hoya villosa* Costantin
BALANOPHORACEAE	*Balanophora harlandii* Hook. f.
BALSAMINACEAE	*Impatiens balansae* Hook. f.
BALSAMINACEAE	*Impatiens mengtzeana* Hook. f.
BEGONIACEAE	*Begonia augustinei* Hemsl.
BEGONIACEAE	*Begonia crassirostris* Irmsch.
BEGONIACEAE	*Begonia versicolor* Irmsch.
BETULACEAE	*Alnus nepalensis* D. Don
BETULACEAE	*Betula alnoides* Buch.-Ham. ex D. Don
BETULACEAE	*Betula luminifera* H.J.P. Winkl.

BIGNONIACEAE	*Mayodendron igneum* (Kurz) Kurz
BURSERACEAE	*Canarium pimela* Leenh.
BURSERACEAE	*Canarium strictum* Roxb.
BURSERACEAE	*Canarium tonkinense* (Leenh.) Engl.
CAESALPINIACEAE	*Bauhinia variegata* L.
CAESALPINIACEAE	*Caesalpinia cucullata* Roxb.
CAESALPINIACEAE	*Cassia agnes* (De Wit) Brenen
CAESALPINIACEAE	*Gleditsia fera* (Lour.) Merr.
CAPPARIDACEAE	*Capparis fohaiensis* B.S. Sun
CAPRIFOLIACEAE	*Viburnum cylindricum* Buch.-Ham. ex D. Don
CAPRIFOLIACEAE	*Viburnum punctatum* Buch.-Ham. ex D. Don
CARLEMANNIACEAE	*Silvianthus bracteatus* Hook. f.
CELASTRACEAE	*Celastrus angulata* Maxim.
CELASTRACEAE	*Celastrus paniculata* subsp. *multiflorus* (Roxb.) Hou
CELASTRACEAE	*Celastrus paniculatus* Willd.
CELASTRACEAE	*Glyptopetalum sclerocarpum* (Kurz) Lawson
CELASTRACEAE	*Microtropis discolor* (Wallich) Arn.
CELASTRACEAE	*Microtropis tetragona* Merr. & F.L. Freeman
CHLORANTHACEAE	*Sarcandra glabra* subsp. *brachystachys* (Blume) Verdc.
COMMELINACEAE	*Amischotolype hispida* (Less. & A. Rich.) D.Y. Hong
COMMELINACEAE	*Amischotolype hookeri* (Hassk.) H. Hara
COMMELINACEAE	*Commelina paludosa* Blume
COMMELINACEAE	*Cyanotis cristata* (L.) D. Don
COMMELINACEAE	*Cyanotis vaga* (Lour.) Roem. & Schult.
COMMELINACEAE	*Dictyospermum conspicuum* (Blume) Hassk.
COMMELINACEAE	*Floscopa scandens* Lour.
COMMELINACEAE	*Porandra scandens* D.Y. Hong

COMMELINACEAE	*Rhopalephora scaberrima* (Blume) Faden
COMPOSITAE	*Artemisia argyi* H. Lév. & Vaniot
COMPOSITAE	*Dichrocephala benthamii* C.B. Clarke
COMPOSITAE	*Emilia prenanthoidea* DC.
COMPOSITAE	*Senecio scandens* Buch.-Ham. ex D. Don
COMPOSITAE	*Vernonia cinerea* (L.) Less.
CONNARACEAE	*Connarus paniculatus* Roxb.
CORNACEAE	*Mastixia euonymoides* Prain
CORNACEAE	*Mastixia pentandra* subsp. *chinensis* (Merr.) K.M. Matthew
CORYLACEAE	*Carpinus londoniana* H.J.P. Winkl.
CUCURBITACEAE	*Gynostemma laxum* (Wall.) Cogn.
CUCURBITACEAE	*Gynostemma pentaphyllum* (Thunb.) Makino
CUCURBITACEAE	*Gynostemma pubescens* (Gagnep.) C.Y. Wu
CYPERACEAE	*Carex baccans* Nees
CYPERACEAE	*Mariscus sumatrensis* var. *subcompositus* (C.B. Clarke) S. Karthikeyan
DIOSCOREACEAE	*Dioscorea bulbifera* L.
DIOSCOREACEAE	*Dioscorea chingii* Prain & Burkill
DIOSCOREACEAE	*Dioscorea esquirolii* Prain & Burkill
DIOSCOREACEAE	*Dioscorea glabra* Roxb.
EBENACEAE	*Diospyros kaki* var. *silvestris* Makino
EBENACEAE	*Diospyros kerrii* Craib
EBENACEAE	*Diospyros nigrocortex* C.Y. Wu
EBENACEAE	*Diospyros yunnanensis* Rehder & E.H. Wilson
ELAEAGNACEAE	*Elaeagnus conferta* var. *menghaiensis* W.K. Hu & H.F. Chow
ELAEAGNACEAE	*Elaeagnus gonyanthes* Benth.
ELAEAGNACEAE	*Elaeagnus macrantha* Rehder
ELAEOCARPACEAE	*Elaeocarpus apiculatus* Masters in Hook. f.

ELAEOCARPACEAE	*Elaeocarpus austroyunnanensis* Hu
ELAEOCARPACEAE	*Elaeocarpus decipiens* Hemsl.
ELAEOCARPACEAE	*Elaeocarpus glabripetalus* Merr.
ELAEOCARPACEAE	*Elaeocarpus glabripetalus* var. *alatus* (Kunth) Hung T. Chang
ELAEOCARPACEAE	*Elaeocarpus howii* Merr. & Chun
ELAEOCARPACEAE	*Elaeocarpus petiolatus* (Jack) Wall. ex Kurz
ELAEOCARPACEAE	*Sloanea mollis* Gagnep.
ELAEOCARPACEAE	*Sloanea tomentosa* (Benth.) Rehder & E.H. Wilson
ERICACEAE	*Craibiodendron stellatum* (Pierre) W.W. Sm.
ERICACEAE	*Rhododendron moulmainense* Hook.
ESCALLONIACEAE	*Itea macrophylla* Wall.
EUPHORBIACEAE	*Antidesma fordii* Hemsl.
EUPHORBIACEAE	*Antidesma montanum* Blume
EUPHORBIACEAE	*Aporusa dioica* (Roxb.) Müll. Arg.
EUPHORBIACEAE	*Aporusa villosa* (Lindl.) Baill.
EUPHORBIACEAE	*Aporusa yunnanensis* (Pax & K. Hoffm.) F.P. Metcalf
EUPHORBIACEAE	*Baccaurea ramiflora* Lour.
EUPHORBIACEAE	*Baliospermum effusum* Pax & Hoffm. in Engl.
EUPHORBIACEAE	*Baliospermum montanum* (Willd.) Müll. Arg.
EUPHORBIACEAE	*Bischofia javanica* Blume
EUPHORBIACEAE	*Breynia fruticosa* (L.) Hook. f.
EUPHORBIACEAE	*Bridelia tomentosa* Blume
EUPHORBIACEAE	*Croton caudatus* Geiseler
EUPHORBIACEAE	*Croton damayeshu* Y.T. Chang
EUPHORBIACEAE	*Drypetes cumingii* (Baill.) Pax & K. Hoffm.
EUPHORBIACEAE	*Drypetes salicifolia* Gagnep.
EUPHORBIACEAE	*Glochidion assamicum* (Müll. Arg.) Hook. f.

EUPHORBIACEAE	*Glochidion hirsutum* (Roxb.) Voigt
EUPHORBIACEAE	*Glochidion khasicum* (Müll. Arg.) Hook. f.
EUPHORBIACEAE	*Glochidion lanceolarium* (Roxb.) Voigt
EUPHORBIACEAE	*Glochidion puberum* (L.) Hutch.
EUPHORBIACEAE	*Gymnanthes remota* (Steenis) Esser
EUPHORBIACEAE	*Macaranga denticulata* (Blume) Müll. Arg.
EUPHORBIACEAE	*Macaranga henryi* (Pax & K. Hoffm.) Rehder
EUPHORBIACEAE	*Macaranga indica* Wight
EUPHORBIACEAE	*Macaranga kurzii* (Kuntze) Pax & Hoffm. in Engl.
EUPHORBIACEAE	*Mallotus barbatus* (Wall.) Müll. Arg.
EUPHORBIACEAE	*Mallotus macrostachyus* (Miq.) Müll. Arg.
EUPHORBIACEAE	*Mallotus paniculatus* (Lam.) Müll. Arg.
EUPHORBIACEAE	*Mallotus philippinensis* (Lam.) Müll. Arg.
EUPHORBIACEAE	*Mallotus tetracoccus* (Roxb.) Kurz
EUPHORBIACEAE	*Ostodes katharinae* Pax
EUPHORBIACEAE	*Ostodes kuangii* Y.T. Chang
EUPHORBIACEAE	*Ostodes paniculata* Blume
EUPHORBIACEAE	*Phyllanthus emblica* L.
EUPHORBIACEAE	*Sapium baccatum* Roxb.
EUPHORBIACEAE	*Sapium discolor* (Champ. ex Benth.) Müll. Arg.
FAGACEAE	*Castanopsis argyrophylla* King ex Hook. f.
FAGACEAE	*Castanopsis calathiformis* (Skan) Rehder & E.H. Wilson
FAGACEAE	*Castanopsis carlesii* var. *spinulosa* W.C. Cheng & C.S. Chao
FAGACEAE	*Castanopsis ceratacantha* Rehder & E.H. Wilson
FAGACEAE	*Castanopsis echidnocarpa* Hook. f. & Thomson ex Miq.
FAGACEAE	*Castanopsis hystrix* Miq.
FAGACEAE	*Castanopsis indica* (Roxburgh ex Lindl.) A. DC.

FAGACEAE	*Castanopsis mekongensis* A. Camus
FAGACEAE	*Castanopsis tcheponensis* Hickel & A. Camus
FAGACEAE	*Cyclobalanopsis kerrii* (Craib) Hu
FAGACEAE	*Cyclobalanopsis myrsinifolia* (Blume) Oerst.
FAGACEAE	*Lithocarpus fohaiensis* (Hu) A. Camus
FAGACEAE	*Lithocarpus fordianus* (Hemsl.) Chun
FAGACEAE	*Lithocarpus grandifolius* (D. Don) S.N. Biswas
FAGACEAE	*Lithocarpus hancei* (Benth.) Rehder
FAGACEAE	*Lithocarpus hypoglaucus* (Hu) C.C. Huang
FAGACEAE	*Lithocarpus microspermus* A.Camus
FAGACEAE	*Lithocarpus pseudoreinwardtii* A. Camus
FAGACEAE	*Lithocarpus rhabdostachyus* subsp. *dakhaensis* A. Camus
FAGACEAE	*Lithocarpus truncatus* (King ex Hook. f.) Rehder & E.H. Wilson
FLACOURTIACEAE	*Xylosma congesta* (Lour.) Merr.
FLACOURTIACEAE	*Xylosma longifolia* Clos
FUMARIACEAE	*Corydalis balansae* Prain
GENTIANACEAE	*Tripterospermum membranaceum* (C. Marquand) Harry Sm.
GESNERIACEAE	*Rhynchotechum ellipticum* (Wall. ex D. Dietr.) A. DC.
GNETACEAE	*Gnetum montanum* fo. *megalocarpum* Markgr.
GNETACEAE	*Gnetum montanum* Markgr.
GNETACEAE	*Gnetum pendulum* C.Y. Cheng
GUTTIFERAE	*Calophyllum polyanthum* Wall. ex Choisy
GUTTIFERAE	*Garcinia cowa* Roxb.
HAMAMELIDACEAE	*Altingia excelsa* Noronha
HAMAMELIDACEAE	*Distyliopsis yunnanensis* (Hung T. Chang) C.Y. Wu
HYDRANGIACEAE	*Dichroa febrifuga* Lour.
HYPERICACEAE	*Cratoxylum cochinchinense* (Lour.) Blume

HYPPOCRATEACEAE	*Pristimera arborea* (Roxb.) A.C. Sm.
ICACINACEAE	*Apodytes dimidiata* E. Mey. ex Arn.
ICACINACEAE	*Gomphandra tetrandra* (Wall.) Sleumer
ICACINACEAE	*Iodes ovalis* Blume
ICACINACEAE	*Mappianthus iodoides* Hand.-Mazz.
ICACINACEAE	*Natsiatopsis thunbergiaefolia* Kurz
ICACINACEAE	*Nothapodytes collina* C.Y. Wu
ICACINACEAE	*Platea latifolia* Blume
JUGLANDACEAE	*Engelhardia roxburghiana* Wall.
JUGLANDACEAE	*Engelhardia serrata* Blume
JUGLANDACEAE	*Engelhardia spicata* Lesch. ex Blume
JUGLANDACEAE	*Juglans sigillata* Dode
LABIATAE	*Gomphostemma arbusculum* C.Y. Wu
LABIATAE	*Gomphostemma crinitum* Wall. ex Benth.
LABIATAE	*Gomphostemma stellatohirsutum* C.Y. Wu
LABIATAE	*Leucosceptrum canum* Sm.
LABIATAE	*Paraphlomis javanica* (Blume) Prain
LABIATAE	*Pogostemon glaber* Benth.
LARDIZABALACEAE	*Stauntonia brunoniana* Wall. ex Hemsl.
LAURACEAE	*Actinodaphne henryi* Gamble
LAURACEAE	*Actinodaphne obovata* (Nees) Blume
LAURACEAE	*Alseodaphne andersonii* (King ex Hook. f.) Kosterm.
LAURACEAE	*Alseodaphne petiolaris* (Meisn.) Hook. f.
LAURACEAE	*Beilschmiedia linocieroides* H.W. Li
LAURACEAE	*Beilschmiedia percoriacea* C.K. Allen
LAURACEAE	*Beilschmiedia purpurascens* H.W. Li
LAURACEAE	*Beilschmiedia robusta* C.K. Allen

LAURACEAE	*Beilschmiedia roxburghiana* Nees
LAURACEAE	*Beilschmiedia yunnanensis* Hu
LAURACEAE	*Cassytha filiformis* L.
LAURACEAE	*Cinnamomum austroyunnanense* H.W. Li
LAURACEAE	*Cinnamomum bejolghota* (Buch.-Ham.) Sweet
LAURACEAE	*Cinnamomum glanduliferum* (Wall.) Nees
LAURACEAE	*Cinnamomum iners* Reinw. ex Blume
LAURACEAE	*Cinnamomum mollifolium* H.W. Li
LAURACEAE	*Cinnamomum tamala* (Buch.-Ham.) T. Nees & Eberm.
LAURACEAE	*Cinnamomum tenuipilis* Kosterm.
LAURACEAE	*Cryptocarya brachythyrsa* H.W. Li
LAURACEAE	*Cryptocarya calcicola* H.W. Li
LAURACEAE	*Cryptocarya densiflora* Blume
LAURACEAE	*Cryptocarya rolletii* H. Wang & H. Zhu
LAURACEAE	*Iteadaphne caudata* (Nees) H.W. Li
LAURACEAE	*Lindera latifolia* Hook. f.
LAURACEAE	*Lindera menghaiensis* H.W. Li
LAURACEAE	*Lindera metcalfiana* var. *dictyophylla* (C.K. Allen) H.B. Cui
LAURACEAE	*Litsea atrata* S.K. Lee
LAURACEAE	*Litsea balansae* Lecomte
LAURACEAE	*Litsea baviensis* Lecomte
LAURACEAE	*Litsea chinpingensis* Yen C. Yang & P.H. Huang
LAURACEAE	*Litsea cubeba* (Lour.) Pers.
LAURACEAE	*Litsea elongata* (Nees) Benth. & Hook. f.
LAURACEAE	*Litsea euosma* W.W. Sm.
LAURACEAE	*Litsea garrettii* Gamble
LAURACEAE	*Litsea glutinosa* (Lour.) C.B. Rob.

LAURACEAE	*Litsea lancifolia* (Roxb. ex Nees in Wall.) Benth. & Hook. f. ex Villar
LAURACEAE	*Litsea lancifolia* var. *ellipsoidea* Yen C. Yang & P.H. Huang
LAURACEAE	*Litsea lancifolia* var. *pedicellata* Hook. f.
LAURACEAE	*Litsea liyuyingi* H. Liu
LAURACEAE	*Litsea longistaminata* (H. Liu) Kosterm.
LAURACEAE	*Litsea magnoliifolia* Yen C. Yang & P.H. Huang
LAURACEAE	*Litsea vang* Lecomte var. *lobata* Lecomte
LAURACEAE	*Litsea verticillata* Hance
LAURACEAE	*Machilus salicina* Hance
LAURACEAE	*Persea robusta* (W.W. Sm.) Kosterm.
LAURACEAE	*Persea rufipes* (H.W. Li) Kosterm.
LAURACEAE	*Persea shweliensis* (W.W. Sm.) Kosterm.
LAURACEAE	*Phoebe lanceolata* (Nees) Nees
LAURACEAE	*Phoebe macrocarpa* C.Y. Wu
LAURACEAE	*Phoebe puwenensis* Cheng
LAURACEAE	*Phoebe rufescens* H.W. Li
LILIACEAE	*Asparagus subscandens* F.T. Wang & S.C. Chen
LILIACEAE	*Aspidistra typica* Baill.
LILIACEAE	*Campylandra chinensis* (Baker) M.N. Tamura, S.Yun Liang & Turland
LILIACEAE	*Chlorophytum malayense* Ridl.
LILIACEAE	*Dianella ensifolia* (L.) DC.
LILIACEAE	*Disporopsis longifolia* Craib
LILIACEAE	*Disporum calcaratum* D. Don
LILIACEAE	*Disporum cantoniense* (Lour.) Merr.
LILIACEAE	*Liriope graminifolia* (L.) Baker
LILIACEAE	*Ophiopogon tsaii* F.T. Wang & Ts. Tang
LILIACEAE	*Peliosanthes sinica* F.T. Wang & Ts. Tang

LILIACEAE	*Reineckea carnea* (Andrews) Kunth
LILIACEAE	*Smilax hemsleyana* Craib
LILIACEAE	*Smilax hypoglauca* Benth.
LILIACEAE	*Smilax megacarpa* A. DC.
LILIACEAE	*Smilax myrtillus* A. DC.
LILIACEAE	*Smilax ocreata* A. DC.
LILIACEAE	*Smilax perfoliata* Lour.
LILIACEAE	*Smilax quadrata* A. DC.
LILIACEAE	*Tupistra grandistigma* F.T. Wang & S.Yun Liang
LOGANIACEAE	*Buddleja officinalis* Maxim.
LYTHRACEAE	*Rotala rotundifolia* (Buch.-Ham. ex Roxb.) Koehne
MAGNOLIACEAE	*Alcimandra cathcartii* (Hook. f. & Thomson) Dandy
MAGNOLIACEAE	*Manglietia forrestii* W.W. Sm.ex Dandy
MAGNOLIACEAE	*Manglietia garrettii* Craib
MAGNOLIACEAE	*Manglietia insignis* (Wall.) Blume
MAGNOLIACEAE	*Michelia cavaleriei* Finet & Gagnep.
MAGNOLIACEAE	*Michelia floribunda* Finet & Gagnep.
MAGNOLIACEAE	*Michelia hedyosperma* Y.W. Law
MAGNOLIACEAE	*Parakmeria yunnanensis* Hu
MAGNOLIACEAE	*Paramichelia baillonii* (Pierre) Hu
MALVACEAE	*Hibiscus indicus* (Burm. f.) Hochr.
MALVACEAE	*Kydia calycina* Roxb.
MALVACEAE	*Kydia glabrescens* var. *intermedia* S.Y. Hu
MALVACEAE	*Sida szechuensis* Matsuda
MALVACEAE	*Urena lobata* L.
MARANTACEAE	*Phrynium placentarium* (Lour.) Merr.
MARANTACEAE	*Stachyphrynium sinense* H. Li

MELASTOMACEAE	*Medinilla septentrionalis* (W.W. Sm.) H.L. Li
MELASTOMACEAE	*Melastoma affine* D. Don
MELASTOMACEAE	*Melastoma normale* D. Don
MELASTOMACEAE	*Oxyspora vagans* (Roxb.) Wall.
MELIACEAE	*Aglaia abbreviata* C.Y. Wu
MELIACEAE	*Aglaia perviridis* Hiern
MELIACEAE	*Amoora yunnanensis* (H.L. Li) C.Y. Wu
MELIACEAE	*Dysoxylum binectariferum* (Roxb.) Hook. f. ex Bedd.
MELIACEAE	*Dysoxylum lukii* Merr.
MELIACEAE	*Melia toosendan* Siebold & Zucc.
MELIACEAE	*Toona ciliata* M. Roem.
MELIACEAE	*Toona sinensis* (Juss.) Roem.
MELIACEAE	*Trichilia connaroides* (Wight & Arn.) Bentv.
MELIACEAE	*Walsura yunnanensis* C.Y. Wu
MENISPERMACEAE	*Cocculus laurifolius* DC.
MENISPERMACEAE	*Stephania forsteri* (DC.) A. Gray
MIMOSACEAE	*Albizia bracteata* Dunn
MIMOSACEAE	*Albizia chinensis* (Osbeck) Merr.
MIMOSACEAE	*Albizia crassiramea* Lace
MIMOSACEAE	*Albizia lucidior* (Steud.) I.C. Nielsen
MIMOSACEAE	*Albizia odoratissima* (L. f.) Benth.
MIMOSACEAE	*Cylindrokelupha kerrii* (Gagnep.) T.L. Wu
MIMOSACEAE	*Pithecolobium clypearia* Benth.
MORACEAE	*Artocarpus lakoocha* Wall. ex Roxb.
MORACEAE	*Artocarpus nitidus* subsp. *griffithii* (King) F.M. Jarrett
MORACEAE	*Artocarpus tonkinensis* A. Chev.
MORACEAE	*Broussonetia papyrifera* (L.) L'Hér. ex Vent.

MORACEAE	*Ficus auriculata* Lour.
MORACEAE	*Ficus cyrtophylla* Wall. ex Miq.
MORACEAE	*Ficus esquiroliana* H. Lév.
MORACEAE	*Ficus fistulosa* Reinw. ex Blume
MORACEAE	*Ficus hookeriana* Corner
MORACEAE	*Ficus semicordata* Buch.-Ham. ex Sm.
MORACEAE	*Morus macroura* Miq.
MUSACEAE	*Musa acuminata* Colla
MYRICACEAE	*Myrica esculenta* Buch.-Ham. ex D. Don
MYRISTICACEAE	*Horsfieldia glabra* (Reinw. ex Blume) Warb.
MYRISTICACEAE	*Horsfieldia tetratepala* C.Y. Wu
MYRISTICACEAE	*Knema cinerea* var. *glauca* (Blume) Y.H. Li
MYRISTICACEAE	*Knema erratica* (Hook. f. & Thomson) J. Sincl.
MYRISTICACEAE	*Knema furfuracea* (Hook. f. & Thomson) Warb.
MYRISTICACEAE	*Knema globularia* (Lam.) Warb.
MYRSINACEAE	*Ardisia corymbifera* Mez
MYRSINACEAE	*Ardisia depressa* C.B.Clarke
MYRSINACEAE	*Ardisia thyrsiflora* D. Don
MYRSINACEAE	*Ardisia villosa* Roxb.
MYRSINACEAE	*Ardisia virens* Kurz
MYRSINACEAE	*Embelia laeta* (L.) Mez
MYRSINACEAE	*Maesa indica* (Roxb.) A. DC.
MYRSINACEAE	*Maesa macilentoides* C. Chen
MYRSINACEAE	*Maesa perlaria* (Lour.) Merr.
MYRSINACEAE	*Maesa permollis* Kurz
MYRSINACEAE	*Myrsine seguinii* H. Lév.
MYRTACEAE	*Decaspermum fruticosum* J.R. Forst. & G. Forst.

MYRTACEAE	*Syzygium brachythyrsum* Merr. & L.M. Perry
MYRTACEAE	*Syzygium cathayense* Merr. & L.M. Perry
MYRTACEAE	*Syzygium polypetaloideum* Merr. & L.M. Perry
MYRTACEAE	*Syzygium rockii* Merr. & L.M. Perry
MYRTACEAE	*Syzygium tetragonum* (Wight) Wall. ex Walp.
MYRTACEAE	*Syzygium thumra* (Roxb.) Merr. & L.M. Perry
MYRTACEAE	*Syzygium yunnanense* Merr. & L.M. Perry
NYSSACEAE	*Nyssa wenshanensis* Fang & Soong
NYSSACEAE	*Nyssa wenshanensis* var. *longipedunculata* W.P. Fang & Soong
NYSSACEAE	*Nyssa yunnanensis* W. C. Yin
OLACACEAE	*Schoepfia fragrans* Wall.
OLEACEAE	*Chionanthus ramiflorus* Roxb.
OLEACEAE	*Fraxinus floribunda* Wall.
OLEACEAE	*Jasminum attenuatum* Roxb. ex G. Don
OLEACEAE	*Jasminum lanceolarium* Roxb.
OLEACEAE	*Ligustrum sinense* Lour.
OLEACEAE	*Linociera insignis* C.B. Clarke
OLEACEAE	*Olea rosea* Craib
OXALIDACEAE	*Oxalis corniculata* L.
PAPILIONACEAE	*Craspedolobium schochii* Harms
PAPILIONACEAE	*Dalbergia assamica* Benth.
PAPILIONACEAE	*Dalbergia pinnata* (Lour.) Prain
PAPILIONACEAE	*Dalbergia stipulacea* Roxb.
PAPILIONACEAE	*Erythrina subumbrans* (Hassk.) Merr.
PAPILIONACEAE	*Fordia cauliflora* Hemsl.
PAPILIONACEAE	*Fordia microphylla* Dunn ex Z. Wei
PAPILIONACEAE	*Millettia leptobotrya* Dunn

PAPILIONACEAE	*Millettia pachycarpa* Benth.
PAPILIONACEAE	*Millettia tetraptera* Kurz
PAPILIONACEAE	*Millettia unijuga* Gagnep.
PAPILIONACEAE	*Mucuna pruriens* (L.) DC.
PAPILIONACEAE	*Ormosia fordiana* Oliv.
PAPILIONACEAE	*Ormosia olivacea* L. Chen
PAPILIONACEAE	*Pycnospora lutescens* (Poir.) Schindl.
PAPILIONACEAE	*Spatholobus pulcher* Dunn
PASSIFLORACEAE	*Passiflora siamica* Craib
PASSIFLORACEAE	*Passiflora wilsonii* Hemsl.
PINACEAE	*Pinus kesiya* Royle ex Gordon
PIPERACEAE	*Peperomia blanda* (Jacq.) Kunth
PIPERACEAE	*Peperomia heyneana Miq.*
PIPERACEAE	*Peperomia pellucida* (L.) Kunth
PIPERACEAE	*Peperomia tetraphylla* (G. Forst.) Hook. & Arn.
PIPERACEAE	*Piper chaudocanum* C. DC.
PIPERACEAE	*Piper flaviflorum* C. DC.
PIPERACEAE	*Piper longum* L.
PIPERACEAE	*Piper macropodum* C. DC.
PIPERACEAE	*Piper thomsonii* (C. DC.) Hook. f.
PIPERACEAE	*Piper yunnanense* Y.Q. Tseng
PITTOSPORACEAE	*Pittosporum kerrii* Craib
PLANTAGINACEAE	*Plantago erosa* Wall. ex Roxb.
PLANTAGINACEAE	*Plantago major* L.
POACEAE	*Fargesia plurisetosa* T.H. Wen
POACEAE	*Imperata cylindrica* (L.) P. Beauv.
POACEAE	*Microstegium ciliatum* (Trin.) A. Camus

POACEAE	*Setaria palmifolia* (J. König) Stapf
POACEAE	*Thysanolaena maxima* (Roxb.) Kuntze
PODOCARPACEAE	*Podocarpus neriifolius* D. Don
POLYGALACEAE	*Polygala arillata* Buch.-Ham. ex D. Don
POLYGALACEAE	*Polygala glomerata* Lour.
POLYGALACEAE	*Securidaca inappendiculata* Hassk.
POLYGONACEAE	*Polygonum chinense* L.
POLYGONACEAE	*Polygonum chinense* var. *hispidum* Hook. f.
POLYGONACEAE	*Polygonum chinense* var. *ovalifolium* Meisn.
POLYGONACEAE	*Polygonum hydropiper* L.
POLYGONACEAE	*Polygonum lapathifolium* L.
POLYGONACEAE	*Polygonum orientale* L.
POLYGONACEAE	*Polygonum perfoliatum* L.
PORTULACACEAE	*Portulaca oleracea* L.
PROTEACEAE	*Helicia cochinchinensis* Lour.
PROTEACEAE	*Helicia nilagirica* Bedd.
PROTEACEAE	*Helicia pyrrhobotrya* Kurz
PROTEACEAE	*Helicia reticulata* W.T. Wang
PROTEACEAE	*Helicia shweliensis* W.W. Sm.
PROTEACEAE	*Helicia silvicola* W.W. Sm.
PROTEACEAE	*Helicia tsaii* W.T. Wang
PROTEACEAE	*Heliciopsis terminalis* (Kurz) Sleumer
RANUCULACEAE	*Clematis fulvicoma* Rehder & E.H. Wilson
RANUCULACEAE	*Clematis peterae* Hand.-Mazz.
RANUCULACEAE	*Clematis subumbellata* Kurz
RHAMNACEAE	*Gouania leptostachya* DC.
RHAMNACEAE	*Hovenia acerba* var. *kiukiangensis* (Hu & Cheng) C. Y. Wu ex Y. L. Chen

RHAMNACEAE	*Rhamnus leptophylla* C.K. Schneid.
RHAMNACEAE	*Ventilago calyculata* Tul.
RHIZOPHORACEAE	*Carallia brachiata* (Lour.) Merr.
RHIZOPHORACEAE	*Carallia diplopetala* Hand.-Mazz.
ROSACEAE	*Cerasus cerasoides* (Buch.-Ham. ex D. Don) S.Y. Sokolov
ROSACEAE	*Docynia delavayi* (Franch.) C.K. Schneid.
ROSACEAE	*Duchesnea chrysantha* (Zoll. & Moritzi) Miq.
ROSACEAE	*Eriobotrya bengalensis* var. *angustifolia* Cardot
ROSACEAE	*Eriobotrya obovata* W.W. Sm.
ROSACEAE	*Laurocerasus jenkinsii* (Hook. f.) Browicz
ROSACEAE	*Laurocerasus menghaiensis* T.T. Yu & L.T. Lu
ROSACEAE	*Laurocerasus zippeliana* (Miq.) Yu et Lu
ROSACEAE	*Photinia glabra* (Thunb.) Maxim.
ROSACEAE	*Potentilla kleiniana* Wight & Arn.
ROSACEAE	*Pygeum arboretum* (Bl.) C. Kalkman
ROSACEAE	*Pygeum topengii* Merr.
ROSACEAE	*Pyrus pashia* Buch.-Ham. ex D. Don
ROSACEAE	*Rubus pirifolius* Sm.
ROSACEAE	*Rubus poliophyllus* Kuntze
ROSACEAE	*Rubus rufus* var. *palmatifidus* Cardot
ROSACEAE	*Sorbus corymbifera* (Miq.) Khep & Yakovlev
ROSACEAE	*Sorbus globosa* T.T. Yu & Tsai
ROSACEAE	*Stranvaesia oblanceolata* (Rehder & E.H. Wilson) Stapf
RUBIACEAE	*Aidia cochinchinensis* Lour.
RUBIACEAE	*Brachytome hirtellata* var. *glabrescens* W.C. Chen
RUBIACEAE	*Canthium parvifolium* Roxb.
RUBIACEAE	*Discospermum fruticosum* (Hemsl.) Kuntze

RUBIACEAE	*Geophila herbacea* (Jacq.) K. Schum.
RUBIACEAE	*Hedyotis capitellata* var. *mollissima* (Pit.) W.C. Ko
RUBIACEAE	*Hedyotis diffusa* Willd.
RUBIACEAE	*Hedyotis scandens* Roxb.
RUBIACEAE	*Lasianthus inodorus* Bl.
RUBIACEAE	*Lasianthus lucidus* Bl.
RUBIACEAE	*Lasianthus sikkimensis* Hook.f.
RUBIACEAE	*Metadina trichotoma* (Zoll. & Moritzi) Bakh. f.
RUBIACEAE	*Mussaenda hossei* Craib
RUBIACEAE	*Mycetia gracilis* Craib
RUBIACEAE	*Ophiorrhiza mungos* L.
RUBIACEAE	*Oxyceros sinensis* Lour.
RUBIACEAE	*Psychotria symplocifolia* Kurz
RUBIACEAE	*Tarennoidea wallichii* (Hook. f.) Tirveng. & Sastre
RUBIACEAE	*Uncaria laevigata* Wall. ex G. Don
RUBIACEAE	*Uncaria sessilifructus* Roxb.
RUBIACEAE	*Wendlandia pingpienensis* F.C. How
RUBIACEAE	*Wendlandia scabra* Kurz
RUBIACEAE	*Wendlandia tinctoria* (Roxb.) DC.
RUTACEAE	*Acronychia pedunculata* (L.) Miq.
RUTACEAE	*Evodia austrosinensis* Hand.-Mazz.
RUTACEAE	*Evodia glabrifolia* (Champ. ex Benth.) C.C. Huang
RUTACEAE	*Evodia lepta* (Spreng.) Merr.
RUTACEAE	*Evodia lepta* var. *cambodiana* (Pierre) C.C. Huang
RUTACEAE	*Evodia simplicifolia* Ridl.
RUTACEAE	*Evodia trichotoma* (Lour.) Pierre
RUTACEAE	*Paramignya rectispina* Craib

RUTACEAE	*Toddalia asiatica* (L.) Lam.
SABIACEAE	*Meliosma simplicifolia* (Roxb.) Walp.
SABIACEAE	*Meliosma velutina* Rehder & E.H. Wilson
SALICACEAE	*Salix tetrasperma* Roxb.
SAMYDACEAE	*Casearia balansae* Gagnep.
SAMYDACEAE	*Casearia velutina* Blume
SAPINDACEAE	*Dimocarpus yunnanensis* (W.T. Wang) C.Y. Wu & T.L. Ming
SAPINDACEAE	*Nephelium chryseum* Blume
SAPINDACEAE	*Sapindus rarak* DC.
SAPOTACEAE	*Pouteria grandifolia* (Wall.) Baehni
SAPOTACEAE	*Sarcosperma arboreum* Buch.-Ham. ex C.B. Clarke
SAPOTACEAE	*Sarcosperma griffithii* Hook. f. ex C.B. Clarke
SAPOTACEAE	*Sarcosperma kachinense* var. *simondii* (Gagnep.) H.J. Lam & P. Royen
SAPOTACEAE	*Xantolis boniana* var. *rostrata* (Merr.) P. Royen
SAPOTACEAE	*Xantolis stenosepala* (Hu) P. Royen
SAPOTACEAE	*Xantolis stenosepala* var. *brevistylis* C.Y. Wu
SAURAUIACEAE	*Saurauia cerea* Griff. ex Dyer
SAURAUIACEAE	*Saurauia macrotricha* Kurz ex Dyer
SAURAUIACEAE	*Saurauia miniata* C.F. Liang & Y.S. Wang
SAURAUIACEAE	*Saurauia napaulensis* DC.
SAURAUIACEAE	*Saurauia punduana* Wall.
SAURAUIACEAE	*Saurauia yunnanensis* C.F. Liang & Y.S. Wang
SCHIZANDRACEAE	*Kadsura ananosma* Kerr
SCHIZANDRACEAE	*Kadsura angustifolia* A.C.Smith
SCHIZANDRACEAE	*Schisandra henryi* var. *yunnanensis* A.C. Sm.
SCHIZANDRACEAE	*Schisandra neglecta* A.C. Sm.
SCHIZANDRACEAE	*Schisandra plena* A.C. Sm.

SCROPHULARIACEAE	*Lindenbergia indica* (L.) Vatke
SLADENIACEAE	*Sladenia celastrifolia* Kurz
SOLANACEAE	*Lycianthes biflora* (Lour.) Bitter
SOLANACEAE	*Lycianthes biflora* var. *subtusochracea* Bitter
SOLANACEAE	*Solanum aculeatissimum* Jacq.
SOLANACEAE	*Solanum anguivi* Lam.
SOLANACEAE	*Solanum erianthum* D. Don
SOLANACEAE	*Solanum merrillianum* Liou
SOLANACEAE	*Solanum spirale* Roxb.
SOLANACEAE	*Solanum torvum* Sw.
STAPHYLACEAE	*Tapiscia yunnanensis* W.C. Cheng & C.D. Chu
STAPHYLACEAE	*Turpinia cochinchinensis* (Lour.) Merr.
STAPHYLACEAE	*Turpinia pomifera* (Roxb.) DC.
STEMONACEAE	*Stemona tuberosa* Lour.
STERCULIACEAE	*Pterospermum acerifolium* Willd.
STERCULIACEAE	*Reevesia pubescens* Mast.
STERCULIACEAE	*Reevesia thrsoidea* Lindl.
STERCULIACEAE	*Sterculia lanceifolia* Roxb.
STERCULIACEAE	*Sterculia lanceolata* Cav.
STYRACACEAE	*Bruinsmia polysperma* (Clarke) Steenis
STYRACACEAE	*Styrax grandiflorus* Griff.
STYRACACEAE	*Styrax rugosus* Kurz
STYRACACEAE	*Styrax tonkinensis* (Pierre) Craib ex Hartwich
SYMPLOCACEAE	*Symplocos sulcata* Kurz
SYMPLOCACEAE	*Symplocos wikstroemiifolia* Hayata
TACCACEAE	*Tacca chantrieri* André
THEACEAE	*Adinandra megaphylla* Hu

THEACEAE	*Camellia sinensis var. assamica* (J.W. Mast.) Kitam.
THEACEAE	*Camellia pachyandra* Hu
THEACEAE	*Camellia sinensis* (L.) Kuntze
THEACEAE	*Eurya aurea* H.T. Chang
THEACEAE	*Eurya austroyunnanensis* T.L. Ming & H. Chu
THEACEAE	*Eurya groffii* Merr.
THEACEAE	*Eurya jintungensis* Hu & L.K. Ling
THEACEAE	*Eurya persicaefolia* Gagnep.
THEACEAE	*Eurya pseudocerasifera* Kobuski
THEACEAE	*Gordonia chrysandra* Cowan
THEACEAE	*Pyrenaria yunnanensis* Hu
THEACEAE	*Schima argentea* E. Pritz.
THEACEAE	*Schima khasiana* Dyer
THEACEAE	*Schima wallichii* Choisy
THEACEAE	*Ternstroemia gymnanthera* (Wight & Arn.) Bedd.
THEACEAE	*Tutcheria pingpienensis* Hung T. Chang
THYMELEACEAE	*Eriosolena composita* (L. f.) Tiegh.
TILIACEAE	*Colona floribunda* (Wall. ex Voigt) Craib
TILIACEAE	*Microcos chungii* (Merr.) Chun
TILIACEAE	*Microcos paniculata* L.
ULMACEAE	*Celtis sinensis* Pers.
ULMACEAE	*Celtis timorensis* Span.
ULMACEAE	*Gironniera subaequalis* Planch.
ULMACEAE	*Trema orientalis* (L.) Blume
URTIACEAE	*Boehmeria macrophylla* Hornem.
URTIACEAE	*Debregeasia libera* Chien et C.J. Chen
URTIACEAE	*Debregeasia longifolia* (Burm. f.) Wedd.

URTIACEAE	*Debregeasia squamata* King ex Hook. f.
URTIACEAE	*Dendrocnide sinuata* (Blume) Chew
URTIACEAE	*Oreocnide rubescens* (Blume) Miq.
VACCINIACEAE	*Agapetes lobbii* C.B. Clarke
VACCINIACEAE	*Agapetes mannii* Hemsl.
VACCINIACEAE	*Vaccinium exaristatum* Kurz
VERBENACEAE	*Callicarpa arborea* Roxb.
VERBENACEAE	*Callicarpa bodinieri* H. Lév.
VERBENACEAE	*Callicarpa cathayana* H.T. Chang
VERBENACEAE	*Callicarpa giraldii* Hesse ex Rehder
VERBENACEAE	*Callicarpa longifolia* Lam.
VERBENACEAE	*Clerodendrum bungei* Steud.
VERBENACEAE	*Clerodendrum colebrookianum* Walp.
VERBENACEAE	*Clerodendrum japonicum* (Thunb.) Sweet
VERBENACEAE	*Clerodendrum serratum* (L.) Moon
VERBENACEAE	*Clerodendrum serratum* var. *amplexifolium* Moldenke
VERBENACEAE	*Clerodendrum serratum* var. *herbaceum* (Roxb. ex Schauer) C.Y. Wu
VERBENACEAE	*Clerodendrum villosum* Blume
VERBENACEAE	*Premna scandens* Roxb.
VERBENACEAE	*Vitex quinata* var. *puberula* (H.J. Lam) Moldenke
VIOLACEAE	*Viola diffusoides* Ching J. Wang
VIOLACEAE	*Viola hossei* W. Becker
VITACEAE	*Ampelopsis cantoniensis* (Hook. & Arn.) Planch.
VITACEAE	*Cayratia timoriensis* var. *mekongensis* (C.Y. Wu) C.L. Li
VITACEAE	*Tetrastigma obovatum* (Lawson) Gagnep.
XANTHOPHYLLACEAE	*Xanthophyllum yunnanense* C.Y. Wu
ZINGIBERACEAE	*Amomum koenigii* J.F. Gmel.

ZINGIBERACEAE	*Boesenbergia rotunda* (L.) Mansf.
ZINGIBERACEAE	*Globba barthei* Gagnep.
ZINGIBERACEAE	*Globba racemosa* Sm.
ZINGIBERACEAE	*Globba schomburgkii* Hook. f.
ZINGIBERACEAE	*Rhynchanthus beesianus* W.W. Sm.

OBITUARY

Humphrey Morrison Burkill O.B.E., F.L.S. (1914—2006)

The career and achievements of Humphrey Burkill, who died recently aged 92, parallel those of his father, Isaac Henry Burkill, to a remarkable degree. Both went to Repton School and Gonville and Caius College, Cambridge, both served as Director of Singapore Botanic Gardens and both authored monumental works on the economic botany of large tropical regions. While the direct or indirect influence of his father may have set Humphrey off in his footsteps fate seems to have conspired to keep him returning to the same track. Presumably even his longevity owed much to his parents' staying power.

However, father and son were of very different generations. Burkill senior was very much of the Colonial Age. He served in British India and Malaya at a time when empire was unquestioned. Burkill junior was a prisoner of the Japanese during World War II and served as Director of Singapore Botanic Gardens up to and after independence.

Humphrey Burkill's parents were first cousins and his mother, Ethel Maud Morrison, was 40 when he was born in the Director's House, now Burkill Hall, in Singapore Botanic Gardens. Humphrey was an only child, and like most children of senior colonial officers he was soon shipped back to Britain. At four years old he was 'farmed out' to the family of an impoverished vicar in Yorkshire. At eight he was send to preparatory school where a fellow pupil was one Tommy Disher, nephew to Richmal Crompton and the model for 'Just William'. At thirteen Humphrey went to Repton, followed by Gonville and Caius College, Cambridge, where he read Natural Sciences like his father did before him. Humphrey, by his own admission, was more interested in shooting than science when at University and represented both Cambridge and England at the sport. On graduation in 1936, after flirting with the idea of becoming a policeman, he got a job with Dunlop Malayan Estates. Thus he returned to South-East Asia where he was to spend the bulk of his working life. As a rubber planter, Burkill had to study plantation management including learning the languages needed to organise the staff. Fluency in Malay and Tamil was expected of planters and Burkill, apparently with a facility for languages, also picked up Telugu as many of the workers on his first estate spoke that language. Burkill's adeptness with a rifle and experience with the Officer Training Corps at university made it natural for him to join the Federated Malay States Volunteer Force. The Japanese invasion of Malaya saw the immediate mobilisation of the force and Burkill was part of the retreat to Singapore where he was seconded to the Royal Engineers. Singapore soon fell and like most captured servicemen he was imprisoned in Changi. After six months he was sent, along with many others, to labour camps in Thailand. Burkill reminisced about the activities of the wood-party he worked on during his imprisonment in an article written for the newsletter of a prisoners of war association. Their job was to collect the wood cut in the countryside around the camp, mostly carrying the cut lengths of wood and stacking it in the barges that transported it down river. Burkill's linguistic abilities again came in useful. The Thai he had learned before the war allowed communication with the villagers and illicit trading when the guards were not looking. Skin problems in later life doubtless stemmed from the exposure to the sun during the forced labour.

After the war Burkill returned to work with Dunlops in Malaya; this time with Joan Bloomer, his new wife. In 1948 Burkill joined the staff of the Rubber Research Institute and took on the supervision of the experimental rubber plantings throughout the Malay Peninsula. In 1954 Burkill was offered the post of Assistant Director at Singapore Botanic Gardens by then Director M.R. Henderson. To some extent this was a question of returning a favour to the Burkills. I.H. Burkill had helped Henderson in 1923 by offering him a job in Singapore when his post in Kuala Lumpur was discontinued. H.M. Burkill thought it likely a similar fate awaited him at RRI due to funding uncertainties. After Henderson's retirement Burkill became Acting Director then in 1957 Director of the Gardens.

It had become clear that times were changing and the end of the colonial era was in sight. Burkill was to oversee the change from a largely expatriate British staff of administrators and researchers to one of appropriately qualified locals. People with potential were identified and sent for training. Chew Wee Lek and Chang Khiaw Lan completed Ph.D.s under the supervision of former Assistant Director of the Botanic Gardens, Prof. E.J.H. Corner in Cambridge. Burkill continued in the post of director after Singapore became part of Malaysia and the subsequent expulsion of Singapore from the federation and its own independence. He finally retired in mid-1969. In those final years he tried hard to promote the idea of continuing Singapore Botanic Gardens as a centre for scientific research as well as a beautiful and historic garden. Burkill's administrative burden left him little time for research, and unlike his predecessors as Director such as H.N. Ridley, his father or R.E. Holttum he published little original research while working in Singapore. He had an interest in seaweeds and did go on many collecting trips, particularly to the small islands around Singapore and up the east coast of the Peninsula.

Burkill retired to England in late 1969. Looking for something to do, he was offered work at the Royal Botanic Gardens Kew on a project to revise *Useful Plants of West Tropical Africa.* This was written by J.M. Dalziel and published in 1937. Despite all his tropical experience being in South-East Asia, Burkill took up the job and for eight years was employed on what proved to be an enormous task. This included a long trip to Nigeria in 1973. I.H. Burkill is probably best known in botanical circles for his *Dictionary of the Economic Products of the Malay Peninsula* and it must have seen fitting to his son to also produce a magnum opus on economic botany. The painstaking work compiling information from published material and herbarium specimens continued long after Humphrey retired. Working as an Honorary Research Fellow at Kew, he brought the six volumes covering 5300 species to publication between 1985 and 2004. A masterly work of great scholarship, it will undoubtedly serve as the pre-eminent source of information on West African economic botany for decades to come, much as his father's dictionary has done for South-East Asia. Humphrey Burkill certainly followed the model of his predecessors as Director of Singapore Botanic Gardens in having a long and very productive retirement.

Humphrey's commitment to the *Useful Plants of West Tropical Africa* left no time for the study of his seaweed collections from his Singapore days. They were deposited in the algal herbarium at the Natural History Museum in London.

In relation to South-East Asian botany, H.M. Burkill will be remembered for his long service (1957—1969) as Director of Singapore Botanic Gardens and his efforts to maintain the scientific traditions of such institutions through the transition from colony to independent state. Burkill made the case for continuing government support for the Gardens and their research functions at the highest levels. A newly independent nation had many important items on its agenda for change and the Botanic Gardens was not among them. Far-sightedly parks and street planting were given priority in what was to become the 'Garden City' policy and in the long-term the Botanic Gardens was to prosper as a flagship under that policy. But in the short-term the Gardens became something of a backwater in the civil service and resources were limited, potentially threatening the continued existence of the herbarium and other research facilities. Fortunately the Gardens did come through relatively intact, and Humphrey Burkill will be remembered for his commitment to the concept of Botanic Gardens as scientific institutions, particularly to the one in which he was born.

Mrs Joan Burkill died two years before her husband. Humphrey and Joan are survived by their son and daughter, both of whom have followed in the Burkill tradition of professional involvement in biology.

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1958

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(with J.P.)

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1969

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1977

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1991

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1997

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2000

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2004

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Spermacoce macrantha (Hepper) H.M. Burkill, *Kew Bull.* 41 (1986) 1006.

Spermacoce saxicola (K. Schum.) H.M. Burkill, *Kew Bull.* 41 (1986) 1006.

Eponymy

Scaphium burkillfilii Kosterm., *Gard. Bull. Singapore* 22 (1968) 44.

Bodo burkillii Skvortzov & Noda, *Sci. Rep. Niigata Univ. ser. D* 9 (1972) 28.

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Affiliate Research Associate
Singapore Botanic Gardens

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Titles and authors: The title should give a concise description of the contents of the article. It should include the family name if a taxon name is included in the title. The names(s) and affiliation(s) of the author(s) must be given below the title. A short running title should also be provided. Lengthy papers must have contents listed at the beginning of the paper. Avoid footnotes.

Abstract: An abstract of up to about 100 to 200 words should be provided. It should comprehensively summarise the contents of the article as it is likely to be reproduced without the text.

Scientific names: The complete scientific name – genus, species, authority with family in parenthesis – must be cited for every organism at the time of first mention.

Abbreviations: Standard abbreviations may be used in the text, but the full term should be given on the first mention. Dates should be cited as: 1 Jan 2000. Units of measurement should be spelled out except when preceded by a numeral where they should be abbreviated in standard form: g, ml, km, etc. and not followed by stops.

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CONTENTS

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Studies on the *Alocasia* Schott (Araceae-Colocasieae) of Borneo: I Two new species from Sarawak, Malaysian Borneo

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Abstract

Two new species of *Alocasia*, *A. chaii* P.C.Boyce and *A. infernalis* P.C.Boyce from Kapit Division, Sarawak, Malaysian Borneo, are described and included into an updated key to Bornean *Alocasia*. Both species are illustrated.

Introduction

Publications on *Alocasia* for tropical Asia (Hay, 1994, 1998, 1999, 2000; Hay & Wise, 1991; Hay *et al.*, 1997; Yuzammi & Hay, 1998) have considerably alleviated the previous problems of accurately naming *Alocasia* species and, moreover, provided a stable platform from which to describe further novelties without the concern that obfuscated species names are being overlooked.

Prior to the onset of work on Bornean *Alocasia* by Hay and co-authors (Hay, 1998, 2000, Hay *et al.*, 1997), the species complement for Borneo stood (uncritically) at 16 species. Post publication of Hay's accounts for West Malesia & Sulawesi (Hay, 1998) and the subsequent naming of an additional species [*A. nebula* A.Hay (Hay, 2000) - treated as insufficiently known by Hay, 1998] the total for Borneo stands at 21 species formally recognized. Allowing for synonymization, this represents an increase of more than 45% of the species diversity post 1997.

Since the publication accounts of *Alocasia* in Malesia and Sulawesi (Hay, 1998, 2000) the author of has been fortunate to be able to spend a considerable period of time undertaking fieldwork in Sarawak, frequently in areas that have received little or no botanical investigation in recent years, if ever. One result of this fieldwork has been the discovery of a significant number of additional novel *Alocasia*, such that it is estimated that the total number of Bornean *Alocasia* species will eventually exceed 40, all endemic. Although at the present time there is insufficient fertile material for the preparation of types for all of the taxa considered to be undescribed; as the preparation of types becomes possible from plants flowering in cultivation, it is intended to produce a series of papers dealing with formal recognition of the ca 20 novelties found to date, along with updates on the status of pre-existing described taxa. This paper is the first in this intended series.

1. Alocasia chaii P.C.Boyce, *sp. nov.*
Ab Alocasia scabriscula sed stature valde parviore, folii lamina peltato et spathae fructiferorum extus in toto magenteus vividus differt – TYPUS: Sarawak, Kapit Division, Pergunungan Hose, foothills of Bukit Batu, Camp E, 01° 51' 33.6"; 114° 06' 49.6", 20 Oct. 2000, *C.Lee AL-41* (holo, SAR; iso, SING). Plates 1 & 2.

Small robust **herb** to ca 40 cm tall, stem shortly erect to decumbent, eventually forming a short rhizome; wild plants with rather few leaves (up to 4, usually less), cultivated plants with several **leaves** (up to 7); petioles stout, *ca* 20 cm long, sheathing in the lower ca 1/4, puberulent, pale green with scattered deep red spots and speckles in the lower half; sheath persistent, ± closed; lamina broadly ovato-elliptic, up to 40 cm long but frequently much less and typically reaching c. 23 cm x 10–15, exceptionally up to 25 cm wide, thickly coriaceous to subsucculent, almost completely peltate save for a shallow retuse notch between the tips of the connate posterior lobes, margins reflexed to form a raised smooth rim abaxially, apex acute to obtuse and mucronate for ca 1 cm, lamina adaxially pale matt grey, abaxially greenish white, anterior costa with 1–3 primary lateral veins on each side, diverging at *ca* 90° (proximal ones) to 30° (distal ones); primary veins adaxially somewhat raised proximally to the mid-rib and impressed distally, flush to very slightly impressed with deep red axillary glands abaxially; secondary venation impressed adaxially, more or less flush with the lamina abaxially, forming defined interprimary collective veins when fresh, this decidedly obscure in dried material; posterior lobes about 1/3 – 1/4 the length of the anterior, with the posterior costae diverging at ca 30°; **inflorescences** several together (up to 4 on vigorous plants), each subtended by a short, broad prophyll and a single cataphyll; peduncle short, more or less hidden within cataphyll; *spathe ca* 7 cm long, externally white with a scattered red flecks on the lower part, interior uniformly glossy white; lower spathe 2.5–3.5 cm long, ovoid, separated from limb by a rather weak oblique constriction; limb erect even after anthesis, narrowly lanceolate-triangular, 3–5 cm long; *spadix ca*

Plate. 1. *Alocasia chaii* P.C.Boyce. **A**. Adult plant in habitat; note the few leaves, typical of *A. chaii* in the wild; **B**. Cultivated plant produced from tissue culture introduction; note the many additional leaves and the deep red blands on the visible abaxial leaf surface. Photograph 1A [copyright Chien Lee, used with permission].

2/3 the length of the spathe, *ca* 4.5 cm long, briefly stipitate; stipe cylindrical, *ca* 2–5 mm tall, glossy white; *female zone* about 1/4 of the length of the spadix, pistils moderately densely arranged; ovaries ovoid, *ca* 1.5 mm diam., facing diagonally up, pale greenish white; style ± absent; stigma white, single, bilobed, sometimes trilobed (all variations present in a single inflorescence); sterile interstice absent or represented by a few (less than 5) synandrodia; *male zone* held entirely within the lower spathe, cylindric to barrel-shaped, about 1/4 the length of the spadix, about 2/5 as wide as long, ivory; synandria densely arranged, more or less square in plan view, *ca* 1.5 mm wide, the thecae very slightly overtopped by synconnective; appendix about 1/3 of the length of the spadix, narrowly conic; *fruiting spathe* broadly ovoid, c. 2.5 cm long, erect, glossy brilliant magenta with a few scattered darker spots and streaks at fruit maturation, then splitting longitudinally into several unequal strips, these reflexing to reveal the ripe berries; **berries** bright orange to red, globose, *ca* 0.5 cm diam., each with 1-3 seeds; **seeds,** ca 3mm diam., pace brown.

Distribution: Sarawak, Kapit Division, to date known only from the foothills of Gunung Bukit Batu, Hose Mountains and Ulu Kapit.
Ecology: Steep to precipitous leaf litter-covered red clay-loam slopes beneath open to rather dense canopy of moist upper hill forest in light to moderate shade, 540–760 m asl.

