SANDAKANIA

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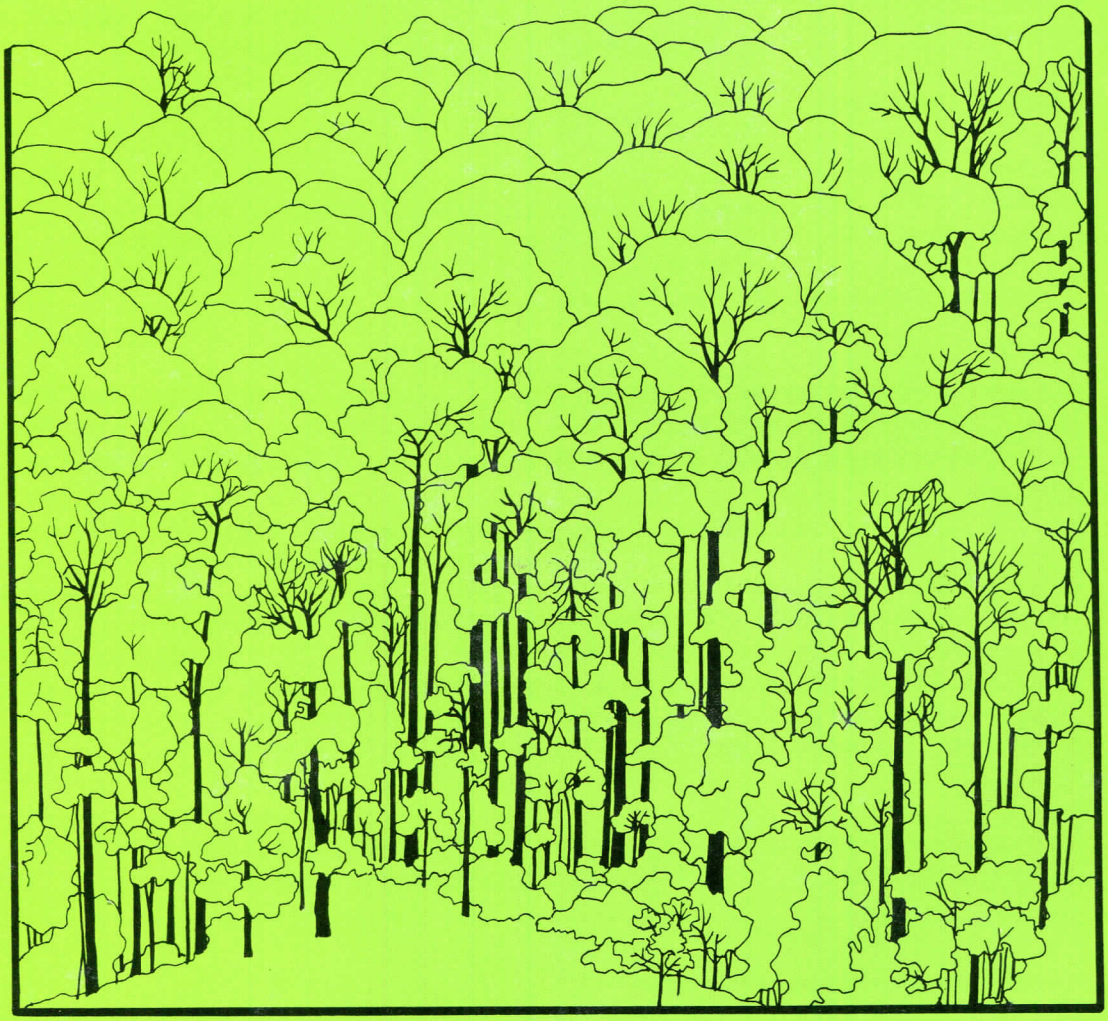

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Four new species of *Engelhardia* (*Juglandaceae*) from Borneo

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Summary. Four new species of *Engelhardia* are described from Borneo and a key to all species present in Borneo is provided.

The genus *Engelhardia* was established in 1825 and is typified by *E. spicata* Leschen. ex Bl. from Java. Until recently, eight species have been recognised in the genus, three in America, the other five from Indo-China through Malaysia to New Guinea. In 1960 Jacobs revised the five Asian species in Flora Malesiana and Cockburn (1976) and Ashton (1988) have since published accounts of the genus in Sabah and Sarawak, respectively. The five Asian species are *E. apoensis* Elmer ex Nagel, *E. rigida* Bl., *E. roxburghiana* Wallich, *E. serrata* Bl. and *E. spicata* Leschen. ex Bl. These five species all occur in Borneo and are highly localised and, thus, rare species mostly occurring at upper elevations on mountains.

With a new revision of the genus in Borneo for the Tree Flora of Sabah and Sarawak, four new species have been distinguished, three occurring in Sabah and one occurring in Sarawak. The distinguishing characteristics of the four new species, notes on their ecology and distribution, and a key to all species in Borneo are provided.

Distinction of the species

Two keys are presented, the first using only vegetative characters, and the other using fruit characters, as these provide good differences. Flowering material is not available for all the taxa. Table 1 lists differences in the fruit characters for the Bornean species, and Fig. 1 shows some important fruit characters.

Table 1. A comparison of some fruit and fruit-bract characters in the Bornean species of *Engelhardia.*

Species	Nut size (mm)	Nut shape	Hairs on nut	Size of abaxial lobe of bract (mm)	Size of lateral lobes of bract (mm)	Form of adaxial lobe of bract	Form & position of perianth
E. apoensis	6-14 x 5-6	ovoid	long, soft	55-75 x 12-15	20-35 x 8	entire to shallowly 4-lobed	inconspicuous tiny lobes, adnate to style
E. danumensis	3 x 3	globose	short	19-30 x 6-9	8-11 x 3-4	shallowly cleft in middle	ovate lobes, apex of nut
E. kinabaluensis	2-3 x 3-4	transversely ellipsoid	short	20-24 x 5-6	8-12 x 2-3	deeply cleft in middle	linear lobes, apex of nut
E. mendalomensis	3-4 x 4-5	transversely ellipsoid	short	21-50 x 8-10	11-18 x 4-6	subtruncate (margin sometimes wavy)	ovate lobes, apex of nut
E. mersingensis	3 x 4-6	transversely ellipsoid	short	20-31 x 7-10	9-16 X 4-6	(nil)	linear lobes, apex of nut
E. rigida	3.5 x 4	globose	long, soft	20-60 x 3-8	12-14 x 3-4	orbicular	ovate lobes, apex of nut
E. roxburghiana	4-5 x 4-5	globose	(nil)	28-55 x 5-8	21 x 5-6	(nil)	ovate lobes, apex of nut
E. serrata	3 x 3	globose	long, stiff	16-40 x 6-11	6-12 x 3-6	frilled to shallowly 2-3-lobed	ovate lobes, apex of nut
E. spicata	3-6 x 3-8	globose to transversely ellipsoid	long, soft	20-60 x 7-15	20-25 x 5-8	frilled to shallowly 4-5-lobed	inconspicuous tiny lobes, adnate to style

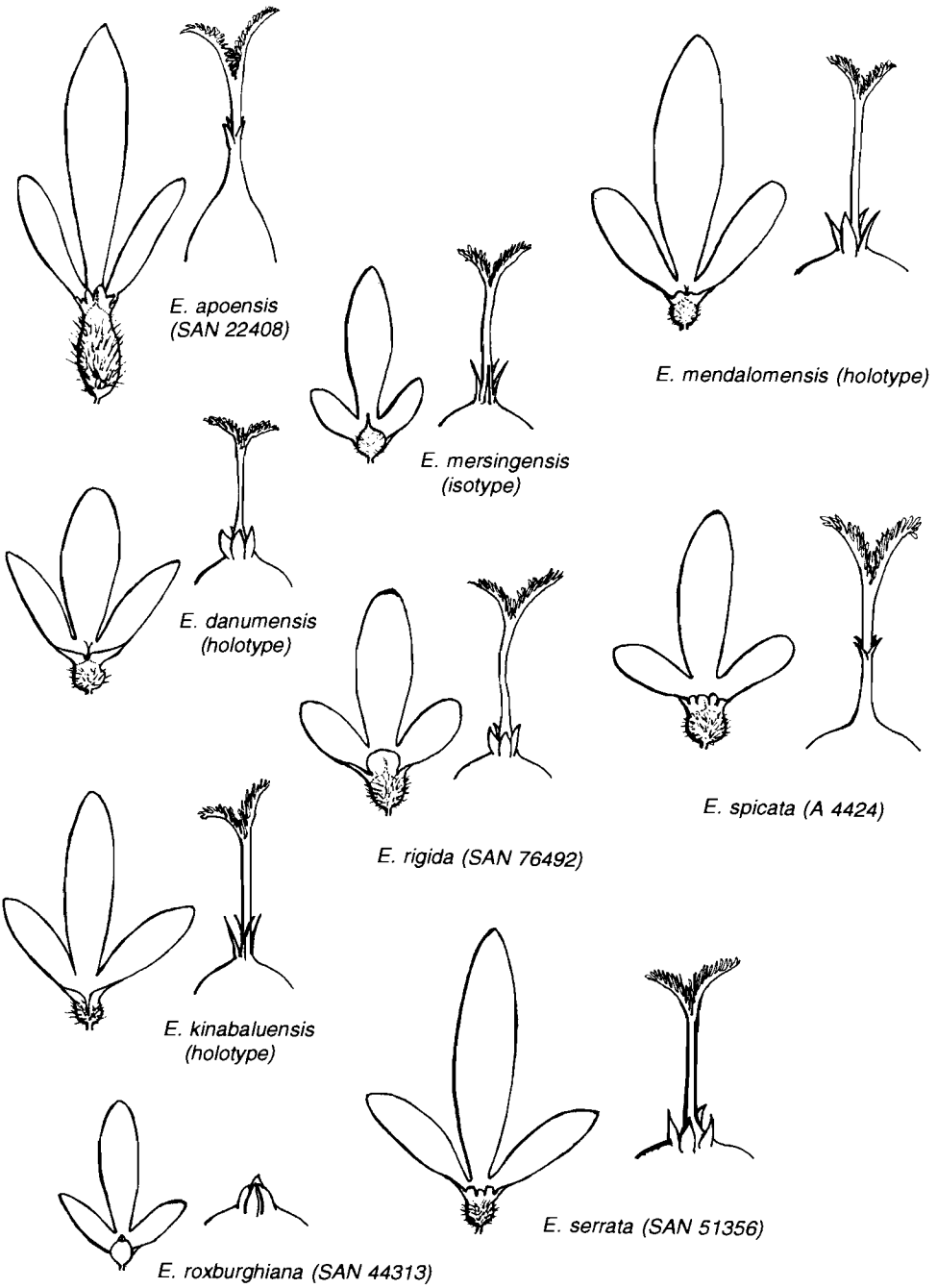

Fig.1. Fruit structures in the different species of *Engelhardia*. For each species, the drawing on the left shows the outline of the fruit and the form of the adaxial (frontal) lobe of the bract (if present), the drawing on the right shows the apex of the nut with the style (if visible) and the perianth lobes.

KEY TO *ENGELHARDIA* SPECIES
(based on vegetative characters)

1a. Leaflet margins distinctly toothed, at least in the upper half.

2a. Distal leaflets often twice as large as the lower ones; leaflet bases acute or wedge-shaped; tertiary veins and areoles mostly invisible on upper surface in dried specimens; stalk nil to 1 mm, rarely more ..... *E. serrata*

2b. Distal leaflets sometimes larger than lower ones but not up to twice as large; leaflet bases rounded to subcordate; tertiary veins and areoles distinct on upper surface in dried specimens; stalk longer, to 4 mm ..... *E. apoensis*

1b. Leaflet margins entire or wavy, not toothed.

3a. Leaflets coriaceous, elliptic-obovate (or if lanceolate-falcate then with nerves impressed on the upper side), and not hairy on the lower side.

4a. Leaflet tertiary venation coarse, the areolation strongly prominent under 10X magnification ..... *E. kinabaluensis*, sp. nov.

4b. Leaflet tertiary venation finer, the areolation only faintly visible under 10X magnification.

5a. Shoot apices and leaf rachises brown scurfy hairy ..... *E. rigida*

5b. Shoot apices and leaf rachises not scurfy hairy .... *E. mersingensis*, sp. nov.

3b. Leaflets chartaceous, or lanceolate-falcate, or with hairy veins on the lower side (the nerves not impressed on the upper side).

6a. Leaflets not decreasing markedly in size from apex to base of leaf rachis; veins on lower side hairy ..... *E. spicata*

6b. Leaflets decreasing in size by one third to half from apex of leaf rachis; veins on lower side minutely scaly to subglabrous or apparently glabrous.

7a. Leaflets elliptic, papery, base slightly unequal, margin not thickened; stalk almost nil or only to 1 mm long ..... *E. danumensis*, sp. nov.

7b. Leaflets ovate to lanceolate or falcate, leathery, base very unequal, margin thickened; stalk 1-10 mm long.

8a. Leaflets to 11 cm long, usually 4-5 pairs per leaf; stalk 1-4 mm long ..... *E. mendalomensis*, sp. nov.

8b. Leaflets usually larger, to 16 cm long, usually 2-3 pairs per leaf; stalk longer, to 10 mm ..... *E. roxburghiana*

KEY TO *ENGELHARDIA* SPECIES
(based on fruit characters)

1a. Nut 6-14 mm long with a conspicuously narrowed apex ..... *E. apoensis*

1b. Nut shorter, to 6 mm long, apex rounded.

2a. Adaxial lobe of bract not developed, the nut fully exposed.

3a. Nut stalk 4-8 mm long. Nut covered with scales only. Perianth lobes broadly ovate ..... *E. roxburghiana*

3b. Nut stalk shorter, to 3 mm long. Nut hairy. Perianth lobes linear ..... *E. mersingensis*, sp. nov.

2b. Adaxial lobe of bract truncate to lobe-like, hiding most of the nut.

4a. Perianth of inconspicuous tiny lobes adnate to the style ..... *E. spicata*

4b. Perianth of ovate to linear lobes at the apex of the nut.

5a. Nut set with stiff, loose, irritant long hairs ..... *E. serrata*

5b. Nut indumentum not so.

6a. Adaxial lobe of bract cleft in the middle.

7a. Adaxial lobe of bract only shallowly cleft. Perianth lobes broadly ovate ..... *E. danumensis*, sp. nov.

7b. Adaxial lobe of bract deeply cleft to the base. Perianth lobes linear ..... *E. kinabaluensis*, sp. nov.

6b. Adaxial lobe of bract not cleft in the middle, either orbicular or subtruncate (margin sometimes wavy).

8a. Adaxial lobe of bract orbicular ..... *E. rigida*

8b. Adaxial lobe of bract subtruncate, the margin sometimes wavy ..... *E. mendalomensis*, sp. nov.

The new species

Engelhardia danumensis *Campbell*, **sp. nov.** *species E. rigidae Bl. affinis sed foliolis in sicco nigrescentibus, quae crassitiem tenuiter papyraceam, inferioris dimidialis parte magnitudinis diminutae, habent et squamis sed nunquam pilis induta sunt, nuce et squamis pilisque vestita differt. Typus: Cockburn SAN 85066, Sabah, Lahad Datu, Ulu Segama Forest Reserve, Ulu Sungai Danum (holotypus SAN; isotypi A, BO, FHO, K, KEP, L, SAR, SING).*

Tree, to 33 m tall and 58 cm diameter. Buttresses thin, plank-like, 1 m tall and 2 m long. Bark surface dark chocolate-brown, fissured and flaking by small rectangular flakes; living bark orange-brown, 1.2 cm thick, fibrous, cut wood and bark smelling like coconut water. Wood white, hard. Twigs and leaves set with golden scales but with no hairs present. Leaf rachis 4-10 cm long, 2.8-4.2 cm to first leaflet, blackish, not thickened at base, scales occasional; leaflets 2-3 pairs, alternate to subopposite; leaflets elliptic, 2.4-7 x 1.5-3.5 cm, decreasing to half the size towards base, lamina below drying dark brown to blackish, texture thin, papery, above glabrous, below with occasional to scattered scales all over; base acute to wedge-shaped, subequal; apex acute to shortly acuminate, acumen to 5 mm long; margin entire, undulate, marginal nerve not thickened; midrib on both sides drying darker than lamina; tuft domatia occasionally found in the nerve axils with the midrib; nerves 8-12 pairs, nerves on both sides raised, conspicuous, drying the same colour as the lamina on the upper side, slightly darker than the lamina on the lower side; veins net-like, obscure on both sides, drying the same colour as lamina, areoles obscure; sessile to stalked 1 mm long, furrowed above, glabrous or with scattered scales. Inflorescences axillary, flowers not known; fruiting catkins 14-18 cm long including peduncle, rachis with scales and hairs. Fruits sessile to 1-mm-stalked, nut globose, 3 x 3 mm, rachis slender, angular, drying blackish, set with golden scales and short golden hairs; bract abaxial wing 19-30 x 6-9 mm, lateral wings 8-11 x 3-4 mm, set with scales and a few hairs, adaxial lobe shallowly cleft in the middle; perianth lobes ovate.

Known only from the type collection.

Ecology: The tree was found on a steep hill with rocky outcrops at 500 m altitude. Vegetatively it approaches *E. rigida* but the leaflets dry almost blackish, have a thin and papery texture, the lower leaflets decrease in size by half, and the lamina is set with scales but never hairs. Also, the nut in this species differs in being set with both scales and short hairs.

Engelhardia kinabaluensis *Campbell*, **sp. nov.** *species E. rigidae Bl. accedens sed foliolis crassis coriaceisque, lamina squamis sed nunquam pilis induta, nuce etiam squamis sed brevis pilis vestita differt. Typus: Aban Gibot SAN 66824, Sabah, Ranau, Mamut copper mining area (holotypus SAN).*

Tree, to 24 m tall and 35 cm diameter. Bark surface grey to blackish, rather scaly to fissured; living bark yellow to pale white, exudate yellow. Wood cream. Twigs, leaves and inflorescence set with gold scales but without hairs. Leaf rachis 3.7-8 cm long, 1.5-3.5 cm to first leaflet, thickened at base, 1-4 mm thick, black, with sparse scales; leaflets 2-3 pairs, subopposite to opposite, elliptic to obovate in outline, 1.5-6.2 x 0.7-2.8 cm, drying grey-brown to orange-brown, thickly leathery, midrib and nerve beginnings impressed, upper side glabrous, lower side glabrous to sparsely scaly, base very unequal, apex acute to shortly acuminate (acumen to 2 mm long), margin entire and wavy with a thickened marginal nerve, tuft domatia absent to rare in the nerve axils with midrib, nerves 5-7 pairs and flat to occasionally impressed on the upper side, often obscure, areoles visible and strongly prominent under 10x magnification; stalk 2-3 mm, furrowed, glabrous or with occasional scales. Inflorescences axillary, flowers not known; fruiting catkins 7-10 cm long, rachis slender, angular, drying blackish, set with scales and hairs. Fruit with a stalk 1-2 mm long; nut transversely ellipsoid, 2-3 x 3-4 mm, set with gold scales and short, golden hairs, surrounded by the bract; bract abaxial wing 20-24 x 5-6 mm, lateral wings 8-12 x 2-3 mm, occasionally scaly, hairs absent, adaxial lobe deeply cleft in the middle; perianth lobes linear.

SPECIMENS EXAMINED - BORNEO. SABAH: Gunung Kinabalu, Mesilau Area, Kundasang, Madani & Ong SAN 111603 (SAN); Ranau, Mamut Copper Mine, Aban SAN 66824 (holotype SAN), Cockburn SAN 74274 (SAN).

Ecology: Found in lowland and montane forest from 200 to 1500 m altitude. Vegetatively it approaches *E. rigida* but the leaflets with their thickly leathery texture, the cover of scales on the leaflets and nut, and the lack of hairs on the leaflets and nut distinguish it from that species.

