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SINGAPORE

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THE

GARDENS' BULLETIN

SINGAPORE

Vol. XXVI, Part I 30th December, 1972

The Lindsaeoid Ferns of the Old World VI
Continental Asia, Japan and Taiwan

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University of Utrecht, Netherlands

I. Introduction

The present revision deals with the Lindsaeoid ferns of Asia from India, Nepal, and Ceylon in the West to China, Japan with the Bonin, Volcano, and Ryukyu Islands, and Taiwan in the East; South it covers the parts of Further India not dealt with in Flora Malesiana, i.e., Thailand up to the border of Malaya.

Prior to the present author's work the knowledge of the taxonomy of the Lindsaeoid ferns of this region was very uneven. Modern and more or less comprehensive treatments were available for Japan (Tagawa 1937, 1938, supplemented by Iwatsuki 1961; Tagawa 1959; Ohwi 1965), China (Ching 1959), Hainan (Chun, Chang & Chen 1964), Burma (Dickason 1946), and Indo-China (Christensen & Tardieu-Blot 1936, Tardieu-Blot & Christensen 1939). No recent or no complete treatments were available for India and the neighbouring countries, Thailand, and Taiwan.

As shown by the synonymy and citations, the author's views on affinity, classification, and synonymy of the species agree well with those of Tagawa and of Iwatsuki but diverge more or less widely from those of Ohwi, Ching, Tardieu-Blot & Christensen, and Dickason. With regard to Ching's work the author was in a difficult position. It proved impossible to examine his holotypes, or photographs of them, and only in about half of the cases there were isotypes or paratypes available which permitted to establish the identity or affinity of the taxa, or published illustrations which to a certain extent served the same purpose. Judging from the cases where a definite conclusion about Ching's species could be reached, most of them are only extreme forms of other, previously described ones.

Due to the relative scarcity of Chinese material in herbaria outside China, except for a few well explored localities like Hong Kong, the citations for China are consequently very incomplete. For this reason, and because of the fluctuating borders between certain Chinese provinces and the difficulties encountered in attempts to locate all, often equally unstable names of places on maps, Chinese specimens are as a rule only cited by province, although it is realized that this does not give more than a very rough impression of the distribution of the taxa. For India it seems also likely that several species are more widely distributed than is shown by the specimens in the herbaria consulted by the author. It is hoped that additional data will some time in the future be furnished by local workers.

II. Phytogeographic Notes

The assortment of Lindsaeoid ferns in the area under consideration is very unevenly distributed. The main centre of the group being in Malesia, the continental areas of several more or less widespread Malesian species may be regarded as extensions of their Malesian ones, although there is no proof that at least in some cases the converse is not true. In the case of the taxa of section Synaphlebium with its strong representation in Malesia and a much weaker one on the continent this may be true, although some endemics do occur in the "continental" part (*L. venusta, L. malabarica, L. lobata* var. *hainaniana* and var. *epirotes*). Section Schizoloma, on the other hand, is so well represented in Continental Asia, especially in Further India and southern Japan, and most species are so much more variable there, that it seems to be the Malesian rather than the continental part of the area that is an extension, or a secondary centre at best. Of the 17 Asiatic species of this section 9 are confined to the continental part, 3 to Malesia (but one extending to Australia), and 5 are common to both areas.

There seems to be two regions in which chiefly Malesian species find their continental limit. One is in the Malay Peninsula (the exact limits are not known due to very incomplete exploration) where *L. integra, L. malayensis, L. napaea, L. parallelogramma*, and *L. doryphora* stop. Another is in the central and eastern Himalayas from Nepal to Assam, where the north-westernmost stations of *L. javanensis, L. orbiculata*, and *L. repens* are; the two last-named species extend to Ceylon, *L. orbiculata* even to S. India. There are very few examples of widespread Malesian species reaching further North on the East Asiatic islands but not on the continent: *Tapeinidium pinnatum* (S. Thailand, Philippines; Taiwan and Ryukyu) and *Lindsaea obtusa* (Malaya, Philippines; Taiwan). Three species extend far into China and Japan, viz. *Sphenomeris chinensis, Lindsaea odorata*, and *L. lucida*; it would be difficult to decide whether these are originally continental or insular species.