Notes: *Alocasia chaii* belongs to the informal *Alocasia scabriscula* group (see Hay, 1998), notable for coriaceous, leathery to subsucculent leaves and the spathe usually constricted at a level above the sterile interstice of the spadix, thus, including the all or at least the majority of male flower zone within the lower spathe. *Alocasia chaii* is most similar to *A. scabriscula* N.E.Br. in overall morphology, differing in the considerably smaller, but hardly less robust habit, the peltate leaves and the persistent lower spathe that turns bright magenta at fruiting. In general stature and by the grey leaves *A. chaii* also vaguely resembles Sabahan *A. melo* A.Hay, P.C.Boyce & K.M.Wong, although the latter is readily distinguished by the rugose and bullate adaxial lamina surface and the fruiting spathe white with slight red speckling. *Alocasia melo* is confined to ultramafic substrates.

There appear to be two closely allied species involved here, one in the lowlands (up to 150 m asl) that has not as yet found fertile, and a higher elevation element (occurring above 500 m asl), here described as *A. chaii*. Aside from the altitudinal differences noted, the lowland element has the leaves proportionately longer than broad (ovato-triangular in outline), lacks the deep red abaxial leaf glands (glands concolorous with the abaxial lamina

Plate. 2. *Alocasia chaii* P.C.Boyce. A. Ripe infructescences; note the bight magenta colour of the lower spathe and the contrasting orange fruits.

surface in the lowland element), and is overall a less robust plant occurring in open habitats. The occurrence of related attitudinally differentiated/ morphologically distinct taxa has been noted elsewhere in *Alocasia*, as for example, *A. beccarii* Engl. (lowland) & *A. peltata* M.Hotta (highland).

Etymology: *Alocasia chaii* is named for Dr Paul P.K. Chai former Forest Botanist, now with ITTO, Forest Department, Sarawak.

Other specimens examined: SARAWAK: **Kapit Division:** Pergunungan Hose, foothills below Bukit Batu, 02° 14' 47.2"; 113° 41' 24.9", 23 April 2004, *P.C.Boyce & Jeland ak Kisai AL-51* (SAR); Ulu Kapit, Sungai Nai, near Punan Bah, 23 Sept. 1973, *P.Chai et al. S.33339* (SAR); Pergunungan Hose, Ulu Sungai Temiai, 5 July 2003, *C.Lee et al., S87433* (SAR).

2. *Alocasia infernalis* P.C.Boyce, *sp. nov.*

Ab alli Alocasii borneensibus stature parviore, foliis ascendentis, folii lamina atropurpureus vel purpureonigris, nitentibus distinguitur – TYPUS: Sarawak, Kapit Division, Nanga Gaat, Rejang Wood Concession, Batang Baleh, 01° 38', 113° 09', 2 April 1998, *C.Lee AL-16* (holo, SAR; iso, SING,). Plates 3 & 4.

Small robust **herb** to *ca* 55 cm tall, stem slender, erect to ultimately decumbent with the active shoot tip ascending; **leaves** several together in nature, in cultivation up to 12, spreading in juveniles but erect in adult plants; petioles slender, spreading to ascending, *ca* 20 cm long, sheathing in the lower *ca* ½, minutely puberulent (lens required), bronze-green to purple-green depending on exposure, stronger light inducing a weak snake-skin marking, particularly on the interior of the sheath; sheath fleshy-membranous, open and recurving in the lower part; lamina ovato-triangular, up to 25 cm long but frequently much less and typically reaching *ca* 15 cm x 10–12 cm, thinly and somewhat weakly coriaceous, juveniles almost completely peltate except for a shallow retuse notch between the tips of the connate posterior lobes, adult leaves strongly peltate but with a 1–2 cm deep notch in the sinal tissue, margins smooth, apex acute, acuminate for *ca* 1 cm, adaxially glossy, very deep purple, abaxially deep purple, anterior costa with *ca* 3 primary lateral veins on each side, diverging at *ca* 60° (proximal ones) to 45° (distal ones); primary veins impressed distally adaxially, prominently raised abaxially; secondary venation obscure adaxially, abaxially forming strongly defined and raised interprimary collective veins; all veins running to a prominently raised (abaxially) inframarginal collecting vein; posterior lobes about ¼ the length of the anterior, posterior costae diverging at *ca*. 20°. **Inflorescences** 2 together, each subtended by a short, broad prophyll and a single cataphyll; peduncle long, *ca* 4–6 cm, pale green or purple flushed; *spath*e 4–9.5 cm long, lower spathe pale green, spathe limb externally glossy purple with the margins pale green; lower spathe 1.5–2.5 cm long, ovoid, separated from limb by a moderate constriction; limb narrowly lanceolate-triangular, at first erect then soon strongly reflexing and twisting with the margins inrolled, 2–6.5 cm long; *spadix* ca 1/2 the length of the spathe, *ca* 4.5 cm long, very briefly stipitate; stipe umbonate, *ca* 2 mm tall, glossy white; *female zone ca* 1/3 of the length of the spadix, pistils moderately densely arranged; ovaries compressed-globose, *ca* 2 mm diam., facing diagonally up, pale greenish white; style absent; stigma white, mostly trilobed, sterile interstice with a few scattered, compressed white synandrodia; *male zone* partially held within the lower spathe, cylindric, *ca* 1/3 the length of the spadix, ivory; synandria somewhat laxly arranged, transversely oblong in plan view, *ca* 2 x 1 mm, thecae extending slightly from the edge of the synconnective; appendix about 1/3 of the length of the spadix, narrowly conic, pointed, white; *fruiting spathe* broadly ovoid, *ca* 2.5 cm long, pendent by reflexing of the peduncle, dull mid-green at fruit maturation, splitting longitudinally into several unequal strips, these reflexing to reveal the ripe berries; **berries** bright orange to red, globose, *ca* 0.5 cm diam., each with 1–3 seeds; **seeds** compressed ovoid, *ca* 2.5 diam., medium brown.

Plate. 3. *Alocasia infernalis* P.C.Boyce. **A**. Juvenile plant in habitat; **B**. Seedlings, Nanga Gaat; note the iridescent leaf surface and also the variability in the intensity of the purple colouration.

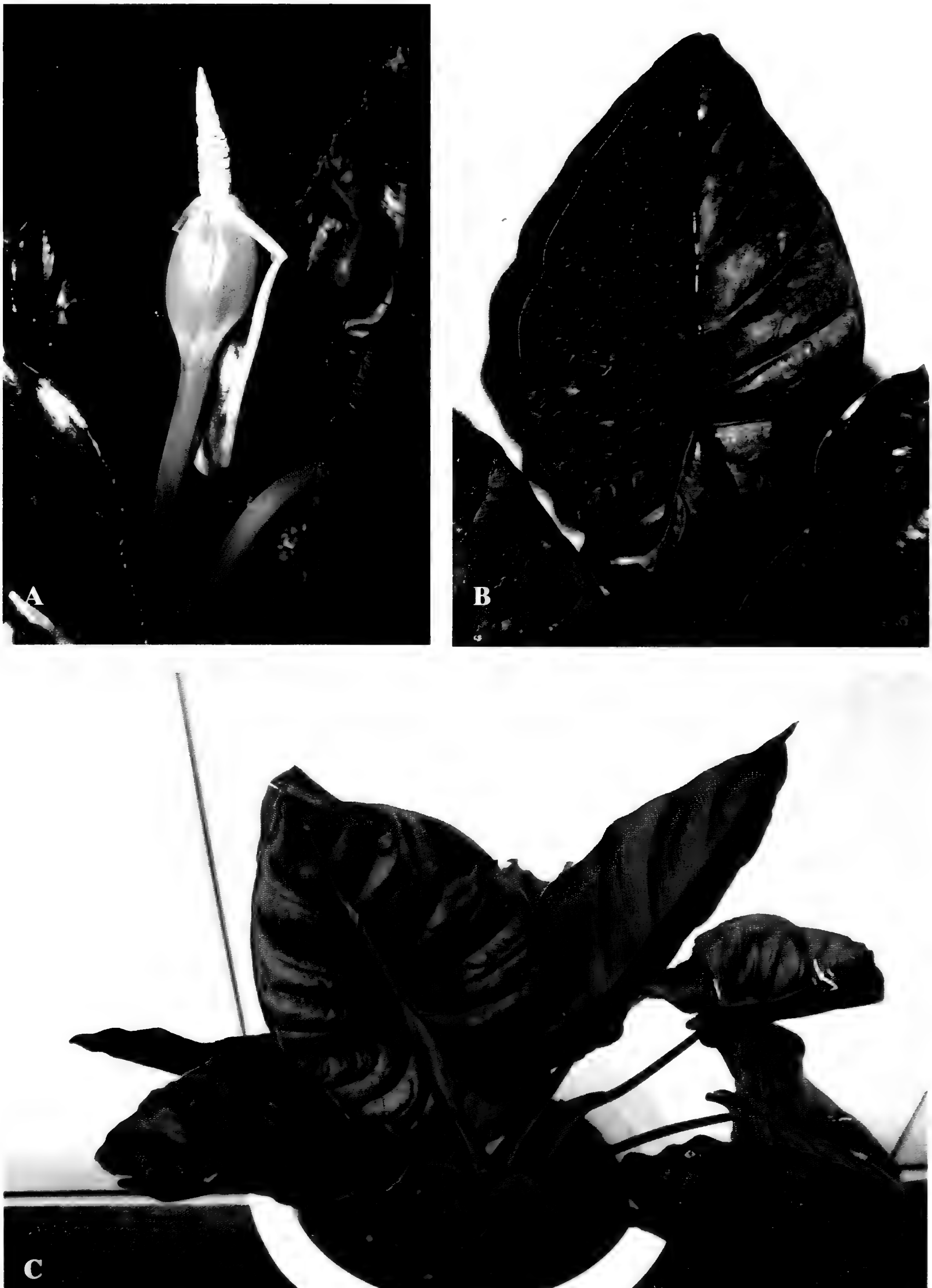

Plate 4. *Alocasia infernalis* P.C.Boyce. **A**. Plant flowering in cultivation; **B**. Deep purple-black leaves of a plant in cultivation produced from tissue culture; **C**. Flowering size plant in cultivation..

Distribution: Sarawak, Kapit Division. To date known only from the Sungai Gaat watershed.

Ecology: Valley bottoms in moist to ever-wet lowland forest on deeply leaf litter-covered red sandstone-derived clay-loams in heavy shade,182–249m asl.

Notes: *Alocasia infernalis* belongs to the *Alocasia scabriscula* group (see Hay, 1998) by virtue of the pubescent petioles and the positioning of the spathe constriction above the base of the male zone of the spadix such that all or at least the basal part of the male zone is held within the lower spathe chamber. However, it is not at all apparent to which other species in the group *A. infernalis* is most closely allied since by the leaf texture and deflexing infructescences it is unique in the group. In overall appearance (leaves rather membranous more-or-less completely peltate, spadix distinctly shorter than the spathe) it is superficially similar to species in the *Alocasia cuprea* (C.Koch & Bouché) C.Koch group but is readily distinguished by the leaves *not* interspersed with cataphylls.

The metallic-purple leaves of the seedlings and juvenile plants is remarkable while the lustrous deep purple-black of the ascending leaves of mature plants, coupled with the dwarf habit, is unmatched by any other species. *Alocasia infernalis* is perhaps the most horticulturally significant species of Bornean *Alocasia* yet discovered.

Etymology: From the Latin, 'Hellish' in fanciful allusion to the remarkable deep purple-black leaves of mature plants; the epithet is inspired by the no-less remarkable vampyromorphoid cephalopod, *Vampyroteuthis infernalis*.

Other specimens examined: SARAWAK: **Kapit Division:** Nanga Gaat, Rejang Wood Concession, km 65 road to Camp Gahada, 01° 42' 01.1", 113° 31' 14.8", 12 May 2004, *P.C.Boyce, Jeland ak Kisai & Jipom ak Tisai AL-57* (SAR); Nanga Gaat, Rejang Wood Concession, km 55 road to Camp Gahada, 01° 44' 44.5", 113° 28' 32.3", 13 May 2004, *P.C.Boyce, Jeland ak Kisai & Jipom ak Tisai AL-66* (SAR); Nanga Gaat, Rejang Wood Concession, km 65 road to Camp Gahada, 01° 41' 59.7", 113° 31' 13.7", oblong leaves, 16 Dec 2004, *P.C.Boyce, Jeland ak Kisai & M.Gibernau AL-123* (SAR).

Conservation

Both species here newly described occur as scattered small populations in restricted habitats. Fortunately all known populations of both species are in remote and inaccessible locations and for the moment probably safe from the deprivations of unscrupulous plant collectors. *Alocasia chaii* and *A. infernalis* were among those species the subject of a joint tissue culture project between Malesiana Tropicals and UNIMAS funded under MOSTI-IGS (IGS R&D Proj. No. 16/03), together with a further 14 Sarawakian *Alocasia* species and representatives of several other aroid genera that are now in Sarawak Forestry Department licensed commercial tissue culture production in Kuching laboratory of Malesiana Tropicals Sdn Bhd.

Key to Bornean *Alocasia* species

1. Leaf blades not peltate in adult plants **2**
1a. Leaf blades distinctly (shallowly to completely) peltate in adult plants **14**

2. Secondary venation distinctly prominent abaxially *and* forming well-defined interprimary collective veins .... ***A. sarawakensis***
2a. Secondary venation not prominent abaxially, or, if prominent, then *not* forming well-defined interprimary collective veins **3**

3. Leaf blade membranous, often immense, abaxially waxy-glaucous .... ***A. robusta***
3a. Leaf blade of various sizes and textures, not waxy-glaucous (though sometimes abaxially grey-green) **4**

4. Male zone of spadix completely exerted from lower spathe chamber (always in association with human disturbance) .... ***A. macrorrhizos***
4a. Male zone of spadix partly or wholly within lower spathe chamber (plants of natural forested habitats) **5**

5. Leaf blade narrowly to broadly ovato-sagittate, nearly always stiffly leathery to subsucculent **6**
5a. Leaf blade hastato-sagittate, triangular in outline, mostly rather thinly leathery **10**

6. Adaxial leaf blade grey-green and distinctly dark green about main veins **7**
6a. Adaxial leaf blade of various colours but not variegated **8**

7. Abaxial leaf blade purple; anterior costa with c. 6 primary lateral veins on each side, with conspicuous subsidiary veins (geology & origin unknown) ....

.... ***A. nebula***
7a. Abaxial leaf blade not purple; anterior costa with 2--3 primary lateral veins on each side; subsidiary veins absent (limestones: SE Sarawak) .... ***A. reversa***

8. Inflorescence pairs solitary *and* secondary venation adaxially impressed (limestones: Mulu) .... ***A. reginae***
8a. Inflorescence pairs clustered or if solitary then secondary venation not impressed **9**

9. Posterior lobes ca 1/2 or more the length of the anterior; blade stiffly leathery (lithophytic on or terrestrial in close association with limestone (limestones: SE Sarawak) .... ***A. ridleyi***
9a. Posterior lobes less than to ca 1/2 the length of the anterior; blade thickly coriaceous to subsucculent; terrestrial and not especially associated with limestone (widespread in Borneo) .... ***A. scabriuscula***

10. Plants terrestrial, not limestone associated **11**
10a. Plants lithophytic on limestone **12**

11. Petioles mottled with wavy oblique zones of dense brown lines, occasionally scabrid; spathes mostly dusky brownish mauve, the limb darker; lower spathe narrowly ovoid; limb mostly narrowly lanceolate (Sabah) .... ***A. wongii***
11a. Petioles variously and more or less haphazardly marked with lines and/or dots, smooth or occasionally faintly bumpy (glands), but not scabrid; spathes mostly ivory to yellowish ivory, variously marked or not with pink to purple, and/or purple-margined; lower spathe broadly ovoid; limb more or less oblong (widespread in Borneo) .... ***A. princeps***

12. Male zone of spadix completely within lower spathe chamber; leaf blades distinctly grey-green adaxially (limestones: Sabah, E. Kalimantan) .... ***A. principiculus***
12a. Male zone of spadix partly exserted from lower spathe chamber; leaf blades dark to bright green adaxially (Sabah) **13**

13. Leaf blade bright green adaxially; inner side of posterior lobe ovate; male zone more or less adjunct to female zone or interstice short, not attenuate, formed of 1-2 whorls of synandrodia, resembling synandria (limestones: Gua Madai) .... ***A. puteri***
13a. Leaf blade dark green adaxially; inner side of posterior lobe elliptic to narrowly ovate; interstice elongate, partly naked, with neuter organs resembling staminodes below and resembling synandria above (limestones:

Gua Madai) .... ***A. pangeran***

14. Leaf blades ± membranous and pendent, often solitary or only 2--3 together, often adaxially dark green with whitish major veins (sometimes adaxially concolorous), often purple-backed, shallowly to deeply peltate; stigma stellate with pointed lobes; interstice corresponding with spathe constriction and male zone completely exerted .... ***A. longiloba* complex** (see Hay, 1998)
14a. Leaf blades variously coriaceous, pendent or not, few to several together, deeply to almost completely peltate; stigma not lobed or lobes rounded; interstice and part or all of male zone within lower spathe cham **15**

15. Leaf blades metallic greenish brown adaxially, bullate between primary veins; lower primary veins diverging at first at more than 90° (Sabah & NE Sarawak) .... ***A. cuprea***
15a. Not this combination **16**

16. Adaxial leaf surface strongly and minutely rugose with the tertiary venation raised (ultramafics: Sabah) .... ***A. melo***
16a. Adaxial leaf surface smooth or with secondary venation impressed **17**

17. Adaxial leaf laminae very dark black-green with white impressed primary and secondary venation; spadix with appendix reduced (limestone: Bukit Tabin) .... ***A. reginula***
17a. Adaxial leaf laminae not variegated, or if variegated then main veins and neighbouring blade darker than the rest; appendix well developed **18**

18. Leaf blades with conspicuous intramarginal vein and marginal vein; laminae broadly to narrowly elliptic, with the base cuneate; male zone wholly within the lower spathe (above 800 m, Borneo) .... ***A. peltata***
18a. Leaf blades with more or less conspicuous marginal vein only; laminae various; male zone wholly or partly within the lower spathe (mostly below 500 m, Borneo) **19**

19. Primary lateral veins numerous, 8-10 on each side of midrib; secondary venation striate; in peat swamp forest (peat swamp forest: Sarawak) .... ***A. minuscula***
19a. Primary lateral veins much fewer; secondary venation clearly colocasioid, but not forming interprimary collective veins **20**

20. Leaf blades thickly coriaceous to subsucculent; male zone of spadix within lower spathe chamber **21**

20a. Leaf blades thinly coriaceous or sub-membranous; male zone only partly included within the lower spathe chamber **22**

21. Leaf laminae broadly ovato-elliptic, adaxially pale matt grey, abaxially greenish white with conspicuous deep red axillary glands abaxially; petioles puberulent; fruiting spathe magenta (Kapit, evergreen upper hill forest on sandstones above 500 m asl) .... ***A. chaii***
21a. Leaf blade narrowly elliptic to ovate to narrowly obovate, mid green above, slightly paler with inconspicuous pale green axillary glands; petioles glabrous fruiting spathe pale green (NW Borneo, kerangas below 500 m) .... ***A. beccarii***

22. Laminae ascending (adult plants) to weakly spreading (juveniles), thinly and weakly coriaceous, lustrous deep purple-black; petioles minutely puberulent; infructescences deflexed (Kapit: sandstones) .... ***A. infernalis***
22a. Laminae pendent to weakly spreading (adult & juvenile plants), thinly, stiffly coriaceous; never deep purple-black; petioles glabrous; infructescences erect (limestones) **23**

23. Leaf blades dark green throughout and somewhat darker around mid-veins; inflorescences to ca 6 together; stigma mostly tri-lobed (limestones: Gua Niah) .... ***A. venusta***
23a. Leaf blades grey-green and dark blue-green around veins; inflorescences solitary to paired; stigma mostly bi-lobed (limestones: SE Sarawak) .... ***A. reversa***

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Taxonomic notes on Asian species of Orthotrichaceae (Bryopsida): *Macromitrium* with gymnostomous capsules *

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Abstract

Nine taxa of the genus *Macromitrium* (Bryopsida, Orthotrichaceae) with gymnostomuous capsules in East Asia, including *Macromitrium benguetense* R.S. Williams, *M. brevituberculatum* Dix., *M. formosae* Card., *M. gymnostomum* Sull. & Lesq., *M. heterodictyon* Dix., *M. holomitrioides* Nog., *M. robinsonii* R.S. Williams, *M. schmidii* C. Muell., and *M. taiheizanense* Nog., are taxonomically revised. *Macromitrium robinsonii* and *M. brevituberculatum* are treated as new synonyms of *M. gymnostomum*, and *M. benguetense* as a new synonym of *M. schmidii.* Neotype was designated for *M. schmidii*, and types were selected for *M. heterodictyon*, *M. gymnostomum*, *M. brevituberculatum*, *M. taiheizanense*, and *M. formosae*. *Macromitrium schmidii* var. *macroperichaetialium* S.L. Guo & T. Cao was described as a new variety. A key to the seven accepted gymnostomous species of *Macromitrium* in East Asia is also given.

Introduction

Macromitrium is a rather large pantropical genus of mesophytic to xerophytic epiphytes, belonging to Orthotrichaceae, Bryopsida. It is distinguished by the creeping, prostrate stems giving rise to branches terminated by a sporophyte, the often contorted leaves twisted around the branches, and with mostly bulging, conic, papillose, or tuberculate leaf cells. Calyptrae are large, mitrate, plicate, naked or hairy. The ovate to cylindric capsules mostly have peristomes, which are at times reduced and fused to a low, single exostomial membrane.

Though Asia is rich in the species of *Macromitrium,* with about 85-90 species recorded (Crosby *et al.*, 1999; Eddy, 1996; Gangulee, 1976; Noguchi, 1967, 1972, 1989; O'Shea, 2002; Redfearn *et al.*, 1996; Tan and Iwatsuki, 1991, 1993), little taxonomic revision has been done except for those in Japan (Noguchi, 1989), Malaysia, Philippine and Indonesia (Eddy, 1996), Eastern India and its adjacent regions (Gangulee, 1976), and Papua New Guinea (Vitt, 1995).

There is a rather special group of *Macromitrium* with gymnostomous capsules, including *M. benguetense* R.S. Williams, *M. brevituberculatum* Dix., *M. formosae* Card., *M. gymnostomum* Sull. & Lesq., *M. heterodictyon* Dix., *M. holomitrioides* Nog., *M. robinsonii* R.S. Williams, *M. schmidii* C. Muell., and *M. taiheizanense* Nog. Since these species were published, there has been little taxonomic information about them, except for *M. gymnostomum* and *M. holomitrioides* (Crosby *et al.*, 1999).

During our taxonomic revision on Asian *Macromitrium*, we found a specimen with gymnostomous capsules marked as "China, Kwangtung: Ngok Shing Shan, Y. M. Taam 402C " in NY, which is rather similar to *M. schmidii* Muell. A further check on this specimen showed that it differs from the later by its rather long inner perichaetial leaves and its gymnostomous capsule that are constricted below the mouth into 4-angles or 4-furrows when dry. This specimen represents a hitherto undescribed taxon, here we placed it at the variety level and named it as *Macromitrium schmidii* var. *macroperichaetialium.* Our further study of the types showed that *M. brevituberculatum* and *M. robinsonii* are two new synonyms of *M. gymnostomum*, and *M. benguetense* is a new synonym of *M. schmidii*. In order to understand these gymnostomous species better and to stabilize the usage of the species epithet, a neotype was designated for *M. schmidii* C. Muell. and types were selected for *M. heterodictyon* Dix., *M. gymnostomum*, *M. brevituberculatum*, *M. taiheizanense* and *M. formosae*, and a key to these gymnostomous species was also given.

Taxonomic treatment

Macromitrium schmidii C. Muell., Bot. Zeit. 11: 61. 1853. Figs. 1-3.
Type: India, Nilgherri, leg. *Perrottet no. 22* (neotype, H-BR 2595002!, designated here) – *Macromitrium benguetense* R.S. Williams, Bull. New York Bot. Gard. 8: 343, 1914. *syn. nov*. **Type**: "Philippine, Baguio, on tree, 1570 meters, Oct. 1904, *Williams 830* (isotype, H-BR 2572023!).

Plants moderate-sized, forming yellowish-brown mats, darkish below. **Stems** creeping, up to 10 cm long, with erect branches, branches 10–20 mm high and 1.5–2 mm wide. **Branch leaves** moderately crisped and somewhat twisted when dry, widely spreading when moist, entire, lanceolate, (2.5) 3.5–4 mm long, 0.5–0.7 mm wide, the apex acuminate, somewhat incurved, keeled, plicate below; margins entire, plane on one side, reflexed-recurved on the other side, particularly in lower portion; costa single, prominent, ending a few cells below the apex or in the apex; laminal cells unistratose from top to base, upper laminal cells subquadrate-rounded to rounded-quadrate, 10–14 μm wide, obscure, densely pluri-papillose; median laminal cells rounded-quadrate or slightly elongate, 10–15 μm wide, 15–20 μm long, with a single, large conical papilla or 3–4 small papillae per cell; basal laminal cells brown-yellowish, rectangular to sublinear, 30–50 μm long, 6–10 μm wide, strongly thick-walled and sinuous, tuberculate to bulging-papillose.

Sporophytes lateral on branches; inner **perichaetial leaves** ovate-oblong, long-acuminate in upper part, 2.8–3.2 mm long, shorter than branch leaves, the costa ending far below the apex. Setae 4–6 mm, smooth, twisted to right. **Capsules** oblong-cylindric or oblong, 1–2 mm long, 0.6-0.8 mm wide, brown, plicate or ribbed under the mouth when dry, peristome absent. **Spores** 25–35 μm in diameter. **Calyptrae** moderate sized, 2–2.5 mm long, campanulate, with brownish hairs.

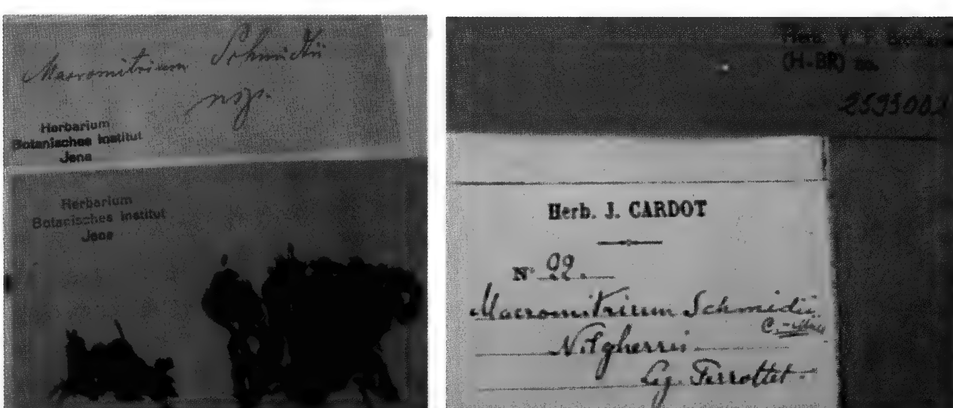

Fig. 1. Neotype and habit of *M. schmidii*: "Nilgherri, Leg. *Perrottet 22*" at H-BR.

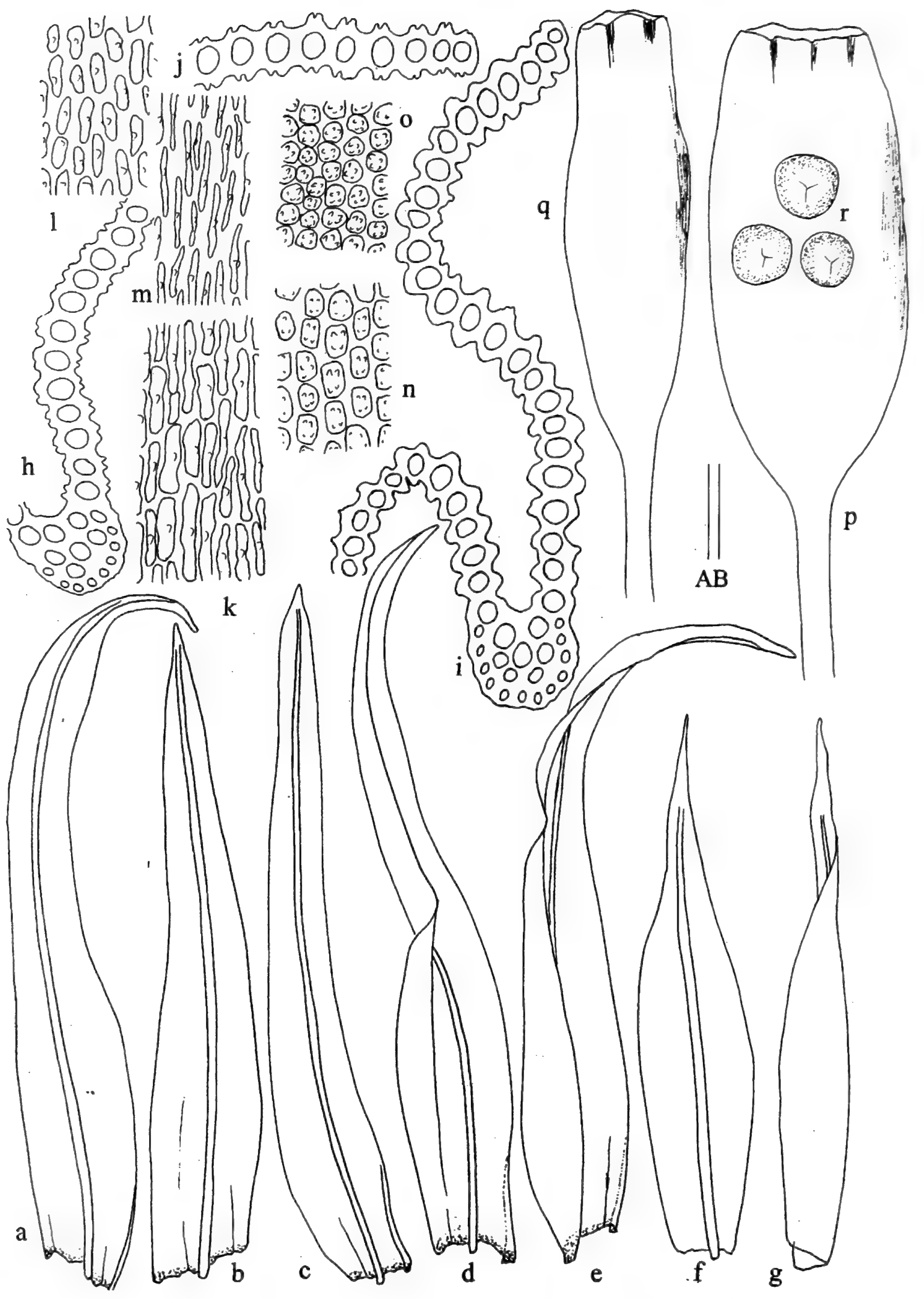

Fig. 2. *M. schmidii* C. Muell. a-e. Branch leaves; f-g. Perichaetial leaves; h. Transverse section of the meddle part of leaf; i. Transverse section of the basal part of leaf; j. Transverse section of the upper part of leaf; k, m. Basal laminal cells; l. lower laminal cells; n. Middle laminal cells; o. Upper laminal cells p–q. Capsules; r. Spores. All from the lectotype of *M. schmidii* at H-BR. Line scales: A = 0.5 mm (a-g, p-q); B = 50 µm (h-o, r).

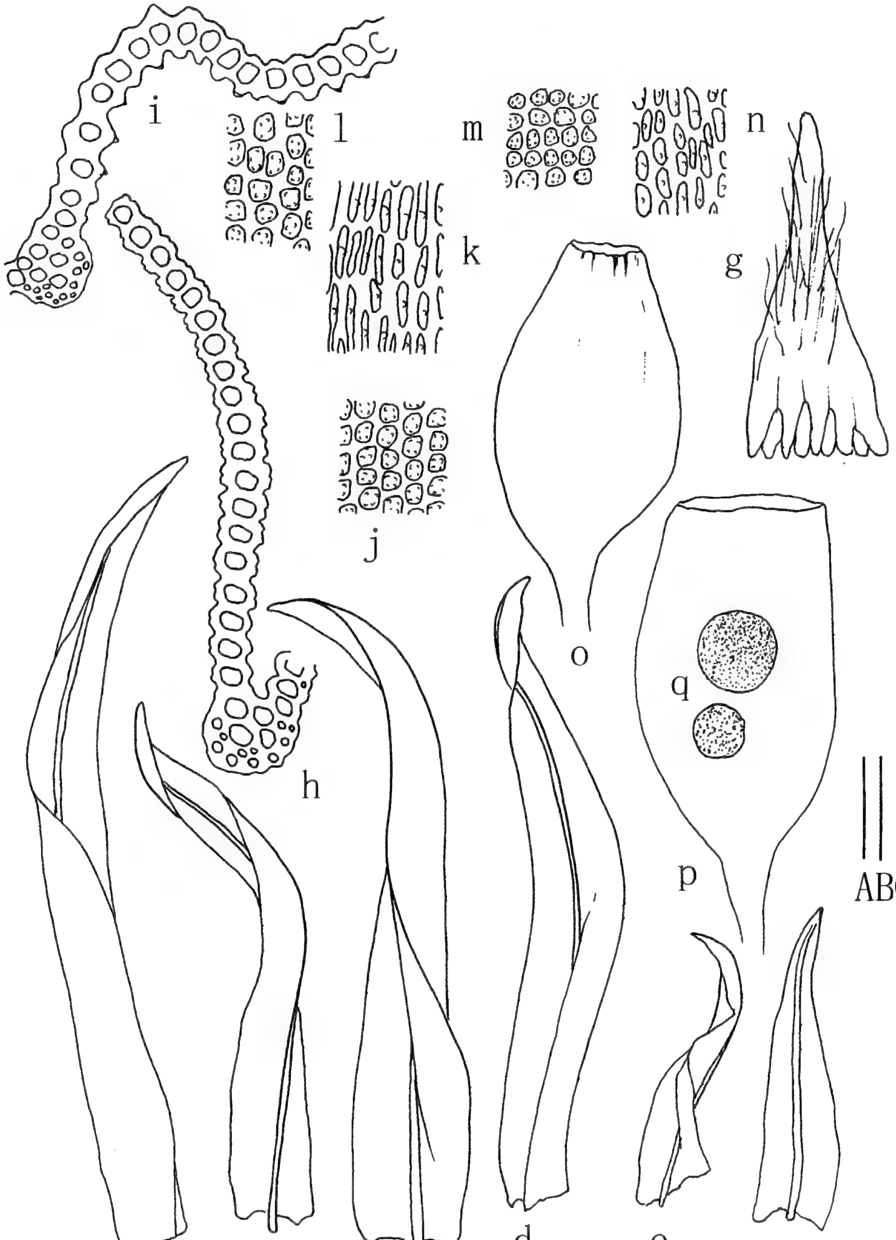

Fig. 3. *M. schmidii* C. Muell. a-d. Branch leaves; e-f. Stem leaves; g. Calyptra; h. Transverse section of the meddle part of leaf; i. Transverse section of the basal part of leaf; j. Upper laminal cells of branch leaf; l. Middle laminal cells of branch leaf; k. Basal laminal cells of branch leaf; m. Upper laminal cells of stem leaf; n. lower laminal cells of stem leaf; o. Dry capsule; p. Wet capsule; q. Spores. All from isotype of *M. benguetense* at H-BR. Line scales: A = 0.5 mm (a-d, f, o,p); B = 50 μm (g-m, q); C = 1 mm (g).

There has been no more taxonomic information of *M. schmidii* after it was published (Crosby *et al*., 1999), and no citation about the type of the species could be found in the original publication by Mueller (1853). According to the title of the publication and context, we surmised that Mueller's original description on *M. schmidii* was based on the collection by Perrottet from Neigherri, South India. There were two specimens collected by Perrottet from Neigherri in H-BR, identified as *M. schmidii* by Mueller himself. We selected the specimen marked with "Neigherri, *Perrottet no. 22*" as the neotype (Fig. 1).

M. benguetense was described by R.S. Williams from Baguio of the Philippine in 1914. The type of *M. benguetense* and *M. schmidii* are rather similar except that the capsules of *M. benguetense* are broadly oval with small mouths, and its calyptrae are sparsely hairy, while the capsules of *M. schmidii* are oblong cylindric, and its calyptrae are densely hairy. Here we treated *M. benguetense* as a new synonym of *M. schmidii.*

Based on the type and other specimens of *M. schmidii*, the diagnostic features of *M. schmidii* are: 1) moderate-sized plants with lanceolate branch leaves; 2) upper laminal cells obscure, densely pluri-papillose; median laminal cells rounded-quadrate or subrectangular, bulging or with a single, large conical papilla, or 3–4 low papillae per cell; 3) inner perichaetial leaves ovate-oblong, long-acuminate in upper part, shorter than branch leaves; 4) the laminal cells of the inner perichaetial leaves elongate to linear-elongate from base to top, sinuous, thick-walled, with a single conical papilla; 5) capsules oblong-cylindric or oblong, peristome none, plicate under the mouth.

Distribution: India, Sri Lanka, Philippine, Vietnam (Tan & Iwatsuki, 1993).

Other specimens examined: **INDIA:** Nilgherri, *Perrottet* (H-BR 2595001); Madras, Madura, *G.. Foreau* 1925 (H); Nilghiri, *Suthi B. 7331* (H-BR 2595003). **SRI LANKA**: *Wichura 2744* (H-BR 2595004); Mire Bamforih (H-BR 2595006); ibid, *C. Mueller 41* (H-BR 2595005); Kalak, *T.W.N. Beckett c 29/2*.(H-BR 2595007).

Macromitrium schmidii var. macroperichaetialium S.L. Guo & Cao T., *var. nov.* (Figs. 4-6)

Macromitrium schmidii Muell. satis similes, sed differt foliis perichaetialibus ad 5.5 mm longis, excedenibus foliis vegetatiis. **Type**: China, Kwangtung: Ngok Shing Shan, Sai-lin-shan Village, Sin-fung district; thicket on steep slope. 23-31 March 1938, *Y. M. Taam 402C* (holotype, NY!).

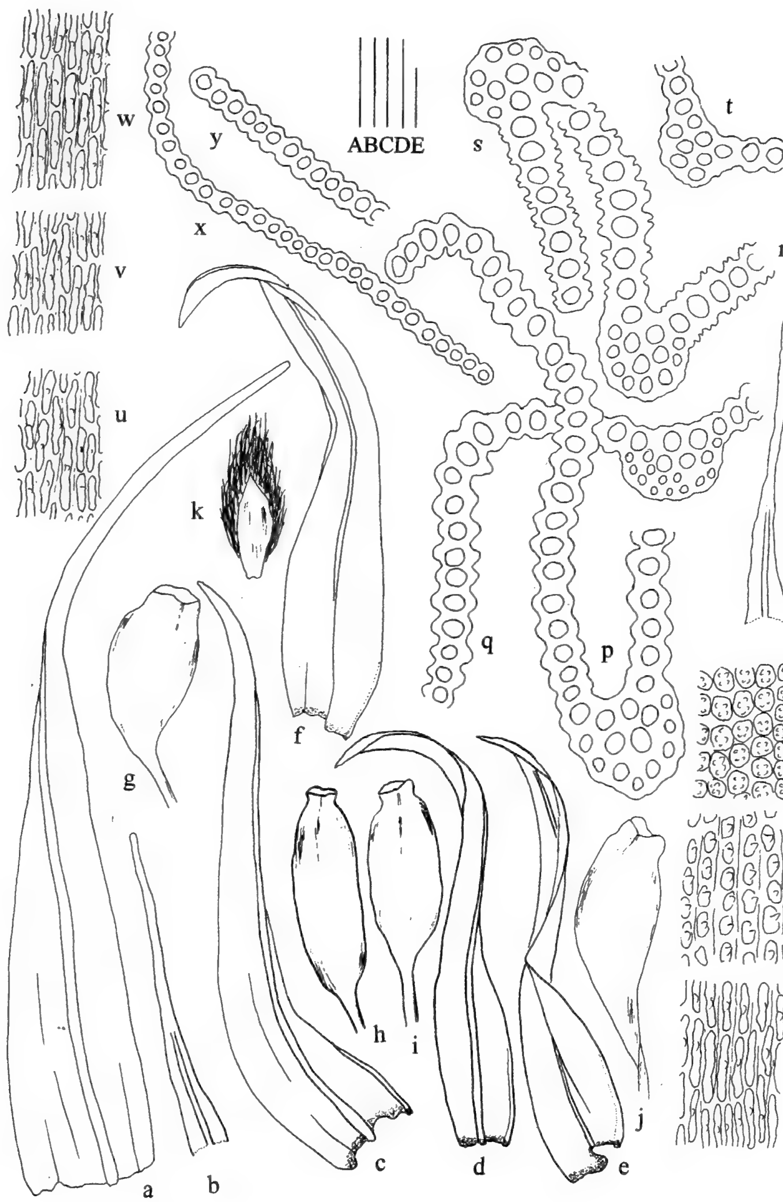

Fig. 4 *Macromitrium schmidii* var. *macroperichaetialium*. a. Perichaetial leaf; b, o. upper part of perichaetial leaf, c-f. branch leaves; g-j. dry capsules; k. calyptra; l. basal laminal cells of branch leaf; m. middle laminal cells of branch leaf; n. upper laminal cells of branch leaf; p. transverse section of the middle part of branch leaf; q. transverse section of the basal part of branch leaf; r, s. transverse section of the upper part of branch leaf; t, y. transverse section of the upper part of perichaetial leaf; u. upper laminal cells of perichaetial leaf; v. middle laminal cells of perichaetial leaf; w. basal laminal cells of perichaetial leaf; x. transverse section of the middle part of perichaetial leaf. All from holotype at NY. Line scales: A = 0.5 mm (a, c-f); B = 50 µm (l-n, p-y); C = 2 mm (k); D= 1 mm (b, o); E= 0.5 mm (g-j).

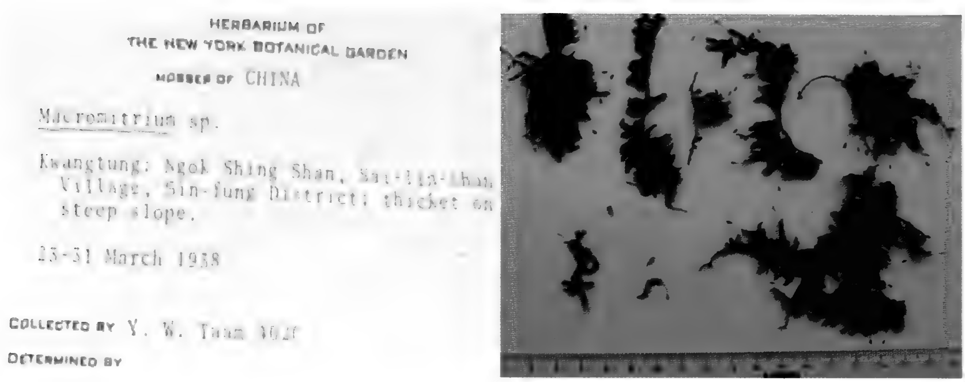

Fig. 5. Holotype and habit of *M. schmidii* var. *macroperichaetialium* in NY.

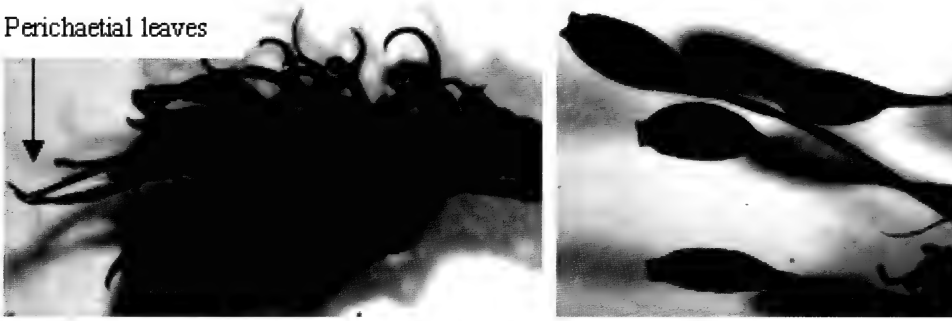

Fig. 6. *M. schmidii* var. *macroperichaetialium* showing the perichaetial leaves and the gymnostomous capsules constricted below the mouth in a 4-angled or 4 –furrowed shape.

Plants moderate-sized, forming yellowish-brown mats, darkish below. **Stems** creeping, up to 10 cm long, with erect branches, branches 10–15 mm high and 1–2 mm wide. **Branch leaves** moderately crisped and somewhat twisted when dry, widely spreading when moist, entire, lanceolate, (2.5) 2.7–3.5 mm long, 0.4–0.6 mm wide, the apex acuminate, somewhat incurved, keeled, slightly plicate below; margins entire, plane on one side, reflexed-recurved on the other, particularly in lower portion; costa single, prominent, ending below the apex or in the apex; laminal cells unistratose from top to base; upper laminal cells subquadrate-rounded to rounded-quadrate, 9–12 μm wide, obscure, pluri-papillose; median laminal cells rounded-quadrate or slightly elongate, thick-walled, 10–11 μm wide, 13–14 μm long, with a single, large conical papilla or pluripapillae; basal laminal cells rectangular to sublinear, 22–30 μm long, 6-8 μm wide, strongly thick-walled and sinuous, often with a single large papilla per cell.

Sporophytes lateral on branches. **Inner perichaetial leaves** lanceolate, gradually long-acuminate in upper part, up to 5.5 mm long, much longer than branch leaves; costa long excurrent, slightly coarse in the upper part; the laminal cells of the perichaetial leaves elongate to linear elongate from base to top, sinuous, thick-walled, with a single conical papilla per cell; Paraphyses numerous. Setae (4) 6–7 mm, smooth, twisted to right. **Capsules** oblong-cylindric or oblong, 1.3–1.5 mm long, 0.5–0.65 mm wide, brown, constricted below the mouth in 4-angled or 4-furrowed shape, peristome absent. Spores not seen. **Calyptrae** large, cucullate, 2.0–2.5 mm long, with many long, flexuose or stiff, brown-yellowish hairs.

The specimen marked as "China, Kwangtung: Ngok Shing Shan, Y. M. Taam 402C (NY) " shares the following characteristics with the neotype of *M. schmidii* at H-BR: 1) moderate-sized plants, with lanceolate branch leaves; 2) upper and median laminal cells subquadrate-rounded to rounded-quadrate, obscure, pluripapillose; basal laminal cells rectangular to sublinear, strongly thick-walled and sinuous, often with a single large papilla per cell; 3) the laminal cells of the inner perichaetial leaves elongate to linear-elongate from base to top, sinuous, thick-walled, with a single conical papillae; 4) gymnostomous capsules. However, the inner perichaetial leaves of the specimen (*Taam 402C*, NY) are long lanceolate, gradually long-acuminate in upper part, much longer than branch leaves, its capsules distinctly constricted below the mouth in a 4-angled or 4-furrowed shape, while the inner perichaetial leaves of *M. schmidii* are similar to its branch leaves, and its capsule only plicate or ribbed without a constriction under the mouth in a 4-angled or 4-furrowed shape. We consider that the specimen represents a hitherto undescribed taxon, here we placed it at variety level and named it as *Macromitrium schmidii* var. *macroperichaetialium* based on its longer inner perichaetial leaves. *Distribution*: China.

Macromitrium heterodictyon Dix., Hong Kong Naturalist, Suppl. 2: 12. 6. 1933. (Fig. 7). **Type**: China, Hong Kong, granite rock, 100-200 ft. alt., Amoy I, 11 Jul 1931, coll. *Herklots* (*B.17 E*) (holotype, BM!); Hongkong, coll. *Ah Nin (B. 21E)*, 12 Jul 1931 (paratype, BM!); Hongkong, granite rock, 1,000-1,500 ft. alt., Shaukiwan, coll. *Ah Nin (H. 4I)*, 5 Oct 1931 (paratype, BM!); Hongkong, Lan Yau Peak, Lan Tau Is., coll. *Herklots 359* (paratype, BM!).

Plants small to moderate-sized, forming yellowish-brown mats. **Stems** creeping, up to 4 cm long, with erect branches, branches 5–6 mm high and 1–1.3 mm wide. **Branch leaves** strongly crisped when dry, widely spreading when moist, entire, long lingulate or lanceolate, 2.5-3 mm long, 0.4–0.5 mm wide; the apex acute or acuminate, somewhat incurved, keeled, slightly plicate below; margins entire, usually plane on one side and recurved on the other; costa single, prominent, ending below the apex or rarely in the apex, smooth; laminal cells unistratose, clear and smooth from top to base, moderate thick-walled; upper and median laminal cells small and clear, in diagonal rows, subquadrate-rounded to rounded-quadrate, 5–7 μm wide, gradually elongate from lower part to base. Basal laminal cells along costa rectangular, thin-walled, 7.5–12.5 μm wide, 20–30 μm long, looking like "calymperoid" cells, those near margins elongate, rectangular to sublinear, 17.5–42 μm long, 5–10 μm wide, thick-walled and slightly sinuous.

Sporophytes lateral on branches. **Inner perichaetial leaves** similar to branch leaves, ovate-oblong, acuminate, 2.5–3 mm long, 0.5–0.6 mm wide; costa smooth, ending below the apex; laminal cells quadrate or subquadrate, smooth and clear. Paraphyses numerous. Setae 2–3 mm, smooth, twisted to right. **Capsules** oblong-cylindric or oblong, 1.6–2 mm long, 0.6–0.9 mm wide, brown, constricted or slightly constricted below the mouth in 4-angled or 4 –furrowed shape, peristome absent. **Calyptrae** rather large, campanulate, 2.5–3 mm long, with many long, brown-yellowish hairs. Spores not seen.

M. heterodictyon is somewhat similar to *M. schmidii*, but differs from the latter by its smooth and clear laminal cells from leaf top to base, and the capsules constricted below the mouth in a 4-angled or 4-furrowed shape. It is also similar to *M. schmidii* var. *macroperichaetialium* in their plant and capsule shape, but the new variety could be distinguished from *M. heterodictyon* by its pluripapillose laminal cells and its longer inner perichaetials leaves with gradually long-acuminate upper part.

In Dixon's original publication of *M. heterodictyon,* he considered the species similar to *M. japonicum*, only differed from the latter by its gymnostomous capsules. Our check on the types of *M. heterodictyon* shows that *M. heterodictyon* is distinctly different from *M. japonicum* by its clear and smooth laminal cells without any papillae, while the upper and median laminal cells of *M. japonicum* are obscure and densely pluripapillose.

M. heterodictyon Dix. is a distinct species, its diagnostic features are: 1) plants small to moderate-sized, branches short, less than 6 mm high; 2) laminal cells smooth and clear from top to base, median and upper laminal cells in diagonal rows, moderately thick-walled, basal laminal cells along costa rectangular, thin-walled, "calymperoid" in areolation; 3) inner perichaetial leaves ovate-oblong, acuminate, similar to branch leaves in length; 4) oblong-cylindrical to oblong gymnostomous capsules, constricted below the

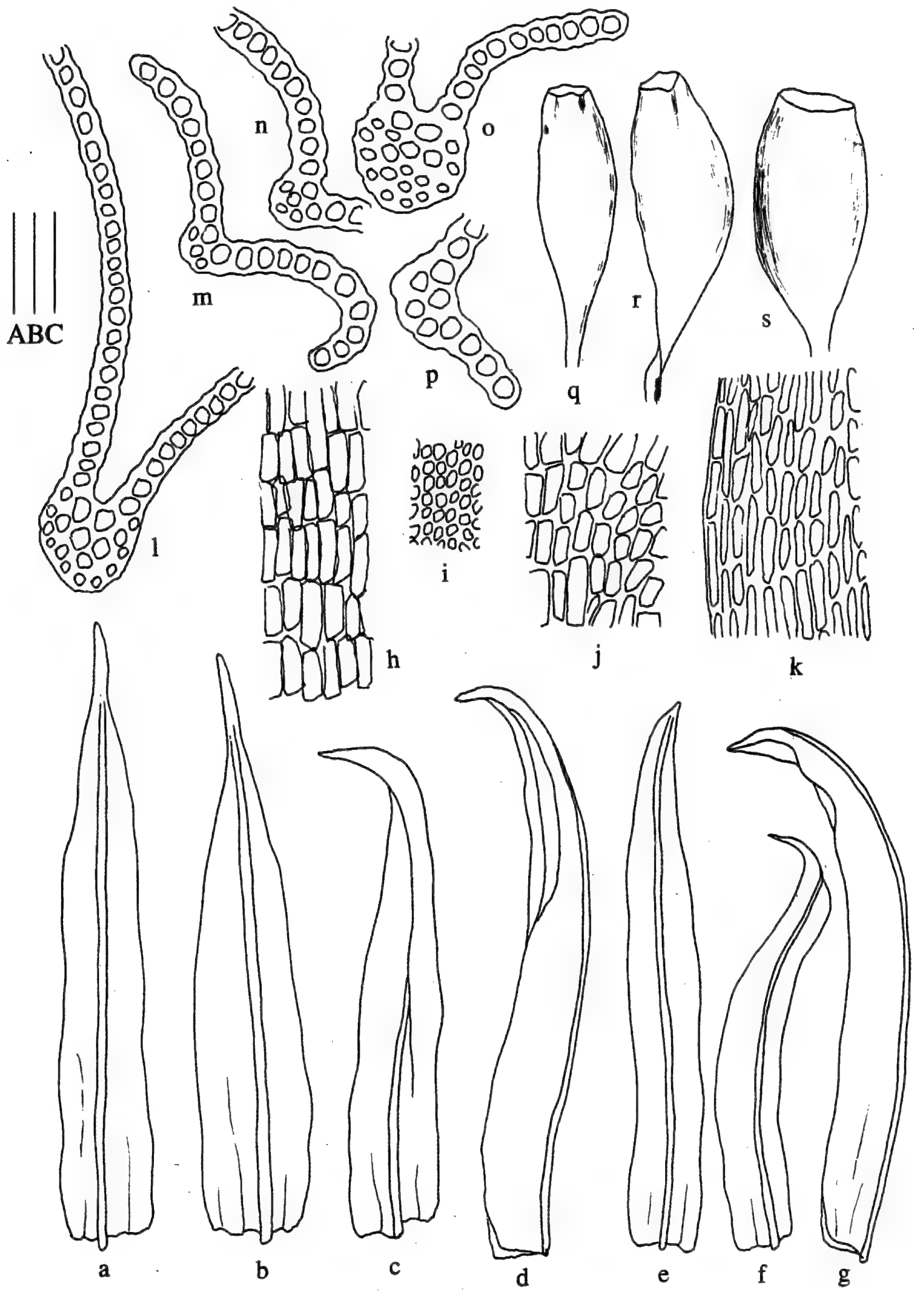

Fig. 7. *Macromitrium heterodictyon* Dix. a-b. Perichaetial leaves; c-g. Branch leaves; h. Basal lamina cells near costa; i. Upper laminal cells; j. Lower laminal cells; k. Basal laminal cells near margins; l. Transverse section of the basal part of leaf; m-o. Transverse section of the middle part of leaf; p. Transverse section of the upper part of leaf; q-r. Dry capsules; s. Wet capsule. All from holotype of *M. heterodictyon* at BM. Line scales: A = 0.5 mm (a-g); B = 50 µm (h-p); C= 0.8 mm (q-s).

mouth in a 4-angled or 4 –furrowed shape; and 5) calyptrae rather large, campanulate, up to 3 mm long, with many long, brown-yellowish hairs.

Distribution: China.

Macromitrium gymnostomum Sull. & Lesq., Proc. Am. Ac. Arts Sc. 4: 278. 1859. (Figs. 8–10)
Type: Japan, Shizuoka Pref., Simoda, *Wright* (lectotype selected by Noguchi, 1967, FH, not seen; isolectotype, NY00512839!); Japan, Ousima, one of the northern Loo Choo Islands (syntype, NY00512840!).
Macromitrium brevituberculatum Dix., Hong Kong Naturalist, Suppl. 2: 14. 5. 1933. *syn. nov.* **Type**: "Granite rock, 1,000-1,500 ft. alt., Shaukiwan, Hong Kong Is, 5 Oct 1931, coll. *Ah Nin* (*H.8*)."(holotype, BM 000576135!); "near sea level, Stanley, Hong Kong, 14 May 1931, coll. *Ah Nin (H. 43A)*" (Paratype, BM 000576134!).
Macromitrium robinsonii R.S. Williams, Bull., New York Bot. Gard. 8: 344, 1914, *syn. nov.* **Type**: "Philippines, Upper Lamao River, on tree, 1000 meters, Jan 1904, *Williams 1760*" (isotype, H-BR 2617006!)