Engelhardia mendalomensis *Campbell*, **sp. nov.** *species ad E. roxburghianam Wall. characteribus vegetativis accedens, sed a qua foliolis usque ad quadri-quinquejugis, in sicco atrobrunneis vel nigrescentibus, nervarum paribus paucioribus, minus dense squamis indutis, nuce sessili vel breviter (usque 1 mm) pedicellata et squamis et pilis induta differt. Typus: Fidilis Krispinus SAN 116714, Sabah, Tenom, Mendalom Forest Reserve (holotypus SAN).*

Tree, to 32 m tall and 80 cm diameter. Buttresses up to 3 m high, 4 m long and 10 cm thick. Bark surface pale brown-grey; living bark pale yellow to orange-brown. Wood cream-white to yellowish. Twigs and leaves set with golden scales, without hairs. Leaf rachis 6-14 cm long, 2.2-6 cm to first leaflet, blackish, thickened at base, 1-4 mm, scales scattered with rarely a few hairs present; leaflets (3-)4-5 pairs, sub-opposite to opposite; leaflets ovate to lanceolate, 4-11 x 2-4 cm, often decreasing markedly towards base to

about two-thirds to half the size, lamina on lower side drying dark brown to blackish, texture thinly leathery, with occasional scales but no hairs all over on both sides; base acute or very occasionally round, very unequal; apex acute to long acuminate, acumen to 10 mm long; margin entire, slightly wavy, with thickened marginal nerve; midrib on both sides drying blackish; occasional to no tuft domatia present in nerve axils with midrib; main nerves 7-11 pairs, nerves on upper side raised but rather obscure, drying the same colour as the lamina, glabrous, nerves on lower side raised, conspicuous, drying darker than lamina; veins net-like, obscure on the upper side, glabrous, drying the same colour as lamina, areoles on both sides obscure; stalk 1-4 mm long, furrowed above, scales scattered. Inflorescences axillary, flowers not known; fruiting catkins 13-30 cm long including peduncle, rachis quite stout, angular, drying blackish, set with scales and hairs. Fruits sessile to 1-mm-stalked, nut transversely ellipsoid to globose, 3-4 x 4-5 mm, set with golden scales and scattered short golden hairs; bract abaxial wing 21-50 x 8-10 mm, lateral wings 11-18 x 4-6 mm, set with scales and hairs, adaxial lobe subtruncate (the margin sometimes wavy); perianth lobes ovate.

SPECIMENS EXAMINED - BORNEO. SABAH: Tenom, Mendalom Forest Reserve, Fidilis Krispinus SAN 116714 (holotype SAN). **NEW GUINEA**: Henty & Forman NGF 42626 (L); Jackson & Womersley 4163 (L); Moll BW9603 (L), 9623 (L); Carr 12885 (L); Darbyshire & Hoogland 8310 (L); Schodde 3060 (L); Hasker BW1043 (L).

Ecology: Primary forest from sea-level to 550 m altitude. Vegetatively it approaches *E. roxburghiana* but differs in having four to five pairs of leaflets drying dark brown to blackish, with fewer pairs of nerves, and being less densely set with scales. Also, a sessile to 1-mm-pedicellate nut set with both hairs and scales distinguish it from that species.

Engelhardia mersingensis *Campbell,* **sp. nov.** *species E. rigidae Bl. accedens sed foliolis majoribus, nervarum paribus paucioribus, squamis sed nunquam pilis vestitis, nuce sessili usque breviter (ad 2 mm) pedicellata, squamis sed brevis pilis vestita differt. Typus: Ashton S. 16724, Sarawak, Bukit Mersing, Ulu Anap (holotypus SAR; isotypi A, BO, K, KEP, L, MEL, SAN, SING).*

Tree, to 30 m tall and 68 cm diameter. Buttresses tall, sinuate and branching. Bark surface pale orange-brown, thin, powdery, flaked. Twigs, leaves and inflorescences set with golden and orange scales, but without hairs. Leaf rachis 4.5-14 cm long, 2.5-4.5 cm to first leaflet, thickened at base, 1-3 mm thick, stout, black, with sparse to scattered scales, not hairy; leaflets 3-4 pairs, alternate to opposite, elliptic to obovate, 4.5-11 x 2.5-4.8 cm, drying orange-brown to blackish, thinly leathery, upper side glabrous, lower side sparsely to scattered scaly; base subequal to very unequal, apex acute to acuminate (acumen to 9 mm long), margin entire and slightly wavy with a thickened marginal nerve, tuft domatia occasionally found in nerve axils with midrib, nerves 7-12 pairs and impressed or keeled on the upper side, areoles only slightly visible under 10x magnification; stalk 1-2 mm long, furrowed, with scattered scales. Inflorescences terminal, occasionally axillary, flowers not known; fruiting catkins 9.5-20 cm long, rachis quite stout, angular, drying dark

brown or blackish, set with scales and hairs. Fruit sessile to 2-mm-stalked; nut transversely ellipsoid, 3 x 4-6 mm, with scales and a few short hairs present; bract abaxial wing 20-31 x 7-10 mm, lateral wings 9-16 x 4-6 mm, glabrous to scaly, without hairs, adaxial lobe not developed; perianth lobes linear.

SPECIMENS EXAMINED - BORNEO. SARAWAK: 3rd Division, Bukit Mersing, Ulu Anap, Ashton S. 16724 (holotype SAR, isotypes A, BO, K, KEP, L, MEL, SAN, SING); Sibat S. 21946 (A, BO, K, KEP, L, MEL, P, SAN, SING); Sibat S. 21883 (A, BO, K, KEP, L, MEL, SAN, SING). **EAST KALIMANTAN**: Balikpapan District, Gunung Beratus, Kostermans 7406 (BO).

Ecology: Found at 600-1000 m in primary submontane forest on sandstone and basaltic soils. Vegetatively this species approaches *E. rigida* but the larger leaflets, fewer pairs of nerves, set with scales but not hairs and a sessile to 2-mm-pedicellate nut with scales and short hairs distinguish it from that species.

ACKNOWLEDGEMENTS

I thank the Malaysian herbaria of Sandakan, Kuching and Kepong, the Royal Botanic Gardens, Kew, and the Rijksherbarium, Leiden, for permission to borrow and consult their material.

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SANDAKANIA 3 (1993): 11-16

Two new species of *Scaevola* (*Goodeniaceae*) endemic to Borneo

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Summary. *Scaevola chanii*, endemic to ultramafic areas on Mount Kinabalu in Sabah, and *Scaevola muluensis*, found only on limestone in Sarawak's Mulu National Park, are described. A key to Bornean species of the genus is provided.

The Goodeniaceae are a largely Australian family with comparatively fewer representatives in Malesia. For *Scaevola*, Leenhouts (1957) listed only *S. micrantha* Presl and *S. sericea* Vahl in Borneo, and later (Leenhouts 1964) added a new species *S. verticillata* Leenhouts. *S. sericea* is usually a seashore shrub, sometimes occurring also on sandy substrates slightly inward from the shore, and has a wide distribution from Madagascar, Southeast Asia through Malesia, tropical Australia, Micronesia, Melanesia, to Hawaii. *S. micrantha* is found in Borneo and the Philippine and Talaud Islands, and in Borneo is known only from ultramafic substrates in Sabah in the north. The curious *S. verticillata*, with leaves in whorls in contrast to the spiral leaf arrangement found in the other two species, has been recorded only from the subalpine vegetation on ultramafic soil at 2500 m on Mt Tambuyukon in Sabah; so far it appears to be absent from the nearby Mt Kinabalu.

The two species described in the present paper are endemic to Borneo, with apparently very restricted occurrence. One, *S. chanii*, is known only from the ultramafic area around 2500-3000 m on Mt Kinabalu. The other, *S. muluensis*, has been documented only from the Mt Api limestone in the Mulu National Park in Sarawak's 4th Division. Thus it appears that the genus in Borneo includes a number of species which have adapted and are narrowly restricted to ultramafic and limestone substrates within the largely sedimentary (sandstone) geology of Borneo. It would not be surprising to find further species with such narrow preferences and distributions in Borneo, as the floras of the limestone, metamorphic and volcanic areas, and that of the high mountains, have not been thoroughly explored.

A key to the species of *Scaevola* in Borneo

1a. Leaves in whorls of four ..... *S. verticillata*

1b. Leaves spirally arranged.

2a. Leaves sessile to subsessile, the blades decurrent more or less all the way to the nodes or the stalks exceedingly short and inconspicuous.

3a. Plants of sandy, rocky or cliff sites beside the sea or along the coast. Leaves large, exceeding 10 cm long, with long-decurrent bases. Cymes (2-)3-5(-6)-times branched, often 6-10 cm long. Calyx lobes linear to lanceolate, 2-3 mm long (sometimes elongating to 5-7 mm long); corolla with a fused part 15-20 mm long and free lobes 5-10 mm long. Fruits broad-obovoid to globose, 8-12 mm long, strongly ridged ..... *S. sericea*

3b. Plants of high elevation on mountains (known only on Mt Kinabalu, Sabah). Leaves small, 1-7 cm long, more or less abruptly sessile. Cymes 1-2-times branched, not exceeding 3 cm long. Calyx lobes triangular, less than 1 mm long; corolla with a fused part 4-6 mm long and free lobes 4-6 mm long. Fruits narrow-obovoid, 3.5-5 mm long, slightly ridged .... *S. chanii*, sp. nov.

2b. Leaves distinctly stalked, decurrent basal part of the blades very narrow and inconspicuous.

4a. Plants of ultramafic substrates (in Borneo known only in Sabah). Leaves large, 8-15 cm long, distinctly crenate-dentate on the margins. Cymes 3-6-times branched, 5-9 cm long, the first pair of bracts conspicuously larger and leaf-like, peduncle 2-3.5 cm long. Flowers in the forks of cyme branches stalked .... *S. micrantha*

4b. Plants of limestone (in Sarawak's Mulu National Park). Leaves small, not exceeding 8 cm long, only minutely and inconspicuously crenate on the margins. Cymes 1-2-times branched, not exceeding 2.5 cm long, the first pair of bracts tiny triangular structures, peduncle to 1 cm long only. Flowers in the forks of cyme branches sessile ..... *S. muluensis*, sp. nov.

The new species

Scaevola chanii *Wong*, **sp. nov**. *S. sericeae affinis sed in regionibus montanis crescens, foliis parvis 1-7 cm longis, cymis solum 1-2 X ramificatis longitudine 3 cm non*

excedentibus, lobis calycis triangularibus minus quam 1 mm longis, parte corollae connata 4-6 mm longa differt. Typus: Chan, Jamal & Wong WKM 2360, Sabah, Ranau, Mt Kinabalu, summit trail through ultramafic soil, 2900 m alt. (holotypus SAN; isotypi K, KEP, L, SAR, SNP).

Shrub or treelet, to 2-3 m high. Bark pale grey brown, smooth to lightly fissured. Leaves spirally arranged, obovate, 1-7 cm long, 0.6-3 cm wide, margin purplish and minutely crenate-dentate, coriaceous; glabrous except for small tufts of silvery white hairs in the leaf axils, and tiny silvery round scales all over the young leaves; nerves 4-8 pairs, inconspicuous; stalks very short, only 1-2 mm long at most, inconspicuous. Inflorescences 1.5-2.5 cm long, branched only 1-2 times, peduncle 0.7-2 cm long; first pair of bracts triangular-linear, small; glabrous except for tufts of pale hairs in the bract axils. Flowers sessile; calyx cup obovoid, glabrous, the lobes triangular, less than 1 mm long, pale pilose on the margins; corolla olive green and sparsely pale hairy on the outside, the fused part 4-6 mm long, the free lobes 4-6 mm long, cream and pale pilose inside; stamens with filaments 3 mm long, anthers 0.7-1 mm long; style green, 6-8 mm long; indusium around the stigma orange-brown, with scattered pale hairs on the surface, densely pale hairy on the margin. Fruits obovoid, 3.5-5 mm long, slightly ridged, green ripening black.

The species is illustrated in Figs. 1 and 2.

Fig. 1. Flower of *Scaevola chanii*.

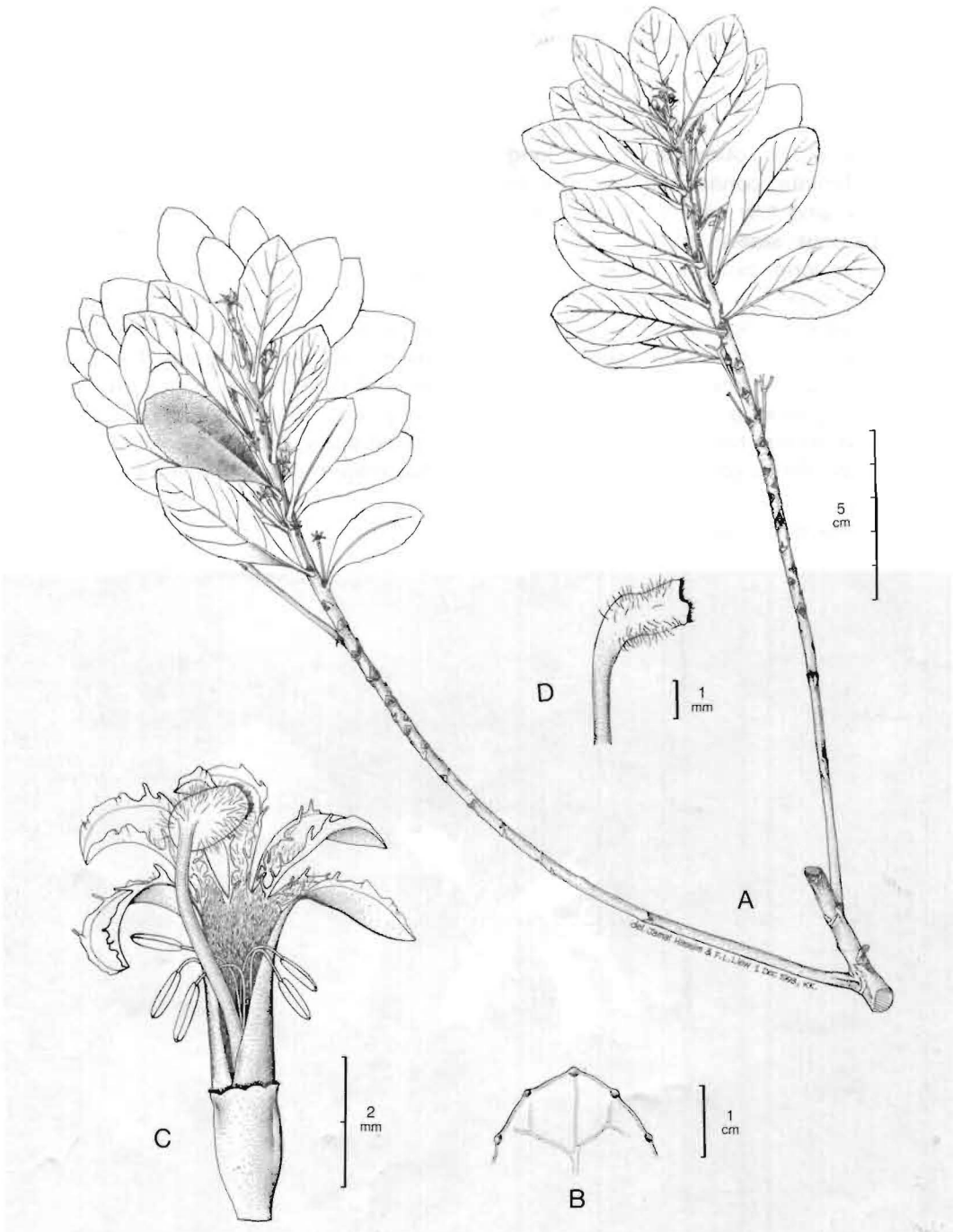

Fig. 2. *Scaevola chanii.* **A.** Flowering leafy branches. **B.** Detail of leaf tip and margin, showing glands. **C.** Flower. **D.** Indusiate stigma at the tip of the style. All from *Chan, Jamal & Wong* WKM 2360.

SPECIMENS EXAMINED - BORNEO. SABAH: Ranau, Mt Kinabalu, summit trail through ultramafic soil, 2900 m alt., *Chan, Jamal & Wong* WKM 2360 (holotype SAN, isotypes K, KEP, L, SAR, SNP), north of Carson's Camp, *Hotta* 389 (SAN), near Carson's Camp, *Lee, Aban & Dewol* SAN 69981 (SAN), 2860 m, *Sato, Jinius & Andau 977* (SAN), about 3000 m, *Watkins* SAN 57946 (SAN).

A species of very restricted occurrence, it can be seen along the usual climbers' trail up Mt Kinabalu, where it is quite noticeable around 2900 m. It appears to flower frequently throughout the year.

Scaevola muluensis *Wong* **sp. nov**. *S. micranthae affinis sed solum in terra calcarea inventa, foliis parvis longitudine 8 cm non excedentibus margine tantum minute crenatis, cymis modo 1-2 X ramificatis longitudine 2.5 cm non excedentibus, pedunculo inflorescentiae ut maximum 1 cm longo, floribus sessilibus in furcis ramulorum cymorum crescentibus differt. Typus: Argent & Jermy RGS Mulu Expedition 1977-78 No. 1011, Sarawak, 4th Division, Gunong Api (holotypus SAN; isotypi E, SAR).*

Shrub to about 1 m high. Leaves spirally arranged, obovate, 4-6.5 cm long, 2-3 cm wide, margin only minutely and inconspicuously crenate, thinly coriaceous; glabrous except for scattered short pale hairs on the stalk and tufts of short pale hairs in the leaf axils; nerves 5-6 pairs, slightly elevated on both surfaces when dry; stalks 5-13 mm long, distinct. Inflorescences 1-2 cm long, branched only 1-2 times, peduncle to 1 cm long only; first pair of bracts tiny triangular structures; glabrous except for scanty pale hairs in the bract axils. Flowers sessile; calyx cup obovoid, glabrous, the lobes triangular, about 0.5 mm long, glabrous to sparsely short-hairy on the margins; corolla sparsely pale hairy on the outside, the fused part 6-6.5 mm long, the free lobes 4.5-5 mm long, pale pilose inside; stamens with filaments 4 mm long, anthers about 1 mm long; style 6-6.5 mm long; indusium around the stigma with pale long hairs all over, densely pale hairy on the margin. Fruits obovoid, 4-5 mm long, slightly ridged, ripening black.

The species is illustrated in Fig. 3.

SPECIMENS EXAMINED - BORNEO. SARAWAK: 4th Division, Gunong Mulu National Park, Gunong Api, 1000 m alt., *Anderson* S.30907 (SAR), 1600 m alt., *Argent & Jermy* RGS Mulu Expedition 1977-78, no. 1011 (holotype SAN, isotypes E, SAR).

This species is probably restricted to limestone, but there are as yet no collections from other limestone areas in Sarawak or Sabah. The glabrous calyx lobes and more cup-shaped indusium at the tip of the style are additional characters distinguishing this species from *S. chanii*, which has leaves and flowers that are similar in size.

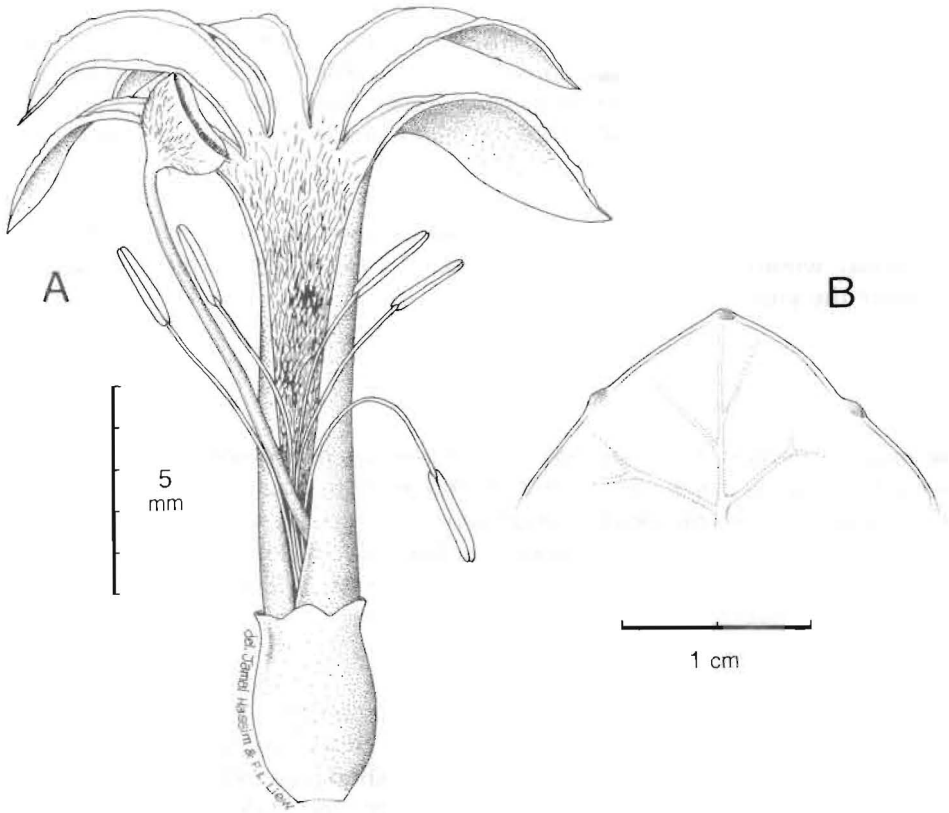

Fig. 3. *Scaevola muluensis.* **A.** Flower. **B.** Detail of leaf tip and margin, showing glands. All from Argent & Jermy RGS Mulu Expedition 1977-78 No. 1011.