The only examples of notable disjunctions are *L. glandulifera* (Ceylon; East Java and Lesser Sunda Islands), *L. cambodgensis* (Ryukyu; S. Cambodia), and *Tapeinidium pinnatum* (S. India; Malesia, westernmost station in S. Thailand). *L. kawabatae* (Yakushima) and *L. dissectiformis* (Annam and Hainan) form a species pair.

Endemics occur in some concentration in Indo-China, sometimes extending into South China and/or Hainan (*L. austro-sinica, L. dissectiformis, L. annamensis, L. chingii*) and in Ceylon, sometimes extending into South India. (*L. caudata, L. venusta, L. schizophylla*). Most, if not all, other species described as endemics from South China by Ching are only doubtfully distinct.

The species that occur furthest from tropical Asia and form the outposts of the group as a whole are *L. odorata* (Cheju Dô and Honshu; Nepal) and *Sphenomeris chinensis* (south coast of Korea; mountains of Uttar Pradesh in NW. India). It is not surprising that these are widespread species, either of open habitats or euryoecious.

III. Taxonomy

KEY TO THE GENERA

(1) Sori on 1–3 (–4) vein-ends; indusium laterally entirely or largely adnate to the lamina; ultimate divisions never dimidiate; veins free; spores monolete.

  (2) Ultimate free divisions not of a linear- or cuneate-divaricate type, subentire to pinnatifid; sori on the lateral margin of the divisions or in their lobes; pluricellular filiform paraphyses usually (always ?) present .... 2. **Tapeinidium**

  (2) Ultimate free or nearly free divisions of a linear- or cuneate-divaricate type, with the sorus (sori) on their apical margin; paraphyses 2- or 3-celled, not usually found .... 1. **Sphenomeris**

(1) Sori on many vein-ends, or, if on 4 or fewer, the sides of the indusium free, or the pinnules dimidiate, or the veins anastomosing, or these characters combined; spores with few exceptions trilete .... 3. **Lindsaea**

N.B. In order to avoid redundance, those genera and their subordinate taxa dealt with in the author's treatment of the group in Flora Malesiana (1971) are not described in the following.

1. Sphenomeris

Maxon J. Wash. Ac. Sc. 3 (1913) 144, nom. cons.; Holttum Rev. Fl. Mal. 2 (1954) 340; Tagawa Col. Ill. Jap. Pterid. (1959) 54, 256; Ohwi Fl. Jap. (1965) 40.

Stenoloma Fée Gen. Fil. (1852) 330, p.p. min.; Beddome Ferns Br. India (1892) 70; Tardieu-Blot & Christensen Fl. Gen. I.-C. 7 (1939) 130, p.p.; Ching Fl. Reip. Pop. Sin. 2 (1959) 275, p.p. mai.; Chun, Chang & Chen Fl. Hain. 1 (1964) 58, p.p.

For further synonymy and description see Fl. Mal. (gen. 1). Eleven species in the tropical and northern subtropical parts of both hemispheres, but wanting in Australia.

KEY TO THE SPECIES*

Rhizome scales up to 5–6-seriate at the gradually broadened base; sori uni- or binerval; larger free ultimate divisions ca. 2 mm wide; lamina subcoriaceous or coriaceous, usually bipinnate & pinnatifid or tripinnate & crenate .... 1. **Sph. biflora**

Rhizome scales 1–3-seriate (or to 4-seriate at the abruptly broadened base); sori 1–3–(4–) nerval; larger free ultimate divisions 1 mm or more wide, or, if narrower, spathulately broadened at the sorus; lamina herbaceous to subcoriaceous, in full-grown plants bipinnate & bipinnatifid, tripinnate & pinnatifid, or even more dissected .... 2. **Sph. chinensis**

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* For *Sph. gracilis* (Tagawa) Kurata and *Sph. minutula* Kurata see the notes at the end of the genus.