Plants small to medium-sized, in dense, dark or reddish-brown mats, younger parts dark-greenish. **Stems** elongate, sparsely leaved, densely covered with reddish rhizoids; branches erect, up to 5 mm long, simple, or with several short branchlets. **Branch leaves** crisped when dry, widely spreading when moist, linear or linear-lanceolate, 1–2.5 × 0.15–0.2 mm; keeled, apex obtuse acute, acute or acuminate, lower half of leaves yellowish and hyaline, upper half rather obscure, leaf margins sometimes slightly recurved; costa yellowish-brown, reaching or almost reaching to the apex; laminal cells unistratose from top to base; median and upper laminal cells rather obscure, rounded or rounded-hexagonal, 4–5 μm, thin-walled, densely pluri-papillose; lower cells longer, rectangular, with or without papillae, basal cells linear, 8–25 μm long, with thickened walls, smooth.

Sporophytes lateral on branches. Inner perichaetial leaves ovate-lanceolate, acuminate, costa extending to leaf apex; laminal cells hyaline, smooth. Paraphyses numerous, slightly exserted beyond leaves. **Setae** brown, smooth, usually 5–8 mm long. **Capsules** obloid-cylindric, brown, deeply plicate, constricted at mouth when dry, peristome absent; operculum conic-subulate. **Spores** finely papillose, 20–25 μm diameter. **Calyptrae** cucullate, 1.7–2 mm long, somewhat lobed and plicate, naked.

M. brevituberculatum was described by Dixon in 1933 based on the

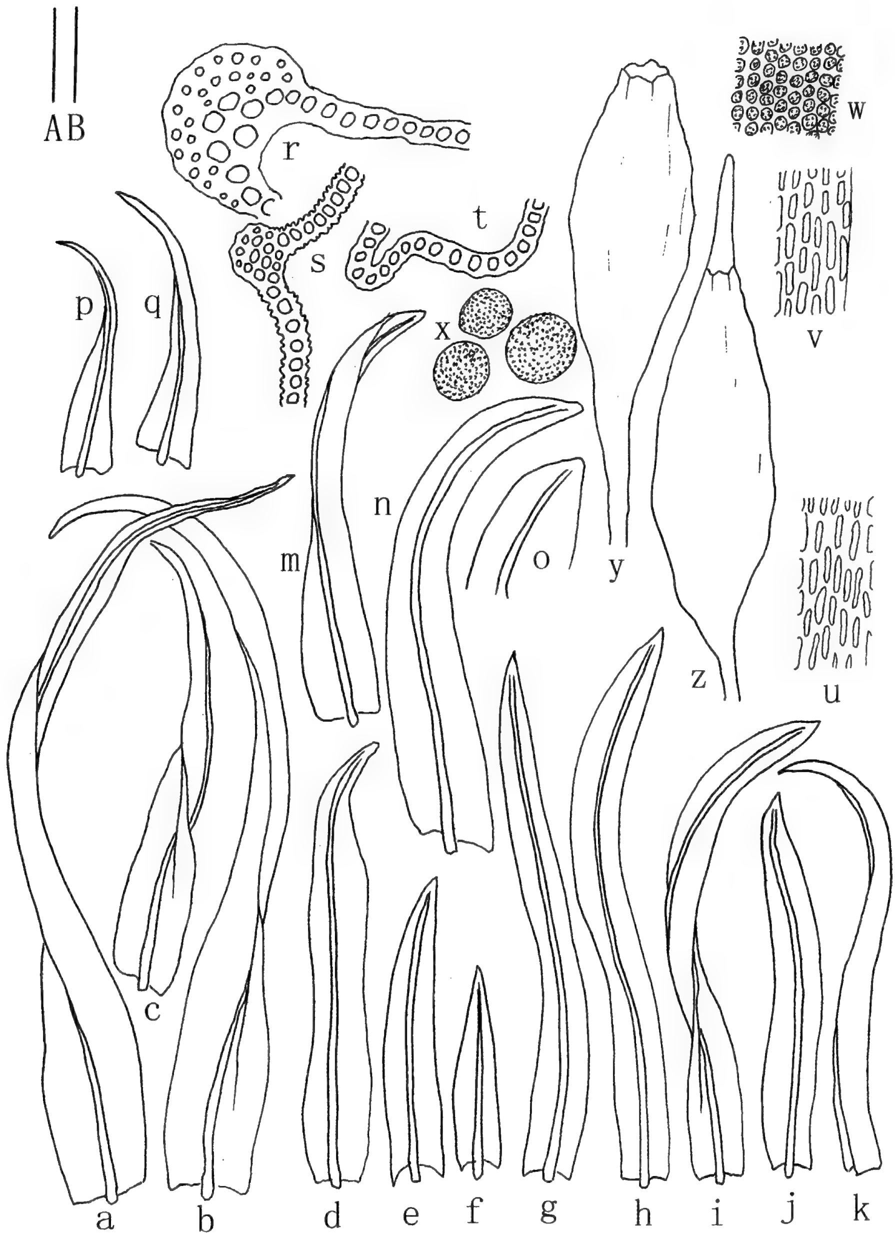

Fig. 8. *M. gymnostomum*. a-d, g-n. Branch leaves; o. Apex of branch leaf; p-q. Stem leaves; r, t. Basal transverse section of leaf; s. Upper transverse section of leaf; u. Basal laminal cells; v. Basal laminal cells near margins; w. Upper laminal cells; x. Spores; y-z. Capsules. (a-c, p-r,x from Hongkong, *Merrill 11159*, marked as "*M. gymnostomoides* Broth."; e-k, s-w, y-z, from isolectotype of *M. gymnostomum*; m-o from Japan, *Ferrie*, marked as "*M. subgymnostomum* Ther.). Line scales: A = 0.5 mm (a-n, p-q, y-z); B = 50 μm (r-x).

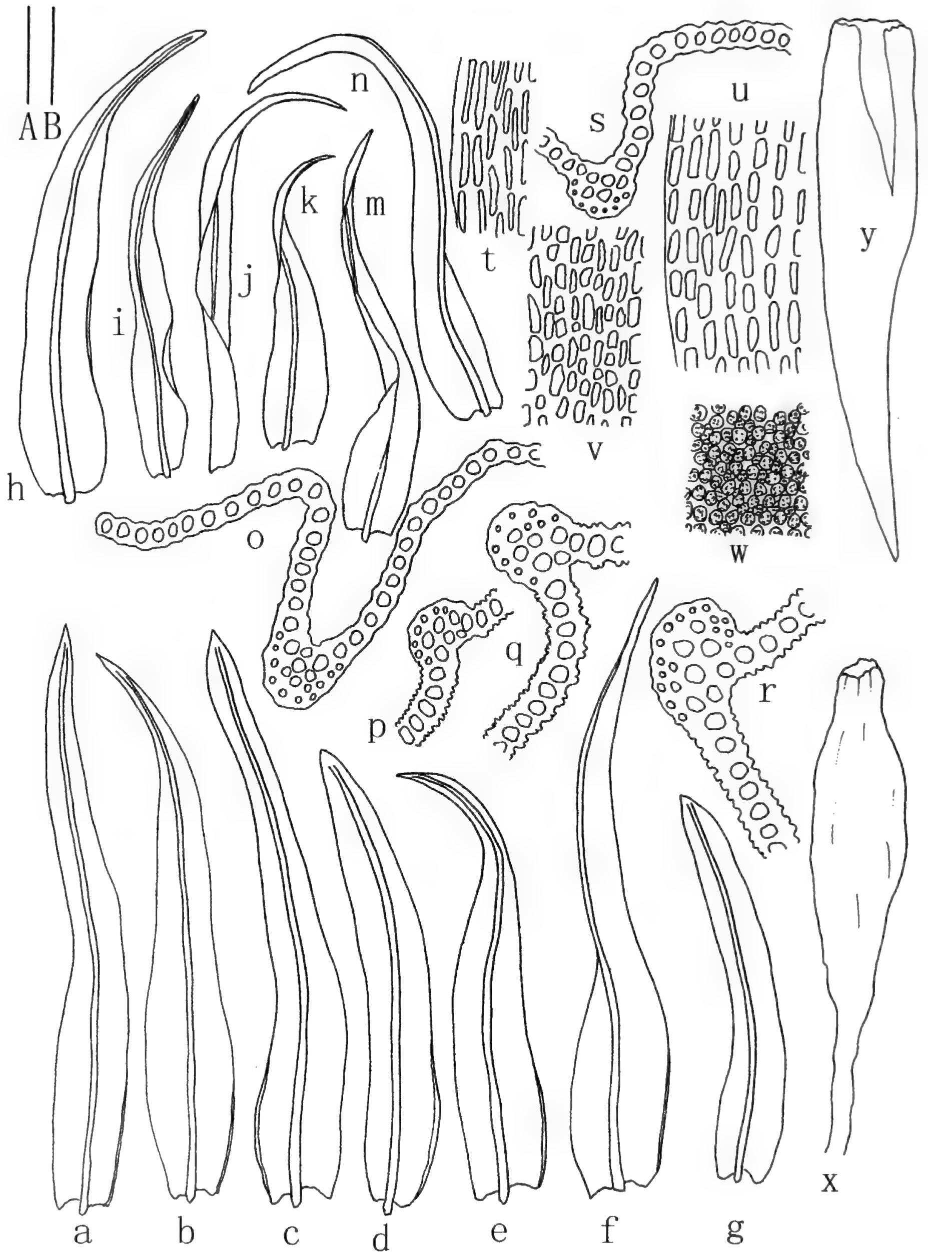

Fig. 9. M. gymnostomum. a-n. **B**ranch leaves; p-r. Upper transverse section of leaf; o,s. Basal transverse section of leaf; t, u. Basal laminal cells near margins; v. Low laminal cells; x. Dry capsule; y. Calyptra. (a-g, o-r, u from holotype of M. brevituberculatum Dix. at BM); (h-n, s-t, v-y from isotype of M. robinsonii at H-BR). Line scales: A = 0.5 mm (a-n, x-y); B = 50 μm (o-w).

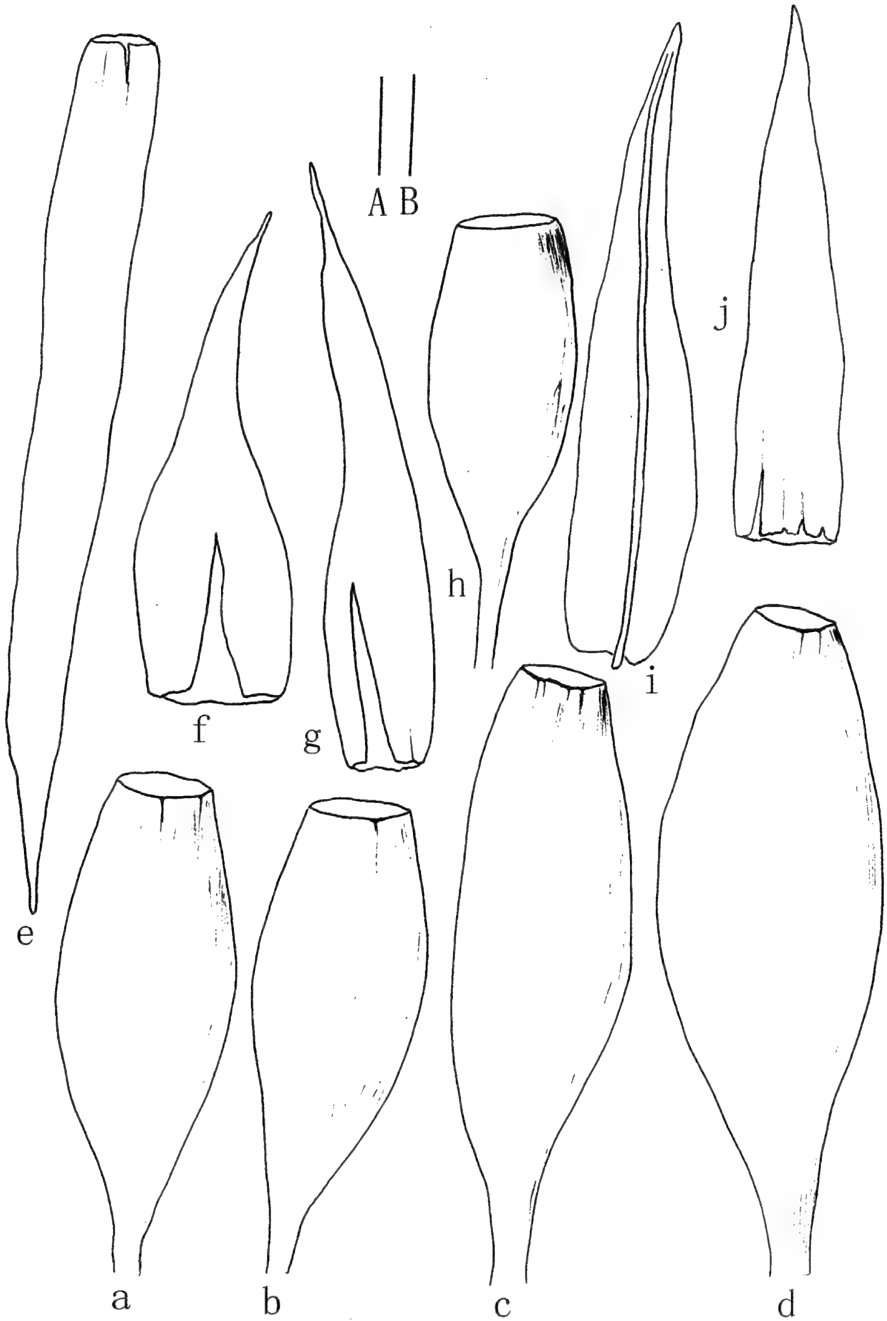

Fig. 10. *M. gymnostomum*. a-d, h. Wet capsules; e-g, j. Calyptrae in different stages; i. Perichaetial leaf. (a from isolectotype of *M. gymnostomum* at NY; b-c, e from Japan, Ferriei, marked as "*M. subgymnostomum* Ther."; f-i from isotype of *M. robinsonii* at H-BR; j from holotype of *M. brevituberculatum* Dix. at BM). Line scales: A = 0.50 mm (a-h, j); B = 0.2 mm (j).

collection by Youngsaye from Taimoshan, Hong Kong, and *M. robinsonii* by R.S. Williams in 1914 based on the material from the Upper Lamao River in the Philippine (in memory of C.B. Robinson who lost his life on a collecting trip). Our check of their types showed that these three species belong to the same taxon, therefore we treated *M. brevituberculatum* and *M. robinsonii* as two new synonyms of *M. gymnostomum*.

Macromitrium gymnostomum was described by Noguchi in details in 1967. The morphological characters of *M. gymnostomum* are relatively stable. Most specimens of this species are characterized by their lanceolate, linear-lanceolate or oblong-lanceolate branch leaves with acute or acuminate apices, usually 1–2.5 × 0.15–0.2 mm. There is a specimen in H-BR collected from Hong Kong, China, marked as "*Macromitrium gymnostomumoides* Broth. sp. nov." (HB2541002). This specimen is rather special in having long linear branch leaves, up to 3.6 mm long, with long acuminate apices. Another specimen collected from Japan was marked as "*Macromitrium subgymnostomum* Thèr. sp. nov." (HB2541001). It is characterized by short lanceolate branch leaves with obtuse acute apices. We consider that the branch leaves of *M. gymnostomum* can vary from lanceolate with obtuse or acute apices to long linear with long acuminate apices, and so, both specimens fall into the range of leaf variation of *M. gymnostomum*. *M. gymnostomum* is easy to separate from other gymnostomous taxa in Asia by its naked calyptrae.

Distribution: China, Japan, Korea, Philippine, Vietnam (Tan & Iwatsuki, 1993).

Other specimens examined: **CHINA: Taiwan**, collector not clear, *no. M3*; **Fujian**, Mt. Wuyi *Guo S.-L. 030001-030008* (SNUH); Amoy, *Chung* (NY); Hong Kong, Loh Fau Mountain (Lofaushan), *E.D. Merrill 11159*, marked as "*Macromitrium gymnostomoides* Broth., new sp."(H-BR 2541002); **Kwangtung** (Guangdong)**,** Ngok Shing Shan, Sai-lin-shan village, *Y.W. Taam 402A* (H); **Hunan**, Badagongshan, *Enroth 58960* (H); Changsha, Mt. Yuelu, *Enroth 48962* (H); Daweishan. *DAW16*, *Virtanen 61994* (H); Mangshan, *Koponen et al. 51680, 51449, 51411, 50762* (H); Shunhuangshan., *Enroth 70674, 70760* (H); Taoyuandong, *Koponen et al. 55092* (H); Wulingyuan, *Koponen et al. 53352, 52057,* 58525 (H); Yuankou, *Enroth 59595* (H); Yunshan, *Enroth 70130* (H). **Zhejiang**, Hangzhou, Tianmu Mountain, *W.R. Buck 23916* (H). **JAPAN: Kagoshima**, Sumiyo-mura, Island. Amami-ohshima, *K. Saito* (H); **Okamura**, Mt. Maya Settsu, *Shutai 684* (H); Okamura, Mt. Kuishi, Tosa, *Shutai 202* (H); Liou, Kine Sushi, 20 Apr 1898, *Ferrie*, marked as "*Macromitrium subgymnostomum* Ther. sp. nov" (H-BR2541001); **Wakayama**, Syögawa, Shirahama-chö. Nishimuro-gun, *T. Nakajima 1129* (H); Ohara, Yuya, Oto-mura, Nishimuro-gun, *T. Nakajima 1229* (H); **Higo,** Aida, *K. Mayebara 3623* (H); **Kumamoto**, Koonose, *K. Mayebara 430* (H).

Macromitrium taiheizanense Nog., J. Sc. Hiroshima Univ. ser. B(2), Bot. 3: 11. 1. 1936. (Fig. 11)
Type: "Formosa: Mt. Taiheizan (ca 2000m), Prov. Taihoku, Aug 1932 (*A. Noguchi 6548*-type, holotype, NICH 365243!)

Plants robust, yellow-brownish above, dark-brownish below, in mats. **Stems** creeping, branches up to 7–8 mm high, densely covered with reddish rhizoids. **Branch leaves** regularly, strongly and spirally twisted when dry, flexuose-spreading when moist, entire, funiculate, or gradually narrowed to a slender acuminate acumen or subula from a broadly lanceolate to ovate-oblong lower portion, 5–7 mm long, 0.5–0.6 mm wide at base, leaf basal longitudinal plicate; margins entire plane; costae ending in the apex; laminal cells unistratose from top to base; upper and median laminal cells smooth and clear, subquadrate-rounded to rounded-quadrate, 8-10 μm wide; basal laminal cells somewhat sinuous, gradually elongate from lower part to base, thick-walled, 22–50 μm, 3.5-7.5 μm wide, bulging and with a papillae per cell.

Sporophytes lateral on branches. Inner perichaetial leaves ovate-oblong, long-acuminate in upper part, 6–7 mm long, similar to the branch leaves in length. Setae rather short, 1–1.2 mm long. **Capsules** ovate, 1.4–1.5 mm wide, 1.6–1.9 mm long, brown, slightly ribbed under a smooth mouth; peristome absent. **Spores** not seen. **Calyptra** campanulate, with many long, yellowish hairs.

M. taiheizanense is a very distinct species, and could be separated from its allies by its funiculate or linear to linear-lanceolate branch leaves with smooth and clear laminal cells from top to middle.

Distribution: China (Taiwan).

Macromitrium formosae Card., Beih. Bot. Centralbl. 19(2): 104. 8. 1905. (Fig. 12)
Type: "Formosae: Kelung, 1903, *Faurie 181*" (isotype, H3090260!)

Plants medium-sized, forming yellowish-brown mats. **Stems** creeping, with erect branches, branches up to 10 mm high. **Branch leaves** crisped when dry, flexuose-spreading when moist, entire, lanceolate to linear-lanceolate,

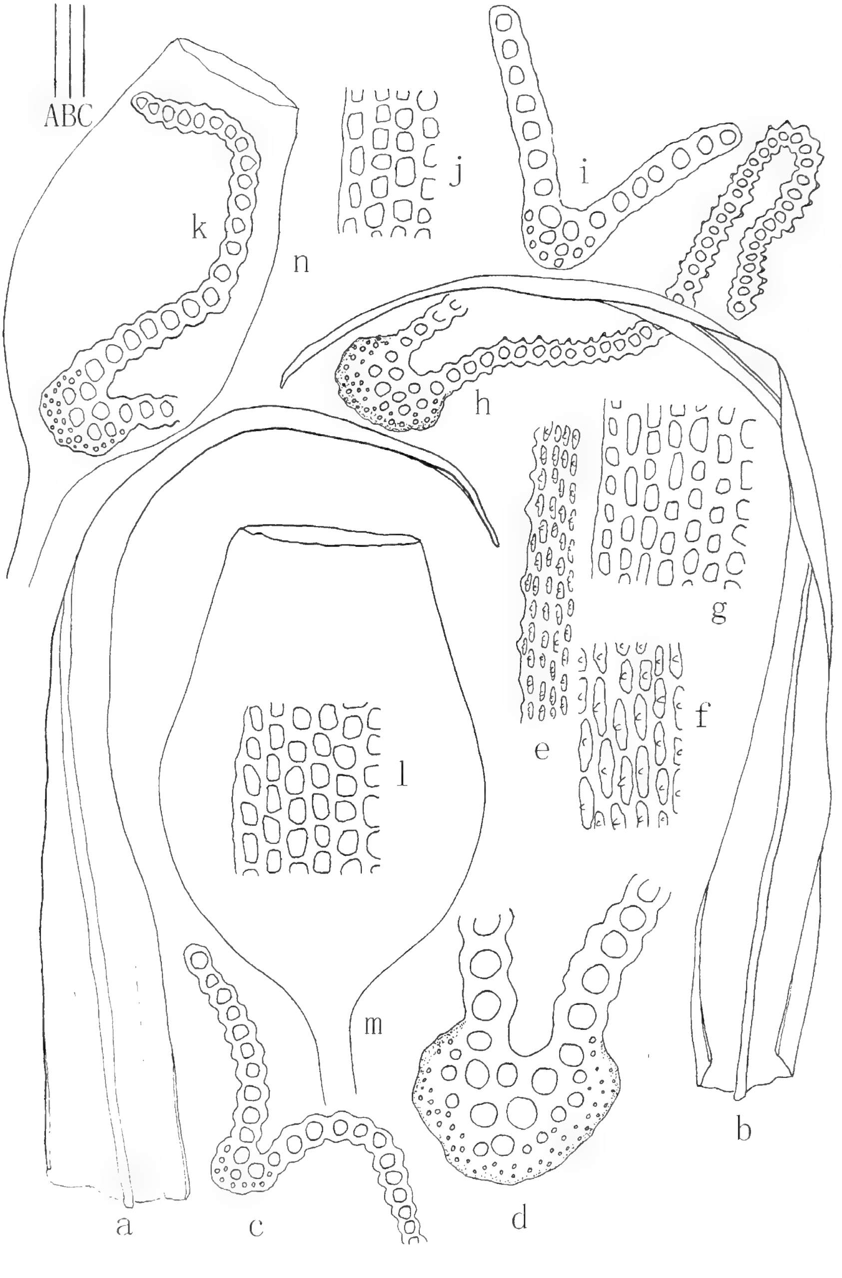

Fig. 11. *M. taiheizanense*. a-b. Branch leaves; c-d, k, i-h. Transverse sections of leaf; e. Lower laminal cells near margin; f. Lower laminal cells;.g. Lower laminal cells near margin; j. Upper laminal cells; m-n. Capsules. All from holotype of *M. taiheizanense* at NICH). Line scales: A = 0.5 mm (a-b, m-n); B = 80 µm (c, h, k); C = 50 µm (d, l, f, g, i-j).

acuminate, revolute below on one side, and somewhat plicate at base. 2.3–2.7 mm long, 0.25–0.4 mm wide; costae single, prominent, ending below the apex; laminal cells unistratose from top to base; upper and median laminal cells irregularly quadrate, 7–8 μm wide, rather obscure, densely pluripapillose, basal laminal cells 12–20 μm long, 3–4 μm wide, cell walls sinuous and thick, without papilliae, those along the basal margins regular and smooth. Setae 5–6 mm long, smooth. **Inner perichaetial leaves** similar to branch leaves. **Capsules** ovate, 1.2–1.4 mm long, 0.65–0.8 mm wide, brown, with a small mouth, slightly ribbed below the mouth when dry; peristome absent. **Calyptrae** campanulate, with many long, brown-yellowish hairs.

M. formosae Card. was described by J. Cardot based on the collection of Faurie from Taiwan in 1905. He had compared it with *M. tylostomum* Mitt. even the latter was distinctly different from *M. formosae* by its larger plants, much wider branch leaves with obtuse to subacute apices with a distinct apiculus (Eddy, 1996). In fact, *M. formosae* is somewhat similar to *M. gymnostomum* in appearance, branch leaf shape and laminal cells, but could be separated from the latter by its hairy calyptrae.

Distribution: China (Taiwan), Philippine (Tan & Iwatsuki, 1991)

Macromitrium holomitrioides Nog., J. Sc. Hiroshima Univ. ser. B(2), Bot. 3: 135. 1938.
Type: "Taiwan, Taihoku, Rahau, *Noguchi*" (holotype, HIRO, not seen)

M. holomitrioides Nog., a species recorded from Japan (Kyushu) and China (Taiwan), was described in details by Noguchi (1938, 1967, 1989). Based on Noguchi's descriptions and our check on the non-type specimens, we found that *M. holomitrioides* is similar to *M. schmidii* var. *macroperichaetialium* in their branch leaf shape, capsules constricted or slightly constricted below the mouth in a 4-angled or 4 –furrowed shape, but the former could be separated from the latter by: 1) its broad leaves with large, mammillose or bulging, collenchymatous upper and middle laminal cells; 2) sublinear or subrectangular basal laminal cells without papillae.

Specimens examined: **CHINA:** Hainan island, Jianfengling Mt., *P.C. Chen et al. 789b* (H); ibid, *P.C. Wu W1185016* (H).

Distribution: China, Japan.

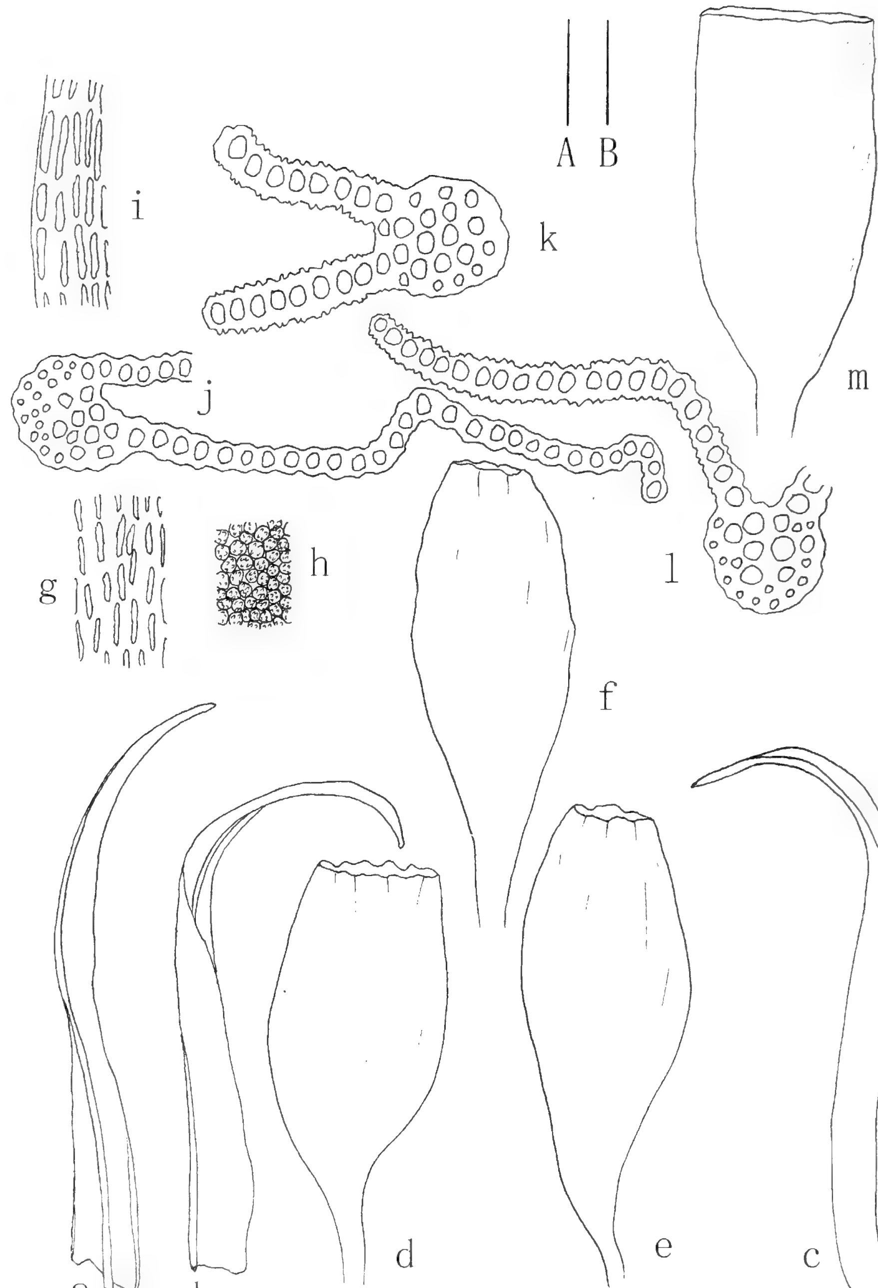

Fig.12. *M. formosae* Card. a-c. Branch leaves; d-f. Dry capsules; m. Wet capsule; g. Basal laminal cells; h. Upper laminal cells; i. Basal laminal cells near margin; j-l. Transverse sections of leaf. All from isotype of *M. formosae* at BH. Line scales: A = 0.5 mm (a-f, m); B = 50 μm (g-l).

Discussion

Taxonomically, the above seven species belong to Sect. *Goniostoma* in the subgenus *Macromitrium*. Based on our checking on the literature and specimens, seven taxa with gymnostomuous capsules of the genus *Macromitirum* in East Asia are confirmed. The main identification characteristics of these seven taxa are the calyptra, shape of branch leaves and inner perichaetial leaves, papillosity of laminal cells and capsule shape. The following key can be applied to separate the above seven taxa.

1. Calyptrae naked, without hairs.............................. ***M. gymnostomum***
1. Calyptrae hairy.. 2

2. Branch leaves funiculate, or linear to linear-lanceolate, up to 5-7 mm long .... ***M. taiheizanense***
2. Branch leaves lanceolate, shorter than 5 mm long 3

3. Median and upper laminal cells smooth or almost smooth .... ***M. heterodictyon***
3. Median and upper laminal cells pluripapillose, mammillose, bulging or collenchymatous 4

4. Median and upper laminal cells mammillose, hyaline, collenchymatous, basal laminal cells smooth .... ***M. holomitrioides***
4. Median and upper laminal cells pluripapillose, basal laminal cells tuberculate or smooth 5

5. Basal laminal cells without papilla .... ***M. formosae***
5. Basal laminal cells tuberculate or with a high papilla 6

6. Inner perichaetial leaves ovate-oblong with acuminate apex, shorter than branch leaves .... ***M. schmidii***
6. Inner perichaetial leaves long lanceolate with linear acuminate apex, much longer than branch leaves .... ***M. schmidii* var. *macroperichaetialium***

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VARIATIONS IN THE *HOYA VERTICILLATA* COMPLEX IN THAILAND

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Abstract

Hoya verticillata (Vahl) G.Don *s.l.* is a climbing epiphyte belonging to the family Apocynaceae. At present, the taxonomic status of this species in Thailand is still uncertain due to the great variability of size, shape and colour of leaf and flower. Morphological variations were explored in 500 fresh plants collected from 50 sites throughout the country. The collected specimens represent the *H. verticillata* complex, including two polymorphic species, namely *H. verticillata s.l.* and closely related species, *H. rigida* Kerr. Based on qualitative macro- and micro-morphological characters, the *H. verticillata* complex can be divided into nine groups. They can be distinguished by leaf shape, leaf base, venation pattern, leaf indumentum, and shapes of sepal, corona and corpusculum. Group I matched with the characteristics of *H. rigida* Kerr, which has ovate leaves with cordate base, 3-5 prominent nerves running from base to apex; indumentum absent on the abaxial surface; and lanceolate sepals. In contrast, Group II is an unidentified taxon that is close to *H. verticillata* (Vahl) G. Don var. *citrina* (Ridl.) Veldkamp. It is charaterized by broad ovate leaves with cordate base, 3-5 prominent nerves running from base to apex; and narrowly oblanceolate-oblong corpusculum. Groups III and IV have distinctly different vegetative characters and do not correspond to the previously described varieties of *H. verticillata*. Their leaf venation is acrodromous, with 3 prominent nerves running from leaf base parallel to the midrib and reaching the apex, but they are different in their shape of leaf and coronal scale. Group III has ovate leaves with subcordate base and elliptic coronal scale, while Group IV has elliptic-oblong leaves with cuneate base and ovate-lanceolate corona. Groups V-IX are still of weak validity, having slightly discontinuity in leaf shape, base and venation; and shape of coronal scale. They are treated in this paper as variable groups within *H. verticillata* var. *verticillata*.

Introduction

Hoya verticillata (Vahl) G.Don (Apocynaceae: Asclepioideae) is one of the most common members of the section *Hoya* (Hooker *f.*, 1883). It is relatively widespread, occurring from E. India-Assam through Myanmar, Thailand, Indo-China, Malay Peninsula, and Sumatra to N. Borneo (Rintz, 1978). The most recent taxonomic study of the species (Kiew, 1995; Veldkamp *et al.*, 1995) included three varieties: *H. verticillata* var. *verticillata*, *H. verticillata* var. *citrina* and *H. verticillata* var. *hendersonii*. These varieties can be distinguished from each other by leaf characters and habitat. *H. verticillata* var. *verticillata* is distinguished from the other two varieties by its elliptic leaf, cuneate base, obscure veins with the lowest pair extending about halfway to apex. The other two varieties are similar in having an ovate leaf with slightly cordate base, but with conspicuous veins and the lowest vein pair extending to apex. As for habitat, var. *hendersonii* grows in lower montane forest between 1,200 and 1,260 m altitude, while the other two are lowland varieties (Kiew, 1995).

In Thailand, *H. verticillata s.l.* is the most common hoya, and is an extremely variable species. There is variation in texture, shape, size and venation of leaves, the size of the flower and shape of corolla lobes (Kerr, 1951). These plants were later named "the *H. verticillata* complex" (Thaithong, 1995). However, variations within this complex did not match properly with the three fomerly recognized infraspecific taxa. Additional intensive research into relationships within this difficult group of plants has not been carried out for many years.

Moreover, previously distinct species, *H. ridleyi* and *H. rigida* have been taxonomically confused with *H. verticillata s.l.* *H. ridleyi* is found in peninsular Thailand (Ridley, 1923), but has also been recognized as *H. parasitica* var. *parasitica*, the synonym of *H. verticillata* var. *verticillata* (Rintz, 1978). Then, Veldkamp *et al.* (1995) suggested that *H. rigida,* a species endemic to Thailand, may be included in *H. verticillata s.l.*. Thus, the taxonomic status of *H. verticillata* complex in Thailand is still uncertain and needs to be reinvestigated.

We suspect that *H. verticillata* complex in Thailand is composed of several undescribed taxa. We have explored all the available variables in the complex and have determined macro- and micro-morphological variations of each group. In this paper, we have (1) described the overall qualitative morphological variations of characters in the complex, (2) classified the variations into groups, and (3) described morphological characters, geographical distribution and ecological features of each recognized group.

We then (4) discuss the taxonomic treatment of these recognized groups as compared with the previous classification.

Materials and methods

Plant Morphology
Plant materials used in this study were collected from 50 sites throughout Thailand during 2002-2003 (Table 1, Fig. 1) and all were raised in the same conditions in a greenhouse at the Department of Botany, Faculty of Science, Chulalongkorn University. Flower and leaf materials were then gathered from the living collection. These were preserved in 70% ethanol for further morphological studies. In general, the morphological characters of leaves and flowers were examined using light microscopy (LM). Leaf indumentum on both surfaces was observed under LM and scanning electron microscopy (SEM).

Habitat and Distribution
Habitats of *H. verticillata* complex were studied and their location recorded using GPS. Collection sites were plotted on an outline map, thus showing their distribution, in relation to forest types and elevation, and characterizing the habitat of particular member of the complex.

Results

General description of *Hoya verticillata* complex (Fig. 2–4)
Glabrous **twiner,** epiphyte, with long internodes. **Leaves** opposite or whorled; *lamina* ovate or elliptic to oblong, glabrous or papillate on abaxial surface; *texture* coriaceous to succulently coriaceous, depending somewhat on habitat; *venation* with three or five principal veins (nerves) arising near the junction of lamina and petiole; *nectary glands* present at the junction of petiole and lamina; *petioles* usually thick and stout, occasionally slender in mature leaves. **Inflorescences** axillary, negative geotropic umbels with almost equal pedicel; **flower** actinomorphic, 5-merous; *pedicels* slender; *calyx* glabrous or covered with hairs on abaxial surface and margin, with a small gland alternately arranged between calyx lobes; *corolla* rotate, abaxial surface glabrous, covered with minute hairs on adaxial surface, reflexed when in full bloom, becoming closed at the end of flowering period; *corolla lobe* ovate-triangular with acute or acuminate apex, inflexed (bent inwards) between corona scales; *corona* longer than corolla tube, coronal scale ovate-elliptic or ovate-lanceolate; the first inner angle abruptly apiculate, slightly raised, the outer angle broadly or narrowly acute, concave on the upper

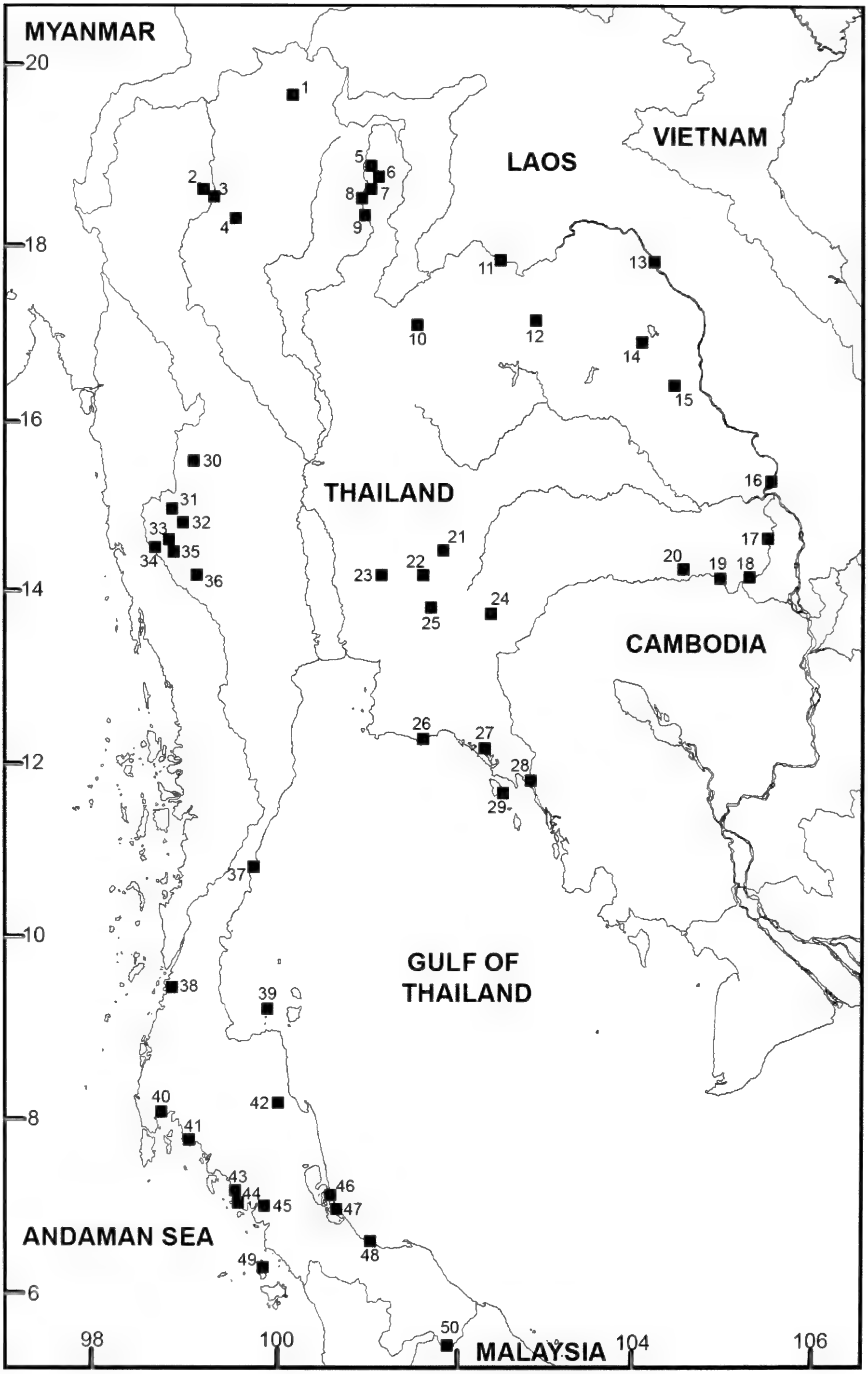

Fig. 1. Sampling sites of *Hoya verticillata* complex in Thailand.

Table 1. Locality and collected groups of the *Hoya verticillata* complex in Thailand.

Site no.[a]	Locality	Group[b]
1.	Mueang, Chiang Rai Province	V
2.	Wang Bua Ban Waterfall, Chiang Mai Province	V, IX
3.	Haew Keaw, Mueang, Chiang Mai Province	VI
4.	Doi Khun Tan National Park, Lampang Province	IX
5.	Silaphet Waterfall, Pua, Nan Province	III, VII
6.	Tat Laung Waterfall, Pua, Nan Province	VII
7.	Ban Muang Wang Nhua, Phu Phiang, Nan Province	IX
8.	Phasing, Mueang, Nan Province	V
9.	Lhinan, Na Noi, Nan Province	VII, IX
10.	Pla Ba Waterfall, Phu Ruea, Loei Province	IX
11.	Than Thong Waterfall, Sri Chiang Mai, Nong Khai Province	IX
12.	Than Ngam Waterfall, Nong Wua So, Udon Thani Province	IX
13.	Tat Kham Waterfall, Ban Phaeng, Nakhon Phanom Province	IX
14.	Phu Phan National Park, Sakon Nakhon Province	IX
15.	Tat Ton Waterfall, Mukdahan Province	IX
16.	Soi Sawan Waterfall, Ubon Ratchathani Province	IX
17.	Huai Sai Yai waterfall, Sirinthon, Ubon Ratchathani Province	IX
18.	Phu Chongna Yoi National Park, Ubon Ratchathani Province	IX
19.	Tat Hai Waterfall, Nam Yuen, Ubon Ratchathani Province	IX
20.	Sam Long Kiat Waterfall, Khun Han, Si Sa Ket Province	IX
21.	Phu Wa Kiew Waterfall, Nakhon Ratchasima Province	IX
22.	Khao Yai National Park, Nakhon Ratchasima Province	I, IX
23.	Pu Kae, Saraburi Province	IX
24.	Pang Sida National Park, Sa Kaeo Province	IX
25.	Prachantakham, Prachin Buri Province	VIII

Site no.[a]	Locality	Group[b]
26.	Ban Pe, Rayong Province	VIII
27.	Nam Tok Phriu National Park, Chanthaburi Province	VIII
28.	Mueang, Trat Province	VIII
29.	Ko Chang, Trat Province	VIII
30.	Thi Lo Su waterfall, Tak Province	IX
31.	Sangkhla Buri, Kanchanaburi Province	IX
32.	Koeng Kra Wia Waterfall, Kanchanaburi Province	IX
33.	Pong Ron, Thong Pha Phum, Kanchanaburi Province	IX
34.	Pha Suk Pass,Thong Pha Phum, Kanchanaburi Province	I
35.	Ban Thamadua, Thong Pha Phum, Kanchanaburi Province	IX
36.	Sai Yok National Park, Kanchanaburi Province	IX
37.	Bang Saphan, Prachuap Khiri Khan Province	VIII
38.	Namtok Ngao National Park, Ranong Province	IX
39.	Ko Wua Ta Lub, Suratthani Province	VIII
40.	Mueang, Phangnga Province	VIII
41.	Noppharat Thara Beach, Krabi Province	VIII
42.	Khao Luang National Park, Nakhon Si Thammarat Province	I
43.	Pakmeng, Trang Province	VIII
44.	Hat Chao Mai National Park, Trang Province	VIII
45.	Thung Kai, Trang Province	VIII
46.	Sathing Phra, Songkhla Province	VIII
47.	Singhanakhon, Songkhla Province	VIII
48.	Pak Bang Sakom Beach, Songkhla Province	VIII
49.	Tarutao National Park, Satun Province	IV, VIII
50.	Sirinthon Waterfall, Waeng, Narathiwat Province	II

a = Site numbers correspond to those in Fig.1; b = Nine groups distinguished in this study.

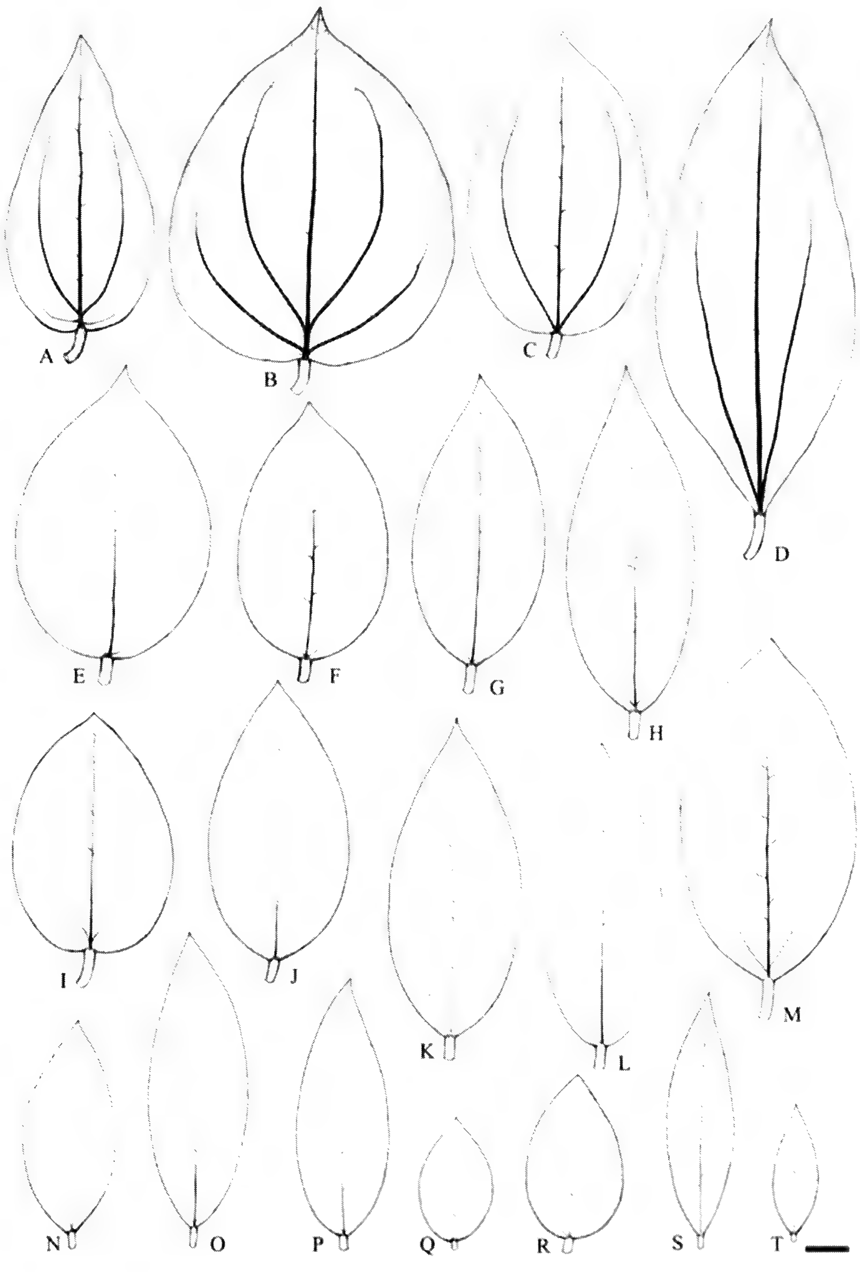

Fig. 2. Leaves of *Hoya verticillata* complex. A: Group I, site 42 (166). B: Group II, site 50 (303). C: Group III, site 5 (380). D: Group IV, site 49 (320). E-F: Group V, E. site 1 (404), F. site 8 (378). G-H: Group VII, G. site 6 (385), H. site 5 (384). I: Group VI, site 3 (289). J-M: Group IX, J. site 11 (559), K. site 14 (436), L. site 24 (3), M. site 33 (258). N-T: Group VIII, N. site 27 (120), O. site 40 (670), P. site 45 (66), Q. site 39 (585), R. site 46(243), S. site 47 (213), T. site 49 (202). Numbers in parenthesis denote the collector number. Bar = 2 cm.

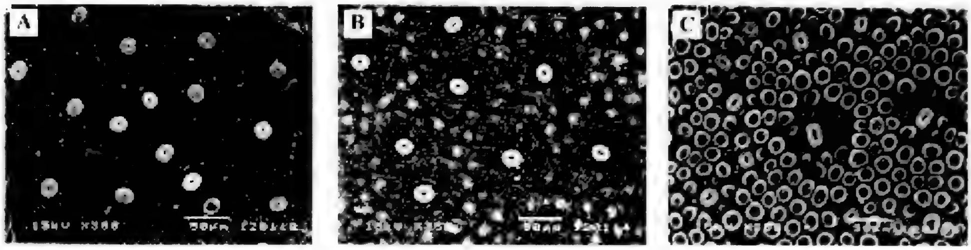

Fig. 3. Scanning electron micrographs of the abaxial surface of leaves of *Hoya verticillata* complex. A: Group I (absent indumentum); B: Group II (minute and scattered indumentum); C: groups III-IX (dense indumentum). Bar = 50 μm.

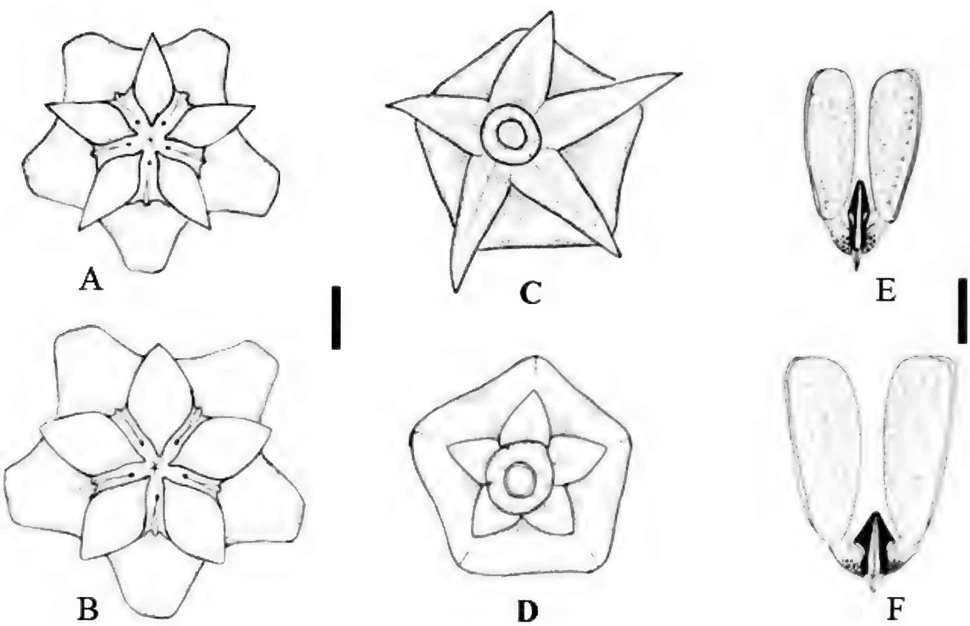

Fig. 4. Flower and flower parts of *Hoya verticillata* complex. A-B (top view of flower), A: Groups II, IV, VI,VIII and IX (coronal scales ovate-lanceolate); B: Group I, III, V, VII (coronal scales broad ovate or ovate-elliptic); C-D (bottom view of flower), C: Group I (sepal lanceolate); D: Group II-IX (sepal ovate); E-F (polinaria), E: Group II (corpuscles oblanceolate-oblong); F: Groups I, III-IX (corpuscles triangular-oblong). A-D: Bar = 2 mm; E-F: Bar = 0.2 mm.

surface usually with a median ridge; *anthers* 5, lying just below the inner coronal angle, each producing two pollen masses or pollinia, each pollen mass from adjacent anther lobes connected by short translator arms with a corpusculum, forming a pollinarium; *pollinium* flattened, oblong, truncate at the top, with narrow translucent longitudinal wing; *corpusculum* dark brown or black. **Fruits** a follicle, pod-like, straight and glabrous.

Comparative morphology

Despite the great observed variations (i.e., habitat, leaf shape, forms of leaf base, venation pattern of leaf, forms of sepal and corona), we can tentatively classify the variations of the complex into nine groups by a comparison of qualitative morphological characters. These groups are then named as Group I-IX (IX being the residual group). A key to the Groups and descriptions of the Groups are presented below.

Key to Groups of wild *H. verticillata* complex in Thailand

1. Sepals lanceolate, longer than the corolla tubes, leaves glabrous (Fig. 3A, 4C) .... **Group I**
1. Sepals ovate, equal in length or shorter than corolla tubes, leaves papillate on abaxial surface (Fig. 3B-C, 4D)

    2. Leaves with prominent basal nerves, extending from base to apex, veins conspicuous (Fig. 1A-D)

        3. Leaves ovate, base rounded to cordate

            4. Coronal scales ovate-lanceolate (Fig. 4A), corpusculum narrowly oblanceolate-oblong (Fig. 4E) .... **Group II**
            4. Coronal scales ovate-elliptic (Fig. 4B), corpusculum broadly triangular-oblong (Fig. 4F) .... **Group III**

        3. Leaves ovate-oblong, base cuneate .... **Group IV**

    2. Leaves with unclear basal nerves, mostly extending about half way to apex, veins obscure (Fig. 1E-T)

        5. Leaf base rounded to subcordate

            6. Coronal scales ovate-elliptic, petioles stout .... **Group V**
            6. Coronal scales ovate-lanceolate, petioles slender .... **Group VI**

5. Leaf base cuneate to obtuse

7. Coronal scales ovate-elliptic .... **Group VII**
7. Coronal scales ovate-lanceolate

8. Leaves relatively narrow, 1.8-(3.8)-5.8 cm wide, base cuneate. Littoral plants .... **GroupVIII**
8. Leaves broad, 4-(5.8)-8.6 cm wide, base variable. Inland plant found throughout Thailand .... **Group IX**

Group I

Leaves rigidly coriaceous, broad ovate to oblong with rounded to cordate base, 13.8-(17.8)-19.1 cm long, 6.8-(8.7)-10.1 wide; nerves 3-5, prominent, extending from base to apex, the other veins conspicuous; glabrous on both surface; petiole slender, 2.7-(3.4)-3.9 cm long. Umbel 7-(30)-65 flowered, peduncle 1.5-(2.9)-4.7 cm long; pedicel glabrous, 2-(2.3)-3 cm long. Sepal lanceolate, longer than corolla tube, 4.9-(5.4)-5.6 mm long, 2-(2.1)-2.2 mm wide. Corolla creamy white, 1.6-(1.9)-2.1 cm diam. Coronal scale broad ovate, 4.2-(4.5)-4.8 mm long, 2.2-(2.4)-2.6 mm wide, the outer angle slightly erected and white, apiculus of the inner angle raised and pink. Pollinia oblong, 0.62-(0.63)-0.64 mm long, 0.21-(0.23)-0.24 mm wide; translator short; corpusculum triangular-oblong, 0.16-0.18 mm long, 0.12-0.13 mm wide.