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A revision of *Bambusa* (*Gramineae : Bambusoideae*) in the Malay Peninsula, with two new species

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Summary. A revision of *Bambusa* in the Malay Peninsula shows that there are nine species there, of which only the newly described *B. farinacea* is undisputedly native. The remaining eight are known only in cultivation, including another newly described species, *B. laxa*. *B. klossii* Ridl. is a synonym of *Dendrocalamus hirtellus* Ridl. *B. magica* Ridl., *B. montana* (Ridl.) Holtt. (synonym *B. pauciflora* Ridl.), *B. ridleyi* Gamble, and *B. wrayi* Stapf are also excluded from *Bambusa* because they represent four other distinct genera.

The revision by Holttum (1958) recognised four species of *Bambusa* in the Malay Peninsula. Among characters which he used to circumscribe this genus were the presence of a terminal vestigial flower and long rachilla internodes which disarticulated below the lemmae in the spikelet, and the presence of three lodicules and a keeled palea with an acuminate or truncate apex in each floret. The nature of the rachilla internodes was of particular importance in distinguishing *Bambusa* from the allied *Gigantochloa* and *Dendrocalamus*, where rachilla internodes are not elongated and do not disarticulate below the lemmae. (*Schizostachyum* has similar rachilla internodes and three lodicules, but is distinguished by a reduced number of flowers, a glabrous ovary and a rigid hollow style with a central strand of tissue in it.)

In his account, Holttum (1958) had reservations about the inclusion of an alliance of Malayan montane species, all characterised by a reduced number of florets in the spikelet, within *Bambusa*. These were: *B. pauciflora* Ridl., *B. montana* (Ridl.) Holtt., *B. klossii* Ridl., and *B. wrayi* Stapf. In the present study, *B. pauciflora* is identified as synonymous with *B. montana*, and *B. klossii* as interpreted by Holttum is found to have two elements: one (corresponding with the type) is *Dendrocalamus hirtellus* Ridl. and the other is *B. montana* (see end of listing under *Bambusa*). In effect, Holttum's reservations about whether certain species of *Bambusa* had been identified with the right genus applied only to *B. montana* and *B. wrayi*. These have now been shown to belong to two distinct genera, *Maclurochloa* and *Kinabaluchloa*, respectively (Wong 1993).

Two other species which (as typical of *Bambusa*) have 3-5 fertile florets separated by rather long rachilla internodes in the spikelet *viz.*, *B. ridleyi* Gamble and *B. magica* Ridl., also have characters that are incongruent with those of the typical and better known species of *Bambusa* (including *B. blumeana, B. vulgaris, B. multiplex* and the generic type *B. bambos*, a spiny bamboo often mistakenly called *B. arundinacea*). These include a wrinkled thickened culm-sheath base much like those in *Dinochloa* and a bifid palea in the flower (for *B. ridleyi*), and a lack of any dominant branches at each node, together with branches that typically do not rebranch (in the case of *B. magica*). These two species also belong to distinct genera, named *Soejatmia* and *Holttumochloa*, respectively (Wong 1993).

Systematic Enumeration

BAMBUSA Schreber, Gen. Plant. ed. 8, 1 (1789) 236. Nom. cons.

Type species: *Bambusa bambos* (L.) Voss

Rhizomes sympodial. Culm sheaths with blades typically erect (at least initially), auricles typically lobe-like and bristly on the margin. Buds at each culm node solitary; the primary-branch bud prophyll with fused margins and hairy keels. Mid-culm branch complement with a dominant primary branch and 1-several secondary branches and usually several smaller branchlets from its base. Leaf blades typically with an obtuse base. Leafy branches becoming much-branched as they develop inflorescences; inflorescences iterauctant. Pseudospikelets typically longer than 1 cm, often several cm long, consisting of 0-several small empty bracts, 1-several bracts subtending prophyllate buds, 0-several transitional (empty) glumes (shorter than the lowest lemma), 3-10 perfect flowers and 1-3 terminal vestigial flowers; rachilla internodes between flowers elongated, disarticulating below the lemmae; palea 2-keeled, apex rounded, truncate or slightly cleft but not distinctly bifid; lodicules 3, margins hairy; stamens 6, filaments free or (sometimes) fused into a tube, anther apices emarginate or apiculate (the connective prolonged beyond the anther apex); ovary obovoid, summit thickened and hairy; stigmas 1-3, plumose, arising directly from the ovary summit or on a short or long hairy style. Fruit obovoid-cylindric, summit thickened and hairy.

KEY TO SPECIES, VARIETIES AND CULTIVARS OF *BAMBUSA* IN MALAYA

1a. Culms with thorny branches at the base.

2a. Culm-sheath auricles felty hairy on the inner surface, the margin with scattered bristles to 8 mm long; culm-sheath ligule a low rim 1-2 mm high with a row of dense short bristles to 4 mm long ..... 1. *B. bambos*

2b. Culm-sheath auricles coarse-bristly on the inner surface and margin, the bristles 4-25 mm long; culm-sheath ligule a rim to 8 mm high with teeth or bristles to 6 mm long on the margin ..... 2. *B. blumeana*

1b. Culms without thorny branches.

3a. Culm internodes basally inflated.

4a. Culm sheaths almost hairless on the back, the auricles only 4-5 mm high ..... 7. *B. tuldoides*

4b. Culm sheaths copiously hairy on the back, the auricles larger .... 8. *B. vulgaris* cv. *wamin*

3b. Culm internodes cylindric, not inflated.

5a. Leaves variegated, with pale stripes ..... 9. *Bambusa* sp.

5b. Leaves plain green.

6a. Culms not thicker than 3 mm ..... 6. *B. multiplex* var. *riviereorum*

6b. Culms thicker.

7a. Culms not white-waxy.

8a. Culm sheaths almost hairless on the back, the auricles only 4-5 mm high ..... 7. *B. tuldoides* (part)

8b. Culm sheaths copiously hairy on the back, the auricles larger.

9a. Culms plain green ..... 8. *B. vulgaris*

9b. Culms yellow streaked green, or completely yellow, and occasionally reverting to plain green .... 8. *B. vulgaris* cv. *vittata*

7b. Culms white-waxy.

10a. Culms to 2 cm diameter only, internodes glabrous; branches not longer than 0.5 m .... 6. *B. multiplex* var. *multiplex*

10b. Culms thicker, internodes with appressed dark hairs at the top; branches longer.

11a. Leaves densely hairy on lower side; culm-sheath auricles typically 1.5-3 cm high; filaments free, anthers yellow; stigmas 3, sessile ..... 3. *B. farinacea*, sp. nov.

11b. Leaves only scattered short-hairy, or glabrous, on the lower side; culm-sheath auricles smaller; filaments fused to form a tube, anthers maroon; stigma 1, at the end of a long style.

12a. Culms stiffly erect except for the slightly outcurved tips, basally with pale green or white streaks; culm-sheath auricles 10-15 mm high and 1-3 cm long; leaf-sheath auricles glabrous; spikelet rachilla internodes glabrous; anther tips with a spiny prolonged connective ..... 4. *B. heterostachya*

12b. Culms arched over nearly to the ground, plain green; culm-sheath auricles less than 10 mm high and 1 cm long; leaf-sheath auricles with fine bristles 2-3 mm long; spikelet rachilla internodes scattered short-hairy below the node; anther tips emarginate, with 1-several spines on one lobe or between the lobes ..... 5. *B. laxa*, sp. nov.

1. Bambusa bambos (L.) Voss in Vilmorin, Blumengartnerei 1 (1896) 1189.

Arundo bambos L., Sp. Pl. (1753) 81. Type: *Rheed*, Hort. Mal. 1 (1686) 25, pl. 16.

Bambos arundinacea Retz. (as *Bambusa*) *sensu* Gamble in Ann. R. Bot. Gard. Calc. 7 (1896) 51, pl. 48; Camus, Les Bambusees (1913) 128, pl. 74 (fig. A), pl. 75 (fig. A); Holttum in Gard. Bull. Sing. 16 (1958) 59, fig. 16 & 17; Gilliland, Revised Flora of Malaya 3 (1971) 17. Type: *Konig* s. n., India [in part: right-side specimen on the sheet] (LD); selected by Holttum in Taxon 5 (1956) 65-67.

[*Bambusa arundinacea* (Retz.) Willd., Sp. Pl. 2 (1799) 245, *pro parte: Arundo* (*Bambos*) & *B. arundinacea* in syn.]

Clumps to 25 m tall, culms slightly arching outwards. Culm 5-12 cm diameter; internodes 15-35 cm long, slightly white-waxy, glabrous, green; lower branches slender, developing spines (indurated short axillary branches) at the nodes, forming an entangled thicket-like growth. Culm sheaths green, often with yellow to orange streaks, scattered dark-brown hairy to glabrous; auricles broad wrinkled lobes continuous with the base of the blade, 10-12 mm high, inner surface densely coarse-velvety, margins sometimes with scattered bristles to 8 mm long; ligule a low rim, to 1-2 mm high, with 2-4 mm long fine bristles on the margin; blade broadly triangular to broadly lanceolate, erect becoming spreading when old, densely felty brown-hairy at the base on the inner surface. Leaf blade 4-13 cm X 6-15 mm; lower side slightly glaucous, glabrous; auricles tiny lobes with scattered pale bristles 2-5 mm long; ligule an inconspicuous ciliolate rim, less than 0.5 mm high. Pseudospikelets 10-20 mm long, consisting of 1-2 small empty bracts, 1-2 bracts

subtending prophyllate buds, no transitional (empty) glumes, 3-4 perfect flowers and 1-2 reduced flowers above these; rachilla internodes to 3 mm long between uppermost flowers, minutely hairy all over; lemma 7-10 mm long, including an apical cusp *c.* 0.5 mm long, glabrous on back, short-hairy near the apex on the inner side, with 17-19 nerves; palea as long as or slightly longer than lemma, 2-keeled, keels with short hairs *c.* 0.5 mm long, apex rounded to acute, each wing with 4 nerves, and 6 nerves between the keels; lodicules 3, the margins long-hairy, membraneous, the anterior two to 2 mm X 1.6 mm, the posterior *c.* 1.2 X 1 mm; stamens 6, anthers 4-5 mm long, tips emarginate, yellow, filaments free; ovary 1-1.5 mm long, obovoid, summit thickened and hairy; stigmas 3, plumose, sessile to subsessile. Fruit not seen.

DISTRIBUTION. In Peninsular Malaysia, it is planted only in the Botanic Garden and on the grounds of the Residency in Penang, where large clumps still exist. Holttum also mentioned a clump in the Singapore Botanic Garden, which has not been found in the course of the present study and which is, presumably, no longer existent. It is indigenous to the Indian subcontinent, Burma and Thailand, and has been introduced also to Borneo, the Philippines, Sumatra, Java, the lesser Sunda Islands, and Sulawesi in Malesia, as well as other parts of the tropics.

PENINSULAR MALAYSIA. Penang: Botanic (Waterfall) Garden, *Wong* FRI 32379 (A, K, KEP, KLU, L, SING), *Wong* s. n. 9.9.1982 (KEP); Residency Garden, *Abdul Kadir* SFN 36177 (K, KEP, L, SING), Cheang SFN 37940 (SING).

The correct application of the name *B. bambos* to this thorny bamboo has been reiterated by McClure (1946) but rejected by Holttum (1956a) on the basis that the basionym *Arundo bambos* L. is a *nomen confusum.* McClure interpreted that Linnaeus' citation of Rheede's work and the Indian name "Ily" for this bamboo, together with the mention of its commonness in India ("*Habitat in India utraque*") was indicative enough that he had this species in mind when the name *Arundo bambos* was first published. It is of secondary importance that in his second edition of Species Plantarum (page 121) in 1762, Linnaeus gave a description of the species based, apparently, on an Osbeck specimen of a different spiny species from China in his herbarium (McClure 1946); it is conceivable that Linnaeus had intended the common thorny bamboo of India and merely filed in his herbarium as this a specimen which had only superficial resemblance, given the state of documentation of bamboos then.

Retzius' *Bambusa arundinacea* was founded on a sheet with two elements mounted on it; the one on the right side has been selected to typify this name (Holttum 1956b) used for the thorny Indian bamboo, whereas the one on the left is *Bambusa vulgaris* (Holttum 1956b, McClure 1957). In spite of this, McClure (1946) had earlier demonstrated that Retzius could have included the species now known as *Bambusa vulgaris* within his concept of *Bambos arundinacea*, and that Willdenow in making the combination *Bambusa arundinacea* certainly had both *B. vulgaris* and *B. bambos* mixed in his concept (the only specimen labelled *Bambusa arundinacea* in his herbarium is in fact *B. vulgaris*). It is useful to note that *B. vulgaris* has apiculate anther tips and a long style, and *B. bambos* has emarginate anthers and sessile stigmas.

Soderstrom (1985) was of the opinion that *Bambusa bambos* (L.) Voss is the correct name for this species, and Soderstrom & Ellis (1988) have used this name in their account of Sri Lankan bamboos.

2. Bambusa blumeana J.A. & J.H. Schultes in Roemer & Schultes, Syst. Veg. 7 (1830) 1343; Munro in Trans. Linn. Soc. 26 (1868) 102; Gamble in Ann. R. Bot. Gard. Calc. 7 (1896) 50, pl. 47; Camus, Les Bambusees (1913) 130, pl. 71 (fig. C), Ridley, Fl. Malay Pen. 5 (1925) 256; Holttum in Gard. Bull. Sing. 16 (1958) 57, fig. 15; Gilliland, Revised Flora of Malaya 3 (1971) 18. Type: *Blume s. n.*, Java (L).

Bambusa spinosa sensu Bl. ex Nees in Bot. Zeit. (1825) 580; Ridley in Mat. Fl. Malay. Pen. 3 (1907) 183, *non* Roxb. ex Buch.-Ham. in Trans. Linn. Soc. 13 (1822) 480.

Clump to 30 m tall, culms slightly arched outwards. Culms 6-10 cm diameter; internodes 13-35 cm long, white-waxy, glabrous, green; lower branches slender, developing spines (short indurated axillary branches) at the nodes, forming an entangled thicket-like growth. Culm sheaths pale green to orange-pink; non-waxy; with dark brown hairs all over; auricles spreading lobes, 2-5 mm high, densely long-bristly on the inner surface and margins, the bristles dark brown and 4-25 mm long; ligule a low rim *c.* 3 mm high with pale bristles 5-6 mm long on the margin; blade broadly to narrowly lanceolate, erect at lower nodes, spreading on all sheaths at middle to upper nodes, green. Leaf blade 6-22 cm X 1.5-3 cm, glabrous; auricles tiny lobes *c.* 0.5 mm long with scattered bristles 1-2 mm long or glabrous; ligule a subentire rim c. 1 mm high, sometimes with a few bristles 1-2 mm long. Pseudospikelets 1.5-3.5 cm long, consisting of 1-2 small empty bracts, 2-3 bracts subtending prophyllate buds, 0-1 transitional (empty) glumes, 3-8 perfect flowers and 1-3 vestigial (reduced) flowers above these; rachilla internodes to 4 mm long between uppermost flowers, minutely hairy all over; lemma 6-10 mm long, including an apical cusp *c.* 0.5 mm long, glabrous, with 15-20 nerves; palea as long as lemma, 2-keeled, keels with short hairs *c.* 0.5 mm long, apex acute, each wing with 3 nerves, and 3-5 veins between the keels; lodicules 3, the margins long-hairy, membraneous, the anterior two to 1.5 X 1 mm, the posterior *c.* 1.2 X 1 mm; stamens 6, anthers 4-5 mm long, tips emarginate, yellow, filaments free; ovary *c.* 1 mm long, obovoid, summit thickened and hairy; stigmas 3, plumose; style short, *c.* 1 mm long; fruit not seen.

DISTRIBUTION. This thorny bamboo is commonly planted in villages and beside rice-fields in the northern states of Perlis, Kedah and Kelantan. Recorded Malay names include "Buloh duri" (generally) and "Buloh sikai" (at Mata Air, Perlis). Elsewhere it is only occasionally encountered, and is not common in the south. Specimen clumps are available in the Lake Gardens (formerly called Public Gardens), Kuala Lumpur and the Forest Research Institute of Malaysia at Kepong. Holttum (1958) records it as native to Java and eastern Malesia; Widjaja (pers. comm. 1988) states it is present in Java and the lesser Sunda Islands. It is also cultivated in Borneo, Thailand and the Philippines.

PENINSULAR MALAYSIA. Perlis: Ngulang, *Kamarudin & Wong* FRI 28821 (K, KEP, KLU, L). Selangor: Kepong, Forest Research Institute, planted, *Holttum, s. n.*, Sept. 1953 (K), *Kamarudin s. n.*, 11.11.1980 (KEP, KLU). Pahang: Pekan, *Ridley s. n.* 1889 (SING). **SINGAPORE**. Botanic Gardens: *Ridley* 3946 (K, SING), *s. n.* 1894 (K).

3. **Bambusa farinacea** K.M. Wong **sp. nov.** *B. tuldae* Roxb. *affinis sed margine lemmatis glabro, carinis paleae pilis brevioribus (0.2-0.3 mm) tectis, nodis rachillae annulo ciliato carentibus bene distincta. Typus: Wong & Saw FRI 34407, Malay Peninsula, Kelantan, track from Brinchang to Gua Musang (holotypus KEP; isotypi A, K, KLU, L, SAN, SAR, SING).* (Fig. 1)

[*Bambusa burmanica sensu* Holttum i n Gard. Bull. Sing. 16 (1958) 62: Holttum s. n., 26.10.1946 (SING); Gilliland, Revised Flora of Malaya 3 (1971) 19; *non* Gamble in Ann. R. Bot. Gard. Calc. 7 (1896) 35, pl. 33 (Type: *Oliver s.n.*, 16.3.1890, Burma, Katha (K!)]

Clump to 8-10 m tall, culms slightly arched outwards. Culms 3.5-7 cm diameter; internodes 20-35 cm long, white-waxy, with scattered dark brown hairs near the top, green. Culm sheaths green, sometimes flushed slightly orange, white-waxy, with dark brown hairs on the back; auricle a large lobe 10-20 mm high, sometimes corrugate, bearing pale bristles 8-20 mm long on its edge; ligule a rim to 4 mm high bearing pale bristles 2-4 mm long; blade broadly triangular, erect, green. Leaf blade 6-22 cm X 1-2.5 cm, lower side bluish green and soft pale-hairy; auricle a lobe 2-4 mm long with pale fine bristles 2-5 mm long; ligule a subentire rim 0.5-1 mm high. Pseudospikelets 20-42 mm long, consisting of 1 small empty bract, 2-3 bracts subtending prophyllate buds, 1-3 transitional (empty) glumes, 5-10 perfect flowers and 1-2 terminal vestigial flowers; rachilla internodes to 5 mm long between uppermost flowers, scantily minute-hairy to glabrescent; lemma to 15 mm long, including an apical cusp *c.* 0.5 mm long, glabrous except for short hairs on the inner side near the apex, with *c.* 18 nerves; palea slightly shorter than lemma, 2-keeled, the keels with short hairs 0.2-0.3 mm long, apex truncate to rounded, each wing with 3-4 nerves and 5-6 nerves between the keels; lodicules 3, the margins long-hairy, membraneous, the anterior two to 3 mm X 3 mm, the posterior *c.* 1.5 mm X 1.5 mm; stamens 6; anthers 5 mm long, tips emarginate, yellow, filaments free; ovary 1-2 mm long, obovoid, summit thickened and hairy; stigmas 3, plumose, sessile on the ovary summit; fruit 5-8 mm long, obovoid-cylindric, summit thickened and hairy.

DISTRIBUTION. Peninsular Malaysia (Kelantan, Kedah, Selangor). Also probable in south Thailand.

HABITAT. Open sites and forest fringes.

PENINSULAR MALAYSIA. Kelantan: track from Brinchang to Gua Musang, *Wong & Saw* FRI 34407 (holotype KEP; isotypes A, K, KLU, L, SAN, SAR, SING). Kedah: Nami area, near Kampung Pulau Belantek, *Wong* FRI 32265 (KEP); near road to Sintok, *Holttum s. n.* 26.10.1946 (SING). Selangor: road to Bukit Tinggi, *Wong* FRI 32238 (K, KEP, KLU). Pahang: Lanchang, road to Bukit Ringet at Krau Game Reserve, *Saw, Wong & Mustapa* FRI 37367 (K, KEP).

This species was identified as *B. burmanica* Gamble by Holttum (1958) based on a sterile collection he made in 1946, in the Sintok area in Kedah. Only in April 1987 was flowering material first collected, in Kelantan. This is the only truly indigenous *Bambusa* of Malaya so far known. The culm sheaths resemble those not only of *B. burmanica*, but also of the related *B. tulda* Roxb., *B. teres* Buch-Ham. ex Munro and *B. nutans* Wall. ex Munro, as

figured by Gamble (1896) and on specimens in the Calcutta, Dehra Dun and Kew herbaria. For the present study, an attempt was made, in April 1983, to compare vegetative characters of the Malayan plant with those of living specimens cultivated in the Indian Botanic Garden, Calcutta and the arboretum of the Forest Research Institute and Colleges, Dehra Dun, some of which were purportedly (Gamble 1896) raised from material from which the type specimens were taken and thus constituted "living type material". These plants all had vegetative differences from the Malayan plant (Table 1).