1. **Sphenomeris biflora** (Kaulfuss) Tagawa J. Jap. Bot. 33 (1958) 203; Col. Ill. Jap. Pterid. (1959) 54, 256, fig. 89; Kramer Blumea 15 (1968) 573, 17 (1970) 162. — *Davallia biflora* Kaulfuss Enum. (1824) 221. — *Stenoloma biflorum* (Kaulfuss) Ching Sinensia 3 (1933) 338; Tagawa J. Jap. Bot. 22 (1948) 160; Ching Fl. Reip. Pop. Sin. 2 (1959) 277, pl. 24 fig. 7–9. Type: *Chamisso* s.n., Manila, Luzon (B). — *Davallia tenuifolia* Swartz var. *lata* Hooker ex Moore Ind. Fil. 2 (1861) 301, based on: var. β of Hooker Sp. Fil. 1 (1846) 186, nom. subnud. Lectotype: "Imp. Acad. Petersb." 44, Bonin Is (K.) — *Odontosoria tsoongii* Ching Bull. Fan. Mem. Inst. 1 (1930) 149. Type: several coll. cited, none seen; the collection Tsoong 1423 from the Hailin Is, Kwangtung, China, prob. most eligible as type. — *Stenoloma littorale* Tagawa Acta Phytotax. Geob. 6 (1937) 25. — *Stenoloma chusanum* (L.) Ching var. *littorale* (Tagawa) Ito Bot. Mag. Tokyo 52 (1938) 6. — *Sphenomeris chusana* (L.) Copel. var. *littoralis* (Tagawa) Ito ex Mizushima Misc. Rep. Inst. Natur. Res. 38 (1955) 115 (not seen; quoted by Tagawa 1959, loc. cit.). — *Sphenomeris chinensis* (L.) Maxon var. *littoralis* (err. 'littorale') (Tagawa) Ohwi Fl. Jap. (1965) 40, comb. invalid sine cit. compl. basion. (but possibly validly published elsewhere). TYPE: *Tasiro* s.n., Oshima, Japan (KYO, not seen). — *Sphenomeris* (or *Stenoloma*) *chinensis* or *chusana* of various authors, in part.

For further synonymy and description see Fl. Mal. (gen. 1 sp. 2).

Distribution. Southern Japan, S.E. coast of China, Taiwan, Marianas, northern Philippines.

Ecology. In more or less exposed places, often by the sea, not in forests, at lower and middle elevation.

JAPAN. Honshu: *Yamada 1525* (GH); *Higuchi 362* (E, L, U); *Uno 7941* (GH). — Oshima: *Faurie 4607* (B); *Kurihara, Kurihara & Ohba 3607* (U). — Hachijo Shima: *Suzuki 391007* (GH). — Shikoku: *Tagawa 6846* (Pic-Ser), *6859* (E, Pic-Ser, U, US); *Ito 79* (SING); *Iwatsuki 600* (US). — Kyushu: *Ichikawa 200599* (S-PA, W); *Wright* s.n. (GH, K, US). — Koshiki I.: *Hatusima 16537* (US). — Ryukyu. Yakushima: *Koidzumi* s.n. (MICH, US); *Hatusima 14871* (US). — Amami-Oshima: *Iwatsuki 5046* (E, K, L, U); *Hosoyamada* s.n. (US). — Okinawa: *Elliott & Nakanyina 562* (US); *Walker, Sonohara, Tawada & Amano 6097* (MICH). — Bonin Is.: *Mertens 68* (L); Acad. Imp. Petersb. 44 (K, lectotype of *Davallia tenuifolia* var. *lata*). — Volcano Is. Iwo Jima: *Porter 8* (BISH, MICH, US); *Henderson* s.n. (GH).

TAIWAN. *Tanaka & Shimada 13523* (E. GH, SING, S-PA, W); *Oldham* s.n. (GH, S-PA, W); *Faurie 273* (S-PA), *620* (W). Orchid I., *Huang & Kao* 7526 (U).

CHINA. 'Macai Peninsula' (prov.?): *Hance 12294* (GH). — Fukien: Kuluntu I. near Amoy, *Sampson* s.n. (BM, W). — Taitan I. near Amoy, *Price 1382* (K). — Kwangtung: Double I. near Swatow, *Dalziel 67* (BM, E); Swatow, *Dalziel* s.n. (E). — Hong Kong: *Taam 1695* (L, US); *Matthew 291* (E); *Hance 44* (B); *Chan 84* (K); *Hillebrand* s.n. (S-PA); *Seemann* s.n. (BM); *Walker* s.n. (BM); *Lamont 1049 A* (BM). — 'Yünnan' (corr.??): *Henry* s.n. (BM).