Ecology and distribution: A long climbing epiphyte, usually on trees along stream banks, in moist evergreen forest, in the eastern, western and southern parts of the country at 700-900 m elevation.
Specimens examined: Kanchanaburi - Thong Pha Phum, *Manit Kidyue 464, 465, 466, 467, 468, 469*. Nakhon Ratchasima - Khao Yai, *Manit Kidyue 360, 361, 997*. Nakhon Si Thammarat - Khao Luang, *Manit Kidyue 166.*

Group II

Leaves coriaceous, broadly ovate or rhombic with cordate base, 14.7–(15.9)–16.7 cm long, 11.3–(12.3)–13.2 cm wide; nerves 3–5, prominent, extending from base to apex, veins conspicuous; hairs minute, scattering on the abaxial surface; petiole slender, 1.8–(2.1)–2.2cm long. Umbel 10–(26)–49 flowered, peduncle 2.5–(3.3)–4.3 cm long; pedicel glabrous, 1.7–(1.9)–2.0 cm long. Sepal ovate, 1.8–(1.9)–2.0 mm long, 1.5–(1.7)–1.8 mm wide. Corolla creamy white, 1.4–1.5 cm diam. Coronal scale ovate-lanceolate, 3.5–(3.8)–4.0 mm long, 1.5–(1.6)–1.7 mm wide, the outer angle flattened and pinkish white, apiculus of the inner angle raised and pink. Pollinium oblong, 0.45–0.46 mm long, 0.15–0.16 mm wide; translator short; corpusculum narrowly oblanceolate-oblong, 0.2–0.22 mm long, 0.07–0.08 mm wide.

Ecology and distribution: A long climbing epiphyte in moist evergreen forest, usually on trees along stream banks, restricted to Bala forest, peninsular Thailand at about 200 m elevation.
Specimens examined: Narathiwat - Sirinthon Waterfall, *Manit Kidyue 128, 303, 304, 305, 306, 688.*

Group III

Leaves rigidly coriaceous, broadly ovate with subcordate base, 14–(14.6)–15.3 cm long, 5.9–(7.4)–8 wide; nerves 3, prominent, extending from base to apex, veins conspicuous; covered with dense hairs on abaxial surface; petiole stout, 1.1–(1.9)–2.1 cm long. Umbel 22–(43)–59 flowered, peduncle 3.1–(4.5)–7.4 cm long; pedicel sparsely pubescent, 1.9-(2.2)-2.4 cm long. Sepal ovate, 1.8–(1.9)–2 mm long, 1.4–(1.6)–1.8 mm wide. Corolla yellowish white, 1.4–1.5 cm diam. Coronal scale ovate-elliptic, 3.5–(3.6)–3.8 mm long, 1.7–(2.0)–2.2 mm wide, the outer angle slightly erect and white, apiculus of inner angle raised and pink. Pollinium oblong, 0.5–0.6 mm long, 0.19–0.22 mm wide; translator short; corpusculum triangular-oblong, 0.17–0.19 mm long, 0.11–0.12 mm wide.

Ecology and distribution: A long climbing epiphyte in mixed deciduous forest, or on rocks along stream banks, at about 400 m elevations, confined to northern Thailand.
Specimens examined: Nan - Silaphet Waterfall, *Manit Kidyue 380, 381, 382.*

Group IV

Leaves large coriaceous, elliptic-oblong, with cuneate base, 18–(19.3)–20.4 cm long, 7.3–(7.7)-8 cm wide; nerves 3, prominent, extending from base to apex, veins conspicuous; covered with dense hairs on abaxial surface; petiole slender, 2–(2.5)–2.9 cm long. Umbel 65–(68)–71 flowered, peduncles 5.6–(7.3)–9.1 cm long; pedicel glabrous, 2–(2.2)–2.3 cm long. Sepal small ovate, 1.7–1.8 mm long, 1.5-1.6 mm wide. Corolla creamy white, 1.2–1.3 cm diam. Coronal scale ovate-lanceolate, 3.4–(3.5)-3.6 mm long, 1.82-(1.86)–1.91 mm wide, the outer angle slightly erect and white, apiculus of the inner angle short raised and pink. Pollinium oblong, 0.45–0.46 mm long, 0.17–0.18 mm wide; translator short; corpusculum triangular-oblong, 0.16–0.17 mm long, 0.11–0.12 mm wide.

Ecology and distribution: A long climbing epiphyte on tree branches along stream banks in evergreen forest, restricted to Tarutao Island, peninsular Thailand.
Specimens examined: Satun - Tarutao National Park, *Manit Kidyue 320, 321*.

Group V

Leaves coriaceous to succulently coriaceous, ovate with round to subcordate base, 8.6–(12.5)–16.2 cm long, 5–(7.1)–10 cm wide; nerves 3, extending about half way to apex or slightly longer, veins obscure; covered with dense hairs on abaxial surface; petiole stout, 0.5–(1.2)-2.9 cm long. Umbel 21–(43)–87 flowered, peduncle 0.6-(3.0)-6.5 cm long; pedicel glabrous to pubescent, 1.9–(2.3)–2.8 cm long. Sepal ovate, 1.45–(1.8)–2.1 mm long, 1.4–(1.6)-1.9 mm wide. Corolla creamy white, 1.3–(1.5)–1.6 cm diam. Coronal scale ovate-elliptic, 3.1-(3.7)–4.4 mm long, 1.9–(2.2)–2.4 mm wide, the outer angle slightly erect to erect and white, apiculus of inner angle short raised and pink. Pollinium oblong, 0.51–(0.55)–0.64 mm long, 0.18–(0.2)–0.21 mm wide; translator short; corpusculum triangular-oblong, 0.15–(0.19)–0.23 mm long, 0.11–(0.12)–0.14 mm wide.

Ecology and distribution: On tree branches by stream banks in mixed deciduous to dry dipterocarp forests, northern Thailand at about 300-600 m elevation.
Specimens examined: Chiang Rai – Mueang, *Manit Kidyue 404, 405, 406, 407, 407/2, 407/3, 408, 409, 409/2, 409/3, 409/4*; Chiang Mai - Wang Bua Ban Waterfall, *Manit Kidyue 281, 282, 283, 284, 285, 292, 293, 294, 295, 296, 312, 313, 411, 413, 414, 414/2, 415, 416, 417, 417/2, 417/3, 418, 419, 425*; Nan – Meang, *Manit Kidyue 331, 332, 333, 378, 378/2, 378/3, 378/4, 378/5, 378/6, 378/7, 379, 379/2, 379/3, 379/4, 379/5, 379/6, 379/7, 379/8, 379/9, 379/10.*

Group VI

Leaves succulently coriaceous, broadly ovate, subcordate at base, 11–(11.2)–11.6 cm long, 7.4–(8.0)–8.3 cm wide, indistinct acrodromous venation, the lowest pair extending about half way to apex; veins obscure; covered with dense hairs on abaxial surface; petiole slender, 1.5–(2.2)–3 cm long. Umbel 26–(29)–30 flowered, peduncle 3.5–(5.8)–7.1 cm long; pedicel pubescent, 1.7–(1.8)–1.9 cm long. Sepal ovate, 2–(2.2)–2.3 mm long, 1.6–(1.7)–1.8 mm wide. Corolla creamy white, 1.3–(1.4)–1.5 cm diam. Corona scale ovate-lanceolate, 3.6–(3.7)–3.8 mm long, 1.8-1.9 mm wide, the outer angle slightly erect and white, apiculus of inner angle short raised and pink. Pollinium oblong, 0.49–(0.5)–0.54 mm long, 0.17–0.18 mm wide; translator short; corpusculums triangular-oblong, 0.17–0.19 mm long, 0.11–0.12 mm wide.

Ecology and distribution: On tree branches in dry dipterocarp forests at 350 m elevation, northern Thailand.
Specimens examined: Chiang Mai - Haew Keaw, *Manit Kidyue 288, 289, 290, 291.*

Group VII

Leaves coriaceous to succulently coriaceous, ovate-oblong with cuneate to obtuse base, 10.4–(13.9)–17.9 cm long, 4.3–(5.6)–7.8 cm wide; 3 nerves, extending about half way to apex or slightly longer, veins obscure; covered with dense hairs on abaxial surface; petiole stout, 0.8–(1.4)–2.1 cm long. Umbel 9–(31)–52 flowered, peduncle 0.6–(3.4)–8.1 cm long; pedicel glabrous to pubescent, 1.8–(2.3)–2.6 cm long. Sepal ovate, 1.5–(1.9)–2.4 mm long, 1.4–(1.6)–2.0 mm wide. Corolla creamy white, 1.5–(1.6)–1.8 cm diam. Coronal scale ovate-elliptic, 3.4–(3.7)–4.1 mm long, 2.1–(2.2)–2.5 mm wide, the outer angle erect and white, apiculus of inner angle short raised and pink. Pollinium oblong, 0.54–(0.58)–0.62 mm long, 0.19–(0.2)–0.24 mm wide; translator short; corpusculum triangular-oblong, 0.16–(0.18)–0.21 mm long, 0.11–(0.12)–0.15.

Ecology and distribution: On tree branches by stream banks in mixed deciduous to dry dipterocarp forests at about 300-600 m elevation, northern Thailand.
Specimens examined: Nan - Silaphet Waterfall, *Manit Kidyue 325, 326, 327, 328, 329, 383, 384/1, 384/2, 384/3, 384/4, 384/5, 384/6*, Tat Laung Waterfall, *Manit Kidyue 342, 343, 344, 345, 385, 385/2, 386, 387*, Lhinan, *Manit Kidyue 391, 392, 393, 394, 395, 391, 392, 393, 394, 396, 396, 402, 402, 403.*

Group VIII

Leaves succulently coriaceous, narrowly ovate or elliptic to oblong, cuneate or rarely obtuse at base, 5–(9.6)–15 cm long, 1.8–(3.8)–5.8 cm wide, indistinct acrodromous venation, the lowest pair extending about half way to apex; veins obscure; covered with dense hairs on abaxial surface; petiole stout, 0.3–(1.2)–2.8 cm long. Umbel 10-(28)–77 flowered, peduncle 0.8–(3.8)–11.4 cm long; pedicel glabrous to pubescent, 1.2–(1.7)–2.6 cm long. Sepal ovate, 1.4–(2.0)-2.9 mm long, 1.1–(1.7)-2.6 mm wide. Corolla creamy white, 1.1–(1.3)–1.6 cm diam. Coronal scale ovate-lanceolate, 2.9–(3.5)–4.2 mm long, 1.5–(1.7)–2.1 mm wide, the outer angle variable from flattened to erect and white, apiculus of inner angle short raised and white to pink. Pollinium oblong, 0.40–(0.48)–0.56 mm long, 0.15–(0.18)–0.2 mm wide; translator short; corpusculum triangular-oblong, 0.13-(0.16)-0.2 mm long, 0.10–(0.12)–0.14 mm wide.

Ecology and distribution: A littoral plant, on tree branches or on rocks, common in beach forest, coastal areas of islands, or mainland in eastern and peninsular Thailand.
Specimens examined: Rayong - Ban Pe, *Manit Kidyue 80, 81, 82, 83, 84, 85, 94, 95, 96, 99, 100*; Chanthaburi - Nam Tok Phriu National Park, *Manit Kidyue 110, 111, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 132, 133, 134, 135, 136*; Trat – Mueang, *Manit Kidyue 163, 164, 250*, Ko Chang *Manit Kidyue 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668*; Prachuap Khiri Khan - Bang Saphan, *Manit Kidyue 622, 623, 624*; Suratthani - Ko Wua Ta Lub, *Manit Kidyue 584, 585, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595*; Phangnga – Mueang, *Manit Kidyue 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 671, 672, 673, 674, 675, 676, 677, 678*; Krabi [Noppharat Thara Beach, *Manit Kidyue 579, 580, 581, 582, 583, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643*]; Trang [Pakmeng, *Manit Kidyue 693, 694, 695, 696, 697*], [Hat Chao Mai National Park, *Manit Kidyue 628, 629, 630, 631, 632, 633*], [Thung Kai, *Manit Kidyue 66, 67, 68, 69, 70, 71, 72, 73, 74*]; Songkhla [Sathing Phra, *Manit Kidyue 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 240, 241, 242, 243, 244, 245, 246, 247, 248*], [Singhanakorn, *Manit Kidyue 212, 213, 216, 217, 218, 219, 220, 221, 222*], [Pak Bang Sakom Beach, *Manit Kidyue 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618*]; Satun [Tarutao National Park, *Manit Kidyue 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 596, 597, 598, 599, 600, 602, 603, 604, 605, 606*].

Group IX (residual group)

Leaves coriaceous to succulently coriaceous, ovate or elliptic to oblong, cuneate or obtuse at base, 7.7–(12.9)–18.6 cm long, 4–(5.8)–8.6 cm wide, indistinctly acrodromous venation, the lowest pair extending about half way to apex; veins obscure; covered with dense hairs on abaxial surface; petiole stout, 0.5–(1.5)–3.2 cm long. Umbel 5–(27)–75 flowered, peduncle 0.3–(3.8)–14.3 cm long; pedicel glabrous to pubescent, 1.3–(2.0)–2.9 cm long. Sepal ovate, 1.3–(1.9)–3 mm long, 1.1–(1.6)–2.1 mm wide. Corolla creamy white, 1.1–(1.4)–1.8 cm diam. Coronal scale ovate to ovate-lanceolate, 2.8–(3.5)–4.4 mm long, 1.5–(1.9)–2.4 mm wide, the outer angle slightly erect to erect and white, apiculus of inner angle short raised and white to pink. Pollinium oblong, 0.41–(0.51)-6.43 mm long, 0.16–(0.19)–0.22 mm wide; translator short; corpusculums triangular-oblong, 0.14–(0.17)–0.21 mm long, 0.10–(0.12)–0.15 mm wide.

Ecology and distribution: Along stream banks in mixed deciduous to dry dipterocarp forests at about 100-600 m elevation. Occurs sporadically throughout northern, north-eastern, eastern, and western to peninsular Thailand.

Specimens examined: Chiang Mai - Wang Bua Ban Waterfall, *Manit Kidyue 299, 300, 301, 412*; Lampang - Doi Khun Tan National Park, *Manit Kidyue 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 380, 410*; Nan [Phu Pieng, *Manit Kidyue 388, 389, 390*], [Rhinan, *Manit Kidyue 398, 399*], Loei [Pla Ba Waterfall, *Manit Kidyue 689, 690, 691, 692*]; Nong Khai [Than Thong Waterfall, *Manit Kidyue 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568*]; Udon Thani [Than Ngam Waterfall, *Manit Kidyue 420, 421, 422, 423, 424*]; Nakhon Phanom [Tat Kham Waterfall, *Manit Kidyue 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505*]; Sakon Nakhon [Phu Phan National Park, *Manit Kidyue 427, 228, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441*]; Mukdahan [Tat Ton Waterfall, *Manit Kidyue 484, 485, 486, 487, 488, 489, 490, 491, 492*]; Ubon Ratchathani [Soi Sawan Waterfall, *Manit Kidyue 540, 541, 542, 543, 544*], [Huai Sai Yai Waterfall, *Manit Kidyue 479, 480, 481, 482, 483*], [Phu Chongna Yoi National Park, *Manit Kidyue 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528*], [Tat Hai Waterfall, *Manit Kidyue 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539*]; Sri Sa Ket [Sam Long Kiat Waterfall, *Manit Kidyue 506, 507, 508, 509, 510, 511*]; Nakhon Rat Chasima [Phu Wa Kiew Waterfall, *Manit Kidyue 545, 546, 547, 548, 549, 550*], [Khao Yai National Park, *Manit Kidyue 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377*]; Saraburi [Pu Kae, *Manit Kidyue 307, 308, 309*]; Prachin Buri [Prachantakham, *Manit Kidyue 315,316,317,318*]; Sa Kaeo [Pang Sida National Park, *Manit Kidyue 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30*]; Tak [Thi Lo Su Waterfall, *Manit Kidyue 570*]; Kanchanaburi [Sangkhla Buri, Manit Kidyue 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 458, 460, 461, 462, 463], [Koeng

Kra Wia Waterfall, *Manit Kidyue 475, 476*], [Pong Ron, Thong Pha Phum, *Manit Kidyue 258, 259, 442, 443, 444, 445, 446*], [Ban Thamadua, Thong Pha Phum, *Manit Kidyue 140, 141, 142, 158, ,165, 473, 474*], [Sai Yok National Park, *Manit Kidyue 150, 151, 152, 153, 155, 156, 157, 159, 160, 162*]; Ranong [Namtok Ngao National Park, *Manit Kidyue 644, 645, 646, 647, 648*].

Discussion

Hoya verticillata has long been recognized as a taxonomically confusing group in the genus. Many authors have discerned differently the taxa within the species complex. The confusion was partly due to the great variations exhibited by the plants in their natural habitats. The results from this present study indicate that nine morphological groups can be recognized based on leaf shape, form of leaf base, leaf venation, leaf indumentum, shape of sepal, and shape of corona scale. However, the *Hoya verticillata* specimens could not be consistently allocated into a discrete group based on lamina texture, color of flower and hair. Lamina texture was found to be slightly discontinuous in its range of variability. This variation appeared to be related to growing conditions in different habitats (Hill, 1988). Colour of flowers has been reported to be highly variable in this species (Kiew, 1995). In our study, we found that the colour of corolla varied from white, creamy white, yellowish white, greenish white, pinkish white to white with brown, pink and violet at apices. Hair is frequently found on the stem, corolla (adaxial surface), calyx (abaxial surface) and pedicel. Young stems and new branches varied from glabrous to pubescent, or earlier pubescent then becoming glabrous when getting old, but some plants are consistently glabrous. Hair on pedicel also varied from glabrous to densely pubescent. In contrast, in some populations hairiness varied from glabrous to densely pubescent, while the others were only glabrous or pubescent. Hair on the corolla varied from minutely pubescent (almost glabrous to the naked eye) to densely pubescent (obvious to the naked eye). All the above characters (lamina texture, color of flower and hair) possess sufficient variability for us to conclude that they are not good discriminant characters for distinguishing taxa of this complex.

Regarding their habitats and distributions, the nine recognized groups of the complex occur in different floristic regions and habitats throughout the country. It was found that Group I, II and IV occur in rather humid forests with medium to low light conditions, while the other Groups usually grow in dry habitat to some extent. These differences are possibly related in part to the degree of succulence and size of leaves that allow plants to withstand different light conditions (Forster and Liddle, 1991). Naturally, the members of the complex occur in a wide range of habitats and geographic features in Thailand. Anyway, the habitat and distribution of the nine Groups overlap to such a degree that they are not good characters to use to distinguish taxa in the complex.

The previous treatments of the genus *Hoya* and the *Hoya verticillata* complex, were based primarily on discrete characters of floral structures (Rintz, 1978; Hooker, 1983; Forster and Liddle, 1991 and Kiew, 1995). In this study, we used floral characters in defining the species, while vegetative characters and their geographical distribution are used to characterize the varieties. Hence, we considered that the nine groups in the *H. verticillata* complex can be treated as either species or varieties. Group I and Group II of the *H. verticillata* complex were already treated at species level, due to their discontinuity in floral and vegetative characters.

Group I corresponds to the previous described species, *Hoya rigida* Kerr (Kerr, 1939). The result from this study shows good diagnostic characters to recognize this species based on leaf shape, venation, sepal shape and ratio of corolla tube length to sepal length. We agree with Kerr (1939) in separating this species from *H. verticillata*; Veldkamp *et al.* (1995) had already a suspicion about including this species in *H. verticillata* s.l.

Group II is somewhat similar to *H. verticillata* (Vahl) G. Don var. *citrina* (Ridl.) Veldkamp, except for its retention of minute hairs, scattered over the abaxial surface. Furthermore the corpusculum of anthers are oblanceolate-oblong. Rintz (1978) describes leaves and flowers of *H. verticillata* var. *citrina* and his illustrations show that lower surfaces of leaves have distinctly dense hairs and triangular-oblong corpusculum. The result from this study indicated that Group II is clearly distinguishable from the *H. verticillata s.l.* Importantly, since it has some diagnostic characters (leaf broad ovate with cordate base; prominent, 3-5 nerves, extending from base to apex, hairs minute, scattered on the abaxial surface; corpusculum oblanceolate-oblong), which did not match any previous described taxa, we consider it should be treated as a new species. In addition, the fragrance of flowers in Group II tends to differ from the other groups. We consider this preliminary evidence suggests a chemical difference that may be used to recognize Group II. At present, we tentatively treat Group II as a cryptic and undescribed species within the *Hoya verticillata* species complex.

Group III and Group IV have conspicuously discrete vegetative characters. Thus, we would define them at the varietal level. Group III is similar to *H.*

verticillata var. *citrina.* They share some common characters: possession of ovate leaves, the basal main veins extending to apex and the other veins being conspicuous, but there are still some differences. Group III has elliptic coronal scales and occurs in lowlands of northern Thailand, while *H. verticillata* var. *citrina* has ovate-lanceolate coronal scales and occurs in Malaysia, being common on limestone hills.

Group IV is an intermediate form between *H. verticillata* var. *citrina* and *H. verticillata* var. *verticillata.* It shares its venation pattern with the var. *citrina*, while leaf shape is elliptic-oblong with cuneate base; this character is similar to the var. *verticillata*.

It is evident that Group III and Group IV do not correspond to the previously described varieties. So we think that these two groups can be treated as undescribed varieties of *H. verticillata* complex. However, these two taxa are rather rare in occurrence, each being found only at one site.

Group V-IX have some discontinuity in flower and leaf characters. They cannot be clearly distinguished as distinct species, neither as varieties. Plants of Group VIII and IX correspond to the previous infraspecific taxon, *H. verticillata* var. *verticillata.* This is characterized by possession of elliptic leaf shape, cuneate base, obscure veins and the lowest basal pair of main veins extending about halfway to apex, while the other groups do not best fit to this taxon. They have broad ovate or elliptic to oblong leaf shape, obtuse to rounded at base and varied in corona lobe shape. However, they are more comparable to var. *verticillata* than the other two previously described varieties, i.e. *H. verticillata* var. *citrina* and var. *hendersonii* which have ovate leaves, cordate base, 3 prominent nerves extending from base to apex and the other veins are also conspicuous (Table 2). So we have treated Groups V-IX as being variable forms of *H. verticillata* var. *verticillata.*

In conclusion, the above reported possibly new cryptic species and maybe undescribed varieties of the *Hoya verticillata* complex in Thailand need to be researched further to reach more definitive taxonomic conclusions. Such study, however, is not part of this paper.

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Table 2. Comparisons of habitat and qualitative characters of nine groups with three varieties in the *Hoya verticillata* complex.

Characters	*var.* citrina (Rintz ,1978; Kiew, 1995)	*var.* hendersonii (Kiew, 1995)	*var.* parasitica (Rintz, 1978; Kiew, 1995)	*Group I*	Group II	Group III	Group IV	Group V-IX
Habitat	lowland; common on limestone	highland; montane forest	lowland; common in stand forest especially on island	lowland; evergreen forest	lowland; evergreen forest	lowland; mixed deciduous forest	lowland; evergreen forest	lowland; mixed deciduous, dry dipterocarp to beach forest
Lamina								
shape	ovate	narrowly ovate-oblong	elliptic	ovate	ovate	ovate	elliptic-oblong	ovate or elliptic to oblong
base	cordate	Cordate	cuneate	cordate	cordate	subcordate	cuneate	cuneate to obtuse or subcordate
indumentum on abaxial surface	densely papillate	unknown	densely papillate	glabrous	scattered papillate	densely papillate	densely papillate	densely papillate
Leaf venation								
nerves	conspicuous	conspicuous	obscure	conspicuous	conspicuous	conspicuous	conspicuous	obscure
extension of the lowest vein pair	to apex	to apex	about half way to apex	to apex	to apex	to apex	To apex	about half way to apex or slightly longer
Sepal								
shape/sepal length	ovate/shorter than corolla tube	ovate/shorter than corolla tube	ovate/shorter than corolla tube	lanceolate/distinctly longer than corolla tube	ovate/shorter than corolla tube	ovate/shorter than corolla tube	ovate/shorter than corolla tube	ovate/shorter than corolla tube
Coronal scale								
shape (top view)	ovate	Elliptic	ovate	ovate	ovate-lanceolate	elliptic	ovate-lanceolate	elliptic or ovate to ovate-lanceolate
Anther								
corpusculum shape(width: length ratio)	triangular-oblong (<1:3)	unknown	triangular–oblong (<1:3)	triangular–oblong (<1:3)	oblanceolate-oblong (>1:3)	triangular – oblong (<1:3)	triangular – oblong (<1:3)	triangular – oblong (<1:3)

Note: Lowland: lower than 1000 m altitude; Highland: above 1000 m altitude.

Begonia (Begoniaceae) from Limestone Hills in the Kuching Division, Sarawak, Borneo, including nine new species

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Abstract

Fifteen *Begonia* species are described from limestone hills in the Kuching Division, Sarawak, Borneo, of which nine are new: *B. andersonii* Kiew & S.Julia, *B. burttii* Kiew & S.Julia, *B. chaiana* Kiew & S.Julia, *B. corrugata* Kiew & S.Julia, *B. kiamfeeii* Kiew & S.Julia, *B. paoana* Kiew & S.Julia, *B. penrissenensis* Kiew & S.Julia, *B. punchak* Kiew & S.Julia and *B. serapatensis* Kiew & S.Julia. The distribution of these begonias confirms that the Bau limestone flora is phytogeographically distinct and shows that the Padawan-Serian and Penrissen limestone areas also form two distinct phytogeographic areas and that there are few species shared between the three areas.

Introduction

In common with limestone elsewhere in Sabah and Sarawak, the limestone hills in the Kuching Division are tower karst formations with sheer cliffs. They occur as isolated hills and in the Kuching Division are now surrounded by cultivation. Geologically, limestone in the Kuching Division has been subdivided into three areas: the Bau, Padawan-Serian and Penrissen limestone areas (Banda *et al.*, 2004).

The Bau limestone is best known botanically (Kiew *et al.*, 2004) and includes both the well-known tourist caves, Wind Cave (formerly called Gunung Lubang Angin) and Fairy Cave (Gunung Kapur). Being closest to Kuching town, it was explored botanically as early as 1845 when Hugh Low collected there (Kiew *et al.*, 2004). Other 19th century collectors include G.D. Haviland (1891-1895) and H.N. Ridley (1893, 1903), who wrote an account of Bornean begonias (Ridley, 1906).

In the 20th century, major collectors include J.A.R. Anderson (1950-1970), one of whose special interests was the Sarawak limestone flora (Anderson, 1965) and B.L. Burtt (1978), who specialized in the Gesneriaceae. Many collections were added to the Sarawak Forest Department Herbarium (SAR) by local staff.

The most recent survey was carried out in 2001-2003 when 20 hills in the Bau area were inventoried (Kiew *et al.*, 2004), as part of Kuching Limestone Biodiversity Project by the Sarawak Biodiversity Centre and the ASEAN Regional Center for Biodiversity Conservation, with the result that six begonias, including one new species, *Begonia lailana* Kiew & Geri, were documented from the Bau limestone (Kiew & Geri, 2003).

In contrast, the botany, including begonias, of the Padawan-Serian and Penrissen limestone remained unstudied. The Padawan-Serian area was better collected before our survey with begonias collected from the Tebedu area (Teng Bekap, Gua Baju and Gunung Mentawa), Bukit Pait, Bukit Angob, Gunung Bra'ang (the highest limestone hill in the Kuching Division reaching 729 m and first climbed by Haviland), Gunung Manok, Gunung Mas, Gunung Sebakap, Gunung Sebengkam, Gunung Selabor, Gunung Seburan and 21st Mile Serian Road.

The Penrissen area was even more poorly known previous to our study with only Bukit Serapat (also known as 13th Mile Kuching-Simanggan Road or 16th Mile Penrissen Road), Gunung Bah (G. Bar on the herbarium specimens) and G. Berloban being represented by herbarium specimens. Our exploration of these hills, as well as of Gunung Burau and Gunung Rimo, show that the Penrissen area is particularly high in endemics.

This study was undertaken to document and describe the begonia species found on limestone in the Kuching Division (nine new species are described below) and in particular to map their distribution. It is likely that as more hills are explored in the Padawan-Serian and Penrissen areas further new species will come to light.

Distribution of Begonias in the Kuching Division

Among species of the limestone flora in Borneo, begonias exhibit one of the highest levels of endemism with many being restricted to a single

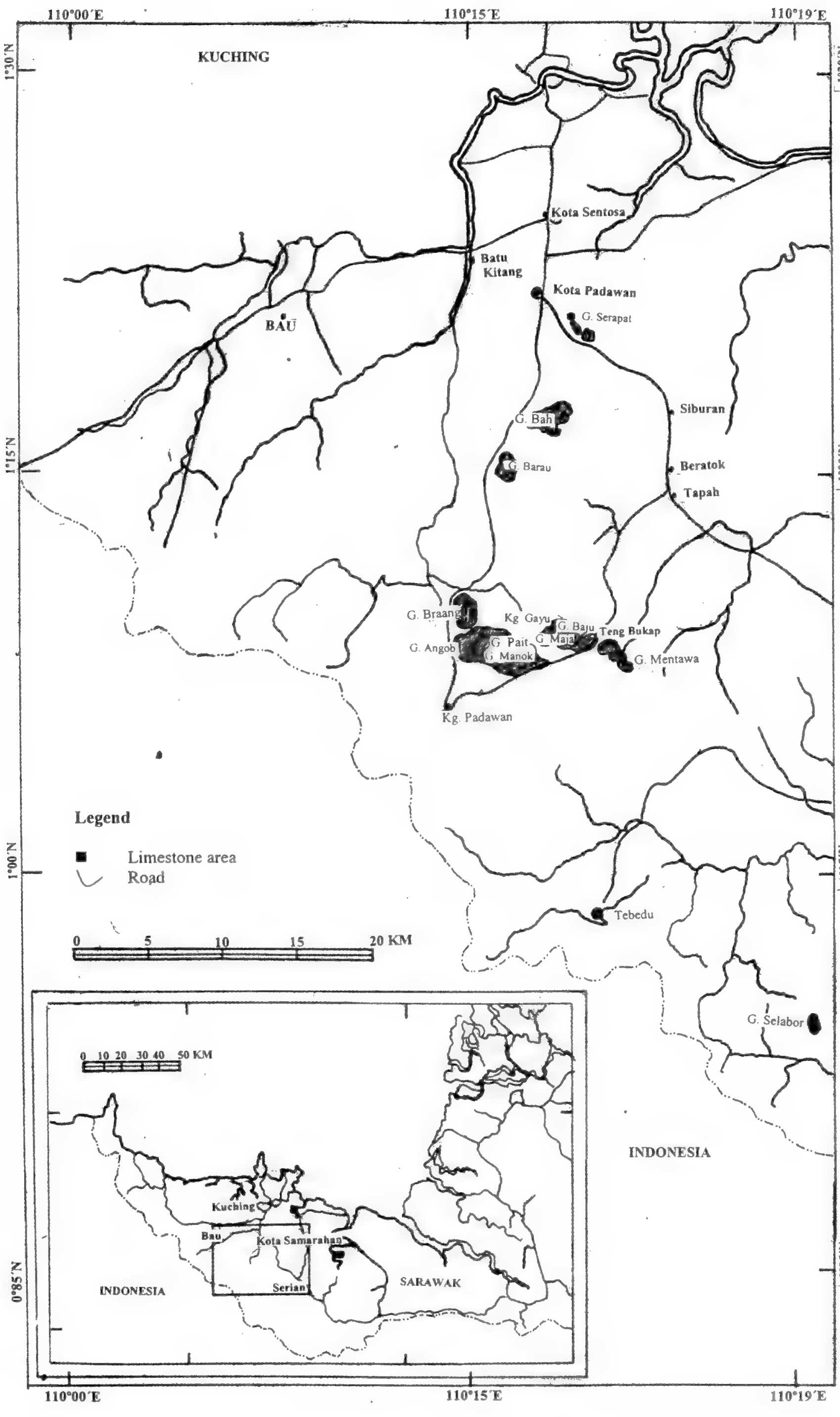

Figure 1. Limestone hills in the Kuching Division, Sarawak.

hill (Kiew, 2001; Pearce, 2003). The distribution of these narrow endemics is therefore useful in delineating phytogeographic areas (Kiew, 2001). Indeed, Burtt (1978) did just this for *Monophyllaea* (Gesneriaceae) in the Kuching Division and was the first to recognise that there were in fact two distinct phytogeographic areas: the Bau hills versus the rest based on the distribution of *Monophyllaea* species and varieties. This distribution pattern is also exhibited by other limestone endemics, such as species of *Begonia* and *Schismatoglottis* (Araceae), and led Kiew *et al.* (2004) to distinguish the Bau limestone as separate from the Padawan-Serian limestone. Our study not only confirms that the Bau limestone is a distinct phytogeographic area but also shows for the first time that the Penrissen limestone is distinct from the Padawan-Serian limestone in which it had previously been included (Burtt, 1978, and Kiew *et al.*, 2004) so that in fact there are three distinct limestone areas in the Kuching Division.

All three areas are equally diverse with six, seven and six begonia species occurring in the Bau, Padawan-Serian and Penrissen areas, respectively. Each area is home to its own endemic species: two in the Bau area (*Begonia congesta* Ridl. and *B. lailana* Kiew & Geri); three in the Padawan-Serian area (*B. andersonii* Kiew & S.Julia, *B. chaiana* Kiew & S.Julia and *B. paoana* Kiew & S.Julia); and four in the Penrissen area (*B. burttii* Kiew & S.Julia, *B. kiamfeei* Kiew & S.Julia, *B. penrissenensis* Kiew & S.Julia, *B. punchak* Kiew & S.Julia and *B. serapatensis* Kiew & S.Julia).

In addition, although the Penrissen area geographically lies between those of the Bau and Padawan-Serian areas, it shares fewer species with the two other areas: only *B. speluncae* Ridl. occurs in all three areas; the Padawan-Serian and Bau areas share three species (*B. calcarea* Ridl., *B. pendula* Ridl. and *B. rubida* Ridl.), while only *B. corrugata* Kiew & S.Julia is found in both the Penrissen and Padawan-Serian areas.

Key to Limestone *Begonia* Species in the Kuching Division

1a. Stems erect and cane-like 2
1b. Stems rhizomatous or creeping 10

2a. Leaves with veins prominently forked and narrowly diverging. Fruits oblong 3
2b. Leaves with veins widely diverging where they fork. Fruits wider than long or much wider distally 4

3a. Leaves glabrous. Female flowers and fruits in a compact cluster; pedicels 4–5 mm long .... 5. ***B. congesta***
3b. Leaves hairy. Female flowers and fruits well-spaced on the inflorescence; pedicels 7–13 mm long.................................... 6. ***B. corrugata***

4a. Leaves lanceolate or oblanceolate; petioles straight or at a slight angle with the midrib 5
4b. Leaves ovate; petioles at a pronounced angle with the midrib 7

5a. Laminas lanceolate, 8–12 cm long. Inflorescences 6-9.5 cm long. Female flowers with 3 tepals .... 4. ***B. chaiana***
5b. Laminas oblanceolate, 12–23 cm long. Inflorescences 10-25 cm long. Female flowers with 5 tepals 6

6a. Laminas 12–17 cm long. Inflorescences 10–16 cm long. Female flowers in a single pair .... 8. ***B. lailana***
6b. Laminas 15–24 cm long. Inflorescences 12–25 cm long. Female flowers in 2 pairs (one pair in the leaf axil and one above) .... 9. ***B. paoana***

7a. Basal lobes up to a third of the lamina length. Inflorescences shorter than the leaves (to 6.5 cm long) 8
7b. Basal lobes about half the lamina length. Inflorescences longer than the leaves (9+ cm long) 9

8a. Leaves with petioles to 4.5 cm on the lower leaves and blades 9.5–12 by 5–6 cm. Inflorescences with female flowers at the base. Male flowers with 2 tepals .... 11. ***B. penrissenensis***
8b. Leaves with petioles to 2.5 cm long and blades to 7 by 4 cm. Female flowers in separate axils from the male inflorescences. Male flowers with 4 tepals .... 12. ***B. punchak***

9a. Laminas more than 9 x 5 cm. Flowers white. Fruit wings 6-9 mm wide .... 14. ***B. serapatensis***
9b. Laminas up to 8 x 5.5 cm. Flowers ruby red. Fruit wings 4–5 mm wide .... 13. ***B. rubida***

10a. Stems thin and creeping. Leaves widely spaced, longer than wide 11
10b. Stems thick and rhizomatous. Leaves tufted, as wide as long 12

11a. Leaves hairy, plain green, ovate, basal lobes 2–4.5 cm long. Inflorescences with several female flowers and fruits. Flowers white. Male flowers with

4 tepals .... 7. ***B. kiamfeeii***
11b. Leaves glabrous, with silver spots, basal lobes 1.2–2 cm long. Inflorescences with one female flower or fruit. Flowers deep pink or red. Male flowers with 2 tepals ....10. ***B. pendula***

12a. Leaves peltate 13
12b. Leaf bases cordate 14

13a. Leaf strongly oblique, laminas broader than long, 1.2–3.5(-12) cm long, apex rounded .... 15. ***B. speluncae***
13b. Leaf scarcely oblique, laminas longer than broad, 4.5–7 cm long, apex acuminate .... 2. ***B. burttii***

14a. Laminas round; petioles shorter than the laminas, 2–10 cm long. Inflorescences among the leaves, erect and longer than the petioles. Flowers pink or white .... 1. ***B. andersonii***
14b. Laminas ovate; petioles longer than the laminas, 14–35 cm long. Inflorescences developing on the bare prostrate rhizome, shorter than the petioles. Flowers peachy orange .... 3. ***B. calcarea***

Begonia specimens from the Bau limestone are listed in Kiew & Geri (2003).

Limestone Begonias in the Kuching Division

1. ***Begonia andersonii*** Kiew & S. Julia, *sp. nov.*

Sect: *Reichenheimia*
A Begonia speluncae Ridl. laminis latioribus 8–15 latis (nec usque 5(-12) cm latis), petiolis lanatis (nec glabris) et foliis basi cordatis (nec peltatis) differt.
Typus: Borneo, Sarawak, Kuching Division, Teng Bekap, Gua Baju, 8 August 2004, *Kiew, Julia & Tan S 93269* (holo, SAR; iso, E, KEP, SING). Figure 2

Rosette begonia; **stems** rhizomatous, creeping and rooting at nodes, up to 7 cm long, woody, hairy, not branched, stout, 6–7 mm thick; without a tuber. Stipules densely hairy, narrowly lanceolate, *ca* 2 x 5 mm, pale green to pale brown, margin entire, apex entire, persistent. **Leaves** tufted and splayed out against the rock face; petiole woolly with pale brown hairs, (2–)5(–10) cm long, slightly succulent, reddish in young leaves, reddish brown in older leaves; lamina oblique, young leaves bronzy, adult leaves plain pale green above with slightly paler green veins, beneath paler and scintillating with brown veins, thinly succulent, drying papery, slightly asymmetric, orbicular,

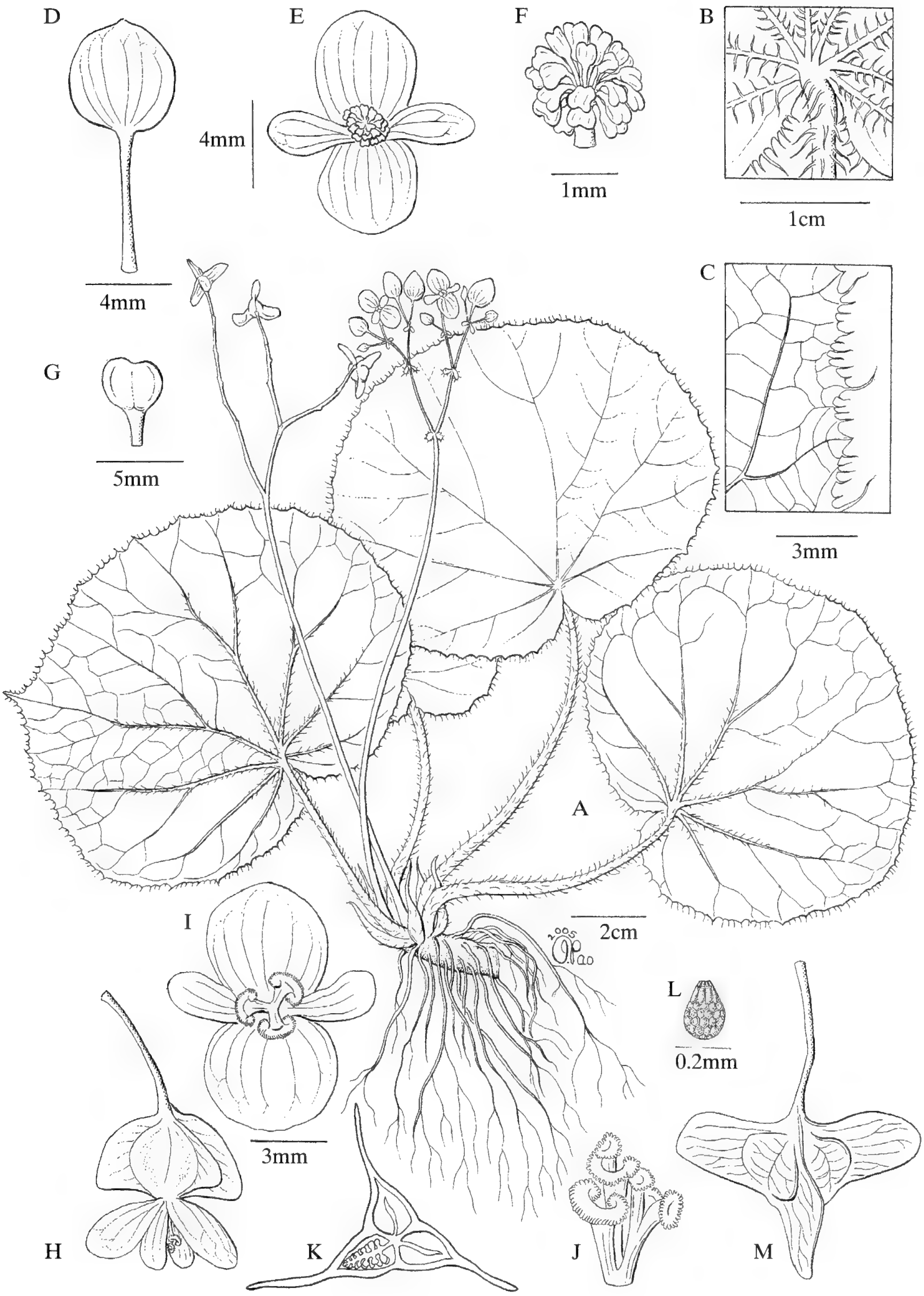

Figure 2. ***Begonia andersonii*** Kiew & S.Julia
A. habit; B. lower leaf surface near the midrib; C. leaf margin; D. male bud: E. open male flower; F. stamen cluster; G. stamens; H. female flower; I. open male flower; J. styles and stigmas; K. TS ovary; L. seed; M. fruit. (A from *CWL 1308*; B-M from *S 93269*).

6.2–11.5 x 8.3–15.75 cm, broad side 4.5–6.5(–9.5) cm wide, base deeply cordate sometimes overlapping, basal lobes 0.75–2(–3.5) cm, margin hairy, crenate, apex rounded or shortly acute; venation palmate with 3--4 pairs of veins branching less than half way to the margin, midrib often branching more or less dichotomously, veins slightly impressed above, beneath prominent and densely hairy, hairs brown. **Inflorescences** terminal, pale red, glabrous, erect, dichasial cyme, longer than the leaves, 9–31 cm long, peduncle 2.5–9 cm long, branches 2 or more, 2.5–9 cm long, male flowers many, female flowers 2–3, protogynous. Bracts obovate, pale green, with long dense hairs, 1–2 mm long, margin entire; bracteoles similar but smaller. Male flowers with a pale pink pedicel 15 mm long; tepals 4, pale pink, margin entire, apex rounded, glabrous, outer two broadly rounded, 6 x 4–6 mm, inner two narrowly oval, 4 x 1.5–2 mm; stamens many, cluster globose, *ca* 2 mm diam., sessile; filaments 1–2 mm long; anthers yellow, narrowly oblong, 1 mm long, apex slightly notched, opening by lateral slits. Female flowers with a pedicel *ca* 20 mm long; ovary *ca* 3 x 4 mm, reddish, wings 3, more or less equal, *ca* 3 mm wide, locules 3, placenta one per locule; tepals 4, pale pink, glabrous, margin entire, apex rounded, outer two rounded, *ca* 3 x 3 mm, inner two smaller 2 x 1 mm; styles 3, styles and stigma yellow, *ca* 1 mm long. **Fruits** pendent on a fine stalk *ca* 9–11 mm long; capsule 4–5 x 11–13 mm, glabrous, wings 3, equal, thinly fibrous, 3–4 mm wide, splitting between the locules and wings. **Seeds** barrel-shaped, *ca* 0.5 mm long, collar cells less than half the seed length.

Distribution: Endemic in Kuching Division, Sarawak; known only from the Padawan-Serian limestone.
Habitat: Locally common, it is restricted to limestone and grows on dry vertical limestone cliffs in light shade.

Specimens examined: *Padawan-Serian limestone* - Teng Bekap [Tiang Bekap], *Anderson S 12345* (SAR); Gunung Mentawa, *Burtt B 8112* (SAR), *Chew CWL 656* (SAR), *CWL 1308* (SAR); Kampung Gayu, *Mohizah & Jegong S 66838* (SAR); 21st Mile Serian Road, *Anderson S 20999* (SAR), *Murthy & Chai S 24699* (SAR); Tebedu, Bukit Kajing, *Abang Mohtar S 48287* (SAR).

Notes: *Begonia andersonii*, like *B. speluncae*, belongs to sect. *Reichenheimia* in its ovary having three locules, each locule with one placenta. They are also similar in their circular leaves and female flowers that are very like the male flowers in having four tepals, the outer pair large and round and the inner pair narrowly oblong. Otherwise, they are different in size - *B. speluncae* is a small plant with leaves 1.4–5.5 cm across (exceptionally up to 12 cm wide), which are almost glabrous (the leaf margin is minutely ciliate) and its leaves are peltate (not cordate as described by Ridley, 1906).

Begonia andersonii has a very local distribution centred on Teng Bekap. Interestingly, although *B. speluncae* Ridl. has a wide distribution in the Kuching Division, and occupies the same habitat as *B. andersonii*, these two species are not found growing on the same hill.

It is named in honour of J.A.R. Anderson, who pioneered the exploration of the limestone flora in Sarawak (Anderson, 1965). His collections include this species.

2. ***Begonia burttii*** Kiew & S. Julia, *sp. nov.*

Sect: *Reichenheimia*
A Begonia speluncae Ridl. laminis foliorum majoribus longitudine latitudinem aequanti 4.5–6.8 x 5.6–6.4 cm (nec latioribus quam longioribus, 1.2–5(-10) x 1.4–5.7(-12) cm) apice acuminatis (nec rotundatis) differt. **Typus:** Borneo, Sarawak, Kuching Division, Gunung Serapat, 8 August 2004, *Kiew, Julia & Tan S 93266* (holo, SAR; iso, E, KEP, SING). Figure 3

Rosette begonia; **stems** rhizomatous, creeping and rooting at nodes, up to 4 cm long, succulent, hairy, not branched, stout, *ca* 4 mm thick; without a tuber. Stipules reddish, hairy, narrowly lanceolate, 3–4 x 1–1.5 mm, margin entire, apex setose, caducous. Leaves tufted, oblique; petiole greenish, glabrous, 4.7–9 cm long, succulent, slightly glaucous; lamina of young leaves rosy red above and beneath, mature **leaves** plain matt, dark green above with paler green veins, beneath reddish green or rosy red, thickly succulent, drying papery and with the tertiary veins slightly raised, slightly asymmetric, peltate, broadly oval, sometimes angular, 4.5–6.8 x 5.6–6.4 cm, broad side *c.* 3.7 cm wide, base rounded, 1.5–1.8 cm from junction with the petiole to the base of the lamina, margin fringed by short hairs, entire to minutely dentate, apex shortly acute; venation palmate with *ca* 4 pairs, veins branching half to one third of the way to the margin, plane above, beneath prominent and glabrous. **Inflorescences** terminal, red, glabrous, erect, dichasial cyme, longer than the leaves, *ca* 9.5–15 cm long, peduncle 9–13 cm long, branches two 0.5–2 cm long, male flowers many, female flowers 2 or more, protandrous. Bracts caducous. Male flowers with a white pedicel 15–17 mm long; tepals 4, red in bud, pale pink when open, margin entire, apex rounded, glabrous, outer two broadly oval to rotund, 4–7 x 5–6 mm, inner two narrowly oval, 3–4 x 1–1.5 mm; stamens many, cluster fan-shaped, stalked; filaments *c.* 2 mm long; anthers pale yellow, oblanceolate, 2 mm long, apex slightly notched, opening by lateral slits. Female flowers with a pedicel *ca* 5 mm long; ovary *ca* 9 x 12 mm, locules light red and wings pale green, wings 3, more or less equal, *ca* 3 mm wide, locules 3, placenta one per locule; tepals 5, rosy pink, glabrous, margin entire, apex rounded, outer two obovate, *ca* 6 x 3 mm, inner

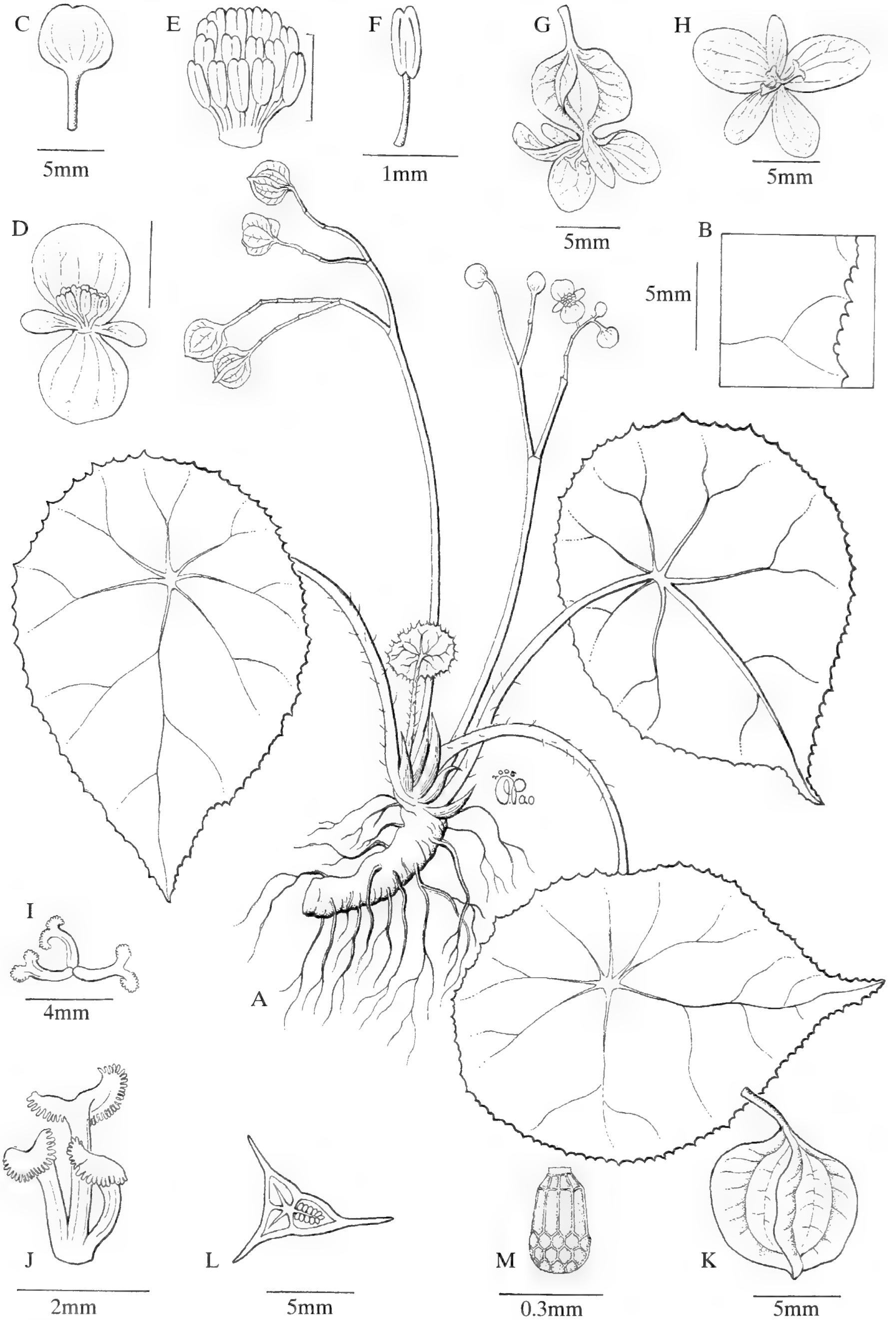

Figure 3. ***Begonia burttii*** Kiew & S.Julia

A. habit; B. lower leaf surface; C. male bud: D. open male flower; E. stamen cluster; F. stamens; G. female flower; H. open male flower; I & J. styles and stigmas; K. fruit; L. TS ovary; M. seed. (All from *S 93266*).

three smaller *ca* 3 x 1 mm; styles 3, styles and stigmas pale yellow, *ca* 2 mm long. **Fruits** pendent on a fine stalk 4–8 mm long; capsule 6–8(–10) x 7–10(–13) mm, glabrous, wings 3, equal, rounded, thinly fibrous, 2–3(–5) mm wide, splitting between the locules and wings. **Seeds** barrel-shaped, *ca* 0.3--0.4 mm long, collar cells *ca* half the seed length.

Distribution: Endemic in the Kuching Division, Sarawak; known only from a single hill in the Penrissen limestone.
Habitat: Restricted to limestone, it grows on deeply shaded vertical limestone rock faces near the base of the hill.

Specimen examined: *Penrissen limestone* - Bukit Serapat, 13th Mile Kuching-Simanggan Road, *Burtt & Martin B 4746* (SAR).

Notes: This is the second peltate begonia to be recorded for the Penrissen limestone. The other is the widespread *Begonia speluncae* collected from Gunung Burau. Compared with *B. speluncae*, *B. burttii* is a larger plant, has a slightly angular lamina with a distinct midrib and an acuminate apex, which is longer or as broad as long, whereas laminas of *B. speluncae* are broader than long and rounded at the apex and the veins appear to branch dichotomously so that there is no distinct midrib. In addition, *B. burttii* has female flowers with five tepals, while those of *B. speluncae* have four.

This species is as yet known from a single hill. It is named in honour of B.L. Burtt, who was one of the early explorers of the Kuching limestone and who first collected this species, in recognition of his work on *Monophyllaea* (Gesneriaceae) that first drew attention to the distinction between the limestone floras of the Bau and Padawan-Serian/Penrissen areas.

3. ***Begonia calcarea*** Ridl.
J. Str. Br. Roy. As. Soc. 46 (1906) 260; Kiew & Geri, Gard. Bull. Singapore 55 (2003) 115.

Distribution: Endemic in the Kuching Division, Sarawak; known only from the *Bau* (Gunung Kawa, G. Lanyang, G. Tabai) and *Padawan-Serian limestone*.

Specimens examined: *Padawan-Serian Limestone* – Gunung Angob, *Anderson S 27513* (SAR); Gunung Bra'ang, *Haviland s.n.* (*n.v.*); Gunung Manok, *Burtt B8134* (SAR).

Notes: Although quite widespread on the Kuching limestone, it is a rare begonia that on the Bau limestone grows in deeply shaded forest on the base of the hills (Kiew & Geri, 2003). Ridley (1906) first described this species from Gunung Bra'ang, from where Haviland had collected it from the summit.

It is an outstandingly decorative begonia - its petioles are densely clothed in long magenta hairs and its bunches of flowers produced from the prostrate rhizome are peach-coloured.