The only characters in which all these plants had in common were the general form of the culm sheath and the hairy lower leaf surfaces. To add to the confusion, the two clumps at the Indian Botanic Garden identified as *B. tulda* had differences from one another and from the plant identified as the same species at Dehra Dun. The late Mr. K.N. Bahadur of the Forest Research Institute at Dehra Dun, greatly familiar with Indian bamboos, had collected a flowering specimen (*Bahadur* 32, Dehra Dun, Arboretum Compartment 2, F.R.I.- DD!) from the clump at Dehra Dun he identified as *B. tulda*. The spikelets from this plant are different from those of *Wallich* 5030 (K!) and *Roxburgh s.n.*, East India (K!), both of which were cited by Munro (1868) under *B. tulda*, and of which the Roxburgh specimen is the type, in having very short (0.1-0.2 mm) hairs on the palea keels compared to those of the Kew specimens (0.5-1 mm long). On the other hand, spikelets from *Bahadur* 29, Dehra Dun, F.R.I. Arboretum Compartment 8 (DD!), taken from the bamboo at Dehra Dun which Bahadur himself identified as *B. nutans*, were the same as those from *Wallich* 5031 (K!), the type of *B. nutans*. From these, it is here suggested that the reference clumps cultivated today at Calcutta and Dehra Dun are not necessarily the same as those referred to by Gamble (1896), nor might they be the same species. There are no fertile Bahadur collections from the Dehra Dun clumps identified as *B. teres* or *B. nutans* which may be compared directly to the type specimens of these species, on which the culm sheaths and other characters are not well preserved nor described.

Under these circumstances, the final resort to determining the identity of the Malayan plant in question had to be made via comparisons of spikelet material with the type specimens of the different species that bore a superficial resemblance to it. This has since become possible with the collection of *Wong & Saw* FRI 34407, and the salient spikelet differences are summarised in Table 2 and Fig. 1. The emarginate anther apices of *B. farinacea* and *B. tulda* immediately distinguish them from *B. burmanica, B. teres* and *B. nutans*, which have apiculate anther apices. This is a reliable character, e. g., the anthers of *B. bambos*

Fig. 1. (opposite page) *Bambusa farinacea* (A-K) and the related species *B. burmanica* (L), *B. tulda* (M), *B. teres* (N), *B. nutans* (O). **A.** Top of culm sheath, dorsal view. **B.** Top of culm sheath, showing ligule on ventral side. **C.** Flowering leafy branch. **D.** Leaf base, ligule and auricle. **E.** Mature pseudospikelet with (from the base) 3 gemmiferous bracts, one transitional glume, 6 perfect flowers and a terminal vestigial flower; one rachilla internode magnified. **F.** lemma. **G.** Palea, dorsal view. **H.** Palea, ventral view. **I.** Lodicule complement. **J.** Two stamens; anther tip magnified. **K.** Fruit. **L-O** shows (left to right) dorsal view of palea with rachilla internode, one stamen, lemma apex and margin. **A-K** from *Wong & Saw* FRI 34407; **L** from *Oliver s.n.*, 16.3.1890; **M** from *Wallich* 5030C; **N** from *Wallich* 5026B; **O** from *Wallich* 5031.

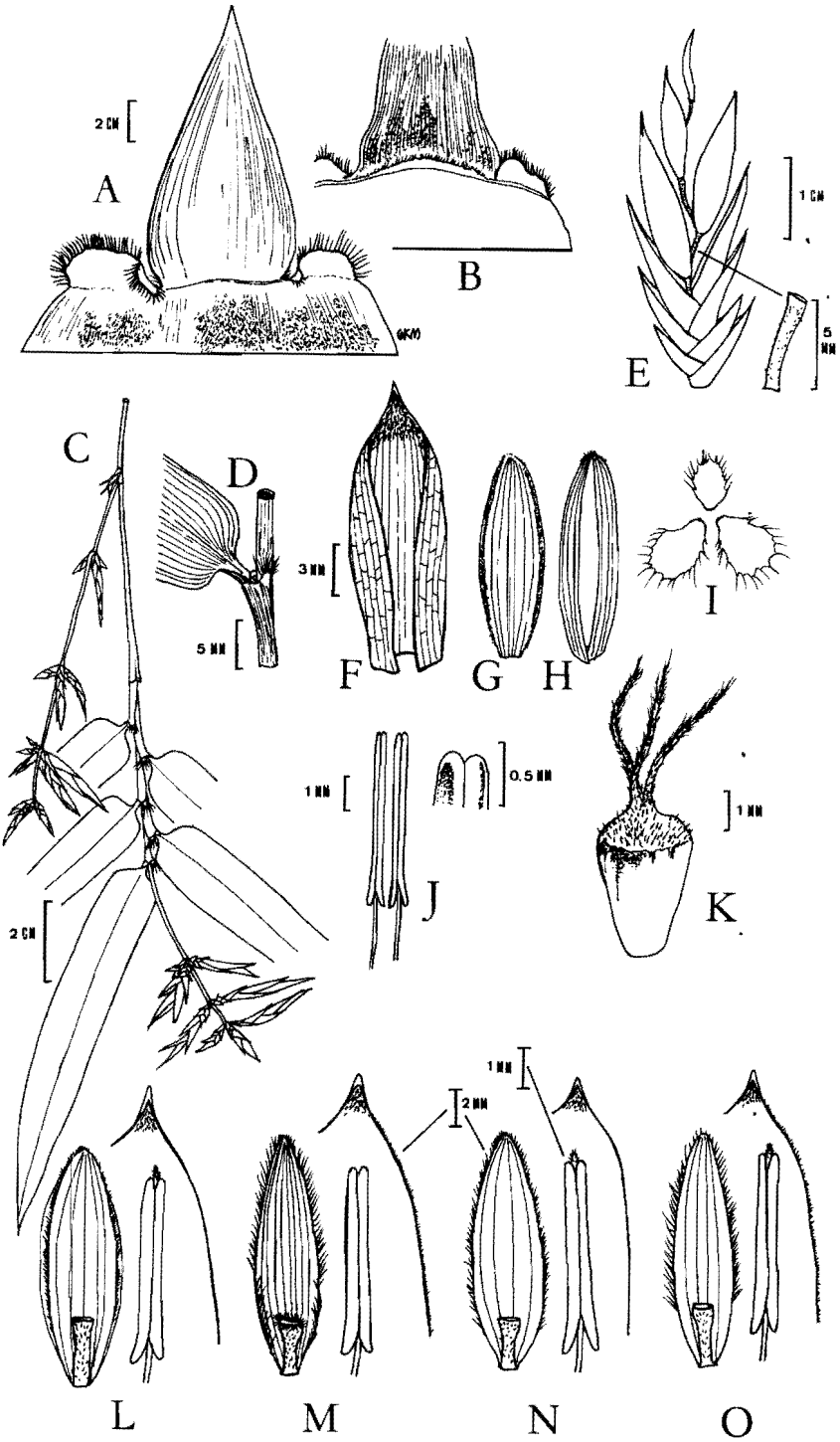
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Table 1. Differences in vegetative characters between the Malayan *Bambusa farinacea* and reference clumps of *B. burmanica, B. tulda, B. teres* and *B. nutans* at the Forest Research Institute, Dehra Dun and the Indian Botanic Garden, Calcutta.

	Culm internode waxiness	Bands of pale felty hairs around the culm nodes	Other hairs on the culm internode	White wax on fresh culm sheaths
B. farinacea	Present	Nil	Dark brown	Present
"*B. burmanica*", Dehra Dun	Nil	Present	Nil	Nil
"*B. tulda*", Dehra Dun	Present	Present	Dark brown	Present
"*B. tulda*", Calcutta	Present in clump A, nil in clump B	Present in both clumps	Dark brown in clump A, nil in clump B	Nil in clump A, present in clump B
"*B. teres*", Dehra Dun	Present	Present	Nil	Present
"*B. nutans*", Dehra Dun	Present	Nil	Nil	Nil

and *B. multiplex* are always emarginate, and those of *B. heterostachya* and *B. vulgaris* always apiculate. The fine-hairy lemma margin, long (0.5-1 mm) hairs on the palea keels and the ciliate ring at rachilla nodes of *B. tulda* distinguish it from *B. farinacea.*

Recently, *B. lixin* Hsueh & Yi has been described without flowers from Xizang in China, and this also has culm sheaths similar to those of *B. farinacea* (Yi 1983). However, in *B. lixin* the culm internodes are glabrous, the young nodes are white-tomentose and the leaf sheaths have no auricles nor oral setae, and so differ from those of *B. farinacea.* Features distinguishing *B. lixin* from other species in this group were not given by the authors. Lin (1968), in listing the bamboos of Thailand, uncritically includes "B. burmanica" and "B. tulda" as indigenous there; these two species, together with *B. farinacea*, are expected in Thailand but it is not clear from Lin's account which species are in fact present.

Table 2. A comparison of spikelet and floral characters in *Bambusa farinacea* and other species with a superficial resemblance.

	Lemma margin	Hairs on palea keels	Anther apices	Rachilla internodes
B. burmanica Type: Oliver s.n. 16.3.1890 Burma, Katha (K)	Glabrous	0.1-0.3 mm	Apiculate	Fine scattered hairs
Gamble 23765 (DD)	Glabrous	0.1 mm	Apiculate	Fine scattered hairs
B. tulda Type: Roxburgh s.n., East India (K)	Fine-hairy	0.5-1 mm	Emarginate	Short-hairy & ring of cilia at nodes
Wallich 5030 (CAL)	Fine-hairy	0.5-1 mm	Emarginate	Short-hairy & ring of cilia at nodes
B. teres Type: Wallich 5026B (K)	Glabrous	0.5 mm	Apiculate	Short scattered hairs
B. nutans Type: Wallich 5031 (K)	Fine-hairy	0.5-1 mm	Apiculate	Short scattered hairs
Bahadur 29 (DD)	Fine-hairy	0.5-1 mm	Apiculate	Short scattered hairs
B. farinacea Type: FRI 34407 (holotype KEP)	Glabrous	0.2-0.3 mm	Emarginate	Glabrous to short scattered hairs

4. **Bambusa heterostachya** (Munro) Holttum in J. Arn. Arb. 27 (1946) 341, in Gard. Bull. Sing. 16 (1958) 65; Gilliland, Revised Flora of Malaya 3 (1971) 18.

Gigantochloa heterostachya Munro in Trans. Linn. Soc. 26 (1868) 125; Gamble in Ann. R. Bot. Gard. Calc. 7 (1896) 66, pl. 57; Hook. f., Fl. Brit. Ind. 7 (1897) 400; Ridley in Mat. Fl. Malay. Pen. 3 (1907) 188; Camus, Les Bambusees (1913) 142; Ridley, Fl. Malay Pen. 5 (1925) 262. Type: *Griffith* 6731, Malay Peninsula, Malacca, Ayer Panas (holotype K).

Gigantochloa latispiculata Gamble in Ann. R. Bot. Gard. Calc. 7 (1896) 67, pl. 59; Hook. f. Fl. Brit. Ind. 7 (1897) 400; Ridley in Mat. Fl. Malay. Pen. 3 (1907) 189; Camus, Les Bambusees (1913) 143; Ridley, Fl. Malay. Pen. 5 (1925) 263. Type: *Alvins s.n.*, 16.1.1886, Malay Peninsula, Malacca, Bukit Bruang (holotype SING).

Bambusa latispiculata (Gamble) Holttum, in J. Arn. Arb. 27 (1946) 341.

Clump 6-12 m tall, culms stiffly erect except for the slightly outcurved tips. Culm 3.5-6 cm diameter; internodes 30-40 cm long, white-waxy when young, with scattered dark hairs just below the nodes, green, with pale green to white stripes at the base of the culm. Culm sheaths pale green, slightly white-waxy, with dark brown to black hairs on the back; auricles large lobes to 3 cm long and 1-1.5 cm high, with pale brown bristles 10-15 mm long on the margins; ligule a subentire rim 6-8 mm tall, with bristles *c.* 3 mm long on the margin; blade broadly triangular to broadly lanceolate, erect, pale green. Leaf blade 15-20 cm X 1.5-2.5 cm, glabrous; auricles small lobes *c.* 1 mm long, glabrous; ligule 1-3 mm high, edge ciliolate. Pseudospikelets 2.5-4 cm long, consisting of 2-3 small empty bracts, 1-2 bracts subtending prophyllate buds, 2 transitional (empty) glumes, 5-6 perfect flowers and a terminal vestigial flower; rachilla internodes to 2.5 mm long between uppermost flowers, glabrous; lemma 15-20 mm long, including an apical cusp *c.* 0.5 mm long, glabrous, with 30-36 nerves; palea slightly shorter than lemma, 2-keeled, keels with short hairs *c.* 0.5 mm long, apex rounded to acute, each wing with 3 nerves, and 7 nerves between the keels; lodicules 3, the margins long-hairy, membraneous, the anterior two to 2 mm X 1 mm, the posterior *c.* 1.5 mm X 0.8 mm; stamens 6, anthers 6-9 mm long, tips apiculate (with a spiny prolonged connective), maroon, filaments fused as a tube; ovary 1-1.5 mm long, obovoid, summit thickened and hairy; stigmas 1-3, plumose; style 4-6 mm long. Fruit 5-6 mm long, obovoid-cylindric, thickened and hairy at the summit.

DISTRIBUTION. This species, although first described from a Malayan specimen, has never been found truly wild in Malaya. On the other hand, it has not been reported from other localities except where known to have been introduced from Malaya, notably at an oil-palm plantation in the Lower Labuk and Ulu Dusun in Sabah (Dransfield 1979) as well as in Nigeria (*fide* S. Dransfield). Recorded common names in Peninsular Malaysia include "Buloh Pering," "Buloh Pengahit" and "Buloh Tilan".

PENINSULAR MALAYSIA. Perak: Changkat Jong, near Telok Anson, *Holttum* SFN 38432 (SING); Parit, *Ng* FRI 27248 (KEP), Padang Tenggala, *Wong* FRI 28976 (K, KEP, KLU, L, SING). Selangor: Bukit Cheraka Estate, *Kochummen* FRI 19458 (KEP); Kelang, Highlands Research Station, *Kochummen* FRI 19457 (KEP, L). Negri Sembilan: Kampung Air Bong, *Wong* FRI 32222 (K, KEP, KLU, L); Peradong, *Hussein* KEP 9597 (SING), KEP 9598 (K), Malacca: *Cantley's coll.* 1717 (SING); Ayer Panas, *Griffith* 6731 (holotype K), Bukit Bruang, *Alvins s.n.*, 16.1.1886 (SING). Johore: Pamolo Estate, *Galpine s.n.*, 9.12.1962 (L). **SINGAPORE**. Botanic Gardens, *Ridley* 6680 (K, SING), 8122 (SING), *s.n.* 28.9.1903 (K); Bukit Sembawang, *Sinclair s.n.*, 29.5.1949 (L); Upper Serangoon Road, *Ahmad s.n.*, 27.9.1946 (SING), *Holttum s.n.* Sept. 1946 (KEP, SING); Pulau Samulun, *Sinclair* SFN 38601 (L, SING).

5. **Bambusa laxa** K.M. Wong **sp. nov.** *B. heterostachydi (Munro) Holttum affinis, sed culmis viridibus valde arcuatis, auriculis vaginarum culmorum minoribus (ad 8 mm altis, 10 mm longis non excedentibus), auriculus vaginarum foliorum setosis, rachillae spiculae internodiis infra nodos pubescentibus, antheris apice emarginatis 1-paucas spinas uno lobo vel inter lobos ferentibus differt. Typus: Wong FRI 32382, Malay Peninsula, Perak, Masjid Tinggi (holotypus KEP; isotypi K, L).* (Fig. 2)

Clump to 5-6 m high. Culms much arched outwards, 2-4 cm diameter; internodes 20-35 cm long, slightly white-waxy when young, with scattered appressed dark brown hairs near the top, green. Culm sheaths pale green, white-waxy, with dark brown hairs on the back; auricle a lobe to 8 mm high and 5-6 mm long, bearing pale bristles 10-12 mm long on its edge; ligule a rim *c.* 2 mm high, bearing fine bristles 3-6 mm long; blade narrowly triangular to lanceolate, erect, green, abaxially with scattered appressed dark brown hairs. Leaf blade 6-15 cm X 1-1.5 cm, glabrous; auricle a tiny lobe bearing fine bristles 2-3 mm long; ligule a short rim *c.* 0.5 mm high, subentire to slightly hairy on the edge, non-bristly. Pseudospikelets to 26 mm long, consisting of 1 small empty bract, 2-3 bracts subtending prophyllate buds, 0-1 transitional (empty) glumes, 6-7 perfect flowers and 1 terminal vestigial flower; rachilla internodes 2-3 mm long between the upper perfect flowers, scattered minute-hairy just below the node; lemma to 15 mm long, without a conspicuous apical cusp, glabrous on the back (abaxial surface), short-hairy on the margins and on the inner side near the apex, with *c.* 28 nerves, palea slightly shorter than lemma, 2-keeled, the keels with long (0.4-0.8 mm) hairs at the upper part and glabrescent lower down, apex truncate to rounded, each wing with 2-3 nerves and 5-6 nerves between the keels; lodicules 3, the margins long-hairy, membraneous, the anterior two to 2 mm X 1 mm, the posterior *c.* 1.5 mm X 0.8 mm; stamens 6: anthers 5-6 mm long, tips emarginate with 1-several spines on one lobe or between the lobes, maroon, filaments fused into a membraneous tube; ovary 0.5-1.5 mm long, obovoid, summit thickened and hairy; style long, hairy, ending in a single plumose stigma.

DISTRIBUTION. Peninsular Malaysia, frequently cultivated in the Alor Setar district of Kedah and the Krian district of Perak, where it is sometimens called "Buloh tilan payong".

PENINSULAR MALAYSIA. Kedah: Alor Setar, Simpang Tiga, Batu 17, *Wong* FRI 32261 (KEP). Perak: Krian, Bagan Serai, *Wong* FRI 32415 (K, KEP, KLU, L), *s. n.* 7 Feb. 1986 (K, KEP, KLU); Masjid Tinggi, *Wong* FRI 32382 (holotype KEP; isotypes K, L).

This species is closely related to *B. heterostachya* in having similar culm sheaths, filaments fused into a tube, maroon anthers, and a long style with a solitary stigma. It is different in being overall smaller, in having culms that much arch outwards, bristly leaf-sheath auricles, spikelet rachilla internodes hairy just below the node and emarginate anther tips. Nothing like it has been found among the Indian and Thai material, or the material at Bogor, Leiden or Kew. Among Chinese bamboos, it bears superficial resemblance to McClure's *B. textilis* var. *fusca* (which is not necessarily conspecific with his *B. textilis* var. *textilis*, both of which were described without flowers). *B. textilis* var. *textilis* has pale hairs on the culm internodes (McClure 1940) and the mature spikelets have longer rachilla internodes that widely separate individual flowers and yellow anthers (see But *et al.* 1985). *B. textilis* var. *fusca* has glabrous culm internodes and is bigger and

more erect in habit, although the culm sheaths are superficially similar to those of *B. laxa*. In 1987 specimens of the species here called *B. laxa* were sent to Professor Liang-chi Chia at the South China Institute of Botany (IBSC) of the Academia Sinica in Guangzhou, who is familiar with McClure's taxa and where much of McClure's material (including the types of *B. textilis*) are preserved at the Lingnan University herbarium (now part of IBSC). He also came to the conclusion that it was undescribed, even though it was suggested that there was a possible affinity with *B. textilis* or one of its varieties which are well-known there for yielding culms good for weaving handicrafts and utensils.

In Peninsular Malaysia it is used as a source of small-diameter poles and fishing rods where it is planted.

6. Bambusa multiplex (Lour.) Raeuschel ex J.A. & J.H. Schultes in Roemer & Schultes, Syst. Veg. 7 (1830) 1350; Camus, Les Bambusees (1913) 132.

var. multiplex

Arundo multiplex Lour., Fl. Cochin. (1790) 58; Camus, Les Bambusees (1913) 132.

Ludolfia glaucescens Willd. in Ges. naturf. Freunde Berl. Mag. 2 (1808) 320.