2. **Sphenomeris chinensis** (L.) Maxon J. Wash. Ac. Sc. 3 (1913) 144; Ohwi Fl. Jap. (1965) 40; Kramer Acta Bot. Neerl. 15 (1967) 565; Blumea 15 (1968) 572; Fosberg Taxon 18 (1969) 596; Kramer Blumea 17 (1970) 163. — *Trichomanes chinense* L. Sp. Pl. 2 (1753) 1099. — *Odontosoria chinensis* (L.) J. Smith Bot. Voy. Herald (1857) 430; Nakai J. Coll. Sc. Imp. Un. Tokyo Bot. 31 (1911) 403;

Merrill Lingn. Sc. J. 5 (1927) 12. — *Stenoloma chinense* (L.) Beddome Ferns Br. Ind. (1883) 70. Type: *Osbeck* s.n., China (S-PA). — *Adiantum chusanum* L. Sp. Pl. 2 (1753) 1095. — *Sphenomeris chusana* (L.) Copeland Bull. Bish. Mus. 59 (1929) 69; Tagawa Col. Ill. Jap. Pterid. (1959) 54, 257, fig. 88; Holttum Rev. Fl. Mal. 2 (1954) 341. — *Stenoloma chusanum* (L.) Ching Sinensia 3 (1933) 337; Tardieu-Blot & Christensen Fl. Gén. I.-C. 7 (1939) 130; Ito Fil. Jap. Ill. (1944) pl. 13; Ching Fl. Reip. Pop. Sin. 2 (1959) 275; Chun, Chang & Chen Fl. Hain. 1 (1964) 59. Type: coll.?, China (not seen.). — *Adiantum tenuifolium* Lam. Encycl. 1 (1783) 44. — *Davallia tenuifolia* (Lam.) Swartz Schrad. J. Bot. 1800^2 (1801) 88; Hope J. Bomb. Nat. Hist. Soc. 13 (1900) 35; Dun & Tutcher Kew Bull. Add. Ser. 10 (1912) 337; Gibbs Common Hongkong Ferns (1927) 8, pl. 4. Type: *Sonnerat* s.n., 'Inde' (P.) — *Hymenophyllum ramosissimum* Ham. ex D. Don Prodr. Fl. Nepal. (1825) 12. Type: *Hamilton* s.n., Nilkantha, Nepal [not seen; this species acc. to Salomon, Nomencl. Gefässkrypt. (1883) 201, and Christensen, Ind. Fil. 1906) 367]

For further synonymy and description see Fl. Mal. (gen. 1 sp. 3).

Distribution. Very widespread in the tropical and northern subtropical parts of the Old World.

Ecology. Terrestical in open or not too shady places; apparently quite euryoecious.

a. Var. **divaricata** (Christ) Kramer Blumea 15 (1968) 672. — *Odontosoria chinensis* (L.) J. Smith var. *divaricata* Christ Journal de Bot. Sér. 2, II (1909) 23. Type: *Chevallier 14309*, São Tomé (P.) — *Sph. chusana* (L.) Copeland var. *tenuifolia* auct. non (Lam.) Holttum, Rev. Fl. Mal. 2 (1954) 341, fig. 198.

Characterized by the shape of the ultimate segments which are cuneate, abruptly spathulately broadened at the sorus, slightly narrowed at the ± rounded apex, the apical margin not rarely erose, the sides often corniculate, the base often ½ mm wide, 1–1½ mm wide at the sorus; the sori are not rarely paired in a segment, mostly uninerval, or, if binerval, on two connivent vein-ends; spores mostly 55–60 μ long.

This variety is not quite sharply distinct from the following; in its typical form it is widespread, and often much more common than var. *chinensis*, in the larger Malesian Islands. The following more or less typical specimens may be cited from the area of the present revision:

CHINA. Yünnan: *Wang 76956* (A). — Prov.? *Harland 43* (E).

INDO-CHINA. Tonkin: *Balansa 105* (B, K).

THAILAND. *Kerr 9656* (K, SING).

BURMA. *Kingdon-Ward 20407* (BM).

SIKKIM. *Hope* (?) s.n. (L).

NEPAL. *Wallich* s.n. (E, K).

INDIA. Assam: *Schiller 19* (B); *Mann* s.n. (L).

b. Var. **chinensis**

See Fl. Mal. (gen. 1 sp. 3, 3). Segments cuneate, gradually broadened from the base, often about twice as long as wide, the apical margin not or scarcely erose; sori not rarely uninerval but most often bi- or tri-, rarely to quadrinerval, most often ¾–1½ mm long. Spores mostly 42–48 μ long.

Distribution. Very widespread, but absent from continental Africa.

Geographically representative or widespread collections:

KOREA. Prov. South Kyŏngsang: *Uno 22953a* (GH). — Cheju Dô (Quelpaert I): *Faurie 92* (B, BM