4. ***Begonia chaiana*** Kiew & S. Julia, *sp. nov.*

Sect. *Petermannia*

A Begonia subisensis K.G.Pearce tepalis femineis 3 (nec 5), fructibus pedicellis brevibus usque 7 mm longis (nec usque 30 mm) et alis angustioribus c. 6 mm latis (nec 10-11 mm) differt. **Typus:** Borneo, Sarawak, Kuching Division, Gunung Mentawa, *Kiew, Julia & Pearce S93270,* 8 August 2004 (holo, SAR; iso, E, KEP, L, SING). Figure 4

Cane-like begonia, whole plant glabrous; **stems** erect, 30–50 cm long, young stem reddish and succulent, mature stem green and woody, slender, 3–4 mm thick, nodes swollen, branching to form a spreading crown; without a tuber. Stipules narrowly lanceolate, *ca* 5 x 2 mm, reddish, margin entire, apex glabrous, persistent. **Leaves** distant, 2–4.5 cm apart, slightly oblique; petiole 1.5–2.2 cm long, succulent, pale red; lamina plain glossy dark green above, beneath deep red with green or deep red veins, succulent, drying thinly papery, asymmetric, lanceolate, 8–12 x 2.2–3.5 cm, broad side 1.2–2.5 cm wide, base unequal, basal lobes rounded 5–10 mm long, margin dentate, scalloped between the teeth, apex caudate; venation palmate-pinnate with 1 pair at the base and 2 pairs along the margin branching towards the margin, and with 1 vein in the basal lobe, veins slightly impressed above in life, raised when dry, beneath prominent. **Inflorescences** axillary, pale red, erect, cymose panicle, shorter than the leaves, 6–9.5 cm long, peduncle 2–3 cm long, branches two 2.5–4 cm long, male flowers many, female flowers 1 at the base, protogynous. Bracts obovate 1–2 mm long, margin entire, caducous; bracteoles similar but smaller. Male flowers with a pale red pedicel 5–7 mm long; tepals 2, in bud green or tinged red outside, greenish white or pale reddish green when open, broadly oval, 5 x 4–6 mm, margin entire, apex rounded, glabrous; stamens many, cluster flattened laterally, *ca* 2.5 mm across, stalked; filaments *c.* 1 mm long; anthers pale yellow, almost rounded, 1 mm long, apex slightly notched, opening by lateral slits. Female flowers with a pedicel *ca* 6 mm long; ovary deep red, 5–13 x 6–15 mm, wings 3, more or less equal, *ca* 7 mm wide, locules 3, placentas 2 per locule; tepals 3, deep red, isomorphic, *ca* 9 x 6 mm, obovate, glabrous, margin entire, apex rounded; styles 3, styles and stigma pale yellow, *ca* 4 mm long. **Fruits** pendent on a stiff

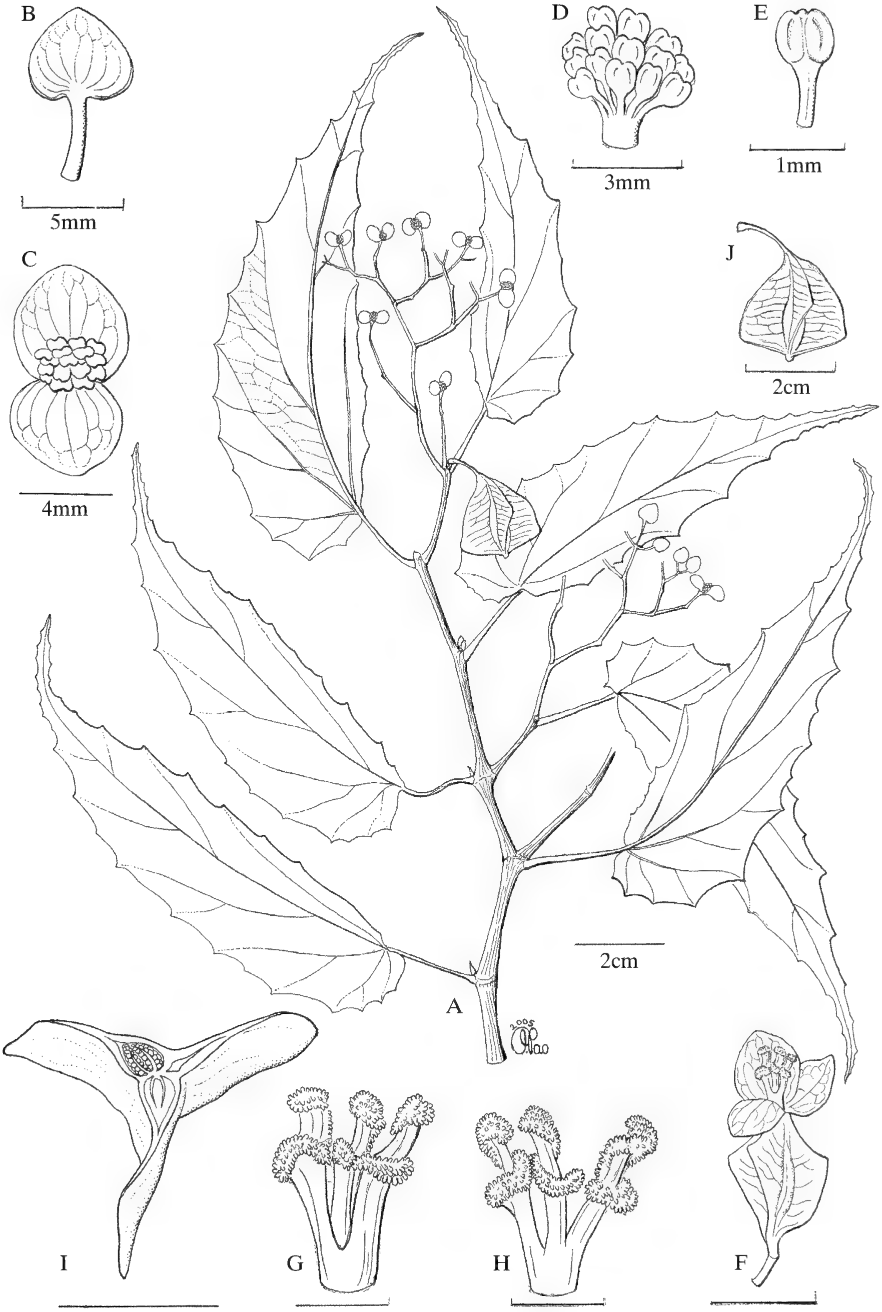

Figure 4. ***Begonia chaiana*** Kiew & S.Julia
A. habit; B. male bud: C. open male flower; D. stamen cluster; E. stamen; F. female flower; G & H. styles and stigmas; I. TS ovary; J. fruit. (A-E from *S 27424*; F-J from *S 93270*).

stalk *ca* 7 mm long; capsule *ca* 15 x 20 mm, hairless, locules 2 (one locule not developing), wings 3, subequal, the longer *ca* 8 mm wide and the shorter two *ca* 6 mm wide, thinly fibrous, splitting between the locules and wings.

Distribution: Endemic in Kuching Division, Sarawak; known from two limestone hills in the Padawan-Serian area.
Habitat: It grows on limestone rocks or jagged cliffs deep in shade below the tree canopy.

Specimens examined: Padawan-Serian limestone - Bukit Pait, *Erwin & Paul Chai S 27424* (SAR), *Julia & Kiew S 95686* (KEP, SAR); Gunung Mentawa, *Anderson 12346* (SAR), *Burtt B 8111*(SAR).

Notes: This is a dainty cane-like begonia with slender stems and rather narrow, glossy dark green leaves that are strikingly deep red underneath. In habit, it is similar to *Begonia subisensis* but differs from this species not only in its female flowers having three tepals (those of *B. subisensis* have 5) but the fruit is also quite different in having a short stiff stalk (whereas that of *B. subisensis* is flexuose, dangling and up to 30 mm long) and the capsule is both smaller and has relatively narrower wings (the fruits of *B. subisensis* are about 14 x 23 mm with wings 10–11.5 mm wide).

It shares the inflorescence type (cymose panicle), two tepals in the male flower and the capsule shape with slightly unequal wings with *Begonia lailana* but differs in its smaller size (*Begonia lailana* grows to 1 m tall, has larger laminas 12.5–17 x 8–10 cm and longer panicles 10–16 cm long) and tepal number in the female flower (5 in *B. lailana*).

In its cane-like habit, its protogynous inflorescences and female flowers with three locules each with two placentas, it conforms to sect. *Petermannia*. However, its fruit wings are slightly unequal and one locule does not develop in the fruit and is empty of placentas and seeds. In addition, the slightly longer wing is not thickened (as it is in sect. *Platycentrum*) and apart from size is identical to the other two wings.

It is an extremely local species known from just two localities.

It is named in honour of Dr Paul Chai Piang Kong, the first Sarawakian appointed as botanist (1971–1986) in the Sarawak Forest Department.

5. ***Begonia congesta*** Ridl.
J. Str. Br. Roy. As. Soc. 46 (1906) 253; Kiew & Geri, Gard. Bull. Singapore 55 (2003) 116.

Distribution: Endemic in the Kuching Division, Sarawak; restricted to the *Bau limestone* (Bidi, Fairy Cave (Bukit Kapur), Bukit Krian, G. Batu, G.

Doya, G. Jebong, G. Kawa, G. Krian, G. lanyang, G. Pambur, G. Ropih, G. Seburan, G. Tai Ton and G. Tongga).
Habitat: In shade on limestone boulders or on damp rock-faces near the cliff base.

Notes: *Begonia congesta* belongs to a group of limestone begonias that are characteristic in their relatively thick stems, often swollen at the nodes, and their leaves that have narrowly bifurcating veins that are impressed above giving the lamina a corrugated surface. It is confined to the Bau limestone where it is common and widespread.

6. ***Begonia corrugata*** Kiew & S. Julia, *sp. nov.*

Section *Petermannia*.
A Begonia congesta Ridl. foliis pubescentibus (nec glabris) et floribus femineis remotis pedicellis longioribus 7–13 mm longis (nec 4–5 mm) differt. **Typus:** Borneo, Sarawak, Gunung Manok, 6 Sept 2005, *Julia & Kiew S 95689* (holo, SAR; iso, E, KEP, L, SING).

Cane-like begonia, ***stems*** greenish or reddish brown, woody, matted ferrugineous, sometimes bristly with translucent/white hairs 3–4 mm long, particularly dense on the uppermost internodes, erect, little branched, to 60 cm tall but flowering at *ca* 10 cm tall, 6–7 mm thick, nodes swollen with a conspicuous stipular scar, internodes 2-6.5 cm long; without a tuber. Stipules narrowly triangular, 7–20 x 4–15 mm, pale green, glabrous, margin entire, apex setose, caducous. **Leaves** oblique, distant, pendent and held flat against the rock surface, petioles (2.5-)4.5–6–5(-7.5) cm long, glabrous and glossy, sometimes densely bristly and bristles 2–3 mm long, narrowly grooved above; laminas plain deep green above, sometimes with a bluish tinge, paler beneath with dense translucent erect bristly hairs 1–2 mm long on the upper surface; thin in life, papery when dry, asymmetric, broadly ovate, 14–22(-25) x 9-16 cm, broad side 7–11 cm wide, base unequally cordate, basal lobes rounded, not overlapping, the larger 1.5–4 cm long, margin ciliate usually almost entire with minute teeth, sometimes serrate, apex shortly acuminate, acumen to 2.25 cm long; venation palmate-pinnate with (1-)2 basal pairs of veins, with 3-5 pairs along the midrib and 3 veins in the basal lobes, veins narrowly parallel and deeply impressed above giving a corrugate appearance, branching once or twice before the margin, beneath prominent, in young leaves red, in mature leaves red and minutely pubescent, sometimes brown and ferrugineous with hairs 1–2 mm long, reticulation of tertiary veins prominent on both surface in dried leaves. **Inflorescences** light green, densely bristly, bristles *ca* 3 mm long, racemose, erect, shorter than the leaves, 13.5–23 cm long, protogynous, female flowers produced singly in the lower part of the inflorescence with up to 5 female flowers *ca* 3.5–5 cm apart, above branches distant and bearing 2–3 cymules of male flowers with one male flower opening at a time. Bracts green, 15–23 x 10–16 mm, minutely hairy especially along the raised midrib, margin entire; bracteoles green, *ca* 8 x 6 mm, decreasing in size towards the apex. Male flowers with a light green pedicel *ca* 4–5 mm long with dense glandular hairs, tepals 2, greenish yellow, broadly oval, margin entire and recurved, apex rounded, on the outer surface densely hairy with short glandular hairs, stamen cluster globose, *ca* 2–3 mm across, sessile, stamens 40–50, filament *ca* 0.75 mm long, anther light yellow, broadly oblanceolate, *ca* 0.75 mm long, apex slightly emarginate, opening by lateral slits. Female flowers with reddish or pale green pedicel and ovary densely covered in short glandular hairs, pedicel 4–10 mm long, ovary oblong 15–19 x 10–12 mm, locules 3, placentas two per locule, wings subequal 2.5–4.5 mm wide, tepals (4 or) 5, ovate, 10–12 x 5–7 mm, toothed towards the apex, teeth tipped by a glandular hair, apex acute, outside glabrous or with dense glandular hairs, greenish yellow or whitish pink, style and stigma greenish yellow *ca* 4 mm long, styles 3, bifid, stigma a papillose spiral band. **Fruit** pendent on a stiff, minutely hairy pedicel (7-)10–13 mm long, capsules 15–20 x 12–15 mm, locules 3, wings 3, subequal, thin, longer wing 4–5 mm wide, narrower wing *ca* 3 mm wide, splitting between the ovules and wing, stigma caducous. **Seeds** barrel-shaped, brown, *ca* 0. 25 mm long, collar cells *ca* half the seed length.

Distribution: Endemic in the Kuching Division, Sarawak; known only from the Padawan-Serian and Penrissen limestone.
Habitat: On steep rock-strewn slopes and on limestone screes in shade under the tree canopy.

Specimens examined: Padawan-Serian limestone - Bukit Angob, *Anderson S 27493* (SAR, SING); Bukit Paya Payung, Tebedu, *Jamree et al. S 73270* (SAR); Gunung Manok, *Burtt B 8133* (SAR); Gunung Mentawa, *Burtt B 8109* (SAR); Gunung Sabu, *Jamree et al. S 75866* (SAR); Gunung Sebakab, *Jamree et al. S75804* (SAR); Gunung Sebengkam, *Jamree et al. S75896* (SAR). *Penrissen limestone* - Gunung Bah, *Julia et al. S 95699* (E, KEP, L, SAR, SING); 16th Mile Penrissen Road, *Anderson S 15274* (SAR).

Notes: Similar to *Begonia congesta* in habit and in its corrugated leaves and in its small male flowers with two tepals that are hairy outside, like *B. congesta* it belongs to sect. *Petermannia* on account of its three-locular ovary, each locule of which has a bilamellate placenta. It differs from *B. congesta* in its densely hairy leaf surface and inflorescences that bear well-spaced single female flowers with long pedicels in the lower part of the inflorescences. (*B. congesta* has two pairs of female flowers with short 4–7 mm-long pedicels that are congested (2–3 mm apart) at the base of the inflorescence).

It is named for its characteristic corrugated leaf surface.

7. ***Begonia kiamfeei*** Kiew & S. Julia, *sp. nov.*

Section: *Petermannia*
A Begonia pendula Ridl. foliis dense hirsutis (nec glabris) et tepalis masculis 4 (nec 2) differt. **Typus:** Borneo, Sarawak, Kuching Division, Gunung Bah, *Julia, Kiew & Leong S 95698,* 17 Nov 2005 (holo, SAR; iso, E, KEP, L, SING). Figure 5

Creeping begonia rooting at the nodes, climbing vertically up rocks and cliffs. **Stems** slender, reddish, unbranched, 23–50 cm long, internodes 2.5–4.5 cm long, succulent and in life *ca* 3 mm thick; without a tuber. Indumentum of uniseriate, translucent or white hairs, scattered and 3 mm long on the stems and petioles; 3–4 mm long on upper and lower surfaces of veins and lamina margin. Stipules broadly ovate, 8–13 x 4–6 mm, membranous, reddish, margin entire, apex setose, rapidly decaying on the plant. **Leaves** alternate, distant, pendent; petioles reddish, succulent, 2.5–6 cm long, terete; laminas oblique, young leaves pale green, adult leaves mid-green with pale green veins, paler beneath, succulent, drying papery, asymmetric, ovate, 6.5–8.5 x 5–8.5 cm, broad side 3.5–5.5 cm wide, base cordate, basal lobes 2–4.5 cm long, margin minutely dentate, teeth tipped by a hair, apex acuminate, acumen 1–1.7 cm long; venation palmate with 2 pairs of veins at the base, 1 pair along the midrib and 2 veins in the basal lobe, branching towards the margin, midrib and veins impressed above, slightly prominent beneath. **Inflorescences** axillary, erect, cymose panicle, pale green, sparsely hairy, 13–23 cm long, longer than the leaves, peduncle 6.5–10 cm long, branches 10-15 mm long, male flowers many, female flowers 1 per branch with up to 6 branches bearing female flowers, protogynous. Bracteole pairs subtending the male flowers white, lanceolate, 4–6 x 3–4 mm, glabrous, margin entire. Male flowers with pedicels 6-10 mm long; tepals 4, pure white, margin entire, apex rounded, glabrous, outer two obovate, 6.5-8 x 6-7 mm, inner two narrowly oblong, 5–7 x 2–3 mm; stamens 26–30, cluster globose, 2–3 mm diam., sessile; filaments *ca* 0.5 mm long; anthers yellow, obovate, 0.75–1 mm long, apex emarginate, opening by lateral slits. Female flowers with white pedicels *ca* 8 mm long; ovary white, *ca* 7 x 14 mm, wings 3, more or less equal, *ca* 5 mm wide, locules 3, placentas two per locule; tepals 4 or 5, white, glabrous margin entire, apex acute, outer ovate, *ca* 4 x 2 mm, inner smaller 3 x 2 mm; styles 3, yellow, *ca* 2 mm long, joined for *ca* half its length, ultimate

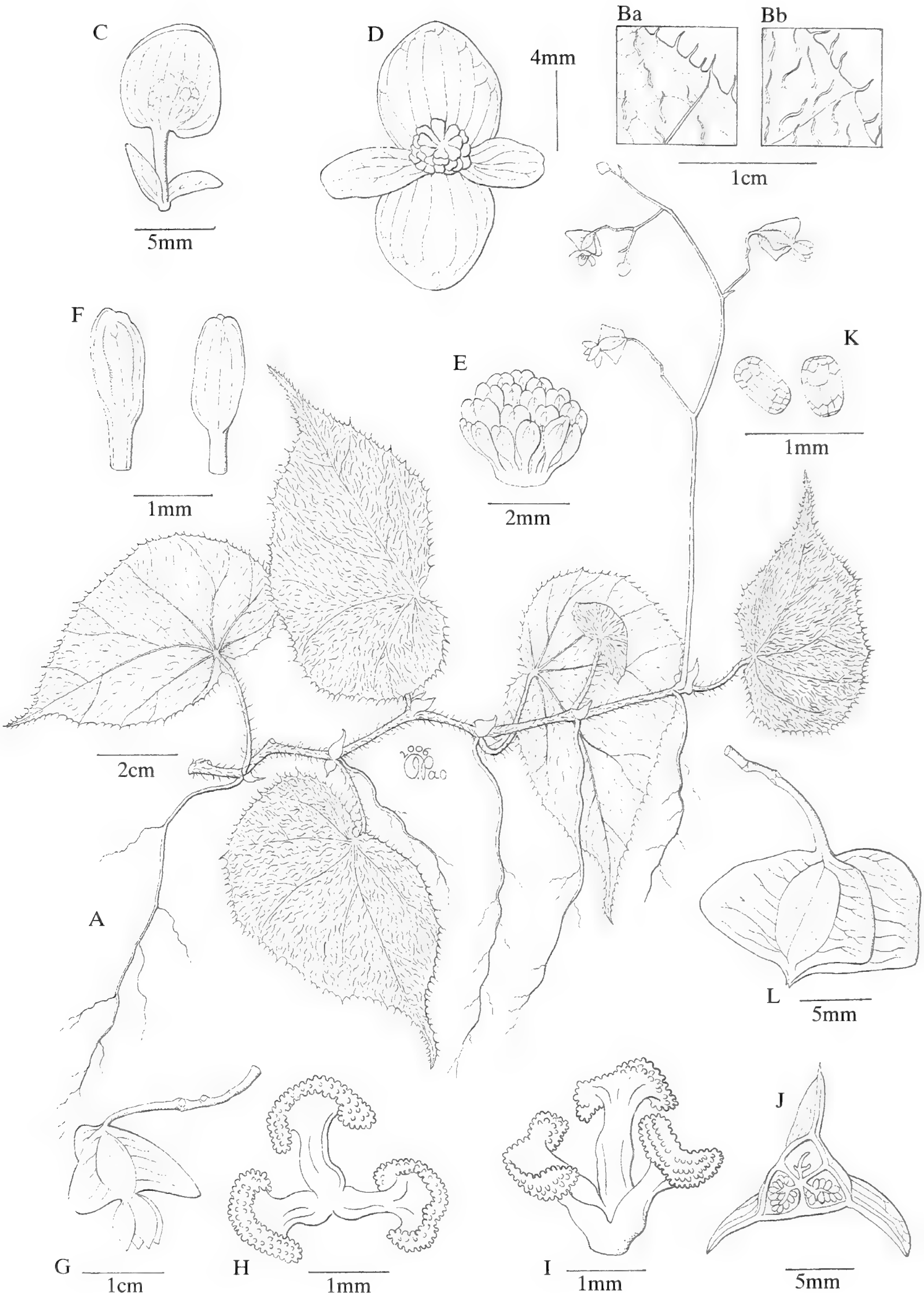

Figure 5. ***Begonia kiamfeei*** Kiew & S.Julia
A. habit; B. leaf surface (a) lower side, (b) upper side; C. male bud: D. male flower; E. stamen cluster; F. stamens; G. female flower; H & I. styles and stigmas; J. TS ovary; K. seed; L. fruit. (All from *S 95698*).

branches broadly U-shaped. **Fruits** pendent on fine stalks *ca* 6–13 mm long; capsules 6–8 x 13–15 mm, glabrous, wings 3, equal, thinly fibrous, (3–)5–6 mm wide, splitting between the locules and wings. **Seeds** barrel-shaped, *ca* 0.5 mm long, collar cells *ca* half the seed length.

Distribution: Endemic in the Kuching Division, Sarawak; on Penrissen limestone, known from a single hill.
Habitat: Growing directly on limestone rocks where there is a deep moss layer in light shade.

Notes: The very pale green leaves and pure white flowers make it a striking begonia. (Most Bornean begonias have pink flowers). It grows on shaded damp mossy vertical cliff faces, the same micro habitat as *Begonia pendula* with which it shares the creeping habit with slender stems that root at the node. However, it is very different from *B. pendula* that is glabrous, has variegated leaves, deep pink or red flowers and male flowers with two tepals. It has been collected from a single hill.

It is named for Leong Kiam Fee, botanist with the Singapore Botanic Gardens, and one of the discoverers of this new species

8. ***Begonia lailana*** Kiew & Geri
Gard. Bull. Singapore 55 (2003) 117.

Distribution: Endemic in the Kuching Division, Sarawak; known only from the Bau limestone (Gunung Aup, G. Batu, G. Doya, G. Kawa, G. Lanyang, G. Podam, G. Poing, G. Tabai).
Habitat: On soil at the base of limestone hills, in light shade.

Notes: It is a cane-like begonia with large, glossy green leaves sometimes with scattered dark red bristles on the upper surface. Its attractive red, toothed tepals in the female flowers are unusual among Bornean begonias.

9. ***Begonia paoana*** Kiew & S. Julia, *sp. nov.*

Sect. *Petermannia.*
A Begonia lailana Kiew & Geri laminis longioribus 17–23 cm longis (nec 12–17 cm) inflorescentis longioribus 12–25 cm longis (nec 10–16 cm longis) et paribus florum femineorum 2 (nec 1) differt. **Typus:** Borneo, Sarawak, Gunung Rimo, *Julia, Kiew & Geri S91390,* 29 April 2005 (holo, SAR; iso, KEP, E, L, SING). Figure 6

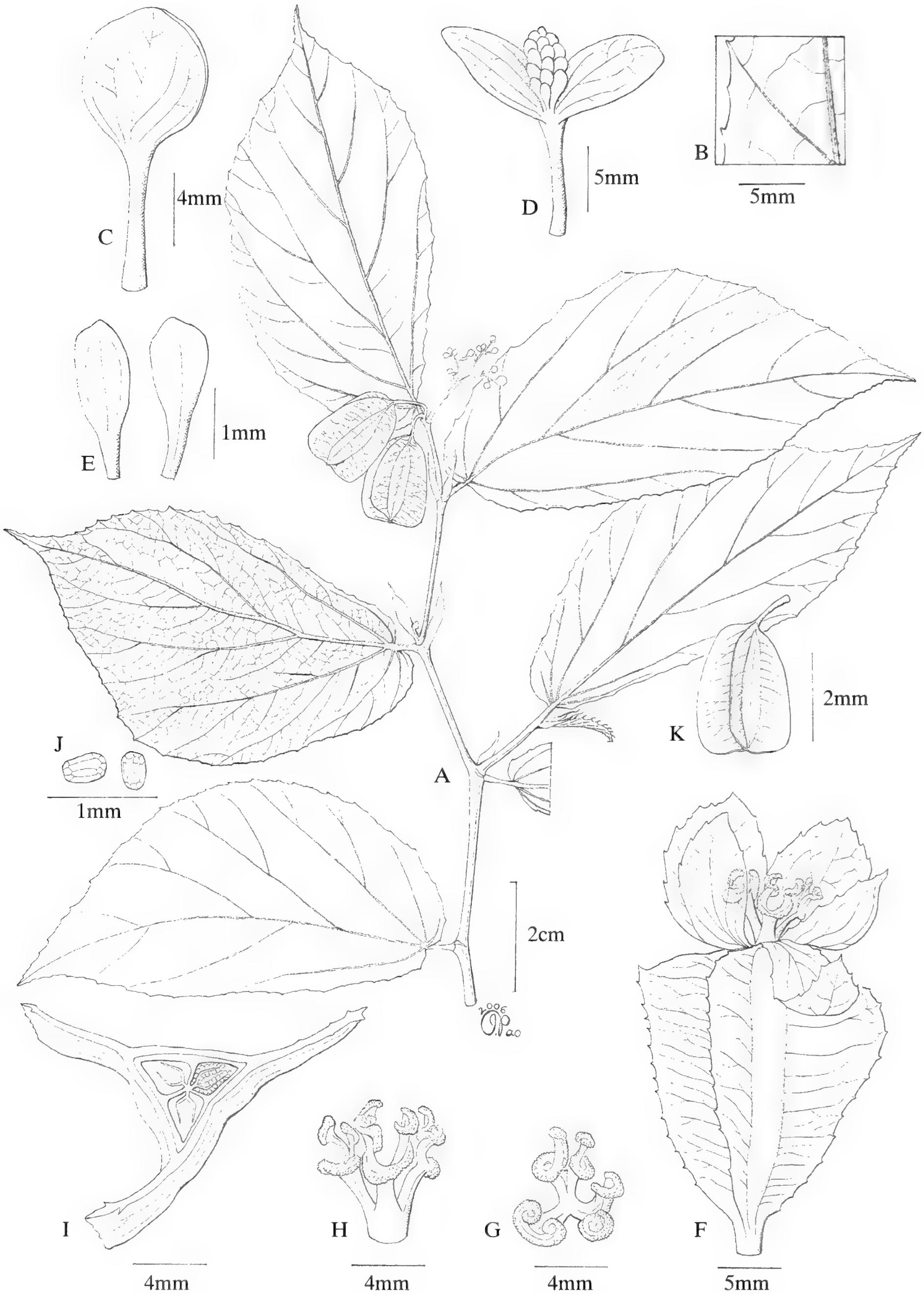

Figure 6. ***Begonia paoana*** Kiew & S.Julia
A. habit; B. lower leaf surface; C. male bud: D. male flower; E. stamens; F. female flower; G & H. styles and stigmas; I. TS ovary; J. seed; K. fruit. (All from *S 91390*).

Cane-like begonia, **stems** up to 1.2 m tall, 3–4 mm diam., reddish brown, woody, minutely pubescent on the uppermost nodes, internodes 3–13.5 cm long, branching; without a tuber. Stipules lanceolate, 16–35 x 6–10 mm, pale green, glabrous, margin entire, midrib ridged, apex attenuate, caducous. **Leaves** alternate, distant, not oblique; petioles 5–10(-18) mm in the lower leaves, 6–10(-20) mm in the upper leaves, slightly thickened, minutely pubescent, brownish red, terete; laminas plain mid-green above, paler below, in most plants leaves glabrous above, a few plants with minute red hairs on a raised hair base, oblanceolate, asymmetric, 15–24 x 4.5–11 cm, broad side 4–8 cm wide, succulent in life, papery when dry, base rounded on the broad side, basal lobe 0.5–1.3 cm long, cuneate or rounded on the narrow side, margin minutely dentate, apex acuminate; venation palmate-pinnate with 1 pair of veins at the base, 4-6 pairs along the midrib and 2-3 veins in the basal lobe, branching twice, impressed above, beneath veins slightly prominent, concolorous and glabrous or minutely pubescent. **Inflorescences** axillary, erect, dull red, (3-)11–25 cm long, longer than the leaves, sessile or with a peduncle *ca* 3 cm long, racemose with cymose branches of male flowers, branches 2–4 cm long, glabrous, protogynous with (rarely 1 or) 2 pairs of female flowers at the base and many male flowers on side branches above. Bracts pale green, *ca* 7 x 3 mm, margin entire, glabrous. Male flowers with glabrous pedicels 6-7 mm long, tepals 2, pale green flushed crimson, round with a recurved margin, 5–7 x 5–7 mm, glabrous, stamen cluster conical, *ca* 2.5 mm across, stamens *ca* 40; filament *c.* 0.75 mm long, anther pale yellow, oblanceolate, *ca* 1 mm long, apex rounded, dehiscing by longitudinal slits. Female flowers with pale red pedicels 7–8 mm long, ovary pale red, glabrous, 15 x 12–14 mm, locules 3, each locule with 2 placentas, wings 3, equal; tepals 5, greenish yellow, isomorphic, oval, 10–11 x 4–6 mm, slightly toothed towards the acute apex; styles 3, 3–4 mm long, bifurcating, stigma a spirally twisted papillose band. **Fruits** on a stiff, decurved stalk, 10–23 mm long, capsules glabrous, oblong, widening towards the apex, 20–28 x 21–25 mm, wings 3, subequal, larger wing 6-10 mm wide and the smaller two 6–8 mm wide, thinly fibrous, dehiscing between the locules and the wings, stigma caducous. **Seeds** barrel-shaped, brown, *ca* 0.25 mm long, collar cells more than half the seed length.

Distribution: Endemic in the Kuching Division; known only from the Padawan-Serian and Penrissen limestone.
Habitat: Slope of limestone hill or on limestone screes, rubble or rocks at 130–280 m altitude, locally common.

Specimens examined: Padawan-Serian limestone - Bukit Peyang, *Yii & Othman S 46218* (SAR); Gunung Manok, *Mamit S 33476* (SAR); Gunung

Mas, *Julia et al. S 95693* (E, KEP, SAR, SING); Gunung Selabor, *Anderson S20827* (SAR), *S28053* (SAR); Selabor, 3 Sept 2005, *Julia & Kiew S 95676* (E, KEP, L, SAR, SING); Seburan, *Anderson S 12921* (SAR); Teng Bekap, *Mamit S 32641* (SAR). *Penrissen limestone* – Gunung Rimo (type).

Vernacular names: Kura (Bidayuh), riang (Iban).

Notes: This cane-like begonia is similar to *Begonia lailana* in habit, size, and the leaves that are not oblique. However, it differs in the petioles not being densely hairy, the juvenile leaves are never spotted, nor are the adult leaves reddish beneath and the leaves are considerably larger, the inflorescences longer, and there are two pairs of female flowers in the inflorescence.

It is more common on the Padawan-Serian limestone; as yet it is known from only one hill (Gunung Rimo) in the Penrissen limestone area.

There are two other specimens collected from Padawan limestone (*S 27425* from Bukit Pait and *CWL 1306* from Gunung Mentawa) that are similar in habit to *B. paoana* but they differ in having narrowly oblong fruits (15 x 9 – 25 x 15 mm) that are narrowed towards the apex. These populations have not been refound and the specimens without inflorescences and flowers are insufficient to describe.

This species is named in honour of Joseph Pao, botanical artist in the Sarawak Herbarium.

10. ***Begonia pendula*** Ridl.
J. Str. Br. Roy. As. Soc. 46 (1906) 257; Kiew & Geri, Gard. Bull. Singapore 55 (2003) 120.

Distribution: Endemic in the Kuching Division, Sarawak: known only from the Bau and Padawan-Serian limestone. *Bau limestone* - Bidi, Bukit Boring, Gunung Apin, G. Aup, G. Batu, G. Berloban, G. Doya, G. Jebong, G. Juita, G. Lobang Angin, G. Pambur, G. Podam, G. Poing, G. Ropih, G. Setiak, G. Stulang, G. Tabai, G. Tai Ton, G. Tongga, G. Umbut; *Padawan-Serian limestone* - Gunung Selabor, *Sinclair SFN 38471* (SING).
Habitat: On damp, mossy vertical limestone cliff faces, in shade beneath the tree canopy.

Notes: It is a decorative begonia with bright green leaves variegated with silver green spots between the veins. Its flowers too are attractive being deep pink or red. On the Bau limestone, it is common. Ridley (1906) named it 'pendula' from its stems that trail down the cliff faces.

11. ***Begonia penrissenensis*** Kiew & S. Julia, *sp. nov*.

Section: *Petermannia*
A Begonia rubida Ridl. laminis longioribus 9–12 cm longis (nec usque 8 cm longis), lamina folii quam lobo basali 5-plo longiore (nec lamina lobo basali duplo longiore) et tepalis masculis 2 (nec 4) differt. **Typus:** Borneo, Sarawak, Kuching Division, Gunung Bah, *Kiew, Julia & Leong S95700,* 17 Nov 2005 (holo, SAR; iso, KEP, E, K, L, SAN, SING). Figure 7

Cane-like begonia, whole plant glabrous; **stems** erect, up to 50 cm long and 5 mm thick, reddish brown, several stems arising from branches from the base, nodes swollen, internodes 2–7 cm long; without a tuber. Stipules lanceolate, pale green, 7–10 x 3.5–6 mm, margin entire, keeled toward the apex, apex apiculate, persistent. **Leaves** distant; petioles deep red, *ca* 2 cm long in the upper leaves, elongating to 4.5 cm in lower leaves, succulent, terete; laminas oblique, deep green above and pale green beneath or bronze green above and purple-red beneath, sometimes with silver-grey spots with a deep green centre in rows between the veins, all colour forms with deep red veins that on the upper surface appear blackish, in life succulent and brittle, drying thinly leathery, asymmetric, narrowly ovate, 9.5–12 x 5–6 cm, broad side 3.2–4 cm wide, base unequal, basal lobe large and rounded, 1.5–2.5 cm long, margin minutely toothed at the vein endings, apex acuminate, acumen *ca* 1–2 cm long; venation palmate-pinnate with 1(-2) pairs at the base and 2-3 pairs along the midrib and with 2(-3) veins in the basal lobe, branching twice, veins slightly prominent above and beneath, red beneath. **Inflorescences** axillary, reddish, glabrous, erect, cymose panicles with up to 4th order branching, shorter than the leaves, (1.3-)2–3.6(-5.2) cm long, peduncles 1.3–1.7 cm long, female flowers on short branches at the base, subsessile to 2–7 mm long, upper branches with male flowers (7-)10–15 cm long, male flowers many, female flowers usually 1 or sometimes 2, protogynous. Bracts pale green, lanceolate, 7–10 x 2–4 mm, margin entire, persistent; bracteoles similar but smaller. Male flowers with green pedicels 6–10 mm long; tepals 2, pale greenish yellow, glabrous, broadly ovate, 5–8 x 6–8.5 mm, margin entire, apex acute to rounded; stamens 30-40, cluster broadly conical, 3–5 mm diam., sessile; filaments *ca* 1 mm long; anthers pale yellow, obovate, 0.75 mm long, apex emarginate, opening by lateral slits. Female flowers with reddish pedicels 10–22 mm long; ovary pale green, 5–12 x 10–15 mm, wings 3, equal, 2–6 mm wide, pointed to rounded, locules 3, placentas 2 per locule; tepals 4, pale green, tinged rosy red, glabrous, isomorphic, lanceolate, 6–8 x 4–5 mm, margin entire, apex acute; styles 3, 2–4 mm long, free to the base and bifurcating with ultimate branches broadly U-shaped. **Fruits** pendent on fine stalks 2.2–3 cm long; capsules 8–13 x 20 mm, locules 3, wings 3,

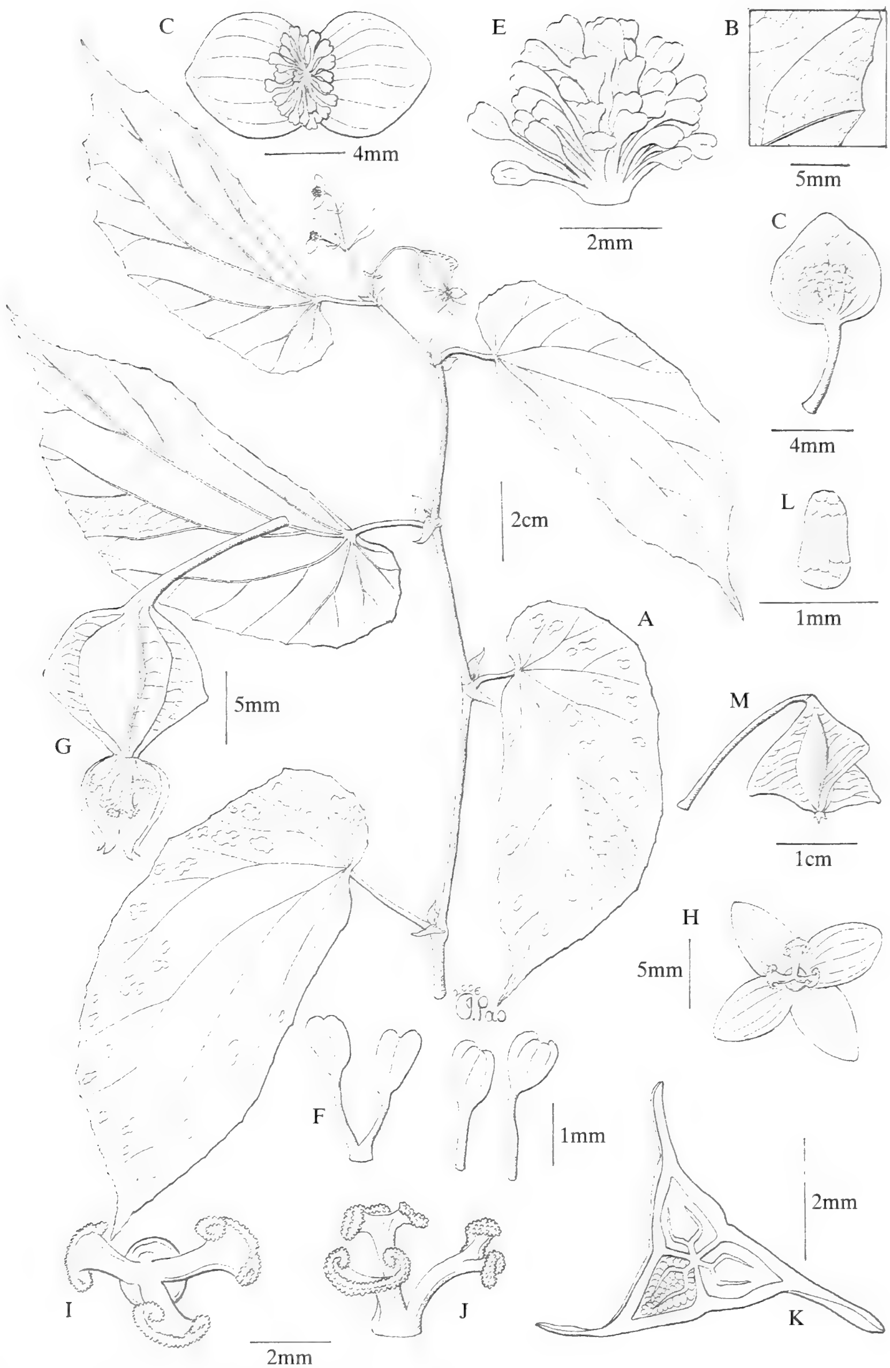

Figure 7. ***Begonia penrissenensis*** Kiew & S.Julia
A. habit; B. lower leaf surface; C. male bud: D. male flower; E. stamen cluster; F. stamens; G. female flower; H. open female flower; I & J. styles and stigmas; K. TS ovary; L. seed; M. fruit. (A-L from *S 95700*; M from *S 91389*).

rounded to pointed, equal, fibrous, wings 6–7 mm wide, splitting between the locules and wings. **Seeds** barrel-shaped, *c.* 0.5 mm long, collar cells about ¾ seed length.

Distribution: Endemic in the Kuching Division, Sarawak, known only from the Penrissen limestone.
Habitat: Confined to limestone, it grows on rocky shoulders of the limestone hill *c.* 250 m high, in light shade.

Specimen examined: Penrissen limestone – Gunung Rimo, *Julia, Kiew & Malcom S 91389* (E, KEP, SAR).

Notes: It is an attractive begonia with the large, pale green pairs of stipules contrasting with its red stems. In addition, some plants have adult leaves with silver-grey spots or are bronze-coloured.

12. ***Begonia punchak*** Kiew & S.Julia, *sp. nov.*

Section: *Petermannia*
A Begonia rubida Ridl. petiolis brevioribus usque 2.5 cm longis (nec 5 cm longis), lamina folii quam lobo basali 3-plo longiore (nec lamina lobo basali duplo longiore) et fructibus alis angustioribus 2-3 mm latis (nec 4–5 mm latis) differt. **Typus:** Gunung Burau, Penrissen, *Julia, Kiew & Malcom S 91392,* 30 April 2006 (holo, SAR; iso, E, KEP, L, SING). Figure 8

Cane-like begonia, whole plant glabrous. **Stems** erect, 50–75 cm tall, glossy, crimson, old stem becoming brown and woody, 6–7 mm thick, several stems produced from branching at the base, nodes swollen with a conspicuous stipular scar, internodes 1.5–2.5 cm, upper branches zigzag; without a tuber. Stipules foliaceous, pale green tinged red, 2.2 x 0.8 cm, margin entire, broadly lanceolate, outside keeled, apex acute, soon caducous. **Leaves** distant, alternate, held almost horizontally; petioles 1–2.5 cm long, dark crimson, succulent, terete; lamina oblique, plain mid-green above with a red patch at the base, yellowish green beneath contrasting with deep crimson veins, glossy, in life succulent, asymmetric, ovate, up to 7 x 4.5 cm, decreasing markedly in size towards the apex, broad side to 3 cm wide, base unequal, basal lobe rounded up to 2.75 cm long, margin undulate with minute distant teeth, apex acuminate; venation palmate-pinnate, 3 veins at the base, 1-2 pairs along the midrib and 2 veins in the basal lobe, branching once, impressed above, prominent beneath. **Inflorescences** axillary, deep crimson, unisexual, protogynous; without bracts. Female inflorescences with a peduncle 1.5–3.5

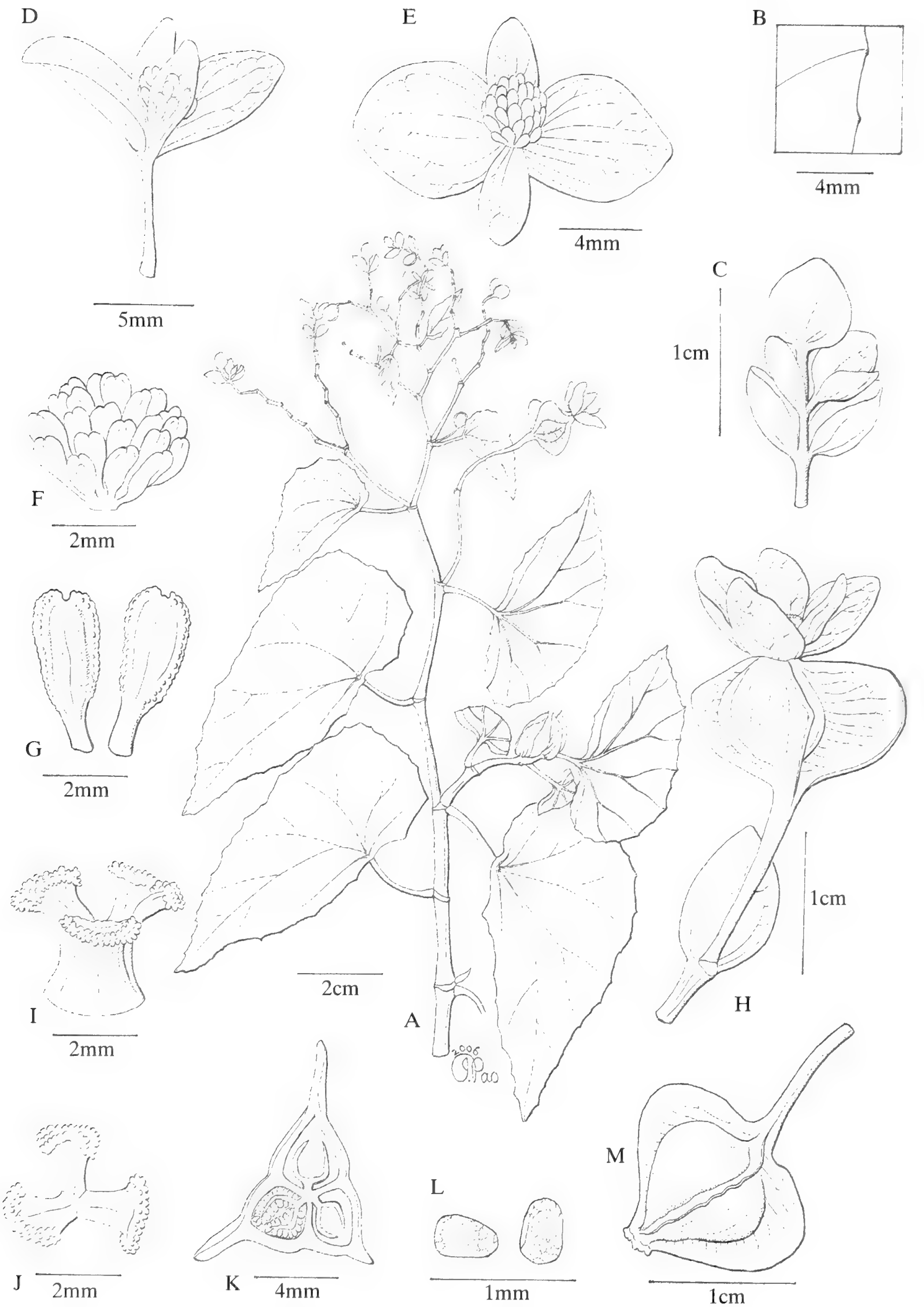

Figure 8. ***Begonia punchak*** Kiew & S.Julia
A. habit; B. lower leaf surface; C. male bud with bracteoles: D. male flower; E. open male flower; F. stamen cluster; G. stamens; H. female flower with bracteole; I & J. styles and stigmas; K. TS ovary; L. seed; M. fruit. (All from *S 91392*).

cm long terminating in 2 pendent female flowers. Male inflorescences with two branches, peduncle 1.5–2.5 cm long, branches up to 4 cm long with 5–10 cymule scars, cymules with 3 male flowers, subtended by foliaceous bracteoles, pale green tinged red, ovate, 5–7 x 6 mm, cucullate, caducous. Male flowers many, pedicels crimson, 2–3 mm long; tepals 4, margin entire, apex rounded, outer two broadly ovate, 5–7 x 7 mm, cream with crimson centre, inner two cream, narrowly lanceolate *ca* 4 x 2 mm; stamens 23–24 in a subsessile, globose cluster, *ca* 2 mm diam., filaments *c.* 1 mm long, anthers yellow, obovate, *ca* 1 mm long, apex emarginate, opening by lateral slits. Female flowers pendent, pedicels crimson, 15–20 mm long; ovary glossy, crimson, *ca* 8 x 12 mm, wings 3, subequal, *ca* 3 mm wide, slightly pointed distally, locules 3, placentas 2 per locule; tepals 5, margin entire, apex acute, outer four isomorphic, elliptic, *ca* 8 x 5 mm, inner one narrow *ca* 4 x 2 mm; styles 3, crimson, widely U-shaped, *ca* 2 mm long. **Fruits** pendent, peduncle and pedicels thin and hair-like, 16–20 mm long; capsules 10–13 x 9–15 mm, wings 3, thinly fibrous, subequal, two rounded, sometimes slightly wider distally, 2–3 mm wide, in some fruits the third wing scarcely developed, dehiscing between the locules and wings. **Seeds** barrel-shaped, *ca* 0.3 mm long, collar cells about ¾ of the seed length.

Distribution: Endemic in the Kuching Division, Sarawak; known from a single hill in the Penrissen limestone.
Habitat: It grows in soil pockets in an exposed position on the limestone rocks near the summit. The summit of this particular hill had been burned leaving bare exposed rocks and it was in this area that it was found.

Notes: This new species is remarkable among Sarawak limestone begonias for its microhabitat. 'Punchak' is the Malay word for summit, hence the species epithet. (In the modern Malay spelling system, 'ch' is spelt 'c', so summit would be written 'puncak'.) This compares with Sabah, where for example, *Begonia keithii* Kiew, grows in similar exposed conditions. *B. rubida* from the Bau limestone grows near the summit of hills but always on a substrate of thick peat where it is lightly shaded by the straggly trees that grow near the summit.

The new species is distinct from *B. rubida* in its shorter petioles and the basal lobe less than half the length of the lamina and in its capsules that have narrower wings. *B. penrissenensis* also has leaves with a basal lobe about a third the lamina length, but *B. punchak* differs from this species in its smaller leaves with shorter petioles and the male flowers with 4 (not 2) tepals.

Begonia punchak is distinctive among limestone begonias in sect. *Petermannia* in that the female flowers are produced in separate leaf axils from the male inflorescences. The more usual conditions are for the female flowers to be produced from the lower branches of the inflorescence or from the base, but still in the same axil. Unlike typical species in this section, its capsule wings are sometimes unequal, two wings being 2–3 mm wide and the third being reduced to almost being wingless. It is an extremely decorative begonia with glossy bright red stems, ovaries and fruits.

13. ***Begonia rubida*** Ridl.
J. Str. Br. Roy. As. Soc. 46 (1906) 256; Kiew & Geri, Gard. Bull. Singapore 55 (2003) 121.

Distribution: Endemic in the Kuching Division, Sarawak; known only from the Bau and Padawan-Serian limestone. *Bau limestone* - Bidi, Bukit Jebong, Bukit Manok, Bukit Numpang, Gunung Apin, G. Batu, G. Juita, G. Meraja, G. Pambur, G. Ropih, G. Setiak, G. Tai Ton, G. Tongga, G. Umbut.
Specimens examined: *Padawan-Serian limestone* - Bukit Regu, *Paul et al. S 37392* (SAR); Gunung Manok, *Erwin & Paul S 27416* (SAR).

Notes: This species is likely to be more widespread on Padawan-Serian limestone but is difficult to collect as it grows on the summit shoulders of the tower karst hills. Erwin & Chai collected it from the summit of Gunung Manok at 330 m altitude.

14. ***Begonia serapatensis*** Kiew & S. Julia, *sp. nov*.

Sect: *Petermannia*
A Begonia rubida Ridl. laminis majoribus 9–11 x 7–10 cm (nec 4.5–8 x 3–5.5 cm), floribus albis (nec rubris) et alis fructus inaequalibus longissima 6–9 mm lata (nec alis inter se aequalibus et 4–5 mm latis) differt. **Typus:** Borneo, Sarawak, Kuching Division, Bukit Serapat, 8 August 2004, *Kiew, Julia & Tan S93267* (holo, SAR; iso, E, KEP, SING). Figure 9

Cane-like begonia, whole plant glabrous; **stems** erect, 20–50 cm long, young stem reddish brown flecked with white, becoming brown and woody at the base, several stems produced from branching at the base, nodes swollen with a conspicuous stipular scar, 6–8 mm thick; without a tuber. Stipules narrowly lanceolate, pale green, 2 x 4–7 mm, margin entire, apex caducous. **Leaves** distant 2.5–3 cm apart; petiole 3.5–5.5 cm long, succulent, reddish brown; lamina oblique, young leaves green with dark red veins and pale green linear spots between the veins, glossy mid-green with a red patch at junction of lamina and petiole, beneath pale green, succulent and brittle, drying papery, asymmetric, broadly lanceolate, 9–11 x 7–10 cm, broad side

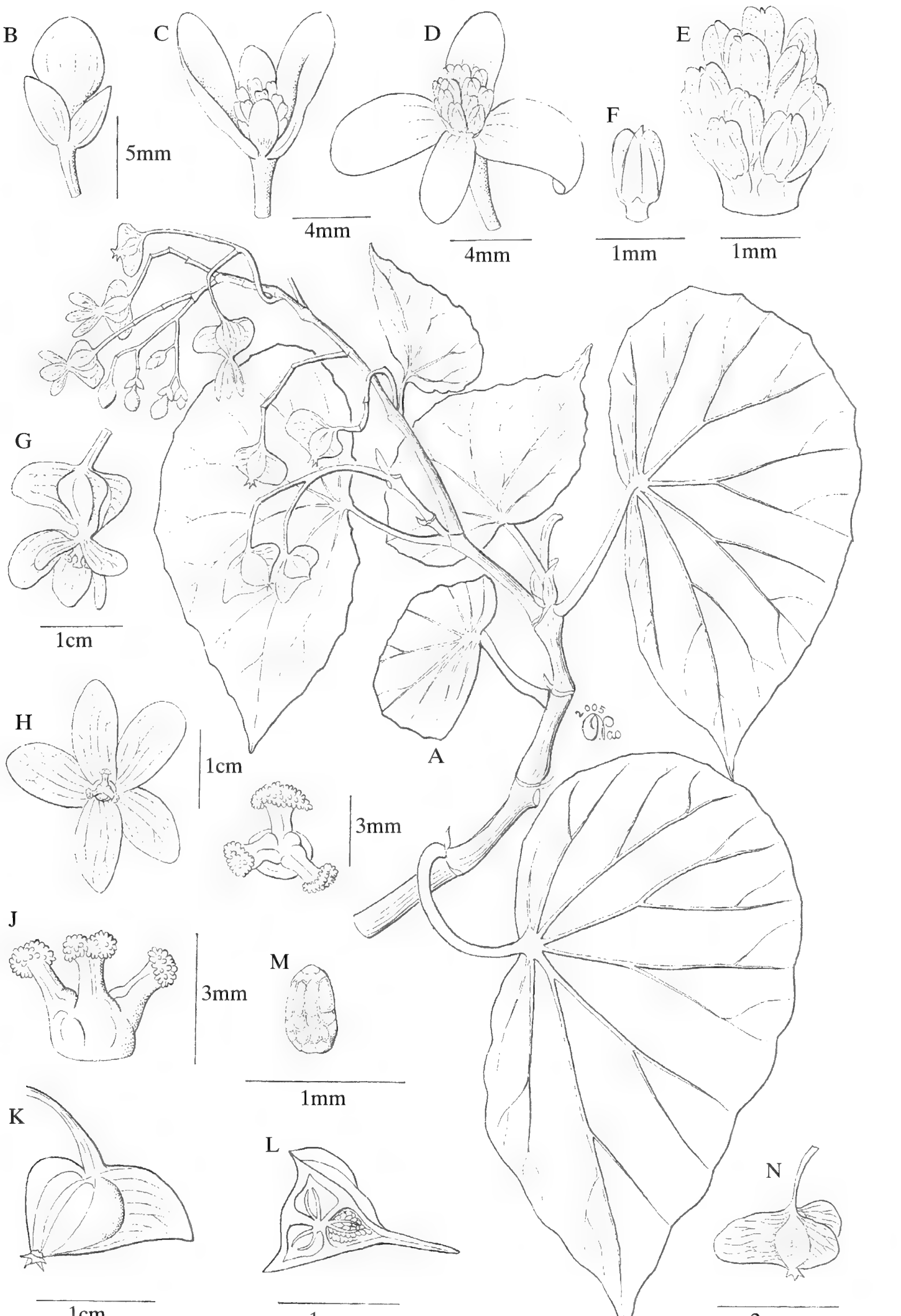

Figure 9. ***Begonia serapatensis*** Kiew & S.Julia
A. habit; B. male bud with bracteoles: C. male flower; D. open male flower; E. stamen cluster; F. stamens; G. female flower; H. open female flower; I & J. styles and stigmas; K. fruit; L. TS ovary; M. seed; N. fruit. (All from *S 93267*).