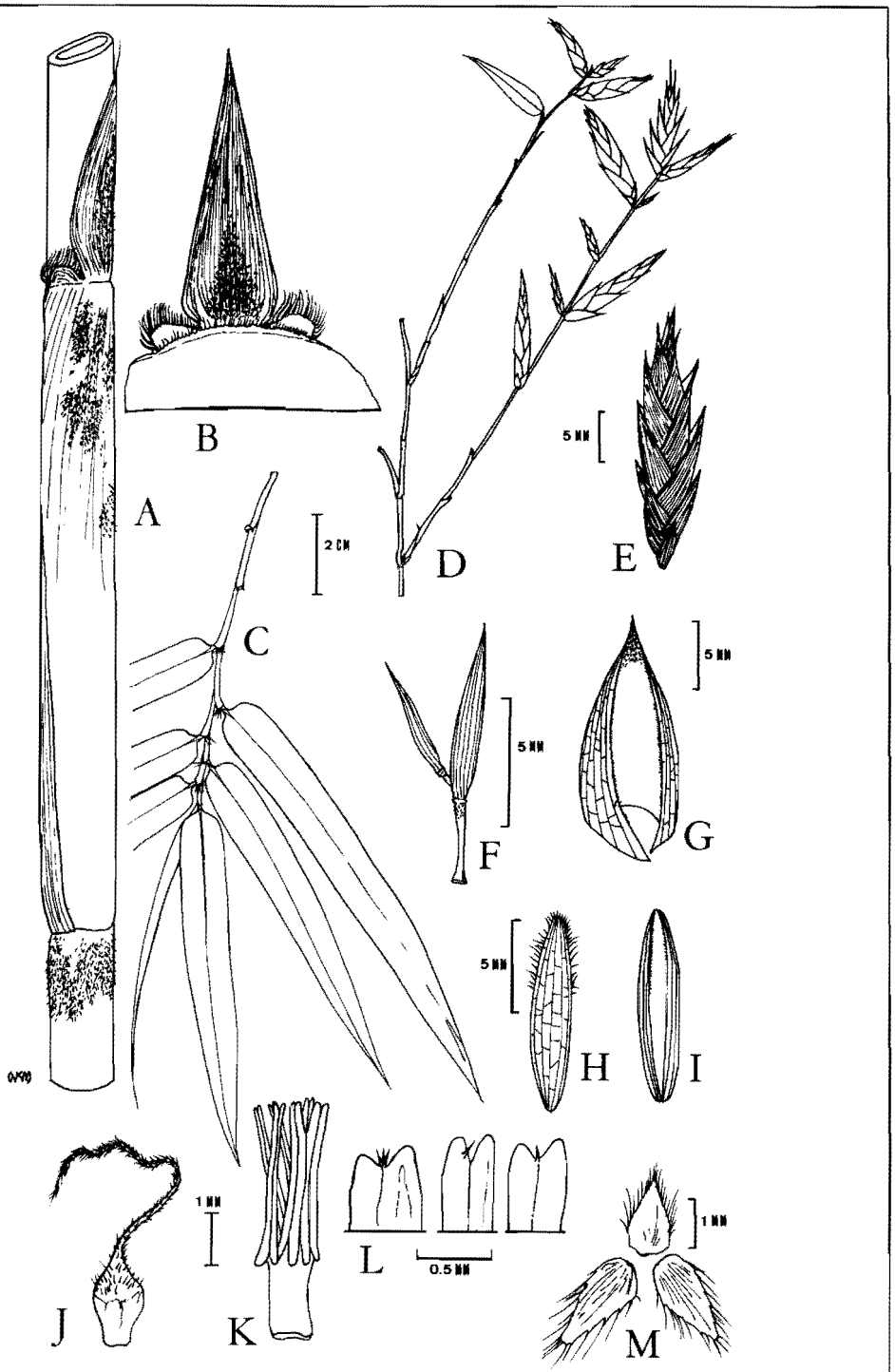
Arundinaria glaucescens (Willd.) Beauv., Essai Agrost. (1812) 144, 152; Munro in Trans. Linn. Soc. 26 (1868) 22.

Bambusa nana Roxb., Fl. Ind., ed. Carey, 2 (1832) 199; Munro in Trans. Linn. Soc. 26 (1868) 89; *sensu* Gamble in Ann. R. Bot. Gard. Calc. 7 (1896) 40, *pro parte* (excl. Wray 1560 = *Holttumochloa magica* (Ridl.) Wong), pl. 38; Ridley in Mat. Fl. Malay. Pen. 3 (1907) 184; Camus, Les Bambusees (1913) 121; Ridley, Fl. Malay Pen. 5 (1925) 258.

Bambusa glaucescens (Willd.) Sieb. ex Munro in Trans. Linn. Soc. 26 (1868) 89; Holttum in Kew Bull. no. 2 (1956) 207-211, in Gard. Bull. Sing. 16 (1958) 67, fig. 19; Gilliland, Revised Flora of Malaya 3 (1971) 20.

Clump 4-6 m tall, culms erect for about halfway and arched broadly outwards. Culm 0.5-1.5 cm diameter, internodes 20-35 cm long, slightly white-waxy, glabrous, green. Culm sheaths pale green, slightly white-waxy, glabrous; auricles none, or sometimes a tiny lobe hardly 0.5 mm high with 1-2 mm long pale bristles; ligule a subentire rim 0.5-1 mm high;

Fig. 2. (opposite page) *Bambusa laxa*. **A.** Culm sheath. **B.** Top of culm sheath, showing ligule on ventral side. **C.** Leafy branch. **D.** Flowering branches. **E.** Pseudospikelet with (from the base) an empty bract, 3 gemmiferous bracts, 7 perfect flowers and a partially hidden terminal vestigial flower. **F.** Uppermost perfect flower and terminal vestigial flower with their rachilla internodes. **G.** Lemma. **H.** Palea, dorsal view. **I.** Palea, ventral view. **J.** Pistil. **K.** Filament tube and anthers. **L.** Detail of anther apices. **M.** Lodicule complement. All from *Wong* FRI 32382.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blade broadly to narrowly triangular, erect, pale green. Leaf blade 2.5-12 cm X 0.3-1.5 cm; lower side glaucous, glabrous to scattered short-hairy; auricles tiny lobes, 0.5-2 mm tall with fine bristles 2-3 mm long; ligule an inconspicuous subentire rim less than 0.5 mm high. Pseudospikelet 2.5-4 cm long, consisting of 2-3 small empty bracts, 2 bracts subtending prophyllate buds, no transitional (empty) glumes, 6-9 perfect flowers and a terminal vestigial flower; rachilla internodes to 5 mm long between uppermost flowers, glabrous; lemma 10-16 mm long, glabrous, with 18-22 nerves; palea slightly shorter than lemma, 2-keeled, keels with short hairs 0.1-0.2 mm long only near the apex, apex rounded to truncate, each wing with 4 nerves, and 6 nerves between the keels; lodicules 3, the margins glabrous or minutely ciliolate, membraneous, the anterior two to 2.2 mm X 0.8 mm, the posterior *c.* 2 mm X 0.5 mm; stamens 6, anthers 4-6 mm long, tips emarginate, yellow, filaments free; ovary 1-1.5 mm long, obovoid, summit thickened and hairy; stigmas 3, plumose, sessile to subsessile. Fruits not seen.

DISTRIBUTION. Holttum (1958) suggested that the species is native to China and Japan. It is commonly found used as hedges or planted as individual clumps throughout southeast Asia and India, and has been introduced to other parts of the tropics. Willdenow's name *Ludolfia glaucescens* was given to a plant which flowered at Berlin, where it was cultivated, in 1808. In Malaysia it is called "Buloh Cina" or "Buloh pagar".

PENINSULAR MALAYSIA. Penang: *Curtis* 1720 (K, SING); between Ayer Itam & Penara Bukit, *Burkill* SFN 1465 (K, SING); Government Hill, *Nauen* SFN 38097 (K, SING), *Ridley s.n.*, Feb. 1892 (SING); Penang Hill, *Wong* FRI 32386 (KEP, KLU), FRI 32387 (KEP, KLU); Westem Hill, *Wong* FRI 32431 (KEP, KLU). Perak: Taiping, *Mahmood* KEP 9989 (KEP, SING). Negri Sembilan: Seremban, *Alvins* 1983 (SING). **SINGAPORE.** Bukit Timah: stream near quarry, *Sinclair s. n.*, 28.5.1949 (L).

Soderstrom & Ellis (1988) have argued that Loureiro's name *Arundo multiplex* should be used as the basis of the name for this commonly cultivated small bamboo; earlier, Holttum (1956c) had dismissed Loureiro's description (Loureiro 1790) as being inadequate for identifying this species. Loureiro's description for his *Arundo multiplex* refers to a bamboo commonly known as "cay hop," which is unarmed and has three sessile stigmas, and is commonly planted as hedges. Only two other species in the region have common names using the word "hop," one being *B. flexuosa* Munro (which is thorny), the other *B. tuldoides* Munro (which is used for hedges but has a distinct style), and both of these were not what Loureiro had intended. There seems no doubt that Loureiro's *Arundo multiplex* was intended for this species.

var. riviereorum R. Maire, Flore Afrique Nord 1 (1952) 355.

B. glaucescens var. *riviereorum* (R. Maire) L.C. Chia & H.L. Fung in Phytologia 52 (1982) 257.

In recent years, a horticultural variant with tiny culms (not thicker than 3 mm) and smaller leaves on short branches, altogether perhaps 30 cm high, popularly called the Chinese Goddess Bamboo (a dwarf form of *B. multiplex* var. *riviereorum* R. Maire), has been occasionally cultivated as a pot plant.

7. **B. tuldoides** Munro in Trans. Linn. Soc. 26 (1868) 93; Camus, Les Bambusees (1913) 117. Type: China, Canton, Millett, s. n. (holotype K).

B. ventricosa McClure in Lingnan Sci. J. 17 (1938) 57; Holttum in Gard. Bull. Sing. 16 (1958) 70; Gilliland, Revised Flora of Malaya 3 (1971) 21. Type: *McClure* 20667, China, Lingnan Univ. Bamboo Garden accession no. 2651 (herbarium, Lingnan Natural History Survey & Museum).

Clump to 4 m tall but usually (in pot-grown specimens) 0.5-1.5 m high, culms slightly arched outwards. Culm 0.5-3.5 cm diameter (in potted specimens 0.5-2 cm); internodes cylindrical but sometimes (in potted specimens, usually) basally inflated, 5-15 cm long (3-6 cm in potted specimens), non-waxy, glabrous, green. Culm sheaths pale green to pinkish green, non-waxy, glabrous; auricles small rounded lobes 1-5 mm high, with scattered short pale bristles 2-3 mm long; ligule a subentire rim 1-4 mm high; blade broadly elliptic to narrowly triangular, erect, pale green. Leaf blade 6-15 cm X 0.8-2 cm, glabrous to short pale-hairy on lower surface; auricles small lobes *c.* 1 mm long with fine bristles 2-3 mm long; ligule a subentire rim *c.* 0.5 mm high. Pseudospikelets 2.5-4.5 cm long, consisting of 1-2 small empty bracts, 1-2 bracts subtending prophyllate buds, 1 transitional (empty) glume, 2-5 perfect flowers and 1-2 reduced flowers above these; rachilla internodes to 4 mm long between uppermost flowers, minutely hairy below nodes; lemma 10-14 mm long, including an apical cusp *c.* 0.5 mm long, glabrous on back, short-hairy near the apex on the inner side, with 12-14 nerves; palea slightly shorter than lemma, 2-keeled, keels with short hairs *c.* 0.5 mm long, apex rounded to acute, each wing with 1 nerve, and 3 nerves between the keels; lodicules 3, the margins long-hairy, membraneous, the anterior two to 1.5 X 0.5 mm, the posterior *c.* 1 X 0.5 mm; stamens 6, anthers 4-5 mm long, tips apiculate, maroon, filaments free; ovary 1-1.5 mm long, obovoid, summit thickened and hairy; stigmas 3, plumose; style 4-6 mm long. Fruit not seen.

DISTRIBUTION. South China. This species is commonly planted as an ornamental and a curiosity in South China and southeast Asia, and has been introduced to Europe, the United States and Puerto Rico. It has not been known to flower in Peninsular Malaysia.

PENINSULAR MALAYSIA. Negri Sembilan: Port Dickson, Merlin Hotel, pot-grown, *Wong* FRI 32193 (KEP, KLU). **SINGAPORE.** Cultivated in Botanic Garden, *Ridley* 451 (K).

Young, Haun & McClure (1961) note that this species (recorded as *B. ventricosa*) grew to 55 feet (*c.* 18 m) high in Puerto Rico and Florida while planted in the ground, and that the distortion of the internodes tended to disappear. As Holttum (1958) noted, the swollen internodes characteristic of pot-grown plants are by no means an irreversible condition for the clump; plants grown in open ground develop culms with more cylindric internodes. This is one of two taxa commonly referred to as the Buddha's Belly Bamboo, which alludes to the resemblance of the distended internodes to the rounded abdomen in popular images of a laughing Buddha; the other is *B. vulgaris* cv. *wamin* McClure. *B. ventricosa* was described by McClure without flowering material, and in 1932 material derived from the plant McClure purchased from a Canton nursery (the basis of his species) was sent to the Tropical Agricultural Research Station in Mayaguez, Puerto Rico, where it was planted. Recently, flowering collections from this plant were made by

Edelman and determined by Soderstrom as identical with *B. tuldoides* (Edelman, Soderstrom & Deitzer 1985). But *et al.* (1985) provided colour photographs for *B. ventricosa* including one clearly showing yellow anthers. They also describe thorny lower branches for the larger, ground-planted form; this is not mentioned in descriptions by McClure (1938), Holttum (1958), and Young, Haun & McClure (1961) and does not occur in ground-planted specimens in the Singapore Botanic Garden. It is possible the photograph showing yellow anthers came from a thorny bamboo described by them under *B. ventricosa*; anthers in *B. tuldoides* (the correct and earlier name for *B. ventricosa*) are maroon.

B. tuldoides cv. *swolleninternode* Xia, published recently (Xia 1985) based on a sterile specimen from Guangdong, China (*Xia* B 0064 at IBSC) is very similar and might be the same.

8. Bambusa vulgaris Schrad. ex Wendl., Collect. Pl. 2 (1810) 26, pl. 47; Munro in Trans. Linn. Soc. 26 (1868) 106; Gamble in Ann. R. Bot. Gard. Calc. 7 (1896) 43, pl. 40; Ridley in Mat. Fl. Malay. Pen. 3 (1907) 185; Camus, Les Bambusees (1913) 122, pl. 76 (fig. A); Ridley, Fl. Malay. Pen. 5 (1925) 256; McClure in Blumea Suppl. 3 (1946) 108; Holttum in Gard. Bull. Sing. 16 (1958) 63, fig. 18; Gilliland, Revised Flora of Malaya 3 (1971) 19.

[*Bambos arundinacea* Retz., Obs. Bot. 5 (1788) 24, *pro parte*: specimen on left side of sheet "India, *Konig*" (LD)].

[*Bambusa arundinacea* (Retz.) Willd., Sp. Pl. 2 (1799) 245, *pro parte*: specimen "*B. arundinacea* 1" (B-W)].

Clump to 12-20 m tall (or only up to *c.* 3 m tall in cv. *wamin*), culms broadly arched outwards (or only slightly outarched in cv. *wamin*). Culm 4-10 cm diameter (or only 1-3 cm in cv. *wamin*); internodes 20-40 cm long (or only 4-10 cm long in cv. *wamin*), cylindrical, but basally inflated in cv. *wamin*, without white-waxy deposits but often quite glossy, glabrous or (rarely) with scattered dark hairs below the nodes, green in the typical form and cv. *wamin*, yellow streaked green to wholly yellow in cv. *vittata*. Culm sheaths green, non-waxy, with dark brown to black hairs on the back; auricles raised, somewhat curved lobes 0.5-2 cm high, with pale brown bristles 3-8 mm long; ligule a rim 3-4 mm high, with scattered pale bristles 1-3 mm long on the edge; blade broadly triangular to broadly lanceolate, erect but sometimes (on old sheaths) spreading, green. Leaf blade 6-30 cm X 1-4 cm, lower side glabrous; auricles small rounded lobes 0.5-1.5 mm high, glabrous or with a few bristles 1-3 mm long; ligule a subentire rim 0.5-1.5 mm high. Pseudospikelets 12-15 mm long, consisting of 2-3 small empty bracts, 2-3 bracts subtending prophyllate buds, 1-2 transitional (empty) glumes, 5-10 perfect flowers, and a terminal vestigial flower; rachilla internodes to 3 mm long between uppermost flowers, densely short-hairy at the upper part; lemma 8-10 mm long including an apical cusp *c.* 0.5 mm long, back glabrous, margins with fine hairs hardly 0.1 mm long near the apex, inside short-hairy at the apex, with 10-16 nerves; palea slightly shorter to slightly longer than lemma, 2-keeled, keels with short hairs 0.5-0.8 mm long, apex rounded to acute, each

wing with 1 nerve, and 3 nerves between the keels; lodicules 3, the margins long-hairy, membraneous, the anterior two to 1.5-2.5 X 0.4-1 mm, the posterior *c.* 1-1.5 X 0.3-0.8 mm; stamens 6, anthers 6-7 mm long, tips apiculate (with a spiny prolonged connective), maroon, filaments typically free but sometimes fused as a tube; ovary 1-1.5 mm long, obovoid, summit thickened and hairy; stigmas 3, plumose; style 3-7 mm long. Fruit not seen.

DISTRIBUTION. Found throughout the tropics and subtropics, *B. vulgaris* is probably the most commonly encountered cultivated bamboo in southeast Asia, found everywhere in villages, on river banks and in towns planted as ornamentals. It is believed to have originated in tropical Asia, but in Malaya has never been found in remote wild places. Typical green *B. vulgaris* has been called "Buloh Aur" (although both Malay words mean bamboo), "Buloh Pau", "Buloh Minyak" and "Aur Beting" in Malay.

PENINSULAR MALAYSIA. Perak: Blanja, Wray 141 (K, SING); Grik, *Hamid* KEP 6421 (KEP, SING), KEP 8255 (K, SING); Parit, *Ng* FRI 27247 (KEP). Selangor: Kepong, Forest Research Institute, *Wong* FRI 28936 (KEP). **SINGAPORE.** Botanic Gardens, *Ridley* 6115 (K, SING), 6545 (K, SING), 6679 (K, SING), 8079 (K, SING), 8899 (K, SING); Colonial Secretary's Garden, *Ridley* 5599 (K, SING).

Retzius' concept of *Bambos arundinacea*, and Willdenow's concept when he made the combination *Bambusa arundinacea* had elements of *Bambusa vulgaris* and *Bambusa bambos* in them (see under *Bambusa bambos* here). Occasionally the filaments of a flower can be fused into a tube, as also noted by Soderstrom & Ellis (1988).

cv. vittata McClure in Fl. Guatemala in Fieldiana Bot. 24 (2) (1955) 60.

B. striata Lodd. ex Lindl., Penny Cyclop. 3 (1835) 357; Hook. f. in Curtis Bot. Mag. 30 (1874), pl. 6079.

B. vulgaris [var.] *vittata* A. Riviere in A. & C. Riviere, Bull. Soc. Acclim. ser. III, 3 (1878) 640.

B. vulgaris var. *striata* (Lodd. ex Lindl.) Gamble in Ann. R. Bot. Gard. Calc. 7 (1896) 44; Holttum in Gard. Bull. Sing. 16 (1958) 63; Gilliland, Revised Flora of Malaya 3 (1971) 20.

This cultivar is indistinguishable from the typical state of the species, which has green culms, except that here the culms are yellow streaked green, or occasionally plain yellow. Reversion to the wholly green state is possible, and probably this is no more than a colour variant which has been selectively propagated. Variegation in monocots is quite well known and during the present study two forms of *Gigantochloa scortechinii* Gamble in the wild have been noted, one with white-striped leaves and the other with wholly orange-yellow culms instead of the typical form with plain green leaves and culms. Plants were established from rhizome offsets of these two forms at the nursery of the Forest Research Institute in Kepong, whereupon only the yellow-culmed form retained its colour difference. No doubt if this were selectively propagated we should also have a cultivar on hand. For

these reasons it is logical that McClure designated the correct rank for plants of *B. vulgaris* with culms yellow streaked green; they are certainly not a clear-cut natural subgrouping of the species.

DISTRIBUTION. Popular as an ornamental throughout the tropics and subtropics. This is commonly called "Buloh Gading", "Aur Gading" or "Buloh Kuning" in Malay.

PENINSULAR MALAYSIA. Perak: Grik, *Hamid* KEP 6426 (KEP, SING), 6428 (SING). Selangor: Petaling Jaya, Taman Jaya, *Wong & Mustapa* FRI 28985 (A, K, KEP, L, SAN, SAR, SING).

cv. wamin McClure, The Bamboos (1966) 162.

B. vulgaris f. *waminii* T.H. Wen in J. Bamboo Res. 4 (2) (1985) 16.

Another popularly cultivated "Buddha's Belly Bamboo," this grows to only about three meters tall and has internodes which are basally inflated. It was originally listed under the Burmese vernacular name "Wamin" by Brandis (1906, p. 685).

DISTRIBUTION. Commonly planted as an ornamental in the South-east Asian and New World tropics and subtropics.

9. Bambusa sp.

Holttum in Gard. Bull. Sing. 16 (1958) 71.

Clumps to *c.* 2.5-3 m high. Culms erect, arching out very slightly; internodes green, without white wax, appressed dark-hairy at the top, *c.* 1-1.5 cm diameter. Culm sheaths black-hairy on the back, auricles small lobes *c.* 2-3 mm high, with bristles 2-3 mm long on the edge; ligule a low rim 2 mm high, subentire to minutely hairy on the edge; blade triangular, erect. Leaf blades 5-14 cm X 1-1.5 cm, glabrous on both sides, green with white longitudinal stripes.

SINGAPORE. Botanic Gardens, Lawn J, *Holttum* SFN 41025 (K, L, US).

This is evidently another common cultivar, but we do not know of which species or if it has a name. The dark-hairy upper part of internodes and more pronounced culm-sheath auricles distinguish it from *B. multiplex*. It has not been collected in flower, and it has not been possible to name it in the herbaria of southeast Asia, Kew or Leiden. It is evidently not of Indian or Malesian origin, and Holttum (1958) speculated a Chinese origin for it. Prof. Wenyue Hsiung of the Nanjing Forestry University was shown some live plants in 1987 and did not recognise it as a Chinese bamboo. There seems to be nothing resembling it among bamboos with variegated leaves from China, Hong Kong or Japan (see also But *et al.* 1985, Okamura & Tanaka 1986). In Peninsular Malaysia and Singapore it is referred to as "Bambusa variegata" in horticultural circles.

Excluded Species

Bambusa klossii Ridl., Fl. Malay Pen. 5 (1925) 259. Type: Malay Peninsula, Kedah, Kedah Peak, *Robinson & Kloss* 6069 (K) = *Dendrocalamus hirtellus* Ridley. Holttum (1958) included *Robinson & Kloss* 6109 under *B. klossii*, this is here reidentified as *Maclurochloa montana* (Ridl.) Wong - see Wong (1993).

Bambusa magica Ridl. = *Holttumochloa magica* (Ridl.) Wong; see Wong (1993).

Bambusa montana (Ridl.) Holtt. (based on *Dinochloa montana* Ridl.) = *Maclurochloa montana* (Ridl.) Wong; see Wong (1993).

Bambusa pauciflora Ridl. = *Maclurochloa montana* (Ridl.) Wong.

Bambusa ridleyi Gamble = *Soejatmia ridleyi* (Gamble) Wong; see Wong (1993).

Bambusa wrayi Stapf = *Kinabaluchloa wrayi* (Stapf) Wong; see Wong (1993).

Summary of taxonomic changes

An enumeration of taxonomic changes to the concept of *Bambusa* embodied in the revision of Holttum (1958) is provided in Table 3.

Table 3. A summary of taxonomic changes to the concept of *Bambusa* in Holttum (1958). For authorities, see Systematic Enumeration.

Species enumerated under *Bambusa* by Holttum (1958)	Status of names used by Holttum (1958)	Accepted identities
Bambusa arundinacea	synonym	*Bambusa bambos*
B. blumeana	no change	*B. blumeana*
B. burmanica	incorrectly applied	new species: *B. farinacea*
B. heterostachya	no change	*B. heterostachya*
B. glaucescens	synonym	*B. multiplex*
B. ventricosa	synonym	B. tuldoides

(continued next page)

(Table 3 continued)

B. vulgaris	no change	*B. vulgaris*
B. sp. indet	insufficient material for identification	*B.* sp. indet.
-	-	new species: *B. laxa*
B. klossii (a) *B. klossii Ridl.*	synonym	*Dendrocalamus hirtellus*
(b) *B. klossii sensu* Holttum, *pro parte*: Robinson & Kloss 6109	synonym	*Maclurochloa montana*
B. montana	basionym of type of distinct genus *Maclurochloa*	*Maclurochloa montana*
B. pauciflora	synonym	*Maclurochloa montana*
B. magica	basionym of type of distinct genus *Holttumochloa*	*Holttumochloa magica*
B. ridleyi	basionym of type of distinct genus *Soejatmia*	*Soejatmia ridleyi*
B. wrayi	basionym of type of distinct genus *Kinabaluchloa*	*Kinabaluchloa wrayi*

With the present understanding, the following conclusions can be made:

(1) *Bambusa* in Malaya is represented by nine species as follows:
one undisputedly native species, *B. farinacea*;
two species that can be found only in cultivation and first described from Malaya (*B. heterostachya* and *B. laxa*);
five species known only in cultivation and first described from elsewhere than Malaya; and
one species known only in cultivation and as yet unidentifiable for lack of good material.

(2) other species placed or maintained in *Bambusa* by Holttum (1958), not without hesitation, have been shown to belong to four distinct genera (Wong 1993). Three of these genera (*Holttumochloa, Maclurochloa* and *Soejatmia*) appear from present inventory to be endemic to Malaya while the fourth (*Kinabaluchloa*) is represented by one Malayan species and one Bornean species.

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SANDAKANIA 3 (1993): 43-47

Developmental heterophylly in a Bornean rheophytic tree, *Syzygium tetragonocladum* (*Myrtaceae*)

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Summary. Developmental heterophylly, or the production of different forms of leaf in the course of a plant's development, is reported for *Syzygium tetragonocladum* Merr. & Perry (synonym: *S. rejangense* Merr. & Perry), a tree restricted to riverbanks in north and west Borneo. In this species, the leaves of juvenile plants are very narrow in comparison to those of adult trees, and possibly reflect a rheophytic adaptation to river currents.

Developmental heterophylly is not uncommon among tropical plants, and in fact in many tropical plant species juvenile leaves tend to be larger than or otherwise markedly different from the leaves of mature-phase individuals (Lee & Richards 1991). Well known examples of Bornean plants showing marked developmental heterophylly include trees such as *Scaphium macropodum* (Miq.) Beum. ex Heyne (Sterculiaceae) and *Artocarpus* spp. (Moraceae), and many aroids which produce only tiny leaves along flagelliform (whip-like) stems which creep along the ground and that contrast with the larger normal leaves produced on climbing, more mature portions of the stem.

Among trees, the functional significance of juvenile leaves being differently shaped in comparison to mature-phase leaves is open to speculation, but perhaps a form-function relationship is obvious in the case of rheophytes, those plants which are naturally restricted to the beds, banks, and flood-zone of swift-flowing streams and rivers (van Steenis 1981). One such rheophyte with a marked developmental heterophylly is the tree *Dipterocarpus oblongifolius* Bl. ("neram" in Peninsular Malaysia or "ensurai" in the Iban language in west Borneo). This species is so characteristic of the rocky, swift-flowing broader segments of some rivers that Corner (1940, 1978) has called such stretches in the Malay Peninsula neram-rivers. van Steenis (1981) and Ashton (1982) have also described the linear-lanceolate leaves in juvenile plants of this species, which are much narrower than the adult leaves (a character that persists even when it is planted far from river banks). van Steenis (1981) discussed the rheomorphic nature of the juvenile leaves

of *D. oblongifolius*, which offer little resistance to water flow and thus survive flooding better. This contrasts with the majority of rheophytes documented that have generally narrow, willow-like leaves in both juvenile and mature stages. Species that experience the full rheophytic environment only as juveniles, including those with obvious morphological adaptations to rheophytism only in the juvenile phases, have been referred to as "paedorheophytes" (van Steenis 1981).

Here we report another example of such developmental heterophylly in the rheophytic tree, *Syzygium tetragonocladum* Merr. & Perr. (synonym: *S. rejangense* Merr. & Perry), a species not mentioned in the monograph on rheophytes by van Steenis (1981).

Distribution and habit

Syzygium tetragonocladum is a riverbank tree of many rivers in lowland north and west Borneo. It occurs in Sabah (where it has been recorded along rivers in the Kota Belud, Penampang and Papar areas in the west coast, in the Ranau area, and in the Sipitang, Keningau and Imbak - Maliau Basin areas of the Interior), Sarawak (along the Lawas and Rejang Rivers and their tributaries), and Brunei (along the Temburong River). I have observed trees of this species along the Temburong River in Brunei and the Kaiduan River (Papar District), and Imbak River (Tongod District) in Sabah.

Fig. 1. A branch of *Syzygium tetragonocladum* with mature-phase leaves displayed near to those of juvenile plants.

S. tetragonocladum trees are low-branching, reaching 13 m tall but often less, and produce branches that usually overhang the river bank. The twigs are characteristically 4-angled and narrowly 4-winged, although in juveniles the angling and wings are usually much less conspicuous. The leaves of seedlings and saplings, and also often those in the lowermost branches of mature trees, whether in shade or in full sunlight, are linear-lanceolate, reaching 10-20 cm long and only 1.5-2 cm broad; their bases are acute to slightly rounded and not obviously cordate. In contrast, the upper leaves of mature individuals are narrowly ovate to lanceolate, typically 15-35 cm long and 4.5-8 cm broad, and their bases are markedly cordate to auriculate (Figs. 1 & 2).

S. tetragonocladum grows on rocky as well as sandy clay banks of rivers and are not found away from river banks. On some clay banks smaller trees of this species are much branched basally, and extensive root systems running along the banks have been observed. Along the Temburong River in Brunei and the Imbak River in Sabah's Tongod District, young leafy shoots were observed to have developed along buried portions of recumbent basal branches 1-1.5 cm thick which sprouted new fine roots. In this manner a thicket of this species consisting of a single genetic individual could develop.

Along the Temburong River in Brunei, and the Kaiduan River in west Sabah, *S. tetragonocladum* was observed growing together with *Dipterocarpus oblongifolius*, the other rheophytic tree that also shows heterophylly and juvenile adaptation to rheophytism.

Fig. 2. Close up of broad mature-phase leaves and linear-lanceolate juvenile leaves of *Syzygium tetragonocladum*.

Discussion

Other rheophytic species of *Syzygium* that are known and documented include the Bornean *S. neriifolium* Becc. and *S. medium* (Korth.) Merr. & Perry (van Steenis 1981). The adaptation to rheophytism presumably must involve more than just an ability to survive flooding by having narrow willow-like leaves, whether in the juvenile or adult stages (van Steenis 1981; Wong, Saw & Kochummen 1987; Dransfield 1992). Perhaps even more intriguing is the ecophysiological plasticity that, while permitting them to tolerate conditions of high moisture and periodic inundation, as well as much exposure and light, does not ensure their dispersal and establishment farther from river banks. Although the fruits of *Syzygium* spp. may well be dispersed by water, their fleshy or pulpy nature and frequently substantial size, and overall palatability to mammals (foresters and field botanists can testify to this) make it unlikely that restriction to a riverine habitat is simply a function of fruit dispersal.

In both *Dipterocarpus oblongifolius* and *Syzygium tetragonocladum*, the seedlings establish below the flood-line on river banks. Thus, although the adult-phase leaves are borne on branches normally beyond the reach of flood waters, the seedling and sapling leaves will frequently be subject to being swept by swift water currrents. The constancy of such leaf form in juvenile individuals establishing in both shade and full sunlight speaks against light intensity or quality exerting any simple physiological control of this difference in leaf form between young and mature plants. It remains that selection for a narrow-leafed condition in juvenile plants of rheophytic trees is related to the selection for those individuals with juveniles able to escape excessive physical damage to their leaves by water currents and, concurrently, maintain enough photosynthetic gain for growth. This appears to contrast with heterophyllous development in some forest species (such as aroids) where the developmental progression from juvenile to adult leaf form seems correlated with the plant growing out of a low-light environment into a situation with higher light intensity and a different spectral quality (Lee & Richards 1991).

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SANDAKANIA 3 (1993): 49-59

Five new *Anisophyllea* species (*Rhizophoraceae*) from Borneo, and the reinstatement of *A. rhomboidea* Jack

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Summary. Five new species of *Anisophyllea* are described from Borneo: *A. chartacea*, *A. glandulifolia*, *A. globosa*, *A. impressinervia*, and *A. nitida*. *A. rhomboidea* Baillon, previously confused with *A. disticha* (Jack) Baillon, is reinstated as a distinct species.

The genus *Anisophyllea* was revised for Malesia by Hou (1958), with two subsequent annotations (Hou 1972, 1978). Hou recognised four species in Borneo: *A. beccariana*, *A. disticha*, *A. ferruginea*, and *A. grandis*. The last mentioned species was recorded (Hou 1978) as new to Borneo through the collection *Anderson* S.4576 from Sarawak, but this specimen was considered by Ashton (1988) to represent *A. corneri*, with which we agree.

Since that last revision, the Bornean material has accumulated, and the present work, in conjunction with the Tree Flora of Sabah and Sarawak, recognises ten species for Sabah and Sarawak, five of which are considered new and described here. Among the species enumerated for the Flora is *A. rhomboidea* Baillon, which Hou (1958) considered a synonym of *A. disticha* (Jack) Baillon, but which is here regarded as distinct.

A. rhomboidea and *A. disticha*

A. disticha is a common small tree distributed throughout the Malay Peninsula, Sumatra and Borneo. Although this species and *A. rhomboidea* are both distinguishable from other species known in having leaves of two sizes along the branches and in the trapezoid shape of the larger leaves, there are important differences between them which are consistent.

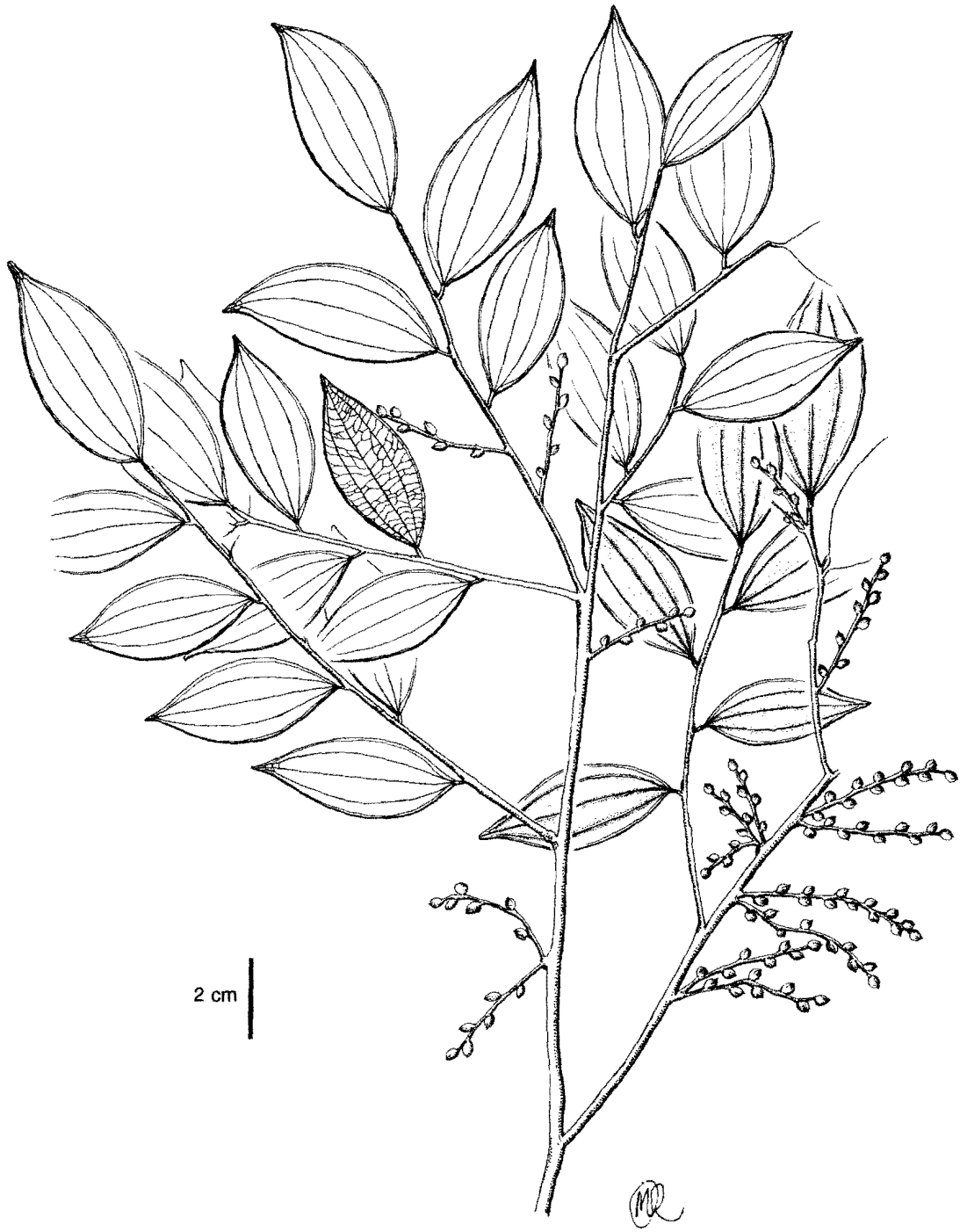

Fig. 1. *Anisophyllea chartacea*: leafy flowering branch. From *Othman* S.29055.

In *A. disticha*, the larger leaves along branches are not longer than 3-3.5 cm, and the fruiting racemes are only 0.5-2.7 cm long. The racemes typically bear a solitary fruit. In *A. rhomboidea*, the larger leaves along branches are typically 5-10 cm long, and the fruiting racemes are longer, measuring 4-10 cm long, and typically bear several fruits on each infructescence. There are no intermediates that could be used to interpret the character states in the two species as extremes of variability. The differences are set out in the key to species given below.

As such, *A. rhomboidea* is considered a distinct species, and thus far appears to be restricted in occurrence to Sarawak's 1st Division.

The new species

Anisophyllea chartacea *Madani*, **sp. nov.** *A. corneri Ding Hou affinis sed foliis chartaceis tantum 5.5-7 cm longis, venulis in pagina inferiore foliorum reticulationem laxam formantibus non distinct tessellatis, floribus sessilibus differt. Typus: Othman S.29055, Sarawak, 3rd Division, Ng. Mengiong, Ulu Balleh, Kapit (holotypus KEP; isotypi A, BO, K, L, MEL, SAR, SING).* Fig. 1.

Medium-sized tree, to 33 m tall, 76 cm diameter. Leaves elliptic, 5.5-7 cm long, not broader than 3.5 cm, chartaceous, glabrous, the upper surface drying dull or matt; apex acuminate, base acute; lateral veins all arising from the very base of the leaf blade, sunken on the upper surface; fine veins on the lower surface forming a loose reticulation and not distinctly tessellated. Inflorescence 1.5-5 cm long; flowers sessile. Fruits not known.

Known only from the type, collected from lowland mixed dipterocarp forest; probably endemic to Sarawak.

Anisophyllea glandulifolia *Madani*, **sp. nov.** *A. chartaceae affinis sed pagina inferiore foliorum glandibus parvis sed conspicuis obsita, costa cum venis lateralibus in pagina superiore foliorum plana non impressa, inflorescentia cyma brevi usque 1 cm longa differt. Typus: Fedilis SAN 128033, Sabah, Pensiangan, Ponontomon (holotypus SAN).* Fig. 2.

Shrub or small tree. Leaves elliptic to oblong, 10-18 cm long, 3.5-5.5 cm wide, chartaceous, glabrous, upper surface drying dull or matt, lower surface with many scattered tiny but conspicuous dot-glands; apex acuminate, base acute to obtuse; lateral veins all arising from the very base of the leaf blade, flat on the upper surface; fine veins on the lower surface forming a loose reticulation and not distinctly tessellated. Inflorescence a short cyme less than 1 cm long; flowers with short 1-2-mm-long stalks. Fruits not known.

SPECIMENS EXAMINED - BORNEO. SABAH: Pensiangan, Ponontomon, *Fedilis* SAN 128033 (holotype SAN); Tenom, Tomani, *George Majawat* SAN 130794 (SAN).