5.5–13 cm wide, base unequal, basal lobe large and rounded, 4.5-6.5 cm long (about half the length of the lamina), margin entire, apex acuminate; venation palmate-pinnate with 2 pairs at the base and 2 pairs along the midrib and with 3 in the basal lobe, branching twice, veins slightly prominent above and beneath, red beneath. **Inflorescences** axillary, reddish, glabrous, erect, cymose panicle, longer than the leaves, 9–15 cm long, peduncle *ca* 6.5 cm long, female flowers on short branches at the base 2.5–3 cm long, upper branches with male flowers 6–8 cm long, male flowers many, female flowers 2 to 10 or more, protogynous. Bracts pale green, broadly ovate, *ca* 5 x 7 mm, margin entire, caducous; bracteoles similar but smaller. Male flowers with a rosy red pedicel 10–15 mm long; tepals 4, white, deep red towards the base, margin entire, apex rounded; outer two oval, 8–10 x 6–8 mm, inner two narrowly oval, 4–6 x 1.5–3 mm; stamens many, cluster globose, 2–3 mm diam., sessile; filaments almost absent; anthers yellow, obovate, *ca* 1 mm long, apex slightly notched, opening by lateral slits. Female flowers with a rosy red pedicel *ca* 5 mm long; ovary pale green, *ca* 12 x 13 mm, wings 3, unequal, longer wing *ca* 8 mm wide, shorter wings *ca* 3 mm wide, locules 3, placenta two per locule; tepals 5, greenish white, outermost reddish at base, margin entire, apex rounded, outer four isomorphic 9–10 x 5–7 mm, inner tepal narrowly oval, 7–8 x 3–4 mm; styles 3, styles and stigmas pale yellow, *ca* 3 mm long. **Fruits** pendent on a thin stiff stalk 11–23 mm long; capsule 9–10 x 14–20 mm, locules 3, wings 3, rounded, unequal, fibrous, longer wing 6–9 mm wide, shorter wings 2–3 mm wide, splitting between the locules and wings. **Seeds** barrel-shaped, *ca* 0.8 mm long, collar cells *ca* half seed length.

Distribution: Endemic in the Kuching Division, Sarawak, known only from a single limestone hill in the Penrissen area.
Habitat: It grows on rocky shoulders of a limestone hill *ca* 250 m high, in light shade.

Notes: In its woody, slightly zig-zag stems and its oblique leaves that are succulent and glabrous and with a large basal lobe almost half the length of the lamina, it resembles *Begonia rubida*. It differs, however, in a number of characters: it does not have the fine ruby coloration of the stems and flowers of *B. rubida* instead the flowers of *B. serapatensis* are white; the leaves are also much larger than those of *B. rubida*. The apparent difference in tepal number in the female flowers between these two species [Ridley (1906) described *B. rubida* as having three tepals] is not supported as the flowers of *B. rubida* we examined had five, three larger and two smaller inner ones.

15. ***Begonia speluncae*** Ridl.
J. Str. Br.Roy. As. Soc. 46 (1906) 258; Kiew & Geri, Gard. Bull. Singpaore. 53

(2003) 122.

Distribution: Endemic in the Kuching Division; from the Bau, Padawan-Serian and Penrissen limestone. *Bau* - Bidi, Fairy Cave, Gunung Aup, G. Batu, G. Doya, G. Jebong, G. Kawa, G. Lanyang, G. Meraja, G. Podam, G. Poing, Quop. *Padawan-Serian* - Bukit Pait , Gunung Berloban, G. Manok, G. Mas, G. Sebengkam, G. Selabor, Sungai Serin, Tebedu. *Penrissen* - Gunung Bah, G. Burau.
Habitat: On vertical rock faces at the base of limestone cliffs or on the vertical sides of large boulders; in the Bau area frequently on dry rock faces, in the Padawan-Serian and Penrissen areas usually on damp, deeply shaded rock faces.

Notes: This is the most common begonia on limestone in the Kuching Division, being found on most hills, although it is interesting to note that it is not found on those hills where the other begonias with a rosette habit, *Begonia andersonii* and *B. burttii*, occur, both of which occupy the same habitat on sheer, shaded, vertical rock faces.

Ridley (1906) described the leaves of this species as orbicular cordate, but they are without exception peltate. Plants of the Bau limestone uniformly have small laminas (1.2–4.5 x 1.4–5.7 cm), but plants in the Padawan-Serian populations show a much greater range from 3.2 x 4 cm to 5 x 5.5 cm with exceptional plants with laminas up to 10 x 12 cm (*Patsipun et al. S 82156*). They are otherwise typical, for example, in the broad laminas with a rounded apex and the indistinct midrib due to its bifurcating.

Specimens examined: *Padawan-Serian limestone* - Bukit Pait, *Erwin & Paul S 27427* (SAR), *Julia & Kiew S 95687* (KEP, SAR); Gunung Berloban, *Yii S46142* (SAR); Gunung Manok, *Burtt B 8132* (SAR), *Julia & Kiew S 95677* (E, KEP, SAR); Gunung Mas, *Julia et al. S 95691* (KEP, SAR, SING); Gunung Sebengkam, *Jamree et al. S 75900* (SAR); Gunung Selabor, *Anderson S 20836* (SAR), *Ilias Paie S 28044* (SAR); Sungai Serin, *Jacobs 5177* (SAR); Tebedu 15th Mile, *Abg. Mohtar S 49238* (SAR); Bukit Payung, Tebedu, *Patsipun et al. S 82156* (KEP, SAR). *Penrissen limestone*: Gunung Bah, *Julia et al. S 95694* (SAR), *Rantai et al. S 66034* [Gunung Bar] (SAR); G. Burau, *Julia et al. S 91388* (E, KEP, L, SAN, SAR, SING).

Incompletely Known

The begonia collected by Yii & Othman (*S 46275*, SAR) from Gunung Selangan (10 km Tebakang/Tebedu Road), Padawan-Serian limestone, is quite unlike any other limestone begonia in its short petiole, non-oblique, narrowly obovate leaves 10 by 3.5 cm and its short inflorescences. It belongs to the same group of begonias as *Begonia pubescens* Ridl., but is very different in being a larger plant (about 15 cm tall) and in being much less pubescent. It is obviously a new species but it has not been recollected and the material available is too incomplete to describe.

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Five new genera and three new species of Grammitidaceae (Filicales) and the re-establishment of *Oreogrammitis*

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Abstract

Five new genera of Grammitidaceae (Filicales) are described: *Ctenopterella* Parris (12 species), *Dasygrammitis* Parris (six species), *Radiogrammitis* Parris (28 species), *Tomophyllum* (E.Fourn.) Parris (22 species) and *Xiphopterella* Parris (six species). *Oreogrammitis* Copel. (Grammitidaceae) is re-established (110 species). New combinations are made in all six genera. Synonymy is provided, types are indicated, including those of synonyms, and lectotypes are chosen for some names. Three new species are described from Peninsular Malaysia, *Oreogrammitis malayensis* Parris, *O. kunstleri* Parris and *Xiphopterella gracilis* Parris.

Introduction

Grammitidaceae contains more than 20 genera and more than 750 species, mostly occurring in montane forests in the wet tropics of both hemispheres. Parris (2003) lists the currently recognized genera. Parris (1997a) notes that in Old World Grammitidaceae, *Ctenopteris* Blume *ex* Kunze, *Grammitis* Sw. *s.l.* and *Xiphopteris* Kaulf. have been used for some time as unsatisfactory artificial genera, based on frond dissection, pending further study on generic boundaries in the family. *Ctenopteris* is a synonym of *Prosaptia* C.Presl, however, while *Xiphopteris* is a synonym of *Cochlidium* Kaulf. and *Grammitis s.str.* is a small genus of *c.* 23 species with blackish sclerotic lamina margins. Ranker *et al.* (2004) demonstrate clearly that *Ctenopteris* and *Grammitis* are not monophyletic. Parris 1997a, 1998a, 2002a and 2004 form part of a series describing new genera in Old World Grammitidaceae and re-assigning the species formerly treated as *Ctenopteris, Grammitis s.l.* and *Xiphopteris*.

Preparation of an account of Grammitidaceae for the Flora of Peninsular Malaysia necessitates the description of five new genera, *Ctenopterella* Parris, *Dasygrammitis* Parris, *Radiogrammitis* Parris, *Tomophyllum* (E.Fourn.) Parris and *Xiphopterella* Parris, and the re-establishment of *Oreogrammitis* Copel., as part of a revision of the Old World genera of Grammitidaceae. Two new species of *Oreogrammitis* and one new species of *Xiphopterella* from Peninsular Malaysia are described here. New species from areas other than Peninsular Malaysia will be described later. Monographs of the new genera, together with *Oreogrammitis*, are currently being prepared and will contain detailed species descriptions, keys to species and distribution maps. Synonymy is provided below for the new combinations. Types of all names are indicated and some lectotypes are chosen here.

Ctenopterella

Ctenopterella Parris, *gen. nov***.**
Typus generis: *C. blechnoides* (Grev.) Parris

Rhizomata dorsiventralia, stipitibus in duobus seriebus, interdum articulatis, interdum phyllopodiis. Paleae pallidae brunneae ad atrobrunneae, non clathratae, non iridescentes, glabrae, impolitae, subpolitae vel politae, cellulis turgidis vel non turgidis, sine septis. Pili integri et ramose, albidi vel pallidi brunnei ad atrobrunnei. Laminae profunde pinnatifidae, pinnatae vel bipinnatifidae; venae non anastomosantes, plerumque pinnatim ramosae, raro dimidiate ramosae, extremis venarum plerumque hydathado in superficie. Pinnae soris plerumque in duobus serialibus, raro uniseriate, sori in lamina non immersi vel parum immersi, rotundi vel elliptici; sporangia glabra. Species 12, Africae ad Polynesiae incolae.

Rhizomes dorsiventral, stipes in two rows, sometimes articulated to rhizome, phyllopodia sometimes present. Rhizome scales pale to medium brown, not clathrate, not iridescent, glabrous, dull to glossy, cells turgid or not, without cross-walls. Hairs simple and branched, whitish or pale to dark brown. **Laminae** deeply pinnately lobed, pinnate or bipinnately lobed; venation free, veins in pinnae usually pinnately branched, rarely dimidiately branched, ends of vein branches usually with hydathodes on adaxial surface of lamina. **Sori** on pinnae, usually in two rows, rarely in one row, superficial or slightly sunken, ± circular to elliptic; **sporangia** glabrous. 12 species, Africa to Polynesia.

The generic name is a diminutive of *Ctenopteris*, in which most of the species were formerly placed.

Species of *Ctenopterella* were not sampled by Ranker *et al.* (2004), so the position of the genus in their clade system is unknown. Four Old World clades are recognised (Ranker *et al.* 2004); I, II, III and VIII. All species in Clades II and VIII have dorsiventral rhizomes, with stipes in two rows, as do most species in Clade 1, except for *Radiogrammitis parva* (Brause) Parris and *R. hirtelloides* (Copel.) Parris, which have radial rhizomes, with stipes in whorls. Species of Clade III belong to *Tomophyllum, Scleroglossum* and *Calymmodon* and all have radial rhizomes, with stipes in whorls. On the basis of rhizome form, type of rhizome scale and hair types *Ctenopterella* is more likely to be in Clade Ia near *Themelium* [including *T. conjunctisorum* (Baker) Parris], or Clade II, than in Clades III or Clade VIII, which contains the Hawaiian Islands endemic genus *Adenophorus*.

1. *Ctenopterella blechnoides* (Grev.) Parris, *comb. nov.*
Grammitis blechnoides Grev., Ann. Mag. Nat. Hist. 2, 1 (1848) 328, t. 17. **Type**: *Sibbald s.n.*, Raiatea, Society Is. (E, lecto., chosen here; E, isolecto.). - *Polypodium blechnoides* (Grev.) Hook., Sp. Fil. 4 (1863) 180. - *Cryptosorus blechnoides* (Grev.) J.Sm., Hist. Fil. (1875) 87. - *Ctenopteris blechnoides* (Grev.) W.H.Wagner & Grether, Univ. Calif. Publ. Bot. 23 (1948) 61. - *Polypodium decorum* Brack., U. S. Expl. Exped. 16 (1854) 7, t. 2 f. 2. **Type**: *U.S. Expl. Exped. s n.,* Tahiti, Society Is. (K, US, *n.v.*). – *Polypodium macgregori* Baker, Ann. Bot. 8 (1894) 130. **Type**: *Macgregor s.n.,* Rossel I., Milne Bay, Papua New Guinea (K, holo.). - *Polypodium moultonii* Copel., Philipp. J. Sci., C. Bot. 10 (1915) 149. **Type**: *Native collector, Bur. Sci. 2572,* Retuh, Sadong, Sarawak, East Malaysia [MICH, lecto. (Parris, 2002b)]. - *Ctenopteris moultonii* (Copel.) C.Chr. & Tardieu, Notul. Syst. (Paris) 8 (1939) 181. – *Polypodium revolvens* Alderw., Bull. Jard. Bot. Buitenzorg, sér. 3, 2 (1920) 170, f. G. **Type**: *Teysmann 50*, Mt Sanggir, Banka Is., Sumatra (BO, *n.v.*; L, *n.v.*). – *Polypodium pseudorevolvens* Alderw., Bull. Jard. Bot. Buitenzorg, sér. 3, 5 (1922) 219. **Type**: *Bunnemeijer 6902*, Mt Tanda, Lingga I., Sumatra (BO *n.v.*; L). - *Polypodium palaoinsulare* Hosokawa, Trans. Nat. Hist. Formosa 31 (1941) 476. **Type**: *Hosokawa 9049*, Mt Sul, Babeldaob, Palau (Herb. Taihoku Imperial Univ., holo., *n.v.*). – *Ctenopteris palaoinsularis* (Hosokawa) H.Ito, Bot. Mag. Tokyo 67 (1954) 215.

2. *Ctenopterella cornigera* (Baker) Parris, *comb. nov.*
Polypodium cornigerum Baker, Syn. Fil. ed. 2 (1874) 508. **Type**: *Thwaites C. P. 4005*, Horton Plains, Sri Lanka (PDA, holo.). - *Grammitis cornigera* (Baker) Ching, Bull. Fan Mem. Inst. 10 (1941) 240. - *Xiphopteris cornigera* (Baker) Copel., Gen. Fil. (1947) 215. - *Micropolypodium cornigerum* (Baker) X.C.Zhang, Fl. Reipub. Pop. Sin. 6 (2000) 301.

3. *Ctenopterella denticulata* (Blume) Parris, *comb. nov.*
Grammitis denticulata Blume, Fl. Javae 2 (1830) 121, t. 50, f. 4. **Type**: *Blume*

s.n., Java (L, *n.v.*). – *Polypodium denticulatum* (Blume) C.Presl, Tentamen (1836) 178. - *Calymmodon denticulatus* (Blume) T.Moore, Index Fil. (1857) lxii. - *Ctenopteris denticulata* (Blume) C.Chr. & Tardieu, Notul. Syst. (Paris) 8 (1939) 181. - *Polypodium solidum* Mett., Abhandl. Senckenberg. Naturf. Gesell. 2 (1857) 53, t. 1, f. 1-3. **Type**: *Zollinger 165,* Java (LZ†). - *Ctenopteris solida* (Mett.) J.Sm., Hist. Fil. (1875) 184. - *Grammitis solida* (Mett.) Ching, Bull. Fan Mem. Inst. Biol. 10 (1941) 241. - *Polypodium undosum* Baker, J. Bot. 28 (1890) 108. **Type**: *Macgregor s.n.*, Mt Musgrave, Central, Papua New Guinea (K, holo.). - *Ctenopteris undosa* (Baker) Copel., Philipp. J. Sci. 81 (1953) 103. - *Polypodium sibarongae* Christ, Ann. Jard. Bot. Buitenzorg, sér. 2, 4 (1904) 36. **Type**: *F. & P. Sarasin 2011*, Mt Sibaronga, Sulawesi (BAS, *n.v*). – *Polypodium serratodentatum* Alderw., Bull. Dép. Agric. Indes Néerl. 18 (1908) 20. **Type**: *Forbes 244,* Java? (BO, holo., *n.v.*). - *Polypodium solidum* var. *bolanicum* Rosenst., Repert. Spec. Nov. Regni Veg. 12 (1913) 177. **Syntypes**: *Keysser B 21 & 39,* Bolan Mts, Papua New Guinea (both UC). – *Polypodium bolanicum* (Rosenst.) Copel., Univ. Calif. Publ. Bot. 12 (1931) 403. - *Ctenopteris bolanica* (Rosenst.) Copel., Philipp. J. Sci. 81 (1953) 103. - *Polypodium serratodentatum* var. *major* Alderw., Bull. Jard. Bot. Buitenzorg, sér. 2, 16 (1914) 59. **Type**: *Matthew 230*, Kapahiang-barisan, Sumatra (BO, n. v.; K). – *Polypodium scalpturatum* C.Chr., Svensk Bot. Tidskr. 16 (1922) 100, f. 6. **Type**: *Kaudern 37,* Bolaang to Mongondou, Sulawesi (BM, *n.v.*). – *Polypodium vernicosum* Alderw., Nova Guinea 14 (1924) 46. **Syntypes**: *Lam 1797, 1850,* Mt Doorman, Papua (both BO, *n.v.*). – *Polypodium pycnophyllum* C.Chr., Brittonia 2: 308 (1937). **Type**: *Brass* 4421, Mt Albert Edward, Central, Papua New Guinea (BM, holo., *n.v.*; BRI, MICH, NY, iso., *n.v.*). – *Ctenopteris pycnophylla* (C.Chr.) Copel., Philipp. J. Sci. 81 (1953) 102.

4. *Ctenopterella gordonii* (S.B.Andrews) Parris, *comb. nov.*
Polypodium gordonii Watts, Proc. Linn. Soc. New South Wales 39 (1915) 792, t. 89, f. 12 *non* Baker (1879). **Type**: *Watts & Gordon s.n.,* Tully Falls, Queensland, Australia [NSW, lecto. (Parris, 1998b); BRI, MEL, isolecto.]. - *Ctenopteris gordonii* S.B.Andrews, Austrobaileya 1 (1977) 12, *nomen novum pro Polypodium gordonii* Watts (1915) *non* Baker (1879).

5. *Ctenopterella khaoluangensis* (Tagawa & K.Iwats.) Parris, *comb. nov.*
Xiphopteris khaoluangensis Tagawa & K.Iwats., Acta Phytotax. Geobot. 23 (1969) 177, f. 14. **Type**: *Iwatsuki et al. T.14594*, Khao Luang, Nakhon Si Thammarat, Thailand (KYO, holo., *n.v.*; K, iso.). – *Ctenopteris malayana* Parris, Kew Bull. 41 (1986) 494. **Type**: *Piggott 1285,* G. Ulu Kali, Pahang/ Selangor, Peninsular Malaysia (K, holo.).

6. *Ctenopterella lepida* (Brause) Parris, *comb. nov.*
Polypodium lepidum Brause, Notizbl. Bot. Gard. Berlin-Dahlem 8 (1922) 139. **Type**: *Vaupel 421*, Mangaloa, Savaii, Samoa (B, *n.v.*).

7. *Ctenopterella macrorhyncha* (Baker) Parris, *comb. nov.*
Polypodium macrorhynchum Baker, J. Bot. 18 (1880) 370. **Type**: *Kitching s.n.,* Tanala, Madagascar (K).

8. *Ctenopterella parvula* (Bory *ex* Willd.) Parris, *comb. nov.*
Polypodium parvulum Bory ex Willd., Sp. Pl. 5 (1810) 182. **Type**: Réunion (B, *n.v.*; photo. FI). - *Ctenopteris parvula* (Bory ex Willd.) J.Sm., Hist. Fil. (1875) 185. - *Grammitis parvula* (Bory ex Willd.) C.V.Morton, Contr. U. S. Nat. Herb. 38 (1973) 261.

9. *Ctenopterella pediculata* (Baker) Parris, *comb. nov.*
Polypodium lobbianum Hook., Sp. Fil. 4 (1863) 226, t. 278B *non* Hook. (1853). **Type**: *Lobb, s.n.*, Sarawak, East Malaysia (CGE, K). – *Polypodium pediculatum* Baker in Hook. & Baker, Syn. Fil. (1868) 455, *nomen novum pro P. lobbianum* Hook. (1863) *non* Hook. (1853). – *Ctenopteris lobbiana* J.Sm., Hist. Fil. (1875) 185, *nomen novum pro P. lobbianum* Hook. (1863) *non* Hook. (1853). – *Polypodium inarticulatum* Copel., Philipp. J. Sci. 1, Suppl. 2 (1906) 160, *nomen superfl. illegit. pro P. pediculatum* Baker (1868). - *Ctenopteris pediculata* (Baker) Copel., Fern Fl. Philipp. 3 (1960) 530.

10. *Ctenopterella seemannii* (J.Sm.) Parris, *comb. nov.*
Polypodium contiguum Brack., Wilkes, U. S. Expl. Exped. 16 (1854) 6, t. 2, f. 1 *non* (G. Forst.) J.Sm. (1841). **Type**: *U.S. Expl. Exped. s. n.*, Muthuata Mts, Fiji (K, MICH, US, *n.v.*). - *Cryptosorus seemannii* J.Sm., Bonplandia 9 (1861) 262, *nomen novum pro Polypodium contiguum* Brack. (1854) *non* (G.Forst.) J.Sm. (1841). - *P. seemannii* (J.Sm.) Copel., B. P. Bishop Mus. Bull. 93 (1932) 69. - *Ctenopteris seemannii* (J.Sm.) Copel., J. Arnold Arboretum 30 (1949) 442.

11. *Ctenopterella vodonaivalui* (Brownlie) Parris, *comb. nov.*
Ctenopteris vodonaivalui Brownlie, Nova Hedwigia, Beih. 55 (1977) 357, t. 40, f. 10. **Type**: *Vodonaivalu 2173,* Namosi, Viti Levu, Fiji (CHR, holo.).

12. *Ctenopterella zenkeri* (Hieron.) Parris, *comb. nov.*
Polypodium zenkeri Hieron., Bot. Jahrb. Syst. 46 (1911) 385. **Type**: *Zenker 1507*, Yaunde, Cameroon (B, lecto., chosen here; BM, E, K, P, isolecto., *n.v.*). – *Ctenopteris zenkeri* (Hieron.) Tardieu in Aubreville, Fl. Cameroun 3 (1964) 327. – *Xiphopteris zenkeri* (Hieron.) Schelpe, Contr. Bolus Herb. 1 (1969)

12. - *Polypodium decorum* var. *excaudatum* Bonap., Notes Ptérid. 4 (1917) 79. **Syntypes**: *Perrier de la Bâthie 7533*, Forêt d'Analamazaotra, Madagascar (BM, P, *n.v.*); *Perrier de la Bâthie 7593*, Manankazo au Nord-Est d'Ankazohe, Madagascar (P, *n.v.*); *Perrier de la Bâthie 7643*, Montagnes du Sambirano, Madagascar (P, *n.v.*). - *Ctenopteris excaudata* (Bonap.) Tardieu, Notul. Syst. (Paris) 15 (1959) 445. - *Polypodium excaudatum* C.Chr., Arch. Bot. Caen. 2 (1928) 215. **Type**: *Perrier de la Bâthie 7533*, Forêt d'Analamazaotra, Madagascar (BM, holo.; P, iso., n. v.).

Dasygrammitis

Dasygrammitis Parris, *gen. nov.*
Typus generis: *D. mollicoma* (Nees & Blume) Parris
Rhizomata radialia, stipitibus in verticillis, non articulatis. Paleae mediae brunneae ad atrobrunneae, non clathratae, non iridescentes, plerumque politae, raro subpolitae, ad marginem pilis mediis brunneis ad atrobrunneis, raro pallidis brunneis, cellulis plerumque turgidis, raro subturgidis, sine septis. Pili integri et ramosi, plerumque atrobrunnei, raro medii brunnei. Laminae plerumque pinnatae, raro pinnatifidae vel bipinnatifidae; venae non anastomosantes, pinnatim ramosae, extremis venarum hydathado in superficie destitutis. Pinnae soris in duobus serialibus, raro uniseriati, sori in lamina non immersi, rotundi vel elliptici; sporangia glabra vel uno vel duobus pilis juxta annulum ad basim sporangio vel apicem versus. Species 6, Ceylonae ad Polynesiae incolae.

Rhizomes radial, stipes in whorls, not articulated to rhizome. Rhizome scales medium to dark red-brown, rarely pale red-brown, concolorous, not clathrate, not iridescent, usually glossy, rarely subglossy, with medium to dark red-brown, rarely pale red-brown, simple eglandular hairs on margin, cells usually turgid, rarely subturgid, without cross-walls. Hairs simple and branched, usually dark brown, rarely medium brown. **Laminae** usually pinnate, rarely deeply pinnately lobed or bipinnatifid; venation free, veins pinnately branched in pinnae, ends of vein branches without hydathodes on adaxial surface of lamina. **Sori** in two rows on pinnae, superficial, ± circular to elliptic; **sporangia** glabrous or with one or two medium to dark red-brown hairs adjacent to annulus at base of sporangium or part way towards apex. Six species, Sri Lanka to Polynesia.

The generic name refers to the often shaggy nature of the frond indumentum and to *Grammitis*, the type genus of the family.

No species of *Dasygrammitis* were sampled by Ranker *et al.* (2004), so its position in their clade system is unknown. On the basis of rhizome form and hair types it is likely to be in Clade III, characterized by radial rhizomes, together with *Tomophyllum, Scleroglossum* and *Calymmodon*. It most closely resembles *Tomophyllum*, but differs from it in darker usually glossy rhizome scales with usually turgid cells, darker hairs and the absence of hydathodes.

1. *Dasygrammitis brevivenosa* (Alderw.) Parris, *comb. nov.*
Polypodium brevivenosum Alderw., Bull. Jard. Bot. Buitenzorg, sér. 2, 28 (1918) 40. **Type**: *Brooks 299/S*, Lebong Simpang, Bengkoelen, Sumatra (BO, *n.v.*). - *Ctenopteris brevivenosa* (Alderw.) Holttum, Rev. Fl. Malaya 2 (1955) 228.

2. *Dasygrammitis crassifrons* (Baker) Parris, *comb. nov.*
Polypodium crassifrons Baker in Hook. & Baker, Syn. Fil. (1867) 325. **Type**: *Deplanche s.n.*, New Caledonia (K). - *Grammitis crassifrons* (Baker) Ching, Bull. Fan Mem. Inst. Biol. 10 (1941) 240. - *Ctenopteris crassifrons* (Baker) Brownlie, Pacific Sci. 14 (1960) 401. - *Prosaptia crassifrons* (Baker) Parris, Kew Bull. 50 (1995) 165. - *Polypodium stenopteron* Baker, J. Bot. 24 (1886) 183. **Type**: *Thurston s.n.*, Viti Levu, Fiji (K). - *Polypodium hispidosetosum* Rosenst., Repert. Spec. Nov. Regni Veg. 10 (1912) 162. **Type**: *Franc 1318*, Mt Mou, New Caledonia (P, *n.v.*).

3. *Dasygrammitis fuscata* (Blume) Parris, *comb. nov.*
Polypodium fuscatum Blume, Enum. Pl. Javae (1828) 129. **Type**: *Blume s.n.*, Java (L, *n.v.*). - *Ctenopteris fuscata* (Blume) Blume ex Kunze, Bot. Zeit. 4 (1846) 425. - *P. mollicomum* Nees & Blume var. *fuscatum* (Blume) Alderw., Malayan Ferns (1908) 601.

4. *Dasygrammitis malaccana* (Baker) Parris, *comb. nov.*
Polypodium malaccanum Baker, Ann. Bot. 8 (1894) 129. **Type**: *Ridley 3345*, G. Mering, Johor, Peninsular Malaysia (K, holo.; SING, iso., *n.v.*). - *Polypodium pachycaulum* Copel., Philipp. J. Sci. 56 (1935) 105, t. 10. **Type**: *Copeland s.n.*, Mt Apo, Mindanao, Philippines (MICH, UC). - *Ctenopteris pachycaulis* (Copel.) Copel., Fern Fl. Philipp. 3 (1960) 529. - *Ctenopteris matutumensis* Copel., Philipp. J. Sci. 81 (1952) 45. **Type**: *Copeland s.n.*, Mt Matutum, Mindanao, Philippines (MICH, holo.).

5. *Dasygrammitis mollicoma* (Nees & Blume) Parris, *comb. nov.*
Polypodium mollicomum Nees & Blume, Nova Acta 11 (1823) 121, t. 12, f. 2. **Type**: *Blume s.n.,* Java (L). - *Ctenopteris mollicoma* (Nees & Blume)

Kunze, Bot. Zeit. 4 (1846) 425. - *Polypodium rufescens* Brause, Bot. Jahrb. Syst. 49 (1912) 43 *non* Blume (1830). **Type**: *Schultze 322*, Augusta River, West or East Sepik, Papua New Guinea (B, left hand plant, lecto., chosen here). – *Polypodium rufidulum* C.Chr., Index Fil. Suppl. 3 (1934) 157, *nomen novum pro P. rufescens* Brause (1912) *non* Blume (1830). - *Ctenopteris rufidula* (C.Chr.) Parris, Fern Gaz. 12 (1980) 118. - *Ctenopteris micropaleata* Copel., Gen. Fil. (1947) 219, *nomen superfl. illegit. pro P. rufidulum* C.Chr., *P. rufescens* Brause (1912), *non* Blume (1830), *non C. rufescens* Kunze.

6. *Dasygrammitis purpurascens* (Nadeaud) Parris, *comb. nov.*
Polypodium purpurascens Nadeaud, Enum. Pl. Indig. Tahiti (1873) 25. **Type**: *Nadeaud s.n.*, Tahiti, Society Is. (P, *n.v.*). – *Ctenopteris purpurascens* (Nadeaud) Copel., J. Arnold Arboretum 30 (1949) 442.

Radiogrammitis

Radiogrammitis Parris, *gen. nov.*
Typus generis: *R. setigera* (Blume) Parris
Rhizomata radialia, stipitibus in verticillis, non articulatis. Paleae pallidae brunneae ad atrobrunneae, plerumque non clathratae, raro clathratae, plerumque non iridescentes, raro iridescentes, plerumque subpolitae, raro impolitae, glabrae, cellulis plerumque non turgidis, raro turgidis, sine septis; paleae interdum absentes. Pili plerumque integri, raro ramosi, albidi vel pallidi brunnei ad atrobrunnei. Laminae plerumque simplices, raro pinnatim lobatae; venae non anastomosantes, plerumque dichotome uni-bi-(tri-)ramosae, raro simplices vel pinnatim ramosae, extremis venarum interdum hydathado in superficie. Sori plerumque in duobus, raro ad duodecimos, serialibus, plerumque uno, raro ad sextos, utroque medio-venae, plerumque in lamina non immersi, interdum parum immersi, raro profunde immersi, rotundi vel elliptici; sporangia praecocia in soris proprie pilis uno usqe ad novena ad apicem juxta annulum, sporangia serotina in soris glabra. Species 28, Ceylonae ad Polynesiae incolae.

Rhizomes radial, stipes in whorls, not articulated to rhizome. Rhizome scales pale to dark brown, usually not clathrate, rarely clathrate, usually not iridescent, rarely iridescent, usually subglossy, rarely dull, glabrous, cells usually not turgid, rarely turgid, without cross-walls; scales sometimes absent. Hairs usually simple, rarely branched, whitish or pale to dark brown. **Laminae** usually simple, rarely pinnately lobed; venation free, veins usually dichotomously one-two-(three-) branched, rarely simple or pinnately branched, ends of vein branches sometimes with hydathodes on adaxial surface of lamina. **Sori** usually in two rows, rarely up to 12, usually one, rarely up to six, on each side of the mid-vein, usually on surface of lamina, sometimes slightly sunken in broad shallow depressions, rarely deeply sunken in steep-sided pits, ± circular to elliptic; first-developed **sporangia** of each sorus characteristically with one to nine hairs at apex of sporangium adjacent to annulus; later-developed sporangia of each sorus glabrous. 28 species, Sri Lanka to Polynesia.

The generic name refers to the radial rhizome and to *Grammitis*, in which the species were formerly placed.

Species of *Radiogrammitis* sampled by Ranker *et al.* (2004) are in the lower part of Clade Ia. *Radiogrammitis* closely resembles *Oreogrammitis*, but differs in its radial, rather than dorsiventral rhizome, and in the absence of rhizome scales in numerous species.

1. *Radiogrammitis ahenobarba* (Parris) Parris, *comb. nov.*
Grammitis ahenobarba Parris, Blumea 29 (1983) 142, f. 22, 3. **Type**: *Gibbs 5551,* Anggi Lakes, Vogelkop Peninsula, Papua (BM, holo.).

2. *Radiogrammitis alepidota* (M.G.Price) Parris, *comb. nov.*
Grammitis alepidota M.G.Price, Philipp. Agricult. 57 (1974) 34, f. 1. **Type**: *Price 2149*, Mt Banahaw, Luzon, Philippines (PNH, holo., *n.v.*; K, L, US, iso., *n.v.*).

3. *Radiogrammitis beddomeana* (Alderw.) Parris, *comb. nov.*
Polypodium beddomeanum Alderw., Bull. Jard. Bot. Buitenzorg, sér. 2, 28 (1918) 39. **Type**: *Wall 30,* Bogawantalawa, Sri Lanka (BO, *n.v.*; photo., BM). - *Grammitis beddomeana* (Alderw.) Ching, Bull. Fan Mem. Inst. Biol. 10 (1941) 240.

4. *Radiogrammitis cheesemanii* (Parris) Parris, *comb. nov.*
Grammitis cheesemanii Parris, N. Z. J. Bot. 31 (1993) 15. **Type**: *Cheeseman s. n.*, Te Kou, Rarotonga, Cook Is. (AK, holo.; AK, iso.).

5. *Radiogrammitis clavipila* (Parris) Parris, *comb. nov.*
Grammitis clavipila Parris, Blumea 29 (1983) 156, f. 21. **Type**: *Vink 17020*, Ibiwara, Enga, Papua New Guinea, (L, holo.; LAE, iso.).

6. *Radiogrammitis coredrosora* (Alderw.) Parris, *comb. nov.*
Polypodium coredrosorum Alderw., Nova Guinea 14 (1924) 44. **Type**: *Lam 1550A*, Mt Doorman, Papua [BO, lecto. (Parris, 1983); BM, L, isolecto.]. *Grammitis coredrosora* (Alderw.) Copel., Philipp. J. Sci. 80 (1952) 179.

7. *Radiogrammitis graminella* (C.Chr.) Parris, *comb. nov.*
Polypodium simplex Baker, J. Bot. 14 (1876) 12 *non* Burm.f. (1868) *nec.* Sw. (1801) *nec* Lowe (1858). **Type**: *Whitmee 123*, Samoa (CGE, GH *n.v.*; K). - *Polypodium graminellum* C.Chr., Index Fil. (1906) 530, *nomen novum pro P. simplex* Baker *non* Burm.f. (1868) *nec* Sw. (1801) *nec* Lowe (1858). - *Grammitis graminella* Sledge, Brit. Fern Gaz. 9 (1967) 340.

8. *Radiogrammitis havilandii* (Baker) Parris, *comb. nov.*
Polypodium havilandii Baker, Trans. Linn. Soc. London, Bot. 2, 4 (1894) 253. **Type**: *Haviland 1488*, Mt Kinabalu, Sabah, East Malaysia (K, holo.). - *Polypodium multisorum* Copel., Philipp. J. Sci., C. Bot. 12 (1917) 61. **Type**: *Topping 1665*, Mt Kinabalu, Sabah, East Malaysia [MICH, lecto. (Parris 1990); BM, US, isolecto., *n.v.*). - *Grammitis havilandii* (Baker) Copel., Gen. Fil. (1947) 211.

9. *Radiogrammitis hirtella* (Blume) Parris, *comb. nov.*
Polypodium hirtellum Blume, Enum. Pl. Javae (1828) 122. **Type**: *Blume 71*, G. Gede, Java (L, lecto., chosen here). - *Grammitis hirtella* (Blume) Tuyama, Bot. Mag. Tokyo 51 (1937) 125. - *Grammitis pusilla* Blume, Fl. Javae 2 (1829) 109, t. 46, f. 4, excl. varieties, *nomen illegit. superfl. pro Polypodium hirtellum* Blume. – *Polypodium pusillum* (Blume) Christ, Ann. Jard. Bot. Buitenzorg 15 (1897) 145.

10. *Radiogrammitis hirtelloides* (Copel.) Parris, *comb. nov.*
Polypodium hirtelloides Copel., Bull. B. P. Bishop Mus. 59 (1929) 17. **Type**: *Gillespie 2387*, Nadarivatu, Viti Levu, Fiji (BISH, MICH, UC, *n.v.*). - *Grammitis hirtelloides* (Copel.) Copel., Philipp. J. Sci. 80: 146 (1952).

11. *Radiogrammitis hirtiformis* (Rosenst.) Parris, *comb. nov.*
Polypodium hirtiforme Rosenst., Repert. Spec. Nov. Regni Veg. 12 (1913) 176. **Type**: *Keysser B.48*, Bolan Mts, Morobe, Papua New Guinea [S, lecto. (Parris 1983); BM, UC, isolecto.].

12. *Radiogrammitis holttumii* (Copel.) Parris, *comb. nov.*
Grammitis holttumii Copel., Univ. Calif. Publ. Bot. 18 (1942) 224. **Type**: *Holttum SFN 23384*, Cameron Highlands, Pahang, Peninsular Malaysia (MICH, holo.; K, SING, UC, iso.).

13. *Radiogrammitis jagoriana* (Mett. ex Kuhn) Parris, *comb. nov.*
Polypodium jagorianum Mett. *ex* Kuhn, Linnaea 36 (1869) 128. **Type**: *Jagor 835*, Luzon, Philippines (B, lecto., chosen here; BM, isolecto.). - *Grammitis*

jagoriana (Mett. *ex* Kuhn) Tagawa, Acta Phytotax. Geobot. 10 (1941) 284. - *Polypodium koordersii* Christ, Ann. Jard. Bot. Buitenzorg 15 (1897) 144, t. 15, f. 19 A-C. **Type**: *Koorders 17135B,* Mt Klabat, Minahassa, Sulawesi (BO, lecto., chosen here; L, isolecto.). - *Polypodium christii* Copel., Polypodiaceae Philipp. (1905) 118. **Type**: *Copeland 1520,* Mt Apo, Mindanao, Philippines (MICH, lecto., chosen here; BM, isolecto.). - *Grammitis cuneifolia* Copel., Philipp. J. Sci. 56 (1935) 479, t. 8, f. 2. **Type**: *Clemens 40962*, Mt Kinabalu, Sabah, East Malaysia [MICH, lecto. (Parris *et al.*, 1992)].

14. ***Radiogrammitis kinabaluensis*** (Copel.) Parris, *comb. nov.*
Polypodium kinabaluense Copel., Philipp. J. Sci. 12, C. Bot. (1917) 60. **Type**: *Clemens 10649 p.p.*, Mt Kinabalu, Sabah, Malaysia [MICH, lecto. (Parris *et al.* 1992); BM, UC, isolecto.]. - *Grammitis kinabaluensis* (Copel.) Copel., Philipp. J. Sci. 56 (1935) 479.

15. ***Radiogrammitis ligulata*** (Baker) Parris, *comb. nov.*
Polypodium ligulatum Baker in Hook. & Baker, Syn. Fil. (1867) 320. **Type**: *Wilkes in S. Pacific Expl. Exped. 1838-1842,* Fiji (K). - *Grammitis ligulata* (Baker) Ching, Bull. Fan Mem. Inst. Biol. 10 (1941) 240. - *Polypodium trachycarpum* Mett. *ex* Kuhn, Linnaea 36 (1869) 127. **Type**: *Vesco s.n.,* Tahiti, Society Is. (B, lecto., chosen here). - *Grammitis trachycarpa* (Mett. *ex* Kuhn) Copel., Occ. Papers Bishop Mus. 14 (1938) 72.

16. ***Radiogrammitis meijer-dreesii*** (Copel.) Parris, *comb. nov.*
Grammitis meijer-dreesii Copel., Univ. Calif. Publ. Bot. 18 (1942) 223. **Type**: *Brass 9898 & Meijer-Drees,* Mt Trikora, Papua (MICH, holo.; A, BO, L, iso.).

17. ***Radiogrammitis multifolia*** (Copel.) Parris, *comb. nov.*
Polypodium alpestre Blume, Enum. Pl. Javae (1828) 123 *non* (Hoppe) Spenner (1825). **Type**: *Blume s.n.*, Java [L, lecto. (Parris, 1986)]. - *Grammitis pusilla* var. *alpestris* Blume, Fl. Javae 2 (1829) 110, t. 46, f 5, *pro P. alpestre* Blume (1828) *non* (Hoppe) Spenner (1825). - *Grammitis pusilla* var. *lasiosora* Blume, Fl. Javae 2 (1829) 110, t. 46, f 6. **Type**: *Blume s.n.*, G. Panggrango, Java [L, lecto. (Parris, 1986)]. - *Polypodium lasiosorum* (Blume) Hook., Sp. Fil. 4 (1863) 166. - *Grammitis lasiosora* (Blume) Ching, Bull. Fan Mem. Inst. Biol. 10 (1941) 15. *Grammitis multifolia* Copel., Philipp. J. Sci. 46 (1931) 219. **Type**: *Copeland s.n.*, G. Panggerango, Java [MICH, lecto. (Parris, 1986); BM, BO, UC, isolecto.]. - *Polypodium multifolium* (Copel.) C.Chr., Index Fil. Suppl. 3 (1934) 154.

18. ***Radiogrammitis ornatissima*** (Rosenst.) Parris, *comb. nov.*

Polypodium ornatissimum Rosenst., Repert. Spec. Nov. Regni Veg. 5 (1908) 41. **Type**: *Rosenstock's Filices Novoguineensis Exsiccatae 9, Werner 47*, Mt Gelu, Madang, Papua New Guinea [UC, lecto. (Parris, 1983); B, BM, E, S, isolecto.]. - *Grammitis ornatissima* (Rosenst.) Copel., Philipp. J. Sci. 80 (1952) 195. - *Polypodium ornatissimum* var. *dichotomum* Brause, Bot. Jahrb. Syst. 180 (1920) 56. **Type**: *Ledermann 11809*, Mt Schrader, Madang, Papua New Guinea [B, lecto. (Parris, 1983); B, BM, S, isolecto.].

19. *Radiogrammitis parva* (Brause) Parris, *comb. nov.*
Polypodium parvum Brause, Bot. Jahrb. Syst. 49 (1912) 36, f. 2C. **Type**: *Schlechter 17156*, Kani Mts, Morobe, Papua New Guinea [B, lecto. (Parris 1983); BISH, BM, K, L, MICH, UC, isolecto.]. - *Grammitis parva* (Brause) Copel., Gen. Fil. (1947) 211.

20. *Radiogrammitis peninsularis* (Copel.) Parris, *comb. nov.*
Grammitis peninsularis Copel., Univ. Calif. Publ. Bot. 18 (1942) 224. **Type**: *Holttum SFN 20678*, G. Tahan, Pahang, Peninsular Malaysia (MICH, holo.; SING, UC, iso.).

21. *Radiogrammitis plana* (Alderw.) Parris, *comb. nov.*
Polypodium planum Alderw., Bull. Jard. Bot. Buitenzorg, sér. 2, 16 (1914) 32. **Type**: *Matthew 501*, G. Singgalang, Sumatra (BO, lecto., chosen here). - *Grammitis plana* (Alderw.) Parris, Fern Gaz. 12: 180 (1981).

22. *Radiogrammitis pseudoxiphopteris* (Parris) Parris, *comb. nov.*
Grammitis pseudoxiphopteris Parris, Hooker's Icon. Pl. 40 (1990) t. 3975. **Type**: *Dransfield 837B*, G. Belumut, Johor, Peninsular Malaysia (KLU, holo.).

23. *Radiogrammitis reducta* (Alderw.) Parris, *comb. nov.*
Polypodium reductum Alderw., Nova Guinea 14 (1924) 41. **Type**: *Lam 1550*, Mt Doorman, Papua [BO, lecto. (Parris, 1983); BM, K, L, MICH, UC, isolecto.]. - *Grammitis reducta* (Alderw.) Copel., Philipp. J. Sci. 80 (1952) 167.

24. *Radiogrammitis setigera* (Blume) Parris, *comb. nov.*
Polypodium setigerum Blume, Enum. Pl. Javae (1828) 123. **Type**: *Blume s.n.*, G. Gede, Java [L, lecto. (Parris 1983); K, L, isolecto.]. - *Grammitis fasciculata* Blume, Fl. Javae 2 (1829) 112, *nomen illegit. superfl. pro P. setigerum* Blume. – *Polypodium fasciculatum* C.Presl, Tentamen (1836) 180, *nomen illegit. superfl. pro P. setigerum* Blume. – *Polypodium intromissum* Christ, Verh. Natur. Gesell. Basel 11 (1896) 440. **Type**: *Sarasin 1368*, Wawokaraeng,

Sulawesi [BAS, lecto. (Parris, 1983)]. - *Grammitis intromissa* (Christ) Parris, Fern Gaz. 12 (1981) 180. - *Polypodium heanophyllum* Copel., Philipp. J. Sci. 40 (1929) 310. **Type**: *Copeland's Pteridophyta Philippensis Exsiccata 158 [Sphalm. 185]*, Mt Matutum, Mindanao, Philippines [MICH, lecto. (Parris 1983); BM, K, SING, UC, isolecto.). - *Grammitis setigera* (Blume) Ching, Bull. Fan Mem. Inst. Biol. 10 (1941) 241 *non* J.Sm. (1875). - *Grammitis cyclosora* Copel., Univ. Calif. Publ. Bot. 18 (1942) 224. **Type**: *Clemens s.n.*, Mt Sarawaket, Morobe, Papua New Guinea (MICH, holo.). - *Grammitis latifolia* DeVol, Fl. Taiwan 1 (1975) 223. **Type**: *Yamamoto s.n.*, Taitungshan, Taitung, Taiwan (TAI, *n.v.*).

25. *Radiogrammitis silvicola* (Parris) Parris, *comb. nov.*
Grammitis silvicola Parris, Blumea 29 (1983) 141, f. 22, 2. **Type**: *Croft 134*, Mt Piora, Eastern Highlands, Papua New Guinea (K, holo.; K, LAE, iso.).

26. *Radiogrammitis subpinnatifida* (Blume) Parris, *comb. nov.*
Polypodium subpinnatifidum Blume, Enum. Pl. Javae (1828) 129. **Type**: *Blume s. n.*, Java (K, L, *n.v.*). - *Grammitis subpinnatifida* (Blume) Blume, Fl. Javae 2 (1830) 118. - *Xiphopteris subpinnatifida* (Blume) Copel., Gen. Fil. (1947) 215.

27. *Radiogrammitis tehoruensis* (M.Kato & Parris) Parris, *comb. nov.*
Grammitis tehoruensis M.Kato & Parris, J. Fac. Sci. Univ. Tokyo 3, 15 (1992) 131, f. 4. **Type**: *Kato, Ueda & Fanani C-14155*, Muselleinan Pass, Seram, Moluccas (TI, holo.).

28. *Radiogrammitis tuberculata* (Parris) Parris, *comb. nov.*
Grammitis tuberculata Parris, Blumea 29 (1983) 99, f. 15, 1. **Type**: *Vink 17495*, Mt Ambua, Enga, Papua New Guinea (L, holo.).

Tomophyllum

Tomophyllum (E.Fourn.) Parris, *gen. et stat. nov.*
Polypodium Sect. *Tomophyllum* E.Fourn., Ann. Sci. Nat. 5, 18 (1873) 283.
Type species: *T. subsecundodissectum* (Zoll.) Parris.

Rhizomes radial, stipes in whorls, not articulated to rhizome. Rhizome scales pale to medium brown, not clathrate, not iridescent, usually subglossy, rarely dull, with pale to medium brown hairs on margin and/or apex, cells usually not turgid, sometimes turgid, without cross-walls; scales sometimes absent. Hairs simple and branched, whitish or pale to medium brown. **Laminae** deeply pinnately lobed to tripinnatifid; venation free, veins pinnately branched in pinnae and in pinnules of more dissected species, ends of vein branches with hydathodes on adaxial surface of lamina. **Sori** usually in two rows, rarely in one row, on pinnae, sometimes in one or two rows on pinnules in more dissected fronds, superficial, more or less circular to elliptic; **sporangia** glabrous or rarely with one to three hairs at apex of sporangium adjacent to annulus (*T. congregatifolium*). 22 species, India to Melanesia.

The generic name refers to the pinna dissection of the type species.

Species of *Tomophyllum* sampled by Ranker *et al.* (2004) are in the upper part of Clade III. *Scleroglossum*, also in Clade III, differs from *Tomophyllum* in its simple lamina, with sori deeply sunken in two grooves, one each side of the mid-vein. *Calymmodon*, also in Clade III, has the same type and colour of hairs as *Tomophyllum* and most species of *Calymmodon* also have hydathodes, but the veins of *Calymmodon* are simple, rather than pinnately or bipinnately branched, and each fertile pinna bears a solitary sorus that is protected by a fold of the basiscopic pinna margin, rather than two or more sori that are not protected. See under *Dasygrammitis*, above, for differences between it and *Tomophyllum*.

1. ***Tomophyllum beleense*** (Copel.) Parris, *comb. nov.*
Ctenopteris beleensis Copel., Univ. Calif. Publ. Bot. 18 (1942) 225. **Type**: *Brass 11041,* Bele R., Papua (MICH, holo.; A, *n.v.*; UC, iso.).

2. ***Tomophyllum bipinnatifidum*** (Baker) Parris, *comb. nov*.
Polypodium bipinnatifidum Baker, J. Bot. 28 (1890) 109. **Type**: *Macgregor s.n.*, Owen Stanley Range Central, Papua New Guinea (K, holo.). – *Ctenopteris bipinnatifida* (Baker) Copel., Univ. Calif. Publ. Bot. 18 (1942) 225. – *Ctenopteris sesquipinnata* Copel., Univ. Calif. Publ. Bot. 18 (1942) 225. **Type**: *Brass 9510*, L. Habbema, Papua (MICH, holo.; A, *n.v.*, K, UC, iso.).

3. ***Tomophyllum bipinnatum*** (Copel.) Parris, *comb. nov*.
Ctenopteris bipinnata Copel., Univ. Calif. Publ. Bot. 18 (1942) 225. **Type**: *Brass 9433*, L. Habbema, Papua (MICH, holo.; A, *n.v.*, K, UC, iso.).

4. ***Tomophyllum brachyphlebium*** (Baker) Parris, *comb. nov.*
Polypodium brachyphlebium Baker, Ann. Bot. 8 (1894) 129. **Type**: *Hancock 49,* Barisan Ra., Bengkoelen, Sumatra (K, holo.).

5. ***Tomophyllum brooksiae*** (Alderw.) Parris, *comb. nov*.
Polypodium brooksiae Alderw., Bull. Jard. Bot. Buitenzorg, sér. 2, 23 (1916)

19, t. 2. f. 2a & b. **Type**: *Brooks 265/S*, Lebong Tandai, Bengkoelen, Sumatra (BO, *n.v.*; WELT). - *Ctenopteris brooksiae* (Alderw.) Parris, Fern Gaz. 12 (1981) 180.

6. *Tomophyllum capillatum* (Brause) Parris, *comb. nov.*
Polypodium capillatum Brause, Bot. Jahrb. Syst. 49 (1912) 39, f. 2, g. **Type**: *Schlechter 18032*, Finisterre Mts, Madang, Papua New Guinea (B, lecto., chosen here).

7. *Tomophyllum congregatifolium* (Alderw.) Parris, *comb. nov.*
Polypodium congregatifolium Alderw., Nova Guinea 14 (1924) 47. **Type**: *Lam 1544*, Mt Doorman, Papua (BO, *n.v.*, K, SING, UC). - *Ctenopteris congregatifolia* (Alderw.) Copel., Philipp. J. Sci. 81 (1953) 112.

8. *Tomophyllum epaleatum* (Parris) Parris, *comb. nov.*
Ctenopteris epaleata Parris, Fern Gaz. 16 (2002) 239. **Type**: *Faden 76/282*, Horton Plains, Nuwara Eliya, Sri Lanka (K, holo.; GH, UC, US, iso.).

9. *Tomophyllum hymenophylloides* (Parris) Parris, *comb. nov.*
Ctenopteris hymenophylloides Parris, Kew Bull. 59 (2004) 221, f. 1 A. **Type**: *Edwards 4061 et al.,* Mt Jaya, Papua (K, holo.; A, *n.v.*, BISH, *n.v.*, BO, *n.v.*, CANB, *n.v.*, FRE, *n.v.*, L, *n.v.*, MAN, *n.v.*, all iso.).

10. *Tomophyllum inconspicuum* (Blume) Parris, *comb. nov.*
Polypodium inconspicuum Blume, Enum. Pl. Javae (1828) 130. **Type**: *Blume s.n.*, Java (L). - *Ctenopteris inconspicua* (Blume) Copel., Philipp. J. Sci. 81 (1953) 103. - *Polypodium gedeense* Alderw., Bull. Jard. Bot. Buitenzorg, sér. 2, 16 (1914) 33. **Type**: *Raciborski s.n.*, G. Gede, Java (BO, *n.v.*).

11. *Tomophyllum macrum* (Copel.) Parris, *comb. nov.*
Polypodium macrum Copel., Perkins' Fragm. (1905) 189. **Type**: *Copeland 1016*, Mt Apo, Mindanao, Philippines (MICH, lecto., chosen here). - *Ctenopteris macra* (Copel.) Copel., Fern Fl. Philipp. 3 (1960) 529.

12. *Tomophyllum millefolium* (Blume) Parris, *comb. nov.*
Polypodium millefolium Blume, Enum. Pl. Javae (1828) 134. **Type**: *Blume s.n.,* Java (L, *n.v.*). - *Grammitis millefolia* (Blume) Ching, Bull. Fan Mem. Inst. Biol. 10 (1941) 240. - *Ctenopteris millefolia* (Blume) Copel., Gen. Fil. (1947) 219.

13. *Tomophyllum minutum* (Blume) Parris, *comb. nov.*
Polypodium minutum Blume, Enum. Pl. Javae (1828) 130. **Type**: *Blume s.n.*, G.

Gede, Java (L *n.v.*). *Ctenopteris minuta* (Blume) Holttum, Rev. Fl. Malaya 2 (1955) 228. *Polypodium callophyllum* C.H.Wright, Bull. Misc. Inform., Kew 1909 (1909) 362. **Type**: *Matthew s.n.*, G. Hijau, Perak, Peninsular Malaysia (K, holo.; K, iso.).

14. *Tomophyllum perplexum* (Parris) Parris, *comb. nov.*
Ctenopteris perplexa Parris, Fern Gaz. 16 (2001) 201. **Type**: *Sledge 1330 p.p.*, Kandapola, Nuwara Eliya, Sri Lanka (K, holo.).

15. *Tomophyllum polytrichum* (Copel.) Parris, *comb. nov.*
Ctenopteris polytricha Copel., Univ. Calif. Publ. Bot. 18 (1942) 225. **Type**: *Brass 10518*, L. Habbema, Papua (MICH, holo.; A, *n.v.*, UC, iso.).