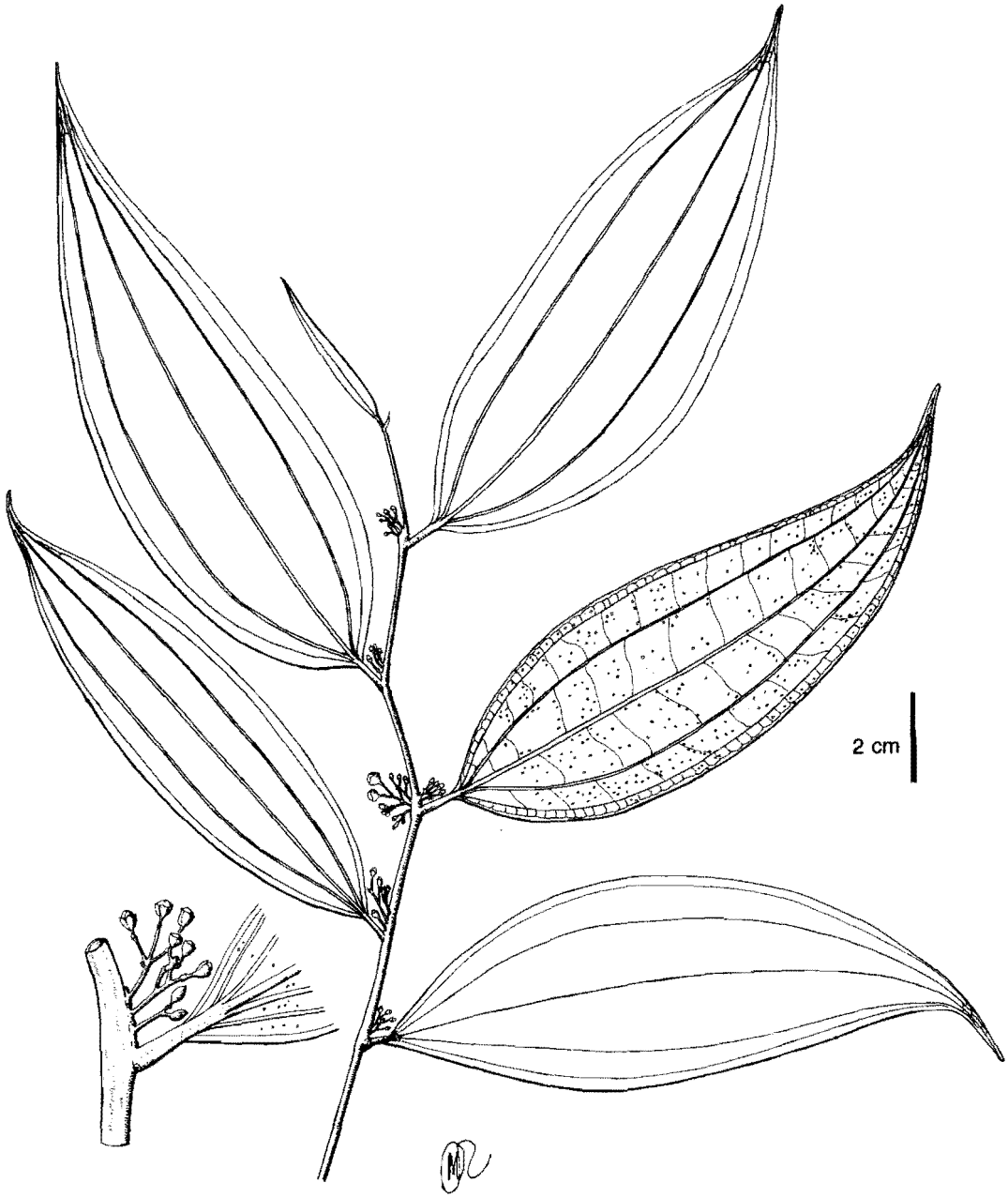

Fig. 2. *Anisophyllea glandulifolia*: flowering leafy branch, inset showing inflorescences developing from serial axillary buds. From *Fedilis* SAN 128033.

A rare species, possibly endemic to Sabah, collected from lowland swamp and also dipterocarp forest.

Anisophyllea globosa *Madani,* **sp. nov.** *A. beccarianae Baillon affinis sed foliis chartaceis costa venis lateralibus crassitudine simili (in A. beccariana foliis coriaceis costa venis lateralibus conspicue crassiore), fructo maturo globoso (non ellipsoideo) differt. Typus: Shea & Minjulu SAN 76131, Sabah, Kudat, Bengkoka Peninsula, about 1.3 km northeast of Kg. Bawing (holotypus SAN; isotypi K, L).* Fig. 3.

Small tree to 10 m tall, 9 cm diameter; outer bark smooth, greyish; inner bark red-brown; sapwood white. Leaves narrowly elliptic, 5-7 cm long, 1.5-2.5 cm wide, chartaceous, glabrous, apex acute, base acute to obtuse; lateral veins similar in thickness to the midrib, flat or raised on the upper surface, one or both pairs arising from the midrib away from the base of the blade; fine veins indistinct or forming a loose network. Fruit globose, to 5.5 cm across, surface irregularly bumpy when dried; seed 1, to 1 cm diameter.

Known only from the type, probably endemic to Sabah.

Anisophyllea impressinervia *Madani,* **sp. nov.** *A. beccarianae Baillon affinis sed omnibus venis (venulis minutis inclusis) in paginam superiorem impressis, fructu maturo globoso differt. Typus: Shea & Minjulu SAN 76094, Sabah, Kudat, Bengkoka Peninsula, about 1.3 km northeast of Kg. Bawing (holotypus SAN; isotypi A, K, L, SAR, SING).* Fig. 4.

Medium-sized tree to 26 m tall, 28 cm diameter; outer bark grey, rough, cracking irregularly; inner bark red to yellowish orange; sapwood pale yellow. Leaves narrowly elliptic to ovate, about 4.5 cm long, 2-3 cm wide, thickly coriaceous, glabrous; apex acute and blunt, base rounded to acute; lateral veins on upper surface sunken, one or both pairs arising from the midrib away from the base of the blade; fine veins forming a loose network, slightly sunken on upper surface. Fruit globose, about 4.5-5 cm across, irregularly lumpy on the surface when dried; seed 1, about 1.5 cm long, 1.3 cm wide.

Known only from the type, collected from a forested gully between two cleared lowland sites; probably endemic to Sabah.

Anisophyllea nitida *Madani,* **sp. nov.** *A. corneri Ding Hou affinis sed foliis valde coriaceis tantum 5.5-10 cm longis pagina superiore in sicco nitida, venulis in pagina inferiore foliorum reticulationem laxam formantibus non distinct tessellatis, axibus infructescentium pilis brevibus purpureo-brunneis persistenter et dense obtectis differt. Typus: Ampuria SAN 40249, Sabah, Kuala Penyu, near Bundu school, 7.8 km road to Kerukan (holotypus SAN).* Fig. 5.

Medium-sized tree to 23 m tall, 22 cm diameter; bark smooth to scaly, pale greyish brown. Leaves broadly elliptic ovate or nearly orbicular, 5.5-10 cm long, 4-6 cm wide, thickly

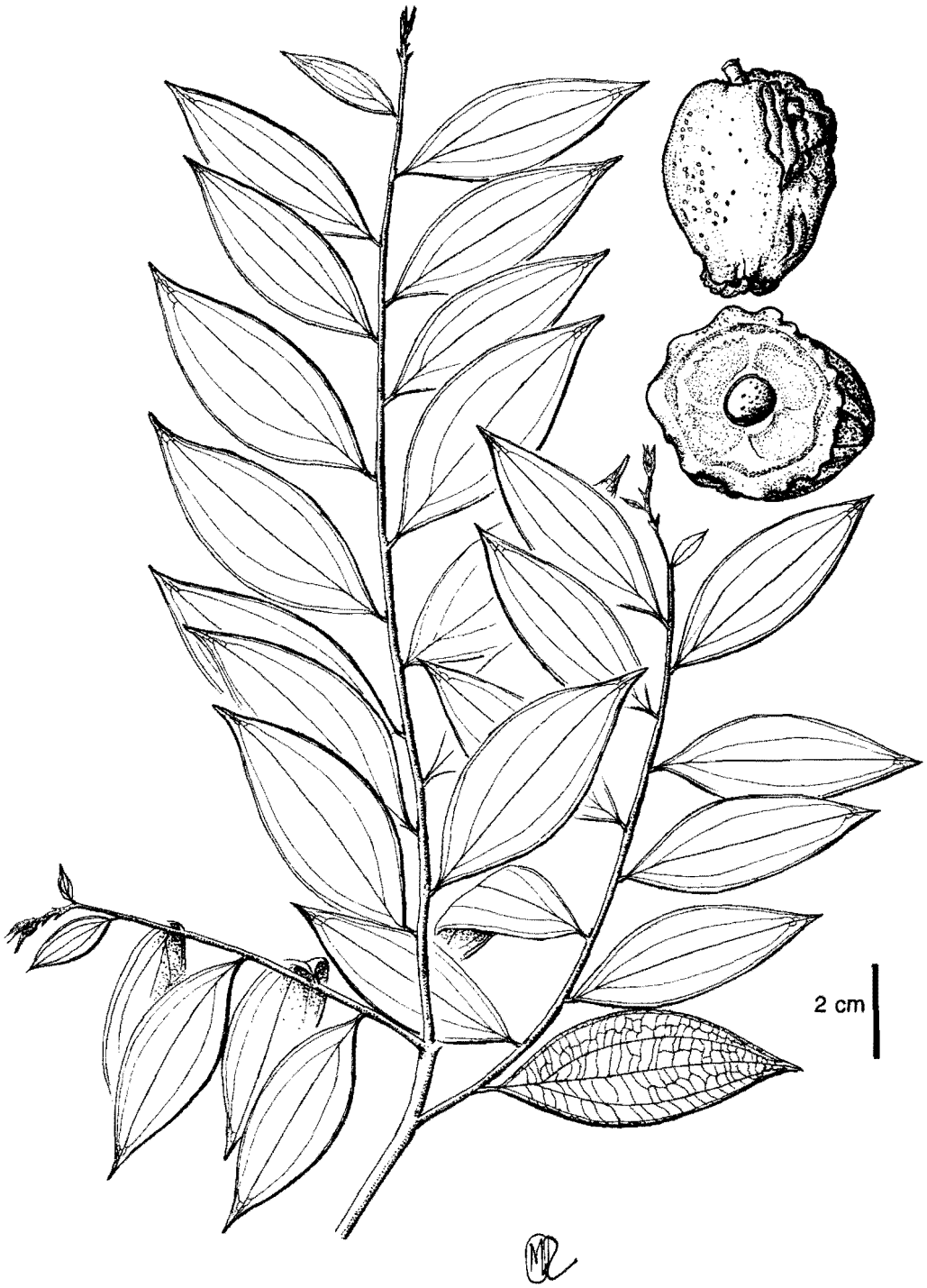

Fig. 3. *Anisophyllea globosa*: leafy branch, insets showing a fruit and a transverse section through a fruit. From *Shea & Minjulu* SAN 76131.

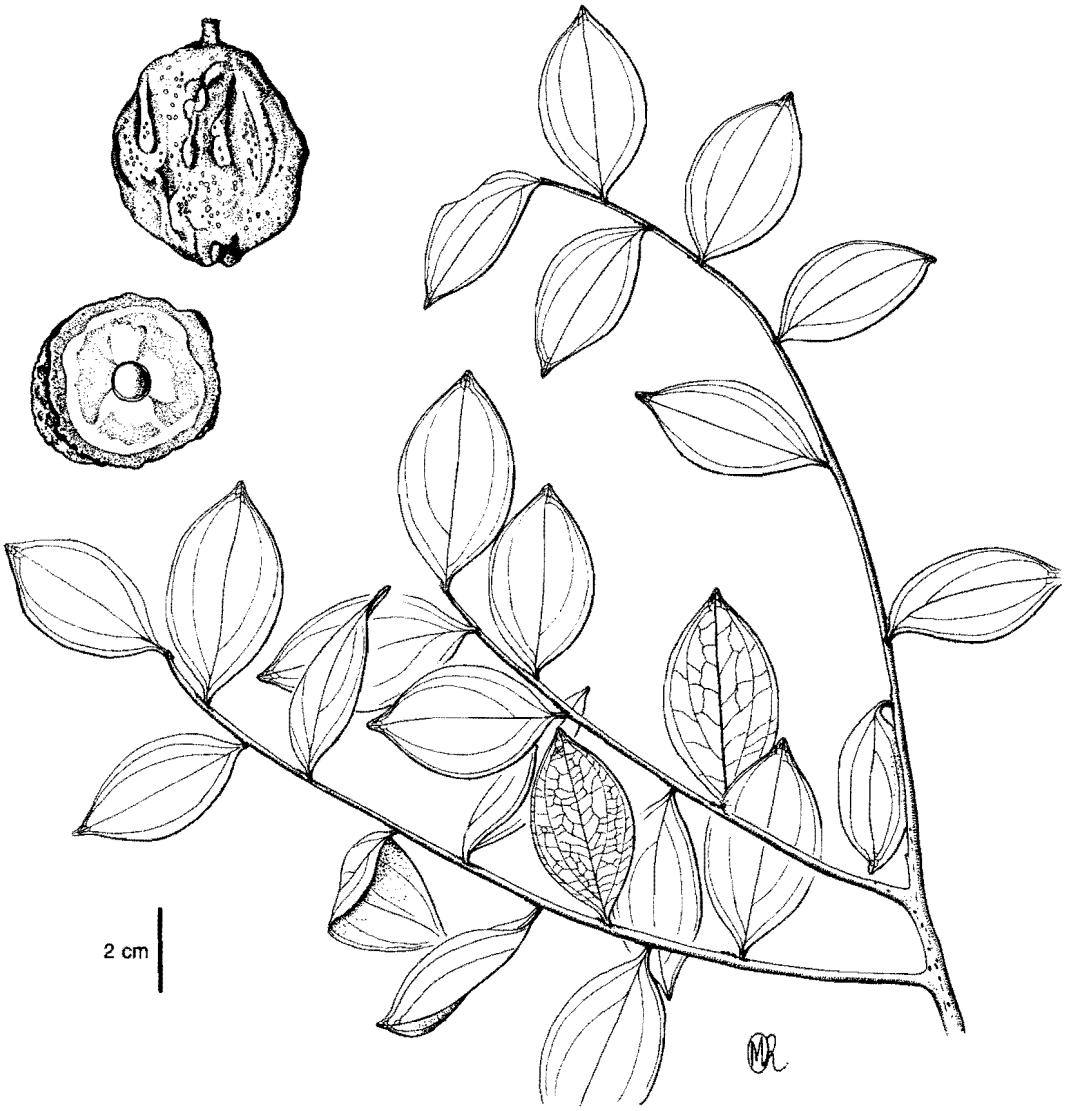

Fig. 4. *Anisophyllea impressinervia*: leafy branch, insets showing a fruit and a transverse section through a fruit. From *Shea & Minjulu* SAN 76094.

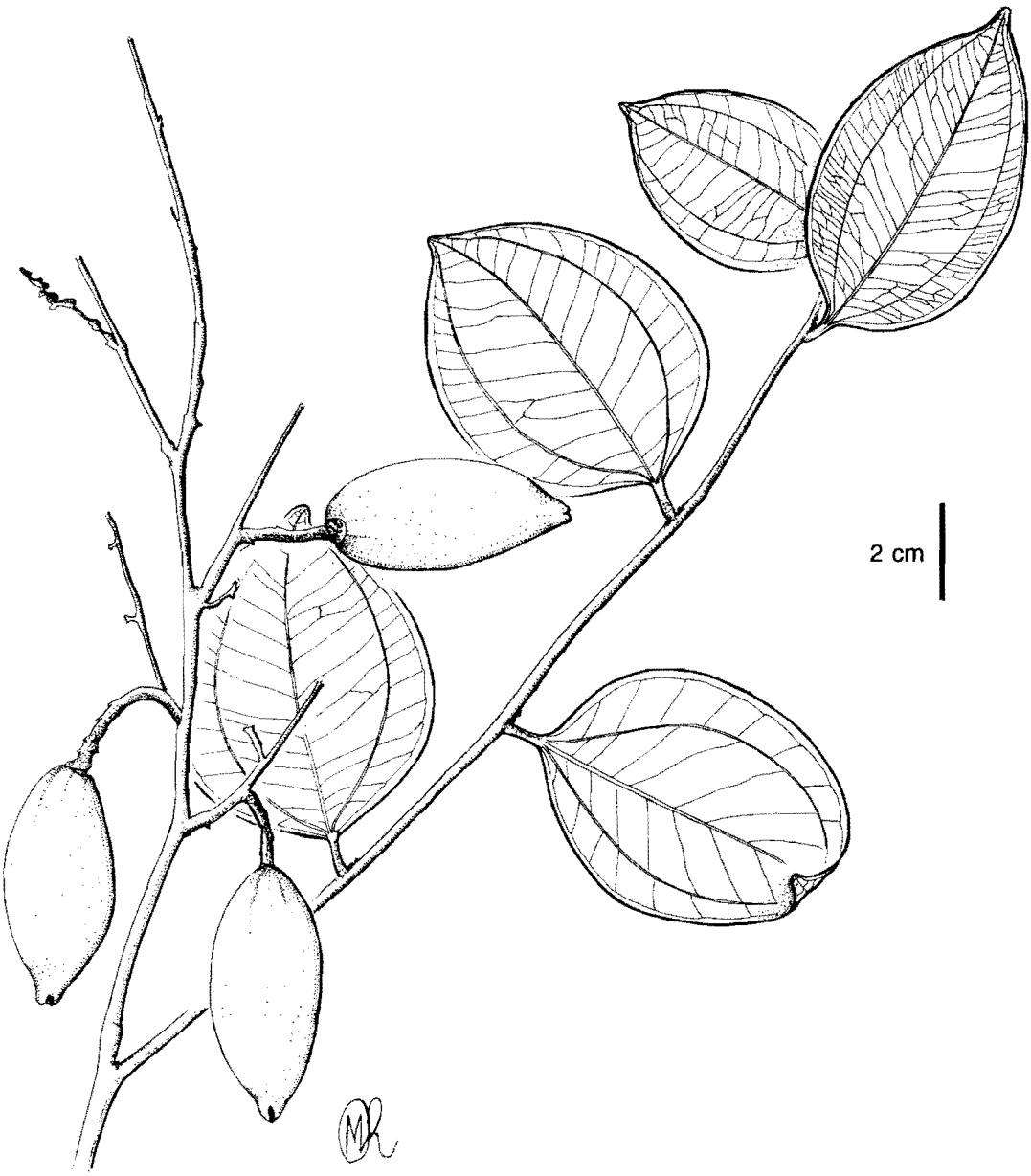

Fig. 5. *Anisophyllea nitida*: fruiting leafy branch. From *Ampuria* SAN 40249.

coriaceous, glabrous, drying glossy on the upper surface; apex acute to abruptly short-caudate, base obtuse, quite rounded; lateral veins all arising from the very base of the leaf blade, raised on the upper surface; fine veins on the lower surface forming a loose reticulation and not distinctly tessellated, slightly raised on both surfaces. Infructescence axis 1.5-2.5 cm long, 4-5 mm thick, persistently covered with short purple-brown hairs; fruit broadly ellipsoid, blunt at both ends, slightly mammilate at apex, about 5 cm long, 2.5 cm across, greenish to yellowish.

SPECIMENS EXAMINED - BORNEO. SABAH: Kuala Penyu, near Bundu school, 7.8 km road to Kerukan, *Ampuria* SAN 40249 (holotype SAN). SARAWAK: Niah Forest Reserve, Coupe 2, *Anderson* S.31660 (A, K, L, SAN, SAR, SING).

Apparently a species of disturbed or secondary lowland forest, possibly restricted to the southwest Sabah and north Sarawak area.

Key to Sabah and Sarawak *Anisophyllea*

1a. Leaves along branches of two markedly different sizes, the larger ones trapezoid.

2a. Larger leaves not longer than 3-3.5 cm. Fruiting racemes 0.5-2.7 cm long, typically bearing a solitary fruit ..... *A. disticha* (Jack) Baillon

2b. Larger leaves typically 5-10 cm long. Fruiting racemes 4-10 cm long, typically bearing several fruits ..... *A. rhomboidea* Baillon

1b. Leaves of only one type, basically elliptic or ovate.

3a. Lateral veins all arising from the very base of the leaf blade.

4a. Fine veins on the lower leaf surface conspicuously raised, forming a finely tessellated pattern ..... *A. corneri* Hou

4b. Fine veins on the lower leaf surface not conspicuously raised, forming a loose reticulation and not distinctly tessellated.

5a. Leaves coriaceous, broadly ovate; upper leaf surface drying glossy, the lateral veins raised. Inflorescence axes persistently densely covered with velvety purple-brown hairs ..... *A. nitida*, sp. nov.

5b. Leaves chartaceous, elliptic; upper leaf surface drying dull or matt, the lateral veins sunken or flat. Inflorescence axes subglabrous.

6a. Leaves not longer than 8 cm. Lower leaf surface without any conspicuous glands. Midrib and lateral veins

on the upper leaf surface sunken. Inflorescence an elongate raceme 1.5-5 cm long ..... *A. chartacea*, sp. nov.

6b. Leaves 10-18 cm long. Lower leaf surface with many scattered tiny but conspicuous dot-glands. Midrib and lateral veins on the upper leaf surface flat. Inflorescence a short cyme not longer than 1 cm ..... *A. glandulifolia*, sp. nov.

3b. One or both pairs of lateral veins arising from the leaf midrib away from the base of the blade.

7a. Leaves rusty hairy on lower surface, the remains of the hairs always visible with 10X magnification, even on old leaves. Fine veins on lower leaf surface finely tessellate ..... *A. ferruginea* Hou

7b. Leaves glabrous. Fine veins on lower leaf surface indistinct or forming only a loose network.

8a. All veins, including the fine veins, on upper leaf surface sunken. (Mature fruit globose.) ..... *A. impressinervia*, sp. nov.

8b. Veins flat or raised on upper leaf surface.

9a. Leaves thinly coriaceous; apex rather abruptly caudate. Midrib conspicuously thicker than lateral veins. Mature fruit ellipsoid ..... *A. beccariana* Baillon

9b. Leaves chartaceous; apex acute. Midrib similar to lateral veins in thickness. Mature fruit globose ..... *A. globosa*, sp. nov.