16. *Tomophyllum repandulum* (Mett.) Parris, *comb. nov.*
Polypodium repandulum Mett., Abhandl. Senckenb. Naturforsch. Ges. 2 (1857) 50. **Type**: *Gardner 58,* Sri Lanka (BM, OXF). - *Ctenopteris repandula* (Mett.) C.Chr. & Tardieu in Lecompte, Fl. Gen. Indo-china 7 (1941) 533. - *Polypodium subfalcatum* var. *ß glabrum* Beddome, Ferns Brit. India (1866) t. 189, f. B. **Type**: *Thwaites/Gardner C.P. 1290*, Sri Lanka [BM, *lecto*. (Parris, 2002b); B, BM, CGE, E, K, L, P, PDA, UC, all *isolecto*.].

17. *Tomophyllum sakaguchianum* (Koidzumi) Parris, *comb. nov.*
Polypodium sakaguchianum Koidzumi, Acta Phytotax. Geobot. 1 (1932) 29. **Type**: *Sakaguchi s.n.*, Kawakamimura Shiwonoha, Honto, Japan (KYO, *n.v.*). - *Ctenopteris sakaguchiana* (Koidzumi) H.Ito, J. Jap. Bot. 11 (1935) 90. - *Grammitis sakaguchiana* (Koidzumi) Sugimoto [*ex* Kurata], Hokuriku J. Bot. 6 (1957) 9.

18. *Tomophyllum sinicum* (Christ) Parris, *comb. nov.*
Polypodium sinicum Christ, Bull. Boiss. 7 (1899) 3. **Type**: *Henry 10186*, Mt Teng Chen Len, Yunnan, China, (K). - *Polypodium convolutum* Baker, Bull. Misc. Inform., Kew 1906 (1906) 12. **Type**: *Henry 10186*, Ten Chen Liu Mts, Yunnan, China (K, holo.). - *Polypodium trichophyllum* Baker, Bull. Misc. Inform., Kew 1906 (1906) 13. **Type**: *Hancock 153,* Red R., Yunnan, China (K, holo.). – *Polypodium tenuissimum* Hayata, Icon. Pl. Formosa 4 (Nov. 1914) 254 *non* Copel. (Feb. 1914). **Type**: *Hayata & Sasaki s n.,* Arisan, Taiwan (TI, *n.v.*; photo. PE). – *Polypodium hayatae* Masamune, J. Soc. Trop. Agric. Formosa 2 (1930) 31, *nomen novum pro P. tenuissimum* Hayata (Nov. 1914) *non* Copel. (Feb. 1914). - *Ctenopteris hayatae* (Masamune) H.Ito, J. Jap. Bot. 11 (1935) 90.

19. *Tomophyllum subfalcatum* (Blume) Parris, *comb. nov.*

Polypodium subfalcatum Blume, Enum. Pl. Javae (1828) 130. **Type**: Java (L). - *Ctenopteris subfalcata* (Blume) Kunze, Bot. Zeit. 6 (1848) 120. - *Grammitis subfalcata* (Blume) Ching, Bull. Fan Mem. Inst. Biol. 10 (1940) 16. - *Polypodium subfalcatum* var. *ß* Blume, Enum. Pl. Javae (1828) 130. **Type**: *collector unknown,* Sulawesi (L).

20. ***Tomophyllum subminutum*** (Alderw.) Parris, *comb. nov.*
Polypodium subminutum Alderw., Malayan Ferns (1908) 598. **Type:** *Forbes s.n.,* Java (BO, *n.v.*). - *Ctenopteris subminuta* (Alderw.) Holttum, Rev. Fl. Malaya 2 (1955) 228.

21. ***Tomophyllum subrepandulum*** (Christ) Parris, *comb. nov.*
Polypodium subrepandulum Christ, Ann. Jard. Bot. Buitenzorg, sér. 2, 5 (1905) 119. **Syntypes**: *Hallier 3138* (SAR), *Hallier 3299* (K), Borneo.

21. ***Tomophyllum subsecundodissectum*** (Zoll.) Parris, *comb. nov.*
Polypodium subsecundodissectum Zoll., Syst. Verz. (1854) 37, 48. **Type**: *Zollinger 1578*, Java (G, *n.v.*). - *Ctenopteris subsecundodissecta* (Zoll.) Copel., Philipp. J. Sci. 81 (1953) 114. – *Polypodium subfalcatum* var. *semiintegrum* Copel., Philipp. J. Sci., C. Bot. 2 (1907) 138. **Type**: *Merrill 5971*, Mt Halcon, Mindoro, Philippines (MICH, lecto., chosen here). – *Polypodium secundum* Ridl., Trans. Linn. Soc. London, Bot. 2, 9 (1916) 262. **Type**: *Kloss s.n.*, Mt Carstensz, Papua (BM).

22. ***Tomophyllum walleri*** (Maiden & Betche) Parris, *comb. nov.*
Polypodium walleri Maiden & Betche, J. & Proc. Roy. Soc. New South Wales 35 (1911) 799. **Type**: *Waller s.n.*, Herberton, Queensland, Australia [NSW, lecto. (Parris, 1998b); BRI, iso.]. - *Ctenopteris walleri* (Maiden & Betche) S.B.Andrews, Austrobaileya 1 (1977) 12.

Xiphopterella

Xiphopterella Parris, *gen. nov.*
Typus generis: *X. hieronymusii* (C.Chr.) Parris
Rhizomata radialia, stipitibus in verticillis, non articulatis. Paleae pallidae brunneae ad mediae brunneae, non clathratae, non iridescentes, subpolitae, glabrae vel ad apicem pili uno vel duobus, cellulis plerumque non turgidis, raro turgidis, sine septis. Pili integri et ramosi, albidi vel pallidi brunnei ad medii brunnei. Laminae pinnatifidae vel pinnatae; venae non anastomosantes, plerumque dichotome uni-ramosae, raro dimidiate bi-ramosae, extremis venarum interdum hydathado in superficie. Sori in duobus serialibus, uno utroque rhachidis, plerumque uno, raro duo, in pinnam, in lamina non

immersi, rotundi vel elliptici; sporangia glabra. Species 6, Malesiae incolae.

Rhizomes radial, stipes in whorls, not articulated to rhizome. Rhizome scales pale to medium brown, not clathrate, not iridescent, subglossy, glabrous or with one or two simple unjointed-hairs or branched hairs at apex, cells without cross-walls. Hairs simple and branched, whitish or pale to medium brown. **Laminae** deeply pinnately lobed to pinnate; venation free, veins usually dichotomously one-branched, rarely dimidiately two-branched, ends of vein branches sometimes with hydathodes on adaxial surface of lamina. **Sori** in two rows, one each side of rachis, usually one, rarely two, per pinna, superficial, ± circular to elliptic; **sporangia** glabrous. Six species, in Malesia.

The generic name is a diminutive of *Xiphopteris*, in which the species were formerly placed.

No species of *Xiphopterella* were sampled by Ranker *et al.* (2004), so its position in their clade system is unknown. On the basis of rhizome form and hair types, it is likely to be in Clade III. *Xiphopterella* resembles *Calymmodon* (in Clade III) in having similar rhizome scales, similar frond dissection and one row of sori on each side of the rachis, but has the veins forked rather than simple and does not have the sori protected by the upward-folded basiscopic margin of the pinna. *Micropolypodium* Hayata *s.str.* (Old World species only) resembles *Xiphopterella* in having a radial rhizome and one sorus per pinna, but has rhizome scales always glabrous, lacks branched hairs and has dark brown simple hairs.

Xiphopterella gracilis Parris, *sp. nov.*
Type: *Holttum SFN 20673*, c. 1520 m (5000 ft) alt., 30 Aug 1928, G. Tahan, Pahang, Peninsular Malaysia (SING, holo.; BM, *n.v.*, K, iso).
– *Xiphopteris alternidens sensu* Parris (1986), Parris & Edwards (1988) & Parris & Latiff (1997) *non* (Ces.) Copel.

Species X. alternidenti similis aspectu et rheophytica item, sed stipitibus atris non mediis brunneis, pinnis 18-26 paribus non 8-10, textura coriacea non tenuiter coriacea, pilis integris non ramosis, rhachidi in superficie plus minusve immersa non prominenti, hydathodis praesentibus non carentibus differt.

Stipes winged to base or 1-2 x *c.* 0.2 mm; glabrous. **Laminae** 35-87 x 2(-3) mm, linear-oblanceolate, obtuse to bluntly acute at apex, long-attenuate at base, pinnate or deeply pinnately divided to wing *c.* 0.1 mm wide along rachis, pinnae 18-26 pairs, longest pinnae 1 x 1-2 mm, obovate, oblong, triangular or broadly triangular, obtuse to bluntly acute at apex, entire; glabrous or with simple jointed hairs (*c.* 0.1 mm long) occasional to sparse on abaxial surface of rachis; rachis slightly prominent to prominent and concolorous to slightly darker on abaxial surface of lamina, slightly sunken and darker on adaxial surface; lateral veins invisible in transmitted light, not prominent, simple in sterile fronds and some fertile fronds or 1-forked in fertile fronds, acroscopic branch ± as long as basiscopic branch, not extending beyond sorus, vein endings with hydathodes. **Sori** 1.1-1.8 x 1.0-1.3 mm, slightly sunken in shallow depressions which may appear slightly prominent on adaxial surface of lamina, discrete when mature, on 9-18 pairs of pinnae, in apical 1/4 to 2/3 of lamina, one per pinna, more or less throughout pinnae, nearer to rachis than margin.

Distribution: Peninsular Malaysia, Pahang, (G. Tahan), known only from the type locality.
Specimens examined in addition to type: Peninsular Malaysia, Pahang, G. Tahan, 1520-1680 m (5000-5500 ft), 12 July1905, *Wray & Robinson 5522* (SING); ibid, July 1911, *Ridley 15975* (SING); G. Tahan, 1520 m (5000 ft), 15 June 1922, *Haniff & Nur SFN 7989* (SING).

1. *Xiphopterella alternidens* (Ces.) Parris, *comb. nov.*
Polypodium alternidens Ces., Atti Ac. Napoli 7 (1876) 25, t. 2, f. 4. **Type**: *Beccari s.n.*, G. Gading, Sarawak, Malaysia (K). – *Xiphopteris alternidens* (Ces.) Copel., Gen. Fil. (1947) 215. – *Polypodium murudense* Copel., Philipp. J. Sci. C, Bot. 12 (1917) 61. **Type**: *Bur. Sci. 2924,* G. Murud, Sarawak, Malaysia (PNH†). - *Xiphopteris murudensis* (Copel.) Copel., Gen. Fil. (1947) 215.

2. *Xiphopterella govidjoaensis* (Brause) Parris, *comb. nov*.
Polypodium govidjoaense Brause, Bot. Jahrb. Syst. 49 (1912) 41, f. 2, K. **Type**: *Schlechter 19747*, Govidjoa, Madang or Morobe, Papua New Guinea (B, lecto., chosen here). – *Xiphopteris govidjoaensis* (Brause) Copel., Gen. Fil. (1947) 215. – *Xiphopteris exilis* Parris, Kew Bull. 41 (1986) 503. **Type**: *Holttum SFN 10680,* G. Belumut, Johor, Peninsular Malaysia, (K, holo.; SING, iso.).

3. *Xiphopterella hecistophylla* (Copel.) Parris, *comb. nov*.
Polypodium hecistophyllum Copel., Philipp. J. Sci. 56 (1935) 477, t. 8, f. 1. **Type**: *Clemens 40837*, Mt Kinabalu, Sabah, East Malaysia [MICH, lecto. (Parris *et al.*, 1992); BM, K, UC, isolecto.]. – *Xiphopteris hecistophylla* (Copel.) Copel., Gen. Fil. (1947) 215.

4. *Xiphopterella hieronymusii* (C.Chr.) Parris, *comb. nov*.
Polypodium sertularioides J.Sm. ex Hieron., Hedwigia 44 (1905) 98 *non*

Baker (1876). **Syntypes**: *Cuming 380*, Malacca, Peninsular Malaysia (B, *n.v.*, K) & *Griffith s.n.* (B), *Wray in herb. Mus. Perak 1551*, G. Beremban, Pahang, Peninsular Malaysia (B, *n.v.*, UC). – *Polypodium hieronymusii* C.Chr., Index Fil. (1906) 533, *nomen novum pro P. sertularioides* J.Sm. ex Hieron. (1905) *non* Baker (1876). – *Xiphopteris hieronymusii* (C.Chr.) Holttum, Rev. Fl. Malaya 2 (1955) 218.

5. *Xiphopterella sparsipilosa* (Holttum) Parris, *comb. nov***.**
Ctenopteris sparsipilosa Holttum, Gardens' Bull. 11 (1947) 268. **Type**: *Holttum SFN 23522*, G. Batu Brinchang, Pahang, Peninsular Malaysia (SING, holo.; K, UC, iso.). – *Xiphopteris sparsipilosa* (Holttum) Holttum, Rev. Fl. Malaya 2 (1955) 219.

Oreogrammitis

The genus *Oreogrammitis* was established by Copeland (1917) for one species, *O. clemensiae* Copel. [**Type**: *Clemens 10618 p. p.*, Mt Kinabalu, Sabah, Malaysia (MICH, lecto. (Parris, 1983); BM, isolecto.)], then known only from Mount Kinabalu in Sabah, East Malaysia.

The brief generic description reads '*Frondibus confertis, stipitatis, simplicibus, integris, parvis; venis (nisi soriferis) liberis; soro costa parallelo et proximo, lineare, superficiale, nudo; paraphysibus nullis. Genus Eupolypodium derivatum.*'

The description of *O. clemensiae* gives a few more details: '*Rhizomate adscendente, brevissimo, paleis pallido-fuscis lanceolatis vel ovatis acutis 2 ad 3 mm longis dense obtecto; stipitibus filiformibus, castaneis, 1.0 ad 2.5 cm altis; fronde lineari-oblanceolata, 1.5 ad 3.0 mm lata, 2 ad 3 cm longa, obtusa, deorsum sensim attenuata, subcucullata, subcoriacea, fusca, pilis sparsissimis concoloribus mox deciduis vestita; venis inconspicuis, simplicibus vel furcatus; soris usque 12 mm longis, subapicalibus, lateribus frondis deflexis protectis.*' Copeland regarded his new genus as being related to *Scleroglossum,* but differing in its superficial, rather than sunken sori. He did not mention that the sporangia were setose, nor that the rhizome scales were glabrous. Christensen (1929) retained *Oreogrammitis clemensiae* as a dubious taxon known only from the type collection, commenting on the scanty material not permitting a detailed examination and being unable to form a definite idea of its systematic position. He noted that its scales were like those of *Scleroglossum*, but it seemed very different in its filiform long stipes, long brown hairs along the edges and superficial sori. Christensen & Holttum (1934) also retained the genus after Holttum had collected the species again on Mount Kinabalu, mentioning that the species was distinct, but the validity of the genus was very problematical.

Parris made three further collections of the species from Mount Kinabalu (Parris *et al.*, 1992) and noted (Parris, 1983) that '*Oreogrammitis clemensiae* was previously placed in a separate monotypic genus because of its fused sori (Copeland, 1917). Collections from the type locality show all degrees of soral fusion from complete to all sori (11 per row) discrete when young and confluent when mature, and the genus is not worthy of recognition. Fused sori are occasionally also found in the circum-antarctic species *Grammitis poeppigiana* (Mett.) Pic. Serm., to which *O. clemensiae* is not closely related. The genus *Scleroglossum* has fused sori, but *O. clemensiae* cannot be regarded as a link between *Grammitis* and *Scleroglossum* as postulated by Copeland (1917). Examination of the rhizome and the frond hairs shows that *O. clemensiae* has no near relationship to *Scleroglossum*.'

The acceptance that *Grammitis* Sw. *s.l.* is an artificial genus based on frond dissection (Parris, 1997a, 1998a; Ranker *et al.,* 2004) and the restriction of *Grammitis* to the black-margined taxa related to and including the type of the genus, *G. marginella* (Sw.) Sw., necessitates the removal from it of numerous Old World species. *Oreogrammitis* is an available name for those that are related to *O. clemensiae,* with the following characters.

Rhizomes dorsiventral, stipes in two rows, sometimes articulated to rhizome, sometimes with prominent phyllopodia. Rhizome scales pale to dark brown or blackish, usually not clathrate, rarely clathrate, usually not iridescent, rarely iridescent, usually subglossy, rarely dull or glossy, glabrous, cells usually not turgid, rarely subturgid or turgid, without cross-walls except in *O. dolichosora*. Hairs usually simple, rarely branched. Laminae usually simple, rarely pinnatifid or pinnate; venation usually free, rarely with occasional anastomoses, veins usually dichotomously one-two(-four)-branched, rarely pinnately branched, ends of vein branches sometimes with hydathodes on adaxial surface of lamina. Sori in two (to six or more) rows on ± simple laminae, one (to three or more) on each side of the mid-vein, in two rows, one on each side of pinna mid-vein when pinnate, superficial or slightly sunken in broad shallow depressions, rarely deeply sunken in steep-sided pits, on abaxial surface of lamina, ± circular to narrowly elliptic; first-developed sporangia of each sorus characteristically with one to nine simple eglandular hairs clustered at apex of sporangium adjacent to annulus; later-developed sporangia of each sorus glabrous. 110 species, India to Polynesia.

The generic name refers to the montane habitat of the type species and to *Grammitis*, in which the species were formerly placed. Species of

Oreogrammitis sampled by Ranker *et al.* (2004) are in the upper part of Clade Ia. See under *Radiogrammitis* above for differences between it and *Oreogrammitis*.

Oreogrammitis kunstleri Parris, *sp. nov.*
Type: *Kunstler s.n.*, April 1880, G. Ledang, Johor, Peninsular Malaysia, (E, holo.).
Species aspectu O. reinwardtio similis, sed pilis brevioribus densioribus, venis non manifestis, ramis venarum in longitudine aequalibus non ramo acroscopico multo breviore quam ramo basiscopico et hydathodis destitutis non praesentibus differt.

Stipes not articulated to rhizome, phyllopodia absent. Stipes 3-6 x 0.3-0.6 mm; with dense dark red-brown simple unjointed hairs 0.5-0.8 mm long. **Laminae** *c.* 128 x 6 mm, linear-oblanceolate, bluntly acute at apex, long-attenuate at base, slightly crenulate, teeth to 0.2 mm long; with dark red-brown simple unjointed hairs 0.4-1.1 mm long frequent to dense on abaxial surface of lamina, frequent to dense on abaxial surface of mid-vein, frequent to dense on margin, frequent on adaxial surface of lamina and frequent on adaxial surface of mid-vein; mid-vein slightly prominent and concolorous on abaxial surface of lamina, not evident on adaxial surface; lateral veins invisible in transmitted light, not prominent on either surface, 1-forked, acroscopic branch extending beyond sorus, more or less as long as basiscopic branch, vein endings without hydathodes. **Sori** 1.7-2.5 x 1.3-1.9 mm, on surface of lamina or slightly sunken in broad shallow depressions, discrete when mature, in apical 2/3 of lamina, *c.* 33 in each row, nearer to mid-vein than margin. **Sporangia** setose.

Distribution: Peninsular Malaysia, Johor (G. Ledang), known only from the type collection.

Oreogrammitis malayensis Parris, *sp. nov.*
Type: *Nor Ezzawanis A. T. FRI 52316*, ca 1760 m, 12 Aug 2006, Telekom road to Gunung Ulu Kali, Pahang/Selangor, Peninsular Malaysia (KEP, holo.).

– *Grammitis sp. 9* in Parris & Latiff (1997).

Species aspectu Radiogrammitidi peninsulari simillima, sed rhizomate dorsiventrale non radiale, pilis in pagina inferiore laminae brevioribus et pilis sporangiorum longioribus differt.

Stipes sometimes articulated to rhizome, phyllopodia sometimes present.

Stipes 1-7 x 0.2-0.3 mm; with dense dark red-brown simple unjointed hairs 0.3-0.7 mm long. **Laminae** 26-60 x 2-6 mm, narrowly oblanceolate to linear-oblanceolate, bluntly acute to obtuse at apex, long-attenuate at base, entire or slightly crenulate; with dark red-brown simple unjointed hairs 0.2-0.9 mm long scattered to dense on abaxial surface of lamina, sparse to frequent on abaxial surface of mid-vein, frequent to dense on margin, occasional to frequent on adaxial surface of lamina and occasional to frequent on adaxial surface of mid-vein; mid-vein slightly prominent to prominent on abaxial surface of lamina, not prominent to slightly prominent on adaxial surface, concolorous on both surfaces; lateral veins invisible in transmitted light, sometimes slightly prominent and concolorous on adaxial surface of lamina, not prominent on abaxial surface, 1-2-(3-) forked, acroscopic branch extending beyond sorus or not, shorter than basiscopic branch, vein endings without hydathodes. **Sori** 1.3-3.3 x 1.2-2.5 mm, on surface of lamina or slightly sunken in broad shallow depressions, discrete to confluent when mature, in apical 1/3 to 1/2 of lamina, 4-18 in each row, nearer to mid-vein than margin. **Sporangia** setose.

*Distribution***:** Peninsular Malaysia, known from Pahang/Selangor and Johor.
Specimens examined in addition to type: Peninsular Malaysia, Pahang/ Selangor, Telekom road to G. Ulu Kali, *ca* 1760 m, 12 Aug. 2006, *Nor Ezzawanis A. T. FRI 52318, 52328* (both KEP); Johor, G. Belumut, 910 m (3000 ft), 25 May1923, *Holttum SFN 10860 bis* (MICH, SING); G. Ledang, *ca* 1070 m (3500 ft), 21 April 1930, *Holttum SFN 23701* (MICH, SING, UC); G. Mering, *Ridley 3354 p p.* (SING).

1. *Oreogrammitis adspersa* (Blume) Parris, *comb. nov.*
Polypodium adspersum Blume, Enum. Pl. Javae (1828) 123 *non* Schrad. (1818). **Type**: *Blume s.n.*, Java [L, lecto. (Parris 1983); L, isolecto.]. – *Grammitis adspersa* Blume, Flora Javae 2 (1830) 115, t. 48, f. 2, *nomen novum pro Polypodium adspersum* Blume (1828) *non* Schrad. (1818). – *Polypodium sessilifolium* Hook., Sp. Fil. 4 (1863) 168 *non* Liebm. (1849). **Type**: *Cuming 222*, Luzon, Philippines [K, lecto. (Parris 1983); BM, CGE, isolecto.]. – *Polypodium subevenosum* Baker in Hook. & Baker, Syn. Fil. (1867) 320. **Type**: *Mactier s.n.*, Penang, Peninsular Malaysia [K, holo; E, iso.]. – *Grammitis subevenosa* (Baker) C.Chr. & Tardieu, Notul. Syst. (Paris) 8 (1939) 179. – *Grammitis sessilifolia* J.Sm., Hist. Fil. (1875) 181, *nomen novum pro P. sessilifolium* Hook. (1863) *non* Liebm. (1849). – *Polypodium maxwellii* Baker, Bull. Misc. Inform., Kew 1893 (1893) 211. **Type**: *Hose 296*, Mt Gading, Sarawak, East Malaysia (K, holo.; E, SAR, iso.). – *Grammitis maxwellii* (Baker) Parris, Fern Gaz. 12 (1980) 118. – *Polypodium paucisorum*

Copel., Philipp. J. Sci., C. Bot. 2 (1907) 137. **Type**: *Merrill 5964*, Mt Halcon, Mindoro, Philippines [MICH, lecto. (Parris, 1983)]. – *Polypodium malaicum* Alderw., Malayan Ferns (1909) 577, *nomen novum pro P. sessilifolium* Hook. (1863) *non* Liebm. (1849). – *Grammitis malaica* (Alderw.) Tagawa, Acta Phytotax. Geobot. 8 (1939) 173, *nomen superfl. illegit. pro G. sessilifolia* J.Sm. –*Polypodium pilistipes* Alderw., Bull. Jard. Bot. Buitenzorg, sér. 2, 11 (1913) 20. **Type**: no collector, no locality (BO, lecto., chosen here).

2. *Oreogrammitis albosetosa* (F.M.Bailey) Parris, *comb. nov.*
Polypodium albosetosum F.M.Bailey, Rep. Govt Sci. Exped. Bellenden Ker (1889) 78. **Type**: *Bailey s.n.*, Bellenden Ker, Queensland, Australia [BRI, lecto. (Parris, 1975); BM, BRI, K, MEL, NSW, isolecto.]. – *Grammitis albosetosa* (F.M.Bailey) Parris, Bot. J. Linn. Soc. 70: 36 (1975).

3. *Oreogrammitis alta* (Parris) Parris, *comb. nov.*
Grammitis stipitata Brownlie, Nova Hedwigia, Beih. 55 (1977) 345, t. 40, f. 4 *non Grammitis stipitata* Proctor (1966). **Type**: *Brownlie 1785*, Mt Tomaniivi, Viti Levu, Fiji (CHR, holo.). – *G. alta* Parris, N. Z. J. Bot. 18 (1980), *nomen novum pro Grammitis stipitata* Brownlie (1977) *non* Proctor (1966).

4. *Oreogrammitis antipodalis* (Copel.) Parris, *comb. nov.*
Xiphopteris antipodalis Copel., Univ. Calif. Publ. Bot. 18 (1942) 224. **Type**: *Brass 10788*, L. Habbema, Papua (MICH, holo.; BM, K, UC, iso.).

5. *Oreogrammitis archboldii* (C.Chr.) Parris, *comb. nov.*
Polypodium archboldii C.Chr., Brittonia 2 (1937) 305. **Type**: *Brass 4236*, Mt Albert Edward, Central, Papua (BM, holo.; BO, BRI, NY, iso.). - *Grammitis archboldii* (C.Chr.) Copel., Philipp. J. Sci. 80 (1952) 186.

6. *Oreogrammitis attenuata* (Kunze) Parris, *comb. nov.*
Grammitis attenuata Kunze, Linnaea 24 (1851) 251. **Syntypes**: *Schmidt s.n.*, *Koch s.n.,* Nilgiris, India (both at JE, *n.v.*). – *Polypodium parasiticum* Mett., Abhandl. Senckenb. Naturf. Gesell. 2 (1857) 36. Type: based on *Grammitis attenuata* Kunze *non Polypodium attenuatum* Willd.

7. *Oreogrammitis austroindica* (Parris) Parris, *comb. nov.*
Grammitis austroindica Parris, Fern Gaz. 16 (2001) 202. **Type**: *Herb. Beddome s.n.*, Nilgiris, India (BM, holo.).

8. *Oreogrammitis baldwinii* (Baker) Parris, *comb. nov.*
Polypodium baldwinii Baker, Ann. Bot. 5 (1891) 463. **Type**: *Baldwin s.n.*, Kauai, Hawaiian Is. (K). – *Grammitis baldwinii* (Baker) Copel., Philipp. J. Bot. 80 (1952) 158. - *Polypodium knudsenii* Hieron., Hedwigia 44 (1905)

79. **Syntypes**: *Knudsen 90, Baldwin 117,* Kauai, Hawaiian Is.; *Knudsen 7,* Mt Halemanu, Hawaiian Is. (all at B, *n.v.*).

9. *Oreogrammitis brassii* (Copel.) Parris, *comb. nov.*
Grammitis brassii Copel., Philipp. J. Sci. 60 (1936) 112, t. 21. **Type**: *Brass 2926*, Hinuahaoro, San Cristobal, Solomon Is. (PNH†, holo.; A, lecto., chosen here; BRI, GH, MICH, isolecto.).

10. *Oreogrammitis caespitosa* (Blume) Parris, *comb. nov.*
Grammitis caespitosa Blume, Enum. Pl. Javae (1828) 115. **Type**: *Matthew s.n.*, G. Gede, Java [K, neo. (Parris, 1983)]. – *Polypodium caespitosum* (Blume) Mett., Ann. Mus. Bot. Lugd. – Bat. 2 (1866) 219.

11. *Oreogrammitis ceratocarpa* (Copel.) Parris, *comb. nov.*
Grammitis ceratocarpa Copel., Univ. Calif. Publ. Bot. 18 (1942) 223. **Type**: *Clemens 11349*, Ulap, Morobe, Papua New Guinea (MICH, holo.; MICH, UC, iso.).

12. *Oreogrammitis cervicornis* (Alderw.) Parris, *comb. nov.*
Polypodium cervicorne Alderw., Bull. Jard. Bot. Buitenzorg, sér. 2, 28 (1918) 39. **Type**: *Brooks 303/S*, Lebong Simpang, Bengkoelen, Sumatra (BO, lecto., chosen here; BM, isolecto.). – *Grammitis cervicornis* (Alderw.) Adelbert in van Borssum Waalkes, Annales Bogor. 4 (1960) 25.

13. *Oreogrammitis christophersenii* (Copel.) Parris, *comb. nov.*
Grammitis christophersenii Copel, Occ. Papers B. P. Bishop Mus. 15 (1939) 89, f. 8. **Type**: *Christophersen & Hume 2277 p. p.*, Matavanu, Savaii, Samoa (BISH, holo.; MICH, UC, iso.).

14. *Oreogrammitis clavata* (Parris) Parris, *comb. nov.*
Grammitis clavata Parris, Kew Bull. 52 (2004) 219, f. 1 C. **Type**: *Johns 10068*, Mt Jaya, Papua (K, holo.; BO, *n.v.*, FRE, *n.v.*, MAN, *n.v.*, all iso.).

15. *Oreogrammitis collina* (Parris) Parris, *comb. nov.*
Grammitis collina Parris, Blumea 29 (1983) 174, f. 28, 3. **Type**: *Parris 9294 [sphalm. 9224] & Croxall,* Baiyer-Jimi Divide, Western Highlands, Papua New Guinea (K, holo.; K, LAE, iso.).

16. *Oreogrammitis conformis* (Brack.) Parris, *comb. nov.*
Polypodium conforme Brack., U. S. Expl. Exped. 16 (1854) 4, t. 1, f. 2. **Type**: *U.S. Expl. Exped. 3,* Ovalau, Fiji (K, US, *n.v.*). - *Grammitis conformis* (Brack.) J.Sm., Hist. Fil. (1875)181.

17. *Oreogrammitis congener* (Blume) Parris, *comb. nov.*
Grammitis congener Blume, Enum. Pl. Javae (1828) 115. **Type**: *Blume s.n.*, Java [L, lecto. (Parris, 1986)]. – *Polypodium congenerum* (Blume) C.Presl, Tentamen (1836) 180. – *Polypodium alatellum* Christ, Verh. Natur. Gesell. Basel 11 (1897) 441. **Type**: *F & P Sarasin 1368 p. p.*, Wawokaraeng, Sulawesi (BAS, *n.v.*). – *Grammitis brevipila* Copel., Brittonia 1 (1931) 69. **Type**: *Williams 1581*, Trinidad, Luzon, Philippines (NY, holo.; MICH, UC, iso.). – *Polypodium brevipilum* (Copel.) C.Chr., Index Fil. Suppl. 3 (1934) 145. – *Grammitis duplopilosa* Copel., Brittonia 1 (1931) 69. **Type**: *Williams 1582*, Mt Santo Tomas, Luzon, Philippines (NY, holo; UC, iso.). – *Polypodium duplopilosum* (Copel.) C.Chr., Index Fil. Suppl. 3 (1934) 148. – *Grammitis petrophila* Copel., Philipp. J. Sci. 56 (1935) 478. **Type**: *Clemens 50133*, Mt Kinabalu, Sabah, East Malaysia [MICH, lecto. (Parris, 1986); BM, K, UC, isolecto.]. – *Grammitis hirtella* var. *major* Holttum, Rev. Fl. Malaya 2 (1955) 216, *nomen invalidum*.

18. *Oreogrammitis crinifera* (Parris) Parris, *comb. nov.*
Grammitis crinifera Parris, Blumea 29 (1983) 180, f. 29, 2. **Type**: *Pulle 857*, Mt Hellwig, Papua (L, holo.).

19. *Oreogrammitis crispatula* (Holttum) Parris, *comb. nov.*
Grammitis crispatula Holttum, Gardens' Bull. 11 (1947) 268. **Type**: *Burkill SFN 12705*, Maxwell's Hill, Perak, Peninsular Malaysia (SING, holo.; BM, BO, K, iso.).

20. *Oreogrammitis curtipila* (Parris) Parris, *comb. nov.*
Grammitis curtipila Parris, Blumea 29 (1983) 112, f. 16, 4. **Type**: *Brass 25776*, Normanby I., Milne Bay, Papua New Guinea (K, holo.; A, CANB, L, LAE, iso.).

21. *Oreogrammitis debilifolia* (Copel.) Parris, *comb. nov.*
Grammitis debilifolia Copel., Univ. Calif. Publ. Bot. 18 (1942) 223. **Type**: *Brass 10036 & Meijer-Drees,* Mt Trikora, Papua (MICH, holo.; A, BM, BO, K, L, LAE, UC, iso.).

22. *Oreogrammitis dictymioides* (Copel.) Parris, *comb. nov.*
Grammitis dictymioides Copel., Univ. Calif. Publ. Bot. 18 (1942) 223. **Type**: *Brass 11848*, L. Habbema, Papua (MICH, holo.; A, BO, L, iso.).

23. *Oreogrammitis dolichosora* (Copel.) Parris, *comb. nov.*
Polypodium dolichosorum Copel., Philipp. J. Sci. 1 Suppl. (1906) 159, t. 16. **Type**: *Copeland 1524*, Davao, Mindanao, Philippines [MICH, lecto. (Parris,

1983); K, NSW, UC, isolecto.]. – *Grammitis dolichosora* (Copel.) Copel., Philipp. J. Sci. 80 (1952) 188. - *Polypodium ciliolatum* Alderw., Nova Guinea 14 (1924) 43. **Type:** *Lam 1518*, Mt Doorman, Papua [BO, lecto. (Parris, 1983); L, SING, frag. of L at MICH, photo. of L at BM, isolecto.). - *Grammitis ciliolata* (Alderw.) Copel., Philipp. J. Sci. 80 (1952) 187.

24. *Oreogrammitis dorsipila* (Christ) Parris, *comb. nov.*
Polypodium dorsipilum Christ in Warburg, Monsunia 1 (1900) 59. **Type**: *Warburg s.n.*, South China (B, *n.v.*). – *Grammitis dorsipila* (Christ) C.Chr. & Tardieu, Notul. Syst. (Paris) 8 (1939) 179.

25. *Oreogrammitis excelsa* (Parris) Parris, *comb. nov.*
Grammitis excelsa Parris, Blumea 29 (1983) 171, f. 27. **Type**: *Bergman 416*, Kadubaka, Central Range, Papua (S, holo.).

26. *Oreogrammitis fasciata* (Blume) Parris, *comb. nov.*
Grammitis fasciata Blume, Enum. Pl. Javae (1828) 116. **Type**: *Blume s.n.*, G. Gede, Java [L, lecto. (Parris, 1983); BO, K, L, NSW, isolecto.]. – *Polypodium fasciatum* (Blume) C.Presl, Tentamen (1836) 180. - *Themelium fasciatum* (Blume) Parris, Kew Bull. 59 (2004) 225. – *Polypodium integrum* Brause, Bot. Jahrb. Syst. 49 (1912) 37. **Type**: *Schultze Jena (26) 21*, Tami R., West Sepik, Papua New Guinea [B, lecto. (Parris, 1983)]. – *Grammitis integra* (Brause) Copel., Philipp. J. Sci. 80 (1952) 171. – *Polypodium fuciforme* Rosenst., Nova Guinea 8 (1912) 726. **Type**: *von Römer 846*, Hellwig Mts, Papua [BO, lecto. (Parris, 1983)]. - *Polypodium alcicorne* Ridl., Trans. Linn. Soc. London, Bot. 2, 9 (1916) 261 *non* Baker (1888). **Type**: *Kloss s.n.*, Mt Carstensz, Papua [BM, lecto. (Parris, 1983); K, isolecto.]. – *Polypodium dichotomum* Brause, Bot. Jahrb. Syst. 56 (1920) 190 *non* Houttyn (1783) *nec* Thunb. (1784). **Type**: *Ledermann 9246*, Etappenberg, East Sepik, Papua New Guinea [B, lecto. (Parris, 1983); BM, S, isolecto.]. – *Grammitis angustifolia* Gilli, Ann. Naturhist. Mus. Wien 81 (1978) 24, *non* (Sw.) Heward (1838). **Type**: *Gilli 165*, Mingende, Simbu, Papua New Guinea (W, holo., *n.v.*).

27. *Oreogrammitis fenicis* (Copel.) Parris, *comb. nov.*
Grammitis fenicis Copel., Univ. Calif. Publ. Bot. 18 (1942) 224. **Type**: *Ramos Bur. Sci. 80147,* Batanes Is., Philippines, (MICH, holo.; K, PNH†, SING, UC, iso.).

28. *Oreogrammitis flavovirens* (Alston) Parris, *comb. nov.*
Polypodium flavovirens Alston, J. Bot. 78 (1940) 228. **Type**: *Clemens 6764*, Sambanga, Morobe, Papua New Guinea, (B, holo.). – *Ctenopteris flavovirens* (Alston) Parris, Kew Bull. 41 (1986) 69. – *Ctenopteris clemensiae* Copel.,

Univ. Calif. Publ. Bot. 18 (1942) 225. **Type**: *Clemens s.n.*, Rawlinson Range, Morobe, Papua New Guinea (MICH, holo.; UC, iso.). – *Ctenopteris schizophlebia* Copel., Univ. Calif. Publ. Bot. 18 (1942) 225. **Type**: *Clemens s.n.*, Rawlinson Ra., Morobe, Papua New Guinea (MICH, holo.; UC, iso.).

29. *Oreogrammitis forbesiana* (W.H.Wagner) Parris, *comb. nov.*
Grammitis forbesiana W.H.Wagner, Contr. Univ. Michigan Herb. 19 (1993) 70. **Type**: *Wagner 65386*, Haelaau to Puu Kukui, Maui, Hawaiian Is. (MICH, holo., *n.v.*; BISH, iso., *n.v.*).

30. *Oreogrammitis frigida* (Ridl.) Parris, *comb. nov.*
Polypodium frigidum Ridl., Trans. Linn. Soc. London, Bot. 2, 9 (1916) 259. **Type**: *Kloss s.n.*, Mt Carstensz, Papua [BM, lecto. (Parris, 1983)]. – *Grammitis frigida* (Ridl.) Copel., Univ. Calf. Publ. Bot. 18 (1942) 223. – *Grammitis caricifolia* Copel., Univ. Calif. Publ. Bot. 18 (1942) 223. **Type**: *Clemens s.n.*, Mt Sarawaket, Morobe, Papua New Guinea (MICH, holo.). – *Grammitis plurisetulosa* Copel., Univ. Calif. Publ. Bot. 18 (1942) 223. **Type**: *Brass 10109 & Meyer-Drees,* Mt Trikora, Papua (MICH, holo.; A, BO, BRI, L, UC, iso.).

31. *Oreogrammitis glabrata* (Brownlie) Parris, *comb. nov.*
Grammitis glabrata Brownlie, Nova Hedwigia, Beih. 55 (1977) 348, t. 40, f. 1. **Type**: *Brownlie 800*, Mt Delaikora, Vanua Levu, Fiji, (CHR, holo.).

32. *Oreogrammitis glossophylla* (Parris) Parris, *comb. nov.*
Grammitis glossophylla Parris, Blumea 29 (1983) 47, f. 3, 2. **Type**: *Brass 28495*, Rossel I., Milne Bay, Papua New Guinea (L, holo.).

33. *Oreogrammitis graminifolia* (Copel.) Parris, *comb. nov.*
Grammitis graminifolia Copel., Univ. Calif. Publ. Bot. 18 (1942) 223. **Type**: *Brass 5092*, Mt Tafa, Central, Papua New Guinea (NY, holo.; BM, BO, BRI, GH, MICH, iso.). – *Themelium graminifolium* (Copel.) Parris, Kew Bull. 59 (2004) 225.

34. *Oreogrammitis habbemensis* (Copel.) Parris, *comb. nov.*
Grammitis habbemensis Copel., Univ. Calif. Publ. Bot. 18 (1942) 223. **Type**: *Brass 10520*, L. Habbema, Papua (MICH, holo.; A, BO, L, iso.).

35. *Oreogrammitis hispida* (Copel.) Parris, *comb. nov.*
Grammitis hispida Copel., Univ. Calif. Publ. Bot. 18 (1942) 224. **Type**: *Brass 10257*, L. Habbema, Papua (MICH, holo.; A, BM, BO, K, L, LAE, iso.).

36. *Oreogrammitis hookeri* (Brack.) Parris, *comb. nov.*

Polypodium setigerum Hook. & Arnott., Bot. Beechey's Voy. (1832) 103, t. 21A *non* Blume (1828). **Type**: *Bidwill s.n.*, Hawaiian Is. (K). - *Polypodium hookeri* Brack., U.S. Expl. Exped. 16 (1854) 4, *nomen novum pro P. setigerum* Hook. & Arnott (1832) non Blume (1828). - *Grammitis hookeri* (Brack.) Copel., Philipp. J. Sci. 80 (1952) 157. - *Grammitis setigera* J.Sm., Hist. Fil. (1875) 181, *nomen novum pro P. setigerum* Hook. & Arnott (1832) *non* Blume (1828).

37. *Oreogrammitis imberbis* (Parris) Parris, *comb. nov.*
Grammitis imberbis Parris, Blumea 29(1) (1983) 128, f. 19, 3. **Type**: *Croft & Lelean LAE 65885*, Mt Scorpion, West Sepik, Papua New Guinea (LAE, holo.).

38. *Oreogrammitis inconstans* (Alderw.) Parris, *comb. nov.*
Polypodium inconstans Alderw., Nova Guinea 14 (1924) 43. **Type**: *Lam 1882,* Mt Doorman, Papua [BO, lecto. (Parris, 1983)]. – *Grammitis inconstans* (Alderw.) Copel., Philipp. J. Sci. 80 (1952) 193.

39. *Oreogrammitis insularis* (Copel.) Parris, *comb. nov.*
Grammitis insularis Copel., Univ. Calif. Publ. Bot. 18 (1942) 223. **Type**: *Vaupel 451*, Samoa (US, holo., *n.v.*; B, *n.v.*, MICH, iso.). - *Grammitis impressa* Copel., Philipp. J. Bot. 80 (1952) 242, f. 95. **Type**: *Bartlett 7964A*, Dalok Soeroengam, Tapianoeli, Sumatra (US, holo.; UC, iso.).

40. *Oreogrammitis interrupta* (Baker) Parris, *comb. nov.*
Monogramma interrupta Baker, Ann. Bot. 5 (1891) 482. **Type**: *Macgregor s.n.,* Mt Yule, Gulf, Papua New Guinea (K, holo.; BM, iso.). – *Pleurogramme interrupta* (Baker) Christ, Farnkr. der Erde (1897) 55. – *Nematopteris interrupta* (Baker) C.Chr., Dansk Bot. Ark. 6 (1929) 31. – *Grammitis interrupta* (Baker) Copel., Gen. Fil. (1947) 214. – *Polypodium pyxidiforme* Alderw., Bull. Jard. Bot. Buitenzorg, sér. 2, 1 (1911) 28. **Type**: *de Kock 45*, Mt Goliath, Papua [BO, lecto. (Parris, 1983); BM, isolecto].

41. *Oreogrammitis jeraiensis* (Parris) Parris, *comb. nov.*
Grammitis jeraiensis Parris, Hooker's Icon. Pl. 40 (1990), t. 3976. **Type**: *Abdullah 615*, G. Jerai, Kedah, Peninsular Malaysia (KLU, holo.).

42. *Oreogrammitis kjellbergii* (C.Chr.) Parris, *comb. nov.*
Polypodium kjellbergii C.Chr. in Kjellberg & C.Chr., Bot. Jahrb. Syst. 66 (1933) 63. **Type**: *Kjellberg 1102*, B. Watoewila, Sulawesi, (BM, BO, S, *n.v.*).

43. *Oreogrammitis knutsfordiana* (Baker) Parris, *comb. nov.*

Polypodium knutsfordianum Baker, J. Bot. 28 (1890) 107. **Type**: *Macgregor s.n.*, Mt Knutsford, Central, Papua New Guinea (K, holo.). – *Grammitis knutsfordiana* (Baker) Copel., Univ. Calif. Publ. Bot. 18 (1942) 224. – *Polypodium oleandroides* Baker, Ann. Bot. 8 (1894) 128. **Type**: *Macgregor s.n.*, Mt Suckling, Milne Bay, New Guinea (K, holo.). – *Polypodium warburgii* Christ in Warburg, Monsunia 1 (1900) 59. **Type**: *Warburg 17882*, G. Sibella, Bacan, Moluccas [B, lecto. (Parris, 1983)]. – *Polypodium setosum* var. *calvum* Copel., Philipp. J. Sci., C. Bot. 2 (1907) 136. **Type**: *Merrill 5965*, Mt Halcon, Mindoro, Philippines (MICH). – *Polypodium diplosoroides* Rosenst., Nova Guinea 8 (1912) 724. **Type**: *von Römer 1167*, Hellwig Mts, Papua [BO, lecto. (Parris, 1983)]. – *Grammitis nigrosetosa* Copel., Univ. Calif. Publ. Bot. 18 (1942) 224. **Type**: *Stresemann 404*, G. Fogha, Buru, Moluccas (L 936.248…162, holo.; photos at CGE, PARRIS). – *Grammitis stresemannii* Copel., Univ. Calif. Publ. Bot. 18 (1942) 224. **Type:** *Stresemann 268*, Ceram, Moluccas (L936.248...170, holo.; photos at CGE, PARRIS).

44. *Oreogrammitis leonardii* (Parris) Parris, *comb. nov.*
Grammitis leonardii Parris, Bot. J. Linn. Soc. 70 (1975) 38, f. 5 A & B. **Type**: *Brass 20075*, Mt Finnegan, Queensland, Australia (BRI, holo.; A, iso.).

45. *Oreogrammitis locellata* (Baker) Parris, *comb. nov.*
Polypodium locellatum Baker, J. Bot. 28 (1890) 108. **Type**: *Macgregor 26,* Mt Victoria, Central, Papua New Guinea (K, holo.; BM, iso.). – *Grammitis locellata* (Baker) Copel., Occ. Papers Bishop Mus. 15 (1939) 86. – *Grammitis stenocrypta* Copel., Philipp. J. Sci. 46 (1931) 220. **Type**: *Copeland s n.*, G. Gede, Java [MICH, lecto. (Parris, 1983); BM, BO, UC, isolecto.]. – *Polypodium stenocryptum* (Copel.) C.Chr., Index Fil. Suppl. 3 (1934) 158. – *Grammitis stomatocarpa* Copel., Univ. Calif. Publ. Bot. 18 (1942) 223. **Type**: *Brass 9858A & Meijer-Drees,* Mt Trikora, Papua (MICH, holo.; A, BM, BO, BRI, L, iso.).

46. *Oreogrammitis loculosa* (Alderw.) Parris, *comb. nov.*
Polypodium loculosum Alderw., Nova Guinea 14 (1924) 42. **Type**: *Lam 1267*, Doorman R., Papua [L, lecto. (Parris, 1983); BM, isolecto.]. – *Grammitis loculosa* (Alderw.) Copel., Univ. Calif. Publ. Bot. 18 (1942) 223.

47. *Oreogrammitis longiceps* (Rosenst.) Parris, *comb. nov.*
Polypodium longiceps Rosenst., Repert Spec. Nov. Regni Veg. 12 (1913) 177. **Type**: *Keysser B.72*, Bolan Mts, Morobe, Papua New Guinea (S, *n.v.*, UC). - *Ctenopteris longiceps* (Rosenst.) Copel., Philipp. J. Sci. 81 (1953) 103.

48. *Oreogrammitis maireaui* (Copel.) Parris, *comb. nov.*
Grammitis maireaui Copel., B. P. Bishop Mus. Occ. Papers 14 (1938) 71.

Type: *St John & Maireau 15553*, Mt Perahu, Rapa, Austral Is. (BISH 498689, lecto., chosen here; BISH 10935, K, MICH, WELT, isolecto.).

49. *Oreogrammitis marivelesensis* (Copel.) Parris, *comb. nov.*
Grammitis marivelesensis Copel., Univ. Calif. Publ. Bot. 18 (1942) 224. **Type**: *Copeland 215*, Luzon, Mt Mariveles, Philippines (MICH, holo.).

50. *Oreogrammitis medialis* (Baker) Parris, *comb. nov.*
Polypodium mediale Baker in Hook. & Baker, Syn. Fil. ed. 2 (1874) 507. **Type**: *Wall s.n.*, Sri Lanka [K, lecto. (Parris, 2002b)]. – *Grammitis medialis* (Baker) Ching, Bull. Fan Mem. Inst. Biol. 10 (1940) 15.

51. *Oreogrammitis merrillii* (Copel.) Parris, *comb. nov.*
Polypodium merrillii Copel., Perkins' Fragm. (1905) 188. **Type**: *Merrill 754*, Iwahig R., Palawan, Philippines [US, lecto. (Parris, 1983); PNH†, isolecto.]. - *Grammitis merrillii* (Copel.) Copel., Philipp. J. Sci. 80 (1952) 224.

52. *Oreogrammitis mesocarpa* (Alderw.) Parris, *comb. nov.*
Polypodium mesocarpum Alderw., Nova Guinea 14 (1924) 42. **Type**: *Lam 1878*, Mt Doorman, Papua (BO, lecto., chosen here; L, isolecto.). – *Grammitis mesocarpa* (Alderw.) Copel., Philipp. J. Sci. 80 (1952) 181.

53. *Oreogrammitis miltiblepharis* (Copel.) Parris, *comb. nov.*
Grammitis miltiblepharis Copel., B. P. Bishop Mus. Occ. Papers 14 (1938) 71. **Type**: *Mumford & Adamson 586*, Ooumu, Nukuhiva, Marquesas (BISH, holo.; MICH, iso.).

54. *Oreogrammitis mollipila* (Baker) Parris, *comb. nov.*
Polypodium mollipilum Baker, J. Bot. 28 (1890) 107. **Type**: *Macgregor s.n.*, Owen Stanley Range, Central, Papua New Guinea, (K, holo.; BM, iso.). – *Grammitis mollipila* (Baker) Copel., Univ. Calif. Publ. Bot. 18 (1942) 224.

55. *Oreogrammitis montana* (Parris) Parris, *comb. nov.*
Grammitis montana Parris, Blumea 29 (1983) 167, f. 26, 1. **Type**: *Clemens s n.*, Mt Sarawaket, Morobe, Papua New Guinea (BM, holo.; MICH, iso.).

56. *Oreogrammitis monticola* (Sledge) Parris, *comb. nov.*
Grammitis monticola Sledge, Brit. Fern Gaz. 9 (1967) 344. **Type**: *Sledge 1835*, Mt Fito, Upolu, Samoa (K, holo.).

57. *Oreogrammitis murrayana* (C.Chr.) Parris, *comb. nov.*
Polypodium murrayanum C.Chr., Brittonia 2 (1937) 304. **Type**: *Brass 4726*,

Wharton Range, Northern, Papua New Guinea (BM, holo.; BRI, MICH, NY, iso., *n.v.*). - *Grammitis murrayana* (C.Chr.) Copel., Philipp. J. Sci. 80 (1952) 200.

58. *Oreogrammitis neocaledonica* (Copel.) Parris, *comb. nov.*
Grammitis neocaledonica Copel., Univ. Calif. Publ. Bot. 18 (1942) 222. **Type**: *Schlechter 15346*, New Caledonia (L, holo., *n.v.*; E, K, MICH, NSW, iso.).

59. *Oreogrammitis nigropaleata* (Copel.) Parris, *comb. nov.*
Grammitis nigropaleata Copel., Univ. Calif. Publ. Bot. 18 (1942) 224. **Type**: *Clemens 41018*, Matap, Morobe, Papua New Guinea (MICH, holo.; MICH, UC, iso.).

60. *Oreogrammitis nipponica* (Tagawa & K.Iwats.) Parris, *comb. nov.*
Grammitis nipponica Tagawa & K.Iwats., Amer. Fern J. 51 (1961) 150, f. A-C. **Type**: *Nakai 5052*, San-no-taki Falls, Honshu, Japan (KYO, holo., *n.v.*).

61. *Oreogrammitis nuda* (Tagawa) Parris, *comb. nov.*
Grammitis nuda Tagawa, Acta Phytotax. Geobot. 19 (1941) 284. **Type**: *Tagawa 2092*, Tyosyu-gun, Takaio, Taiwan (KYO, holo, *n.v.*).

62. *Oreogrammitis oblanceolata* (Baker) Parris, *comb. nov.*
Polypodium oblanceolatum Baker, Annals Bot. 8 (1894) 128. **Type**: *Macgregor s.n.*, Mt Suckling, Milne Bay, Papua New Guinea (K, holo.). – *Grammitis oblanceolata* (Baker) Copel., Philipp. J. Sci. 80 (1952) 166. – *Polypodium sparsipilum* Copel., Philipp. J. Sci., C. Bot. 6 (1911) 139. **Type**: *Brooks 14*, Bengkarum, Sarawak, East Malaysia [MICH, lecto. (Parris, 1983); BM, isolecto.]. – *Grammitis sparsipila* (Copel.) Parris, Fern Gaz.12 (1980) 118. – *Polypodium hirtellum* var. *subcalvum* Alderw., Bull. Jard. Bot. Buitenzorg, sér. 2, 28 (1918) 39. **Type**: *Brooks 302/S*, Lebong Simpang, Bengkoelen, Sumatra (BM, BO). – *Grammitis brevisetulosa* Copel., Univ. Calif. Publ. Bot. 18 (1942) 223. **Type**: *Clemens 40969 p.p.*, Matap, Morobe, Papua New Guinea (MICH, holo.).

63. *Oreogrammitis oncobasis* (M.G.Price) Parris, *comb. nov.*
Grammitis oncobasis M.G.Price, Contr. Univ. Michigan Herb. 17 (1990) 274, f. 1, D & E. **Type**: *Price 3376*, Mt Burnay, Luzon, Philippines (MICH, holo.).

64. *Oreogrammitis padangensis* (Baker) Parris, *comb. nov.*
Polypodium padangense Baker, J. Bot. 18 (1880) 213. **Type**: *Beccari s.n.*, G. Singgalang, Sumatra (K, holo.). – *Grammitis padangensis* (Baker) Copel., Philipp. J. Sci. 80 (1952) 212. – *Polypodium stanleyanum* Baker, J. Bot. 28

(1890) 107. **Type**: *Macgregor 25,* Owen Stanley Range, Central, Papua New Guinea (K, holo.; BM, iso.). – *Grammitis stanleyana* (Baker) Copel., Philipp. J. Sci. 80 (1952) 168. – *Polypodium durum* Copel., Leafl. Philipp. Bot. 3 (1910) 837. **Type**: *Elmer 11689,* Mt Calelan, Mindanao, Philippines [MICH, lecto. (Parris, 1983)]. – *Polypodium ciliiferum* Alderw., Bull. Jard. Bot. Buitenzorg sér. 2, 16 (1914) 32. **Type**: *Matthew 708*, G. Sago, Sumatra [BO, lecto. (Parris, 1983)]. – *Polypodium trichocarpum* Alderw., Nova Guinea 14 (1924) 41. **Type**: *Lam 1693*, Mt Doorman, Papua [L, lecto. (Parris, 1983); BM, L, isolecto.]. – *Polypodium trichocarpum* var. *inerme* Alderw., Nova Guinea 14 (1924) 42. **Type**: *Lam 1854*, Mt Doorman, Papua [BO, lecto. (Parris, 1983); L, isolecto.].

65. *Oreogrammitis palauensis* (Hosokawa) Parris, *comb. nov.*
Grammitis palauensis Hosokawa, Trans. Nat. Hist. Soc. Formosa 31 (1941) 475. **Type**: *Hosokawa 9769*, Sin-Gaspan, Babeldaob, Palau (TI, holo., *n.v.*; BISH, iso.).

66. *Oreogrammitis papuensis* (Alderw.) Parris, *comb. nov.*
Polypodium papuanum Ridl., Trans. Linn. Soc. London, Bot. 2, 9 (1916) 260 *non* Baker (1886). **Type**: *Kloss s.n.*, Mt Carstensz, Papua [BM, lecto. (Parris, 1983)]. – *Polypodium papuense* Alderw., Handbook Malayan Ferns Suppl. (1917) 521, *nomen novum pro P. papuanum* Ridl. (1916) *non* Baker (1886). - *Grammitis papuensis* (Alderw.) Parris, Fern Gaz. 12 (1980) 118.

67. *Oreogrammitis pilifera* (Ravi & J.Joseph) Parris, *comb. nov.*
Grammitis pilifera Ravi & J.Joseph, J. Bombay Nat. Hist. Soc. 76 (1979) 348, f. 1-5. **Type**: *Ravi 5711*, Ponmudi Hills, Kerala, India (CAL, holo., *n.v.*; MH, n. v., RH, *n.v.,* iso.).

68. *Oreogrammitis pilosiuscula* (Blume) Parris, *comb. nov.*
Grammitis pilosiuscula Blume, Enum. Pl. Javae (1828)115. **Type**: Java, *Blume s.n.* (L, lecto., chosen here). – *Polypodium pilosiusculum* (Blume) C.Presl, Tentamen (1836) 180. - *Grammitis hirta* Blume, Enum. Pl. Javae (1828) 115 *non* Humb., Bonpl. & Kunth (1815). **Type**: *Blume s n.*, G. Gede, Java (L, lecto., chosen here). – *Polypodium hirtum* C.Presl, Tentamen (1836) 180 *pro G. hirta* Blume (1828) *non* Humb., Bonpl. & Kunth (1815), *non P. hirtum* Sw. (1788), *nec* Schkuhr (1806), *nec* C. Presl (1825), *nec* Vell. (1827). – *Grammitis hirta* var. *B* Blume, Fl. Javae 2 (1829) 111. **Type**: *Van Hasselt s.n.*, G. Karang, Java (L).

69. *Oreogrammitis piruensis* (M.Kato & Parris) Parris, *comb. nov.*
Grammitis piruensis M.Kato & Parris, J. Fac. Sci. Univ. Tokyo 3, 15 (1992) 127,

f. 2. **Type**: *Kato, Ueda & Fanani C-12998*, Tanahgoyang to G. Tiang Bendera, Seram, Moluccas (TI, holo.).

70. *Oreogrammitis pleurogrammoides* (Rosenst.) Parris, *comb. nov.*
Polypodium pleurogrammoides Rosenst., Repert. Spec. Nov. Regni Veg. 5 (1908) 42. **Type**: *Werner 22*, Mt Gelu, Madang, New Guinea [UC, lecto. (Parris, 1983); S, isolecto.]. – *Grammitis pleurogrammoides* (Rosenst.) Copel., Occ. Papers Bishop Mus. 15 (1939) 86. - *Grammitis vitiensis* Brownlie, Nova Hedwigia, Beih. 55 (1977) 346, t. 40, 2 & 3. **Type**: *Vodonaivalu 2170*, Mt Voma, Viti Levu, Fiji (CHR, holo.).

71. *Oreogrammitis polita* (Brause) Parris, *comb. nov.*
Polypodium politum Brause, Bot. Jahrb. Syst. 56 (1920) 185. **Type**: *Ledermann 12937A p.p.*, Felsspitze, East Sepik, Papua New Guinea (B, lecto., chosen here).

72. *Oreogrammitis pseudolocellata* (Parris) Parris, *comb. nov.*
Grammitis pseudolocellata Parris, Blumea 29 (1983) 189. **Type**: *Brass 22893*, Mt Dayman, Milne Bay, Papua New Guinea (BM, holo.; A, iso.).

73. *Oreogrammitis pseudospiralis* (Alderw.) Parris, *comb. nov.*
Polypodium pseudospirale Alderw., Bull. Jard. Bot. Buitenzorg, sér. 2, 1 (1911) 29. **Type**: *de Kock 49*, Mt Goliath, Papua (BO, *n.v.*). – *Xiphopteris pseudospiralis* (Alderw.) Parris, Alpine & Subalpine Flora Mt Jaya (2006) 118. - *Polypodium roemerianum* Rosenst., Nova Guinea 8 (1912) 725. **Type**: *von Römer 1227*, Hellwig Mts, Papua [L, lecto. (Morton, 1973)].

74. *Oreogrammitis queenslandica* (Parris) Parris, *comb. nov.*
Grammitis queenslandica Parris, Bot. J. Linn. Soc. 70 (1975) 39, f. 5 E & F. **Type**: *Brass 18222*, Speewah, Queensland, Australia (BRI, holo.; A, iso.).

75. *Oreogrammitis raiateensis* (J.W.Moore) Parris, *comb. nov.*
Polypodium raiateense J.W.Moore, B. P. Bishop Mus. Bull. 102 (1933) 10. **Type**: *Moore 183*, Mt Temehani, Raiatea, Society Is. (BISH 498920, lecto., chosen here; BISH 79273, BISH 498921, isolecto.). – *Grammitis raiateensis* (J.W.Moore) Copel., Occ. Papers B. P. Bishop Mus. 14 (1938) 72.

76. *Oreogrammitis reinwardtii* (Blume) Parris, *comb. nov.*
Grammitis reinwardtii Blume, Enum. Addend. (1828) 2. **Type**: *Reinwardt s.n.,* Sulawesi [L, lecto. (Parris, 1983)]. – *Polypodium reinwardtii* (Blume) C.Presl, Tentamen (1836) 180. - *Polypodium sucklingianum* Baker, Ann. Bot. 8 (1894) 128. **Type**: *Macgregor s.n.*, Mt Suckling, Milne Bay, Papua New

Guinea (K, holo.). – *Grammitis sucklingiana* (Baker) Parris, Fern Gaz. 12 (1980) 118. – *Polypodium brooksii* Copel., Philipp. J. Sci., C. Bot. 12 (1917) 60, *non* (Copel.) C.Chr. (1913). **Type**: *Brooks s.n.*, G. Bongo, Sarawak, East Malaysia (MICH, lecto., chosen here; K, isolecto.). – *Polypodium trichopodum* F.Muell. var. *serratolobatum* Brause, Bot. Jahrb. Syst. 56 (1920) 179. **Type**: *Ledermann 11576*, Lehm River, East Sepik, Papua New Guinea [B, lecto. (Parris, 1983)]. – *Polypodium bongoense* Copel., Philipp. J. Sci. 38 (1929) 153, *nomen novum pro P. brooksii* Copel. (1917) *non* (Copel.) C.Chr. (1913). – *Grammitis bongoensis* (Copel.) Copel., Philipp. J. Sci. 80 (1952) 271. – *Grammitis reinwardtioides* Copel., Philipp. J. Sci. 56 (1935) 478. **Type**: *Clemens 40792*, Mt Kinabalu, Sabah, East Malaysia [MICH, lecto. (Parris *et al*, 1992); BM, isolecto.]. – *Grammitis mariae* Copel., Univ. Calif. Publ. Bot. 18 (1942) 223. **Type**: *Clemens 10251A*, Mt Sarawaket, Morobe, Papua New Guinea (MICH, holo.). – *Grammitis matapensis* Copel., Univ. Calif. Publ. Bot. 18 (1942) 223. **Type**: *Clemens 11176*, Matap, Morobe, New Guinea (MICH, holo.; BM, MICH, UC, all iso.).

77. *Oreogrammitis reptans* (Parris) Parris, *comb. nov.*
Grammitis reptans Parris, Blumea 29 (1983) 156, f. 24, 1. **Type**: *Brass 9841 & Meijer-Drees,* Mt Trikora, Papua (L, holo.; A, BO, MICH, iso.).

78. *Oreogrammitis rivularis* (Parris) Parris, *comb. nov.*
Grammitis rivularis Parris, Kew Bull. 41 (1986) 514. **Type**: *Matthew s.n.*, G. Bubu, Perak, Peninsular Malaysia (K, holo.).

79. *Oreogrammitis rupestris* (Parris) Parris, *comb. nov.*
Grammitis rupestris Parris, Blumea 29 (1983) 172, f. 28, 1. **Type**: *Wakefield 1427*, Narirogo Creek, Central, Papua New Guinea (BM, holo.).

80. *Oreogrammitis salticola* (Parris) Parris, *comb. nov.*
Grammitis salticola Parris, Blumea 29 (1983) 92, f. 13, 1. **Type**: *Parris 5943 & Croxall,* Mt Giluwe, Southern Highlands, Papua New Guinea (K, holo.; K, LAE, iso.).

81. *Oreogrammitis scabristipes* (Baker) Parris, *comb. nov.*
Polypodium scabristipes Baker, J. Bot. 28 (1890) 108. **Type**: *Macgregor s.n.,* Owen Stanley Range, Central, Papua New Guinea (K, holo.). – *Grammitis scabristipes* (Baker) Copel., Univ. Calif. Publ. Bot. 18 (1942) 223. – *Polypodium ludens* Baker, Ann. Bot. 8 (1894) 129. **Type**: *Hancock 53A,* Java (K, holo.). – *Grammitis ludens* (Baker) Copel., Gen. Fil. (1947) 211. – *Polypodium bulbotrichum* Copel., Philipp. J. Sci. 40 (1929) 309. **Type**: *Copeland's Pteridophyta Philippensia Exsiccata 136*, Mt Pulog, Luzon,

Philippines [MICH, lecto. (Parris, 1983); BM, BO, K, SING, UC, isolecto.]. – *Grammitis bulbotricha* (Copel.) Copel., Philipp. J. Sci. 46 (1931) 219. – *Grammitis limapes* Copel., Philipp. J. Sci. 46 (1931) 218. **Type**: *Copeland s.n.*, G. Gede-Panggrango, Java [MICH, lecto. (Parris, 1983); BM, BO, UC, isolecto.]. – *Polypodium limapes* (Copel.) C.Chr., Index Fil. Suppl. 3 (1934) 152. - *Grammitis novoguineensis* Copel., Univ. Calif. Publ. Bot. 18 (1942) 223. **Type**: *Bamler B.41*, Bolan Mts, Morobe, Papua New Guinea (UC, holo.).

82. *Oreogrammitis scleroglossoides* (Copel.) Parris, *comb. nov.*
Grammitis scleroglossoides Copel., B. P. Bishop Mus. Occ. Papers 15 (1939) 86, f. 6. **Type**: *Takamatsu 1095*, Mt Nan-a-lant, Ponape, Caroline Is. (BISH 498214, lecto., chosen here; BISH 103965, MICH, UC, isolecto.).

83. *Oreogrammitis setosa* (Blume) Parris, *comb. nov.*
Grammitis setosa Blume, Enum. Pl. Javae (1828) 116. **Type**: *Blume s.n.*, Java (L, lecto., chosen here). – *Polypodium setosum* (Blume) C.Presl, Tentamen (1836) 180 *non* Thunb. (1784) nec G.Forst. (1786). – *Polypodium sundaicum* C.Chr., Index Fil. Suppl. 3 (1934) 160, *nomen novum pro Grammitis setosa* Blume *non P. setosum* Thunb. (1784), *nec* G.Forst. (1786). – *Grammitis obscura* Blume, Enum. Pl. Javae (1828) 115. **Type**: *Blume s.n.*, G. Gede-Panggrango, Java, (L, lecto., chosen here). – *Polypodium obscurum* (Blume) Mett., Abhandl. Senckenb. Naturf. Gesell. 2 (1857) 38. - *Polypodium reinwardtii* var. *obscurum* (Blume) C.Chr., Index Fil. (1906) 332. – *Grammitis pubinervis* Blume, Enum. Pl. Javae (1828) 116. **Type**: *Blume s.n.,* Java (L, lecto., chosen here). – *Polypodium pubinerve* (Blume) Christ, Ann. Jard. Bot. Buitenzorg 15 (1897) 146. – *Grammitis obscura* var. *angustata* Blume, Fl. Javae 2 (1830) 113. **Type**: *Kuhl & Van Hasselt s. n.*, G. Panggrango, Java (L). – *Grammitis longa* Fée, Genera (1852) 233. **Type**: *Lobb 271*, "Singapore" (BM, K). – *Polypodium diplosorum* Christ, Verh. Natur. Gesell. Basel 11 (1896) 440. **Type**: *Sarasin 1358*, Wawokaraeng, Sulawesi (BAS, *n.v.).*

84. *Oreogrammitis setulifera* (Alderw.) Parris, *comb. nov.*
Polypodium pumilum Brause. Bot. Jahrb. Syst. 49 (1912) 38, f. 2, F *non* Cockayne (1909). **Type**: *Schlechter 19112*, Finisterre Mts, Morobe, Papua New Guinea (B, *n.v.*). - *Polypodium setuliferum* Alderw., Bull. Jard. Bot. Buitenzorg, sér. 2, 16 (1914) 32. **Syntypes**: *Matthew 408*, Malacca, Peninsular Malaysia (BO, *n.v.*); *Matthew 651*, Barisan Mts, Sumatra (BO, *n.v.*; K). – *Xiphopteris setulifera* (Alderw.) Parris, Kew Bull. 41 (1986) 69.

85. *Oreogrammitis sledgei* (Parris) Parris, *comb. nov.*
Grammitis sledgei Parris, Fern Gaz. 16 (2002) 240. **Type**: *Sledge 1281*, Kalu Ganga, Ratnapura, Sri Lanka, (BM, holo.; US, iso.).

86. *Oreogrammitis subdichotoma* (Racib. *ex* Alderw.) Parris, *comb. nov.*
Polypodium subdichotomum Racib. ex Alderw., Bull. Dept. Agric. Indes Néerl. 18 (1908) 20. **Type**: *Forbes 2408,* Sumatra (BO, lecto., chosen here). *Grammitis subdichotoma* (Racib. ex Alderw.) Parris, Fern Gaz. 12 (1981) 180.

87. *Oreogrammitis subfasciata* (Rosenst.) Parris, *comb. nov.*
Polypodium subfasciatum Rosenst., Repert. Spec. Nov. Regni Veg. 5 (1908) 41. **Type**: *Werner 25*, Mt Gelu, Madang, Papua New Guinea [UC, lecto. (Parris, 1983); S, isolecto.]. – *Grammitis subfasciata* (Rosenst.) Copel., Philipp. J. Sci. 80 (1952) 170. – *Polypodium ceramicum* Alderw., Bull. Jard. Bot. Buitenzorg, sér. 3, 2 (1920) 168. **Type**: *Kornassi 1505*, G. Murkele, Seram, Moluccas [BO, lecto. (Parris, 1983); L, isolecto.]. – *Grammitis ceramica* (Alderw.) Ching, Bull. Fan Mem. Inst. Biol. 10 (1941) 240.

88. *Oreogrammitis subreticulata* (Copel.) Parris, *comb. nov.*
Polypodium subreticulatum Copel., Philipp. J. Sci. C. Bot. 9 (1914) 6. **Type**: *Shaw in Copland King 395*, Taupota, Milne Bay, Papua New Guinea [MICH, lecto. (Parris, 1983); BM, NSW, isolecto.]. – *Grammitis subreticulata* (Copel.) Copel., Philipp. J. Sci. 80 (1952) 185.

89. *Oreogrammitis subspathulata* (Brack.) Parris, *comb. nov.*
Polypodium subspathulatum Brack., U.S. Expl. Exped. 16 (1854) 3, t. 1, f. 1. **Type**: *U.S. Expl. Exped. s.n.*, Tahiti, Society Is. (US, *n.v.*). – *Grammitis subspathulata* (Brack.) Farw., Amer. Midland Nat. 12 (1931) 294.

90. *Oreogrammitis sumatrana* (Baker) Parris, *comb. nov.*
Polypodium sumatranum Baker, J. Bot. 18 (1880) 214. **Type**: *Beccari 448*, G. Singgalang, Sumatra (K, lecto., chosen here; BM, BO, FI, *n.v.*, isolecto.). – *Grammitis sumatrana* (Baker) Copel., Philipp. J. Sci. 56 (1935) 105. – *Polypodium subpleiosorum* Racib., Pterid. Buitenzorg (1898) 89. **Type**: *Raciborski s.n.*, Salak West, Java [BO, lecto. (Parris, 1983); KRA, *n. v.,* L, *n. v.,* isolecto.]. – *Polypodium pleiosoroides* Copel., Perkins' Fragm. Fl. Philipp. (1905) 189. **Type**: *Copeland 1011*, Mt Apo, Mindanao, Philippines (PNH†?, *n.v.*). – *Polypodium serraeforme* Brause, Bot. Jahrb. Syst. 49 (1912) 36 *non* (Wall. ex Hook.) J.Sm. (1841). **Type**: *Schlechter 18142*, Finisterre Mts, Morobe, Papua New Guinea [B, lecto. (Parris, 1983); BM, UC, isolecto.]. – *Polypodium subrepandum* Brause, Bot. Jahrb. Syst. 49 (1912) 37. **Type**: *Schultze Jena (26) 16*, Tami, West Sepik, Papua New Guinea [B, lecto. (Parris. 1983)]. – *Grammitis subrepanda* (Brause) Copel., Philipp. J. Sci. 80 (1952) 183. – *Polypodium biseriale* Ridl., Trans. Linn. Soc. London, Bot. 2, 9 (1916) 260 *non* Baker (1867). Type: *Kloss s. n.*, Mt Carstensz, Papua [BM, lecto.

(Parris, 1983)]. – *Polypodium carstenszense* Ridl., Trans. Linn. Soc. London, Bot. 2, 9 (1916) 260. Type: *Kloss s. n.*, Mt Carstensz, Papua [BM, lecto. (Parris, 1983); K, isolecto.]. – *Polypodium brauseanum* Alderw., Malayan Ferns Suppl. (1917) 521, *nomen novum pro P. serraeforme* Brause *non* (Wall. *ex* Hook.) J.Sm.

91. *Oreogrammitis taeniophylla* (Parris) Parris, *comb. nov.*
Grammitis taeniophylla Parris, Blumea 29 (1983) 67, f. 7, 3. **Type**: *Hoogland & Craven 11034*, Mt Hunstein, East Sepik, Papua New Guinea (LAE, holo.; CANB, iso., *n.v.*).

92. *Oreogrammitis temehaniensis* (J.W.Moore) Parris, *comb. nov.*
Polypodium raiateense var. *temehaniense* J.W.Moore, B. P. Bishop Mus. Bull. 102 (1933) 11. **Type**: *Moore 104*, Temehani Plain, Raiatea, Society Is. (BISH 498924, lecto., chosen here; BISH 79247, BISH 498925, isolecto.). – *Grammitis temehaniensis* (J.W.Moore) Parris, Holttum Mem. Vol. (1997) 82.

93. *Oreogrammitis tenuis* (Parris) Parris, *comb. nov.*
Grammitis tenuis Parris, Blumea 29 (1983) 130, f. 19, 2. **Type**: *Parris 6040 & Croxall,* Watut-Aseki Divide, Morobe, Papua New Guinea (K, holo.; K, LAE, iso.).

94. *Oreogrammitis tomaculosa* (Parris) Parris, *comb. nov.*
Grammitis tomaculosa Parris, Blumea 29 (1983) 152, f. 23, 3. **Type**: *Brass 10042A & Meijer-Drees,* Mt Trikora, Papua (BM, holo.; A, BO, L, MICH, iso.).

95. *Oreogrammitis torricelliana* (Brause) Parris, *comb. nov.*
Polypodium torricellianum Brause, Bot. Jahrb. Syst. 49 (1912) 45, f. 3A. **Type**: *Schlechter 14347*, Torricelli Mts, East or West Sepik, Papua New Guinea [B, lecto. (Parris, 1983)]. – *Grammitis torricelliana* (Brause) Parris, Fern Gaz. 12 (1981) 180. - *Grammitis microtricha* Copel., Philipp. J. Sci. 56 (1935) 105, t. 11. **Type**: *Copeland s.n.*, Mt Apo, Mindanao, Philippines [MICH, lecto. (Parris, 1983)].

96. *Oreogrammitis trichopoda* (F.Muell.) Parris, *comb. nov.*
Polypodium trichopodum F.Muell., Trans. Roy. Soc. Victoria 1 (1889) 41. **Type**: *Macgregor 28,* Mt Victoria, Central, Papua New Guinea [MEL, lecto. (Parris, 1983); BM, K, isolecto.]. – *Grammitis trichopoda* (F.Muell.) Copel, Univ. Calif. Publ. Bot. 18 (1942) 224.

97. *Oreogrammitis trogophylla* (Copel.) Parris, *comb. nov.*

Grammitis trogophylla Copel., Univ. Calif. Publ. Bot. 18 (1942) 224. **Type**: *Clemens s.n.*, Mt Sarawaket, Morobe, Papua New Guinea (MICH, holo.).

98. *Oreogrammitis tuyamae* (H.Ohba) Parris, *comb. nov*.
Grammitis tuyamae H.Ohba, Sci. Rep. Tôhuku Univ. 4, 36 (1971) 121, f. 8. **Type**: *Tuyama s.n.*, Minamiiwojima, Volcano Is., Japan (TI, holo., *n. v.*).

99. *Oreogrammitis uapensis* (E.D.Br.) Parris, *comb. nov*.
Polypodium hookeri var. *uapense* E.D.Br., B. P. Bishop Mus. Bull. 89 (1931) 86. **Type**: *Jones 155A (1210)*, Ua Pou, Marquesas [BISH, lecto. (Parris 1997b)]. – *Grammitis uapensis* (E.D.Br.) Parris, Allertonia 7 (1997) 302.

100. *Oreogrammitis universa* (Baker) Parris, *comb. nov*.
Polypodium universa Baker, Annals Bot. 5 (1891) 464. **Type**: *Curtis 633*, Penang, Peninsular Malaysia (K, lecto., chosen here). – *Grammitis universa* (Baker) Copel., Philipp. J. Sci. 80 (1952) 218.

101. *Oreogrammitis velutina* (Parris) Parris, *comb. nov*.
Grammitis velutina Parris, Kew Bull. 52 (2004) 220, f. 1 B. **Type**: *Johns 10678*, Mt Jaya, Papua (K, holo.; BO, *n.v.*, FRE, *n.v.*, MAN, *n.v.*, iso.).

102. *Oreogrammitis viridula* (Alderw.) Parris, *comb. nov*.
Polypodium viridulum Alderw., Nova Guinea 14 (1924) 41. **Type**: *Lam 1853*, Mt Doorman, Papua [L, lecto. (Parris, 1983); BO, isolecto., *n.v.*]. – *Grammitis viridula* (Alderw.) Parris, Fern Gaz. 12 (1980) 118.

103. *Oreogrammitis vittariifolia* (C.Chr.) Parris, *comb. nov*.
Polypodium minimum Baker, J. Bot. 17 (1879) 41 *non* Aublet (1775). **Type**: *Burbidge s.n.*, Labuan or Kinabalu, Sabah, Malaysia [K, lecto. (Parris, 1986); BM, E, K, isolecto.]. – *Polypodium vittariifolium* C.Chr., Index Fil. (1906) 574, *nomen novum pro P. minimum* Baker (1879) *non* Aublet (1775). – *Grammitis vittariifolia* (C.Chr.) Parris, Fern Gaz. 12 (1980) 118.

104. *Oreogrammitis wallii* (Beddome) Parris, *comb. nov*.
Polypodium wallii Beddome, Suppl. Ferns S India & Brit. India (1876) 20, t. 380. **Type**: *Thwaites C. P. 3921*, Adam's Peak, Nuwara Eliya, Sri Lanka [K, lecto. (Parris, 2002b); GH, isolecto., *n.v.*]. – *Grammitis wallii* (Beddome) Copel., Philipp. J. Sci. 80 (1952) 240.

105. *Oreogrammitis whitmeei* (Baker) Parris, *comb. nov*.
Polypodium whitmeei Baker, J. Bot. 14 (1876) 12. **Type**: *Whitmee 124*, Samoa (CGE, GH, *n.v.*, K). - *Grammitis whitmeei* (Baker) Copel., Philipp. J. Sci. 80

(1952) 150.

106. *Oreogrammitis wurunuran* (Parris) Parris, *comb. nov.*
Grammitis wurunuran Parris, Bot. J. Linn. Soc. 70 (1975) 40, f. 5 G & H. **Type**: *Parris 3703 & Croxall,* Mt Bellenden Ker, Queensland, Australia (BRI, holo.; K, iso.).

107. *Oreogrammitis zeylanica* (Fée) Parris, *comb. nov.*
Grammitis zeylanica Fée, Genera (1852) 234. **Type**: *Gardner 56*, Sri Lanka (BM, K, OXF, P). – *Polypodium zeylanicum* (Fée) Mett., Abhandl. Senckenb. Naturf. Gesell. 2 (1857) 38.

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Two New Names and Two New Combinations in Malesian Annonaceae

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Abstract

Two later homonyms in *Polyalthia* are provided with new names: *Polyalthia sinclairiana* I.M.Turner replaces *P. macropoda* King and *Polyalthia dolichopoda* I.M.Turner replaces *P. tenuipes* Merr. (1922, *non* Merr. 1912). The combination *Dasymaschalon dasymaschalum* (Blume) I.M.Turner, which is not a tautonym under the current code, is made. It replaces the superfluous *Dasymaschalon blumei* Finet & Gagnep. A new combination for *Dasymaschalon dasymaschalum* var. *wallichii* is also made. Lectotypes are proposed for *Polyalthia macropoda* King, *Polyalthia tenuipes* Merr. (1922), and *Unona dasymaschala* Blume var. *wallichii* Hook. f. & Thomson.

A new name for *Polyalthia macropoda* King

Polyalthia macropoda King is a cauliflorous tree species widely distributed in the Malay Peninsula. Unfortunately the name is a later homonym, having already been used for a species from New Guinea. A new name is therefore proposed and it is fitting to honour James Sinclair, whose revision of the Annonaceae of the Malay Peninsula (Sinclair 1955) has proved seminal.

Polyalthia sinclairiana I.M. Turner, *nom. nov.*
Pro Polyalthia macropoda King (*non* (Miq.) F. Muell.), J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 61 (1892) 60. **Type**: King's Collector, Perak (*King's Collector 4279*, **lectotype nov**., designated here, K!; isolectotype, BM!).

A new name for *Polyalthia tenuipes* Merr.

Polyalthia tenuipes Merr. is a distinctive and quite widely collected Bornean species. Unfortunately Merrill coined the name for this species having already used the same binomial for a different species from the Philippines. It is therefore necessary to propose a new name for the Bornean species.

Polyalthia dolichopoda I.M. Turner, *nom. nov.*
Pro Polyalthia tenuipes Merr. (*non* Merr., Philipp. J. Sci., C. 7 (1912) 269), J. Straits Branch Roy. Asiat. Soc. 85 (1922) 184. **Type**: Sabah, near Sandakan, *M.*

Ramos 1501 (holotype, PNH destroyed; isotype, SAN destroyed; **lectotype nov.,** designated here, K!; isolectotype, US).

New combinations in *Dasymaschalon*

Presumably Finet and Ganepain, when they published the name *Dasymaschalon blumei* for *Unona dasymaschala* Blume, did so in the belief that the combination *Dasymaschalon dasymaschalum* would be a tautonym and thus illegitimate. However, as recent edition of the International Code of Botanical Nomenclature (Art. 23.4) states: 'The specific epithet … may not exactly repeat the generic name (such repetition would result in a tautonym).' Therefore *Dasymaschalon dasymaschalum* is not a tautonym because the repeat between generic name and specific epithet is not exact. An analogous case (Art. 14, Ex. 1) is *Lycopersicon lycopersicum* (L.) H. Karsten, which is not a tautonym. This combination, however, had to be formally rejected to avoid replacement of the widely used name for the tomato, *Lycopersicon esculentum* Mill. The legitimacy of *Dasymaschalon dasymaschalum* makes *Dasymaschalon blumei* Finet & Gagnep. a superfluous renaming of *Unona dasymaschala* Blume. Below I formally make the new combination for *Unona dasymaschala* in *Dasymaschalon*. *Dasymaschalon blumei* could be revived either through a change of the ICBN code by widening the definition of tautonym, or a formal rejection of the new combination proposed below based on other justifications.

Dasymaschalon dasymaschalum (Blume) I.M. Turner, *comb. nov.*
Basionym: *Unona dasymaschala* Blume, Fl. Javae Anonaceae 23-24 (1830) 55, t. 27. **Type:** Java, *Blume s.n.* [lectotype designated by Nurmawati (2003), L (barcode: L0186230); isolectotype, BO].

Homotypic synonyms: *Dasymaschalon blumei* Finet & Gagnep., Bull. Soc. Bot. France 53, Mémoire 4 (1906) 143, *nom. superfl.*
-*Desmos dasymaschalus* (Blume) Safford, Bull. Torrey Bot. Club 39 (1912) 507.
-*Unona dasymaschala* var. *blumei* Hook.f. & Thomson, Fl. Ind. 1 (1855) 135, *nom. inval.*

Heterotypic synonyms: *Unona coelophloea* Scheff., Flora 52 (1869) 300; -*Dasymaschalon coelophloeum* (Scheff.) Merr., Philipp. J. Sci., C. 10(4) (1915) 237.
-*Unona cleistogama* Burck ex Boerl., Icon. Bogor. 1 (1899) 127; *Dasymaschalon cleistogamum* (Burck ex Boerl.) Merr., Philipp. J. Sci., C. 10(4) (1915) 237.

Dasymaschalon dasymaschalum (Blume) I.M.Turner var. **wallichii** (Hook.f. & Thomson) I.M.Turner, *comb. nov*.
Basionym: *Unona dasymaschala* Blume var. *wallichii* Hook.f. & Thomson, Fl. Ind. 1 (1855) 135. Type: Singapore, *Wallich catalogue 6421A* (**lectotype nov.**, designated here, K-WALL!).

Homotypic synonyms: *Desmos dasymaschalus* (Blume) Safford var. *wallichii* (Hook.f. & Thomson) Ridl., Fl. Malay. Penins. 1 (1922) 47; *Dasymaschalon blumei* Finet & Gagnep. var. *wallichii* (Hook.f. & Thoms.) Bân, Bot. Zhurn. 60 (1975) 228.

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Studies on Schismatoglottideae (Araceae) of Borneo II: *Aridarum crassum*, a New Species from Sarawak, Malaysian Borneo

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Abstract

Aridarum crassum S.Y.Wong & P.C.Boyce is described as a new species from Sarawak, Malaysian Borneo. The existing key to the genus *Aridarum* Ridl. is amended to include the new species.

Introduction

Aridarum Ridl. is a genus consisting of nine species of rheophytic, sometimes facultatively lithophytic, forest herbs, are all endemic to Borneo. Previous work by Bogner & Hay (2000) recognised nine species of which one species was at that time inadequately known and thus not fully described. The species, treated as sp. A in Bogner & Hay (2000), was known from a single collection from the summit (850 m asl) of Gunung Gaharu (Sri Aman Division, Sarawak). Fieldwork by the second author at the same location, although at lower altitude (the summit is no longer accessible) resulted in three collections of what we believe to be the same species. This species is clearly distinguished from the rest of the genus *Aridarum* by the leaf laminae very stiffly coriaceous, glossy deep green adaxially and conspicuously raised punctate abaxially when fresh. We are hereby describing this novelty as *Aridarum crassum* S.Y.Wong & P.C.Boyce.

Key to species of *Aridarum*

1a. Thecae on each end of the anther (Sect. *Aridarum*) **2**
1b. Thecae together on one side of the anther (Sect. *Caulescentia*) **6**

2a. Leaf laminae almost linear; horns of anther thecae long and thin; Sarawak (Santubong.. ***A. montanum***
2b. Leaf laminae very narrowly elliptic to elliptic; horns of anther thecae short and stubby **3**

3a. Leaf arrangement distichous; Sarawak (vicinity of Matang) ....
.... ***A. borneense***
3b. Leaf arrangement spiral.. **4**

4a. Spadix fertile to apex (possibly except a few apical sterile stamens); anthers not excavated; horns of thecae short but robust, their bases occupying the whole upper surface of the anther; West Kalimantan ...... ***A. incavatum***
4b. Spadix with an appendix of staminodes; anthers excavated; horns of the thecae small, on each end of the anther; Sarawak and West Kalimantan ... **5**

5a. Leaf laminae very stiffly coriaceous, glossy deep green adaxially when fresh, conspicuously raised-punctate abaxially when fresh, weakly and minutely punctate in dry material, margins revolute in dry material, primary lateral venation weakly raised adaxially when fresh, 5-8 primary lateral veins at each side but obscure in dry material, obscure abaxially when fresh and in dry material; sweet smelling (esterases) at female anthesis, ovary ovoid to elongate-ovoid, stigma $^2/_3$ of ovary diam. strongly papillate, umbonate, staining brownish red in alcohol; thecae horns very short, rounded at the end; Sarawak (Gunung Gaharu) .... ***A. crassum***
5b. Leaf laminae rubbery-coriaceous, matte medium green adaxially when fresh, inconspicuously raised punctate abaxially when fresh, conspicuously raised punctate in dry material, margins planate in dry material, primary lateral venation obscure adaxially when fresh and in dry material, weakly raised abaxially when fresh and in dry material, to ca 3 primary lateral veins on each side; inflorescence with no smell at female anthesis, ovary ovoid, stigma as wide as ovary, weakly papillate, scutiform, staining light brown in alcohol; thecae horns long, pointed at the end; Sarawak (Bako National Park) and West Kalimantan .... ***A. nicolsonii***

6a. Stamens arranged in pairs; thecae on the inner face of each member of the stamen pair **7**
6b. Stamens single (but crowded); thecae on the proximal (with respect to the spadix axis) side of the anther... **8**

7a. Horns of thecae shorter than width of stamen; Sarawak and Brunei ......
.... ***A. caulescens***
7b. Horns of thecae longer than width of stamen; Sarawak .... ***A. purseglovei***

8a. Stamens and staminodes coarsely verruculate; appendix well-differentiated; spathe beaked for more than half its length; West Kalimantan (Bidang Menabei) .... ***A. rostratum***
8b. Stamens and staminodes not verruculate; appendix reduced to a few terminal sterile stamens; spathe not long-beaked; Sarawak and West & Central Kalimantan .... ***A. burttii***

Aridarum crassum **S.Y.Wong & P.C.Boyce** *sp. nov.*
Aridarum crassum differt ab speciebus ceteris laminis foliorum valde rigide coriaceis, adaxiali atro-viride, nitentibus, abaxiali punctis elevatis instructa (in stato vivo). Aridarum crassum A. nicolsonii similis videtur sed laminis foliorum abaxiali punctis elevatis instructa (in stato vivo) sed folia siccitatae abaxiali perpunctulatus, nervis lateralibus primariis parum prominentibus, 5–8 in quoque latere in stato vivo, valde obcuriis in stato sicco, inflorescentia odorus per anthesin feminae, quam stigmatibus quam ovaria ca $^{2}/_{3}$ *diametro, cum alcoholis rubiginosus, cornu thecis antherae brevissimus, obtusus differt.*

Typus: Malaysia, Sarawak, Sri Aman Division, Pantu, Gn. Gaharu, 01° 02' 39.5"; 110° 53' 18.3", 100 m asl, 23 Sept. 2004, *P.C.Boyce & Jeland ak Kisai AR-692* (holo, SAR). Plates 1 & 2

Small, moderate to robust rheophytic **herbs** to *ca*. 20 cm tall. ***Stem*** epigeal, pleionanthic, erect to semi-decumbent, condensed, to 1.6 cm long x 1.3 cm diam., roots green, photosynthetic, robust to *ca* 2 mm diam. **Leaves** few together, spirally arranged, to *ca* 4 per module; *petioles* stout, glabrous, 4–8 cm long x 3.5–5 mm diam., dark green, similar colour to adaxial side of leaf lamina, D-shaped adaxially in cross section; sheathing only at the extreme base, the sheaths fused and extending into a very narrowly triangular marcescent ligular portion to *ca* 2.8 cm long, $^{1}/_{3}$ to ½ of petiole length; lamina broadly oblanceolate to broadly oblong-lanceolate to elliptic or narrowly obovate, very stiffly coriaceous, glabrous, 11–14 cm long x 3–5 cm wide, base cuneate to decurrent, oblique, apex acuminate, sometimes acute, acuminate for *ca* 1.3 cm, tubular apiculate to *ca* 1.5 mm; margins entire, markedly thickened when fresh, revolute (in dry material), adaxially shining dark green, abaxially matte paler green, minutely rugulose, marked conspicuously with dense, raised punctate when fresh but weakly and minutely punctate in dry material; midrib adaxially flush with lamina, abaxially prominent, raised canaliculate in cross section; primary lateral venation weakly raised adaxially when fresh, 5-8 primary lateral veins at each side but obscure in dry material, very obscure abaxially when fresh and in dry material, secondary venation obscure, primary and secondary venation diverging at 30°-45° from mid-vein, running into obscure marginal vein; tertiary venation invisible.

Inflorescence solitary, sub-erect, sweet smelling (esterases) at female anthesis, peduncle to ca 8 cm long, always exceeding petioles, subtended by a pair of fused ligules, to *ca* 4.5 cm long these spliting into two at the end, to *ca* 2.3 cm long, sometimes two rudimentary leaves present, these to *ca* 2 mm followed by a prophyll and a cataphyll; **spathe** more or less broadly ovate, not constricted, softly coriaceous, interior glossy, exterior semi-glossy, to 6-8 cm long; lower spathe cup-shaped, obconic, 2.2 cm long x 1.9 cm diam. (across), spathe abcission layer coinciding with base of male zone, green when fresh, persistent into fruiting, margins convolute; limb broadly ovate, convolute, white, to *ca* 3.8 cm long, tip mucronate to *ca* 3 mm, caducous after male anthesis; **spadix** sessile, adnate isodiametrically to the spathe in the lower ¼ of female zone on the dorsal side, cylindric, to *ca* 4.5–5.5 cm long, subequalling spathe; female zone cylindric, often constricted at the adnation, green when fresh, *ca* 1 cm long x 8.6 mm-1 cm diam., $^1/_5$ of spadix length; pistils many, somewhat crowded, ovoid to elongate-ovoid, *ca* 1.2 mm long x 0.85 mm diam., turning white in alcohol, stigma sessile, raised, notably papillate, *ca* 0.60–1.1 mm diam., $^2/_3$ of ovary diam., staining brownish red in alcohol; interpistillar staminodes, staminodes confined to a single row at the base of spadix, laxly arranged, more-or-less square to round, impressed in the middle, shorter than pistils, about same size as ovary, shortly stipitate; sterile interstice cylindric, always wider in diameter than female zone, 4–6 mm long x 8 mm–1.1 cm diam., $^1/_{10}$ of spadix length, without constriction, clothed with staminodes, more-or-less circular, sometimes rectangular, truncate, *ca* to 1 mm across, excavation circular deep, sometimes wide impressed; male zone tapering-cylindric, basally slightly thickened above interstice, 2.2 cm long x 8 mm long, ½ of spadix length; stamens arranged in longitudinally aligned pairs, crowded, rectangular, ca 1 mm across; connective deeply excavated, with the cavity not septate; **thecae** opposite on the distal and proximal (with respect to the spadix axis) sides of the anther; horns very short, round to slightly point at end, erect to suberect; appendix tapering-cylindric to a blunt tip, *ca* 8.5 mm long, $^1/_5$ of spadix length, staminodes more or less circular, sometimes irregularly polygonal, 0.6 mm to 1 mm wide, excavations circular deep, sometimes wide impressed. **Infructescence** solitary; peduncle to *ca* 8 cm long, not exserted, erect; fruiting spathe obconic, *ca* 2 cm.

Distribution: Endemic to Sarawak: Sri Aman Division (Gn. Gaharu).
Habitat: Rheophytic on large sandstone boulders at low altitudes, mainly on wet sandstone cliff surfaces at higher altitudes, 100 to 850 m asl.

Notes: *Aridarum crassum* is clearly distinctive from the rest of the genus by the leaf laminae very stiffly coriaceous, glossy deep green adaxially and conspicuously raised punctate abaxially when fresh. *Aridarum crassum* is

Plate 1: ***Aridarum crassum*** S.Y.Wong & P.C.Boyce (Figs. A, B & D) and ***Aridarum nicolsonii*** Bogner (Fig. C): **A.** Note very stiffly coriaceous and glossy deep green leaf laminae and stout petioles of *Aridarum crassum*. **B.** Adaxially weakly raised primary lateral venation seen in *Aridarum crassum*. **C.** Note in *Aridarum nicolsonii* the matte medium green leaf laminae and primary lateral venation obscure adaxially, note slender petioles. **D.** Inflorescence of *A. crassum* in bud.

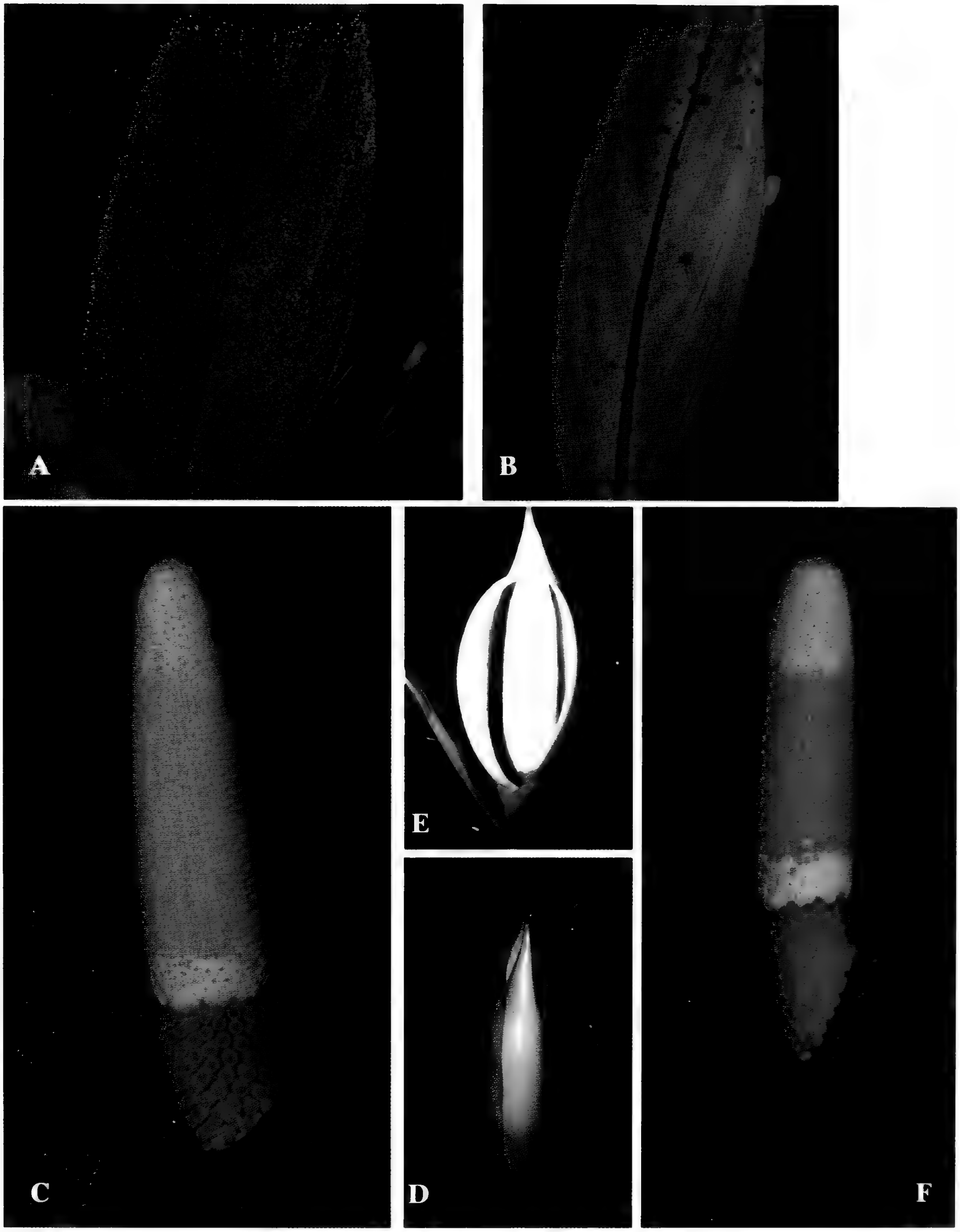

Plate 2: ***Aridarum crassum*** S.Y.Wong & P.C.Boyce (Figs. A, C & E) and ***Aridarum nicolsonii*** Bogner (Figs. B, D & F): **A.** Abaxial surface of leaf lamina of *Aridarum crassum* showing obscure primary lateral venation and conspicuous raised punctae. **B.** Abaxial surface of leaf lamina of *Aridarum nicolsonii* showing showing weakly raised primary lateral venation. **C.** Spadix of *A. crassum* (spathe artifically removed) to display stigma smaller than ovary and tapering male zone. **D.** spathe of *Aridarum nicolsonii* at gaping stage. **E.** Inflorescence of *A. crassum* at male anthesis. **F.** Spadix (spathe artifically removed) of *Aridarum nicolsonii* to display stigma smaller than ovary and cylindrical male zone.

most similar to *A. nicolsonii* Bogner but is readily separable by the above noted characters plus in having stigmas smaller than ovary diameter, by inflorescences fragrant of esterases at female anthesis, and a tapering-cylindric (*vs* cylindric) male zone. Additionally, *A. crassum* is more robust with stouter petioles than *A. nicolsonii*, which tends to be gracile with slender petioles.

Leaf laminae of *A. crassum* are abaxially conspicuously marked with raised punctae when fresh, but weakly and minutely punctate in dry material at which time the margins are conspicuously revolute as compared to *A. nicolsonii* with inconspicuous raised punctae abaxially when fresh but conspicuous raised punctate and a planate leaf margins in dry material. Leaf laminae of *A. crassum* are broadly oblanceolate to broadly oblong-lanceolate to elliptic or narrowly obovate with the apex shortly acuminate (to *ca* 1.3 cm), as compared to elliptic to broadly oblanceolate with the leaf acuminate to *ca* 2 cm in *A. nicolsonii*. Primary lateral venation of *A. crassum* consists of 5-8 primary lateral veins per side are weakly raised adaxially when fresh but obscure in dry material, abaxially these veins are obscure both in fresh and dry material. In *A. nicolsonii* primary lateral venation (to *ca* 3 primary lateral veins per each side) is obscure adaxially when fresh and in dry material, but weakly raised abaxially both in fresh and dry material.

Aridarum crassum emits a sweet smell (esterases) at female anthesis whereas *A. nicolsonii* does not emit any smell at any time during anthesis. Ovaries in *A. crassum* are ovoid to elongate-ovoid (compared to ovoid in *A. nicolsonii*) with a strongly papillate, umbonate, smaller stigma (to $^2/_3$ of ovary diam.) staining brownish red in alcohol (*vs* a less papillate, scutiform stigma as wide as ovary and staining light brown in alcohol in *A. nicolsonii*). The thecae horns are very short and rounded at the tips in *A. crassum*, compared to longer thecae horns that are pointed at the end in *A. nicolsonii*.

Aridarum crassum is endemic to Gunung Gaharu, Sri Aman Division, Sarawak whereas, *A. nicolsonii* is widespread in Bako National Park, Kuching Division, Sarawak and in West Kalimantan.

Etymology: The species epithet is derived from the Latin, *crassus*, 'thick' reflecting the markedly stiffly coriaceous leaf laminae that immediately distinguishes this species.

Other specimens examined: SARAWAK. Sri Aman Division: Pantu, Gn. Gaharu, 01° 02' 39.5"; 110° 53' 18.3", 22 March 2004, *P.C.Boyce & Jeland ak Kisai AR-251* (SAR); *Ibid*, 01° 01' 19.5"; 110° 52' 52.8", 22 March 2004, *P.C.Boyce & Jeland ak Kisai AR-263* (SAR + spirit).

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Reference

Bogner, J. and Hay, A. 2000. Schismatoglottideae in Malesia II – *Aridarum, Bucephalandra, Phymatarum* and *Piptospatha*. *Telopea* **9(1)**: 183–194.

Additional notes on *Aridarum crassum*

Aridarum crassum also occurs on Gn. Lingga (Sri Aman Division) which is 150 km further eastwards from Gn. Gaharu. *Aridarum nicolsonii* also occurs on Gn. Lesung, Lingga (based on a collection of Carlo Hansen No. 1044); the occurrence of two *Aridarum* species together is unusual. Especially interesting is the occurrence of a species at high elevation (*A. crassum*) and another allopatrically at low elevation (*A. nicolsonii*); this is also the instance at Gn. Bako (Kuching Division) where the enigmatic *Aridarum montanum* Ridl. occurs towards the summit, while the lower slopes harbours *A. nicolsonii*.

Additional specimens examined: SARAWAK. Sri Aman Division: Pantu, Gn. Gaharu, 8 Oct. 1974, *Illias & Azahari S. 35676* (SAR); Gn. Gaharu, 7 Dec. 2004, *Bogner 2835* (M); Gn. Lingga, June 1906, *Hewitt series 826* (SAR); *ibid*, June 1906, *Hewitt series 446* (SAR); *ibid,* June 1906, *Hewitt series 1095* (SAR).

Book Review: A.D. Poulsen. 2006. ***Etlingera* of Borneo**. Natural History Publications (Borneo) Sdn. Bhd. in association with Royal Botanic Garden Edinburgh. x + 263 pp. **ISBN:** 983-812-117-7. **Price:** US $55.00

The ginger family (Zingiberaceae) has more than 1500 species worldwide. The genus *Etlingera* comprises more than 100 species, all confined to Indo-Pacific region. The best-known member of this genus is the widely appreciated ornamental torch ginger, *Etlingera elatior*.

The striking plant diversity of Borneo is well known, and, likewise, is the importance of gingers as spice, vegetable, dye, medicine and other uses. There are few vegetation types in humid or monsoonal tropics where gingers are not commonly found. Borneo is home to at least 300 ginger species of which the genus *Etlingera* is perhaps the most prominent, most diverse, and also most attractive.

Gingers are, however, one of the more difficult plant families to collect and study. Meaningful work can only be done on live and fresh flowering plant materials and requires fieldwork with round-a-year observation to catch the appearance of flowers and fruits, both bearing important diagnostic characters. Fresh flowers of gingers are difficult to preserve, and unfortunately, many studies on gingers, especially early ones, are based on herbarium specimens only. Thus, the common outcome of people trying to key out the ginger species using a published key is - giving up in frustration. Fortunately, this is not likely to happen when using the present book.

The new book on the *Etlingera* of Borneo is the result of the author's 15 years of extensive fieldworks and his thorough study of herbarium specimens in more than 20 herbaria. What more, it is a delightful blend of strictly scientific information with beautiful color photographs, illustrations, and color distribution maps, facilitating the dissemination of information to botanists, foresters, eco-tourists, and even, laymen.

The book starts off with a short introduction and is followed by a chapter introducing the typical *Etlingera* plant. Details of the morphological structures shown in this chapter are especially clarified by images made under the scanning electron microscope. The third chapter, *Etlingera* in Borneo, includes a general topical history, distribution, ecology, species richness, reproductive biology, and ends with ethnobotany and notes on conservation. The last chapter deals with the materials and methods and, in particular, highlights the necessity of good photographic documentation and field sketches as two indispensable supplements to herbarium and spirit materials. The last few pages, just before the revision itself, are occupied by a key to the Bornean species of *Etlingera*.

The main part of the book features 42 taxa all together. Sixteen species, one subspecies, one variety, and one combination are described. Each species is accompanied by relevant information about the source of publication, synonymy, nomenclatural details, and the type(s). This is followed by a thorough species description, local names and uses, etymology, ecology and habitat, distribution (supported by colour map clearly showing the locality of type specimen), conservation status, list of materials examined, and ends by elaborate notes helping to pinpoint the differences of the species under discussion from its closest taxa, or discussing the tricky issues of nomenclatural history and taxonomic confusions.

Just before the book concludes, there is a big bonus for all botanists printed between the sections of references and indices to scientific and vernacular names. It is a list of identification of all *Etlingera* specimens examined by the author during the course of his preparation work, alphabetically sorted according to a collector's surname, followed by the collection number of species. In case you get stuck in research, for example, with a sheet of specimen collected by *Gobilik J. et al. 738* kept at SAN Herbarium, you will know within seconds of checking this book that the species of the specimen on this sheet is *E. inundata.*

I tried to find negative points in this new book, however, it turned out to be a tough job. As a true ginger fan, I would welcome the more than 25 pages of introduction part of the book. Nonetheless, information about ethnobotany of various *Etlingera* species is rather little, despite the fact that more than 20 species are used for various purposes. The Table 1 (p. 18) reported uses and number of species used for a particular purpose, e.g., shoot is eaten in 20 species, but the reader is not informed which species are these without going through all the taxa listed. An appendix with an overview of all species and their uses would have been useful.

To facilitate the use of the identification key, more illustrations explaining the various morphological terms would have been welcome because the perception of various structures seen in gingers traditionally deviates from the definition of botanical terms used in other monocot groups. To note, the flower structure is explained well, however, the terms regarding leaf terminology would be particularly useful, if illustrated.

In my opinion, it remains as a matter of fact, that it is faster and much more enjoyable to identify a species while leisurely flipping through the pages full of stunning and beautiful photographs, including close-up details of each species, rather than using the dichotomous key to the species. I have a feeling that most ginger specialists will use the species key published in the new book only for the first few times to satisfy their curiosity rather than using the key as a regular tool for species identification.

Last but not least, it is always necessary to remind ourselves that in our quickly disappearing plant world today, it is difficult to protect something that we do not know properly, nor recognize, and neither can we identify. This published revision study of the genus *Etlingera* is therefore a much welcome step forward, enabling us to protect the endemic and endangered species of a group of prominent gingers in Borneo.

Etlingera of Borneo is definitely a benchmark publication. It shall serve in many years to come as a great example and guide, showing how a modern revision of a complicated genus should be done.

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Book review: Justin W. Tkatchenko, BEM and Steven Kami. 2006. **Spatulata Orchids - Papua New Guinea.** Orchid Society of Papua New Guinea. 96 pp. **ISBN** 9980-86-070-7.

This publication deals with *Dendrobium* sect. *Spatulata*, a fascinating group of attractive orchids. The horticulturally very important group is characterised by mostly cane-like stems, erect and frequently twisted petals (giving this group the common name 'antelope dendrobiums') and a usually three-lobed, concave lip with a 3-5-ridged callus. The area of distribution of this group is in tropical Asia from Java and the Philippines eastwards as far as the Pacific Islands Fiji, Tonga and Samoa, and southwards as far as Queensland (Australia). However, by far the greatest diversity is found in New Guinea where over half of the altogether ca 50 species of this *Dendrobium* section are found.

The brief preface of this semi-scientific book gives relevant background information on *Dendrobium* sect. *Spatulata*, together with notes on its distribution. In the following main part twenty-eight species plus several varieties, colour forms and suspected new species are described in detail, each of them with a short botanical description and comments on its cultivation requirements. An informative outline map indicates its distribution within Papua New Guinea and the adjacent islands, and in the accompanying text the habitat ecology is briefly described. One or several excellent colour pictures are provided for all taxa, in a high quality of photography and reproduction which is not always found in publications. A chapter on the natural habitat in the end of the book explains the growing conditions of the plants, and also chapters of cultivation, watering and fertilising are given here. Also these chapters are illustrated by magnificent photographs. A short list of references as well as an index conclude the book.

There are very few negative points. I personally feel that a detailed map of the area would have helped, as not all of the readers are familiar with the geography of Papua New Guinea and its offshore islands (particularly those not living in this region).

The very minor errors, like author names italicised (p. 13), species and variety names not italicised (p. 13, 89) or missing authors (p. 13), hardly affect the value of this publication. Neither do the few distribution maps which do not exactly reflect what the text actually says (p. 12, 15, 20, 42). I personally would have liked more detailed notes on the distribution outside Papua New Guinea (however, occasional comments on the occurrence in Irian Jaya and Australia are indeed given in the book); but I know that this is not always done in publication of this nature. Perhaps it would also look better if the introductory chapters on habitat and cultivation would be in the front section of the book just behind the preface, but, of course, this too is mainly a matter of personal preference.

Those who would like to cite this publication will not find it easy to find out who actually wrote it as only the preface and the biographies on p. 95 says who the authors are; their names should have been indicated on the title page.

This book is a very useful and informative contribution on an attractive plant group in a floristically incompletely know though extremely diverse country, and can, as such, be recommended to everybody who is interested in tropical Asian orchids. The authors, Mr. Justin W. Tkatchenko, BEM and Mr. Steven Kami, president and vice-president (respectively) of the Orchid Society of Papua New Guinea, can be congratulated for their valuable publication.

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