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A quantitative description of shoot development in *Calamus caesius* (*Palmae : Calamoideae*)

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Summary. The morphology and growth in the apical region of 15 stems of *Calamus caesius* Bl. was studied over fifty two days in a 15-year-old plot. Morphological study showed that the apical meristem was hidden within leaf sheaths about 79 cm below the knee of the youngest expanded leaf. Growth measurements showed that the internode whose distal end bears the youngest leaf with expanded pinnae, but not the older ones, was still expanding, and was about 16% shorter than its mature length. Leaf production averaged 1 per 24 days (15.2 leaves per year). Estimated longevity of expanded leaves was about 4.1 years. These measurements provide the basis for a dynamic model of growth.

For the estimation of the yield in a rattan stand, Lee (in press) suggests several models which are based on mathematical relationships between the number of internodes and the yield parameters of interest to the rattan growers, *i.e.* the length, volume and weight of the stem. These models assume constant or gradually increasing internode length from stem base to tip. However, Fisher (1978) has shown that the last three internodes, whose distal ends bear a frond with expanded pinnae, are still elongating in *Calamus manan* Miq. and *Daemonorops angustifolia* (Griff.) Mart. This feature of rattan shoot development has implications for the practical use of the models proposed, especially in young plants. The present study thus aims to determine the extent of elongation of these developing internodes compared with the eventual length when they have fully elongated, for a widely cultivated small-diameter species, *Calamus caesius* Bl.

The temporal component of this study also permits the estimation of the rate of leaf production, an essential component of any dynamic model of rattan growth. The rate of growth over the lifetime of a stem can be estimated by counting the number of internodes, and dividing by stem age (mean annual increment). For a stem of unknown age the time between the production of successive leaves (the plastochrone) provides a means to estimate current growth rate. Therefore this study also attempts to estimate the plastochrone for this species. The longevity of the leaves of *C. caesius* may also be estimated from the number of living fronds on the stem and the plastochrone.

Materials and methods

Fifteen *C. caesius* stems from four 15-year-old clumps growing on alluvial soil in the arboretum of the Sabah Forestry Department's Forest Research Centre at Sepilok were tagged and their length to the end of the youngest visible leaf sheath was measured (Table 1). The stems chosen have crowns exposed to a rather narrow range of light intensity, *i.e.* visually estimated to be 30-50% of the open. The leaf production and

Table 1. *Calamus caesius* stems selected for investigation of immature internodes in the Arboretum of the Forest Research Centre, Sepilok.

Clump	Sex	Stem number	Stem length (m) at beginning of study
A	Male	1	23
		2	27
B	Male	3	20
		4	21
		5	21
C	Male	6	4
		7	4
		8	12
		9	21
D	Female	10	10
		11	14
		12	14
		13	16
		14	26
		15	27

the length of the four youngest internodes whose distal ends bear fronds with expanded pinnae were recorded at 48-hour intervals over 24 days from 3rd to 27th May, 1993. Thereafter observations were carried out at weekly intervals for four more weeks. As it was impossible to measure the internode length directly without removing the several layers of overlapping leaf sheath (which would have adversely affected the growth of the stems), the internode length was determined indirectly by measuring the distance between the adjacent knees (swellings at the junction between petiole and leaf sheath, Fig.1) with a ruler. Internode diameter was not measured for the same reason. New internodes were recorded only when the pinnae of the fronds at their distal end had expanded. Precautions were taken to minimize disturbance to the stems being studied. However, in order to gain access to the stems and in the process of determining their initial length, disturbance was inevitable and some of the fronds below those being studied were cut.

To determine the reliability of the indirect method of measuring internode length, two stems, nos. 8 and 9 were destructively sampled. The lengths of the last 7 exposed leaf sheaths (leaves L_1-L_7, Fig. 1) and the corresponding internodes (I_1-I_7) were measured with a tape or a ruler to determine the position of the youngest fully elongated sheath. To confirm the basipetal elongation and maturation of leaf reported by Fisher (*op. cit.*), the lengths of the cirri, and the "leaf proper" (the leaflet-bearing rachis and petiole) were similarly measured. The lengths of the internodes, leaf sheaths, "leaf proper", and cirri shorter than 0.5 mm were not measured; and the internodes and leaves which were too small to count with the naked eye were examined under a dissecting microscope.

Results

The morphology of the apical region of a *C. caesius* stem is shown in Fig. 1. In what follows, the position of the various plant parts is defined with reference to the youngest leaf with expanded pinnae (L_1 in Fig. 1). Leaves younger than this are given zero or negative subscripts, and those older, positive.

Internode development is shown in Fig. 2 for stem 1. From this graph the average plastochrone for the stem was estimated to be 20 days during the period of observation. The plastochrone for the other 14 stems was similarly estimated. For the 15 stems investigated, the mean plastochrone as determined graphically in this manner was 24 days (95% confidence interval: 22-26 days). A plot of the plastochrone against the initial stem length (Fig. 3) shows a trend of decrease in the plastochrone with stem length. However, the correlation is not significant ($r = 0.45$, $df = 14$, $p = 0.1$). An analysis of variance, with the initial stem length as the covariate, shows that the plastochrone did not differ among the four clumps investigated.

Fig. 2 also shows that in *C. caesius*, only the last internode (I_1) whose distal end bears a frond with expanded pinnae is still extending. On average, this internode is 84% (95% confidence interval: 80-88%) of the eventual length when it is fully expanded.

The ontogeny of the leaf and internode was followed by examining them along the stem from the apical meristem to the fully expanded mature leaves of the two shoots, one of

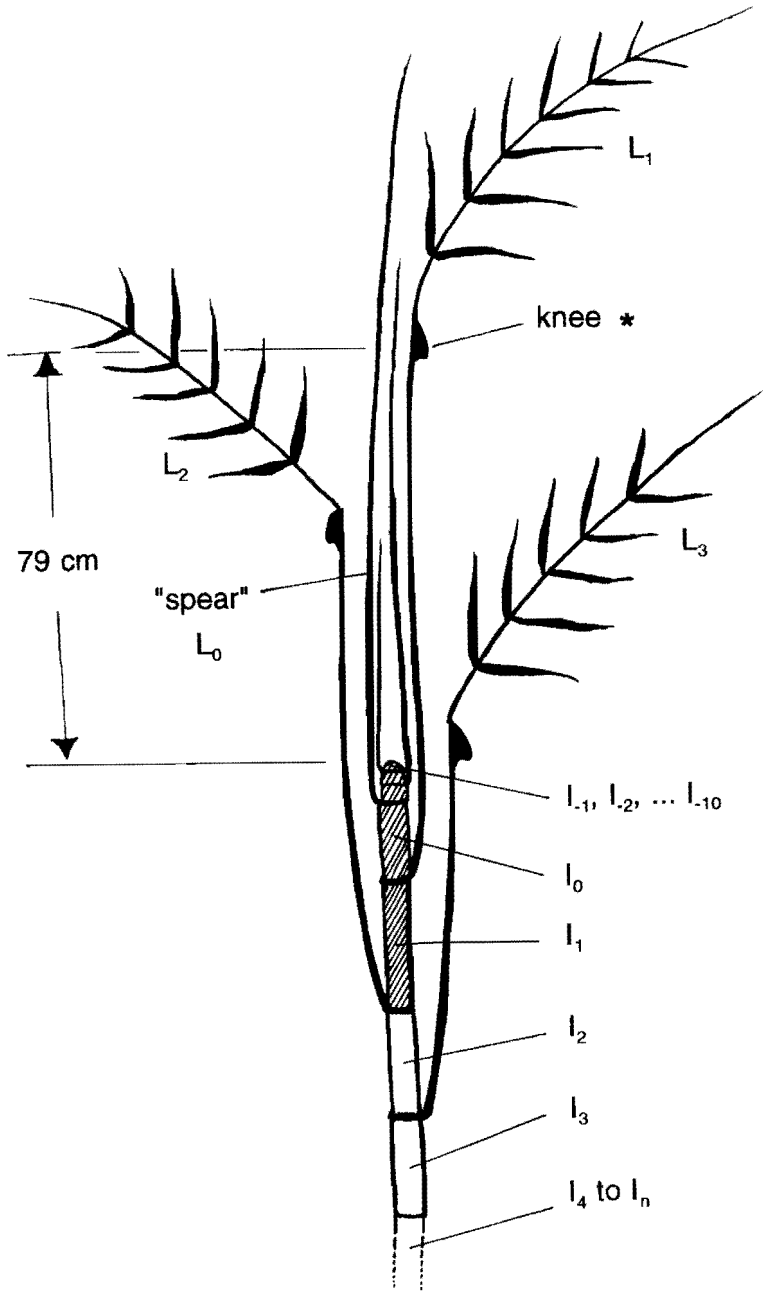

Fig 1. Diagram to show the morphology of the apical region of a *Calamus caesius* stem. Each unit comprises an internode (I), surmounted by a leaf (L), which itself is composed of a sheath (including a knee), the "leaf proper" (petiole and leaflet-bearing rachis), and a cirrus. Fully expanded internodes (I_2, I_3, I_4) are unshaded, immature internodes (I_1, I_0, I_{-1}...) are shaded.

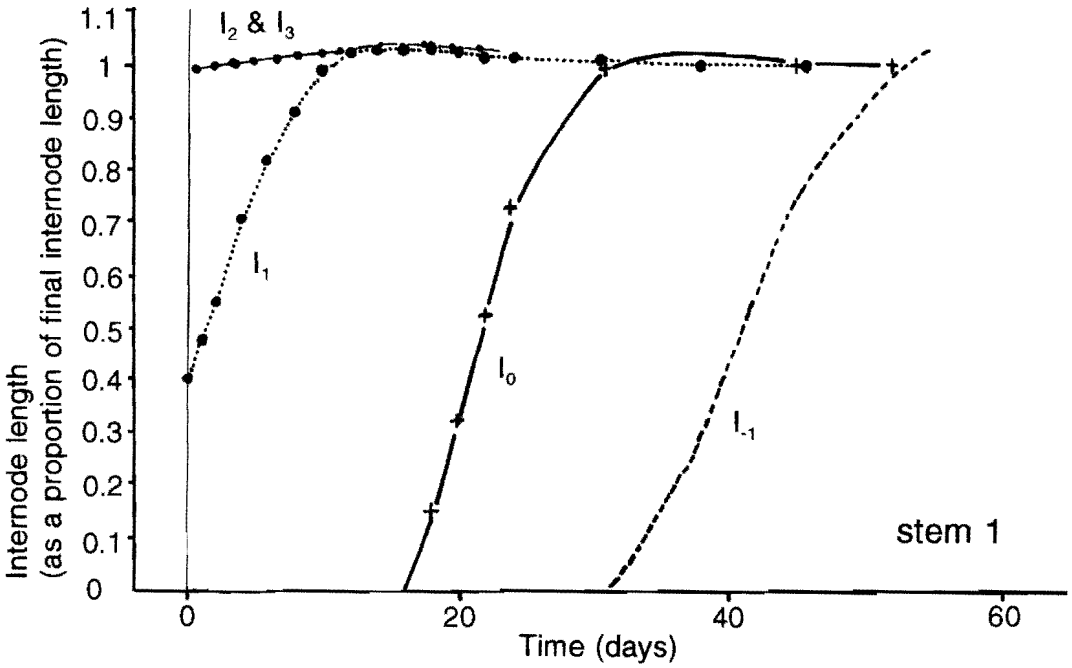

Fig. 2. Changes in internode length (proportion of final length) in the apical region of a *Calamus caesius* stem over 60 days. Internode I_1 (see Fig. 1) was partly expanded at the start of measurements, whilst I_2 and I_3 were already fully expanded. Internodes produced later had an average plastochrone of 20 days.

which (stem 9) is shown (Fig. 4). The mature length of the cirrus is first reached when the leaf (L_0) is one internode above the youngest exposed leaf sheath, while that of the "leaf proper", and the sheath, is first reached at the same time as the leaf sheath is exposed (L_1). This basipetal pattern of development of the leaf was also observed in the other shoot (stem 8) sampled. Expansion of the pinnae occurs and is completed in the leaf with the youngest exposed sheath (L_1). The youngest mature internode (I_1) is that below the youngest mature leaf sheath. This shows that the indirect method for measurement of internode length, by measuring the distance between adjacent knees, is reliable even for the internode (I_1) whose distal end bears the youngest exposed sheath. Thus internode I_1 elongates and pushes the leaf at its distal end, L_1, which reaches its mature length earlier, and the younger internodes, together with the young fronds above them, up the shoot.

The total number of exposed living fronds, defined here as those with exposed pinnae, is 72 and 44 for stems 8 and 9, respectively, whereas that of unexposed fronds is 11 (L_0-L_{-10}) for both stems. An examination of 50 stems in a 13-year-old *C. caesius* plot at Kolapis, 65 km west of Sandakan, gives an average of 63 exposed living fronds (95%

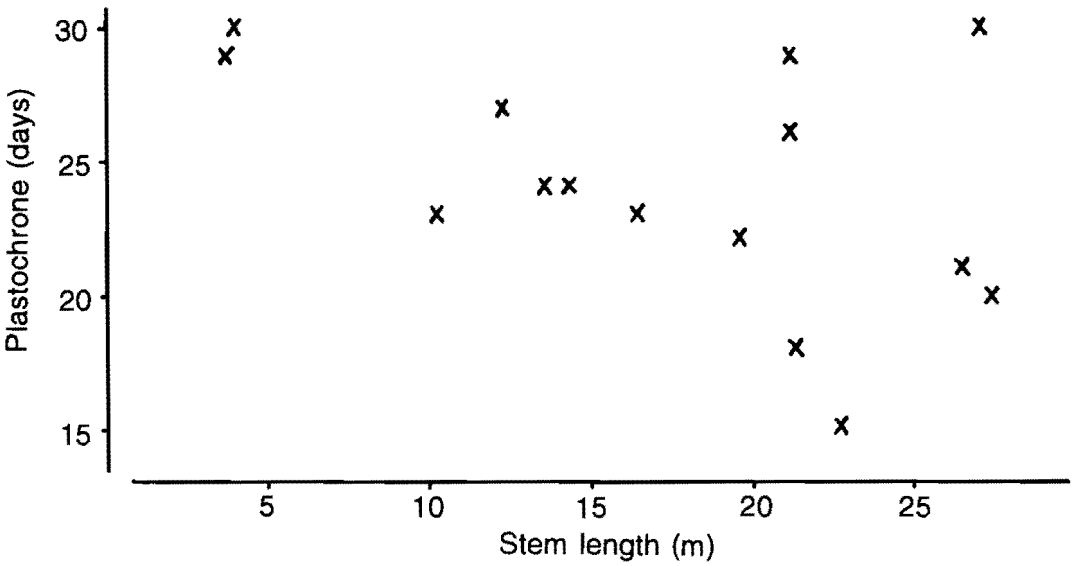

Fig. 3. The time between production of successive internodes (plastochrone, days) plotted against total stem length (m). The apparent correlation is not significant.

confidence interval: 58-67 fronds). Using the mean plastochrone of 24 days, this gives an estimated leaf life span of 1512 days (4.1 years). If the unexposed leaves (counting from the youngest visible primordium) are included, the average number of living leaves is 74, and the equivalent leaf life span is then 1776 days (4.9 years). The ratio of the number of unexposed leaves (including the spear leaves with unexpanded pinnae) to that of exposed leaves was found to be 0.17.

The apical dome, which includes the apical meristem, is defined here as the internodes shorter than 2 mm together with the leaves attached to their distal ends (Fig. 1). The domes of stems 8 and 9 were found to be 78 and 83 cm, respectively, below the distal end of the last exposed leaf sheath (L_1). A similar study on 50 stems in the plot at Kolapis gives an average value of 79 cm (95% confidence interval: 74-84 cm).

Discussion

The plastochrone of 24 days as determined for *C. caesius* in this study gives a growth rate of 15.2 internodes per stem per year. Assuming the average internode length to be

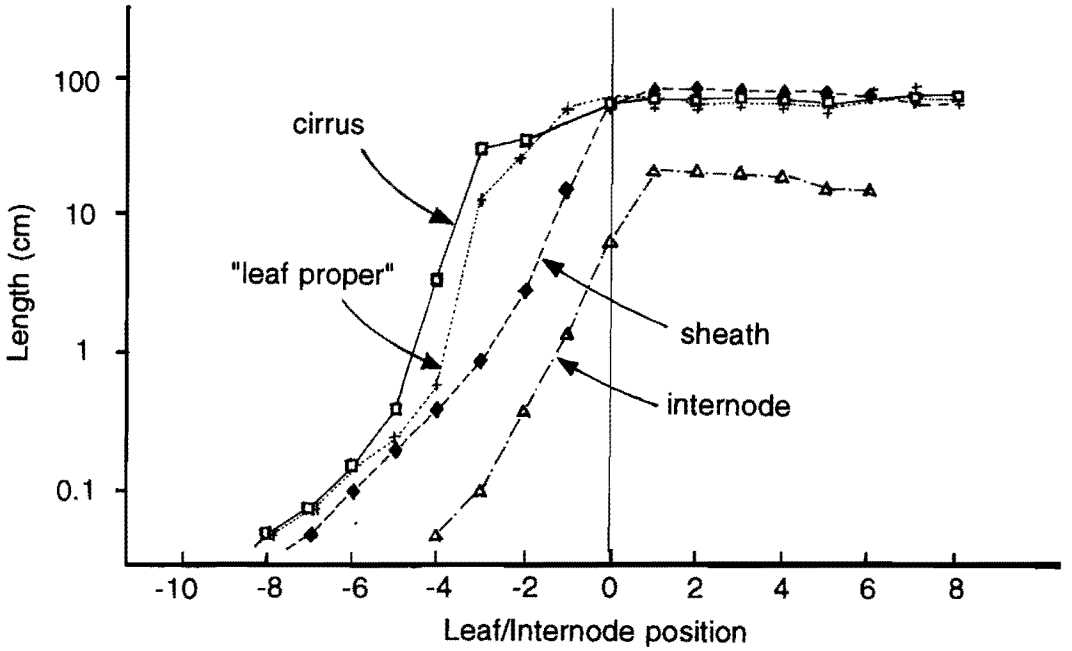

Fig. 4. Growth (cm, log scale) of cirrus, "leaf proper", sheath, and internode in relation to position on the stem (see Fig. 1), in the apical region of a *Calamus caesius* stem.

30 cm, which is the value obtained in this study, the stem growth rate is estimated to be 4.6 m/year. This rate is comparable to the figure of 4 m/year reported by Priasukmana (1986) for the same species but is lower than the 5 m/year and 7m/year reported by Priasukmana (*op.cit.*) and Shim (1989), respectively, for *C. trachycoleus.*

The result of this study shows that the internode (I_1) with the youngest exposed leaf sheath is immature and is, on average, 16% shorter than the fully expanded ones below. Thus, in the application of the yield models which assume constant or gradually increasing internode length from the stem base to tip, it is necessary to deduct 16% of the average internode length for the internode with the youngest exposed sheath in each stem. This study also shows that in the measurement of stem length of *C. caesius,* to determine the actual length of the stem from the base to the apical meristem, about 79 cm should be deducted from the "stem length" normally measured, *i.e.* the distance from the stem base to the distal end of the youngest exposed sheath or last visible knee (marked with an asterisk in Fig. 1).

This leaf sheath (L_1) thus encloses several younger leaves, as also shown by Fisher (1978) for other rattan species, and may protect the apical meristem against herbivores

and pathogens. This can at least partly explain why the apical meristem is seldom damaged in *C. caesius,* as in other rattan species. Protection of the apical meristem is very important in many monocots including rattans because the stem dies if its apex is destroyed.

The number of internodes (11) enclosed by the youngest exposed leaf sheath in *C. caesius* is smaller than that in the large-diameter rattans, *C. manan* and *Daemonorops angustifolia,* which have 15 and 19 internodes, respectively, but is about the same as that in *C. insignis* (Fisher 1978). It can thus be concluded that the apical dome of the small-diameter stem can accommodate fewer internodes than that of the large-diameter ones. The ratio of the number of unexposed leaves (including the spear leaves with unexpanded pinnae) to that of the exposed leaves (0.17), is much lower than the ratio of 1 reported for many palms (Corner 1966, Tomlinson 1990).

The life span (4.9 years) of the leaves of *C. caesius* estimated in this study is comparable to that of such palms as *Cocos nucifera* (5 years; Venkatanarayana 1957) and *Nypa fruticans* (5.5 years; Fong 1986), but is longer than that of other palms, *e.g. Pigafetta filaris* (1.0-1.2 years; Davis & Kuswara 1987) and *Elaeis guineensis* (3.5 years; Rees 1964). There is a large number of old and possibly slowly senescing fronds on *C. caesius* which may have a negative net assimilation rate and could therefore be a burden to the stem. This hypothesis can easily be tested with a suitable experiment such as a frond-pruning trial.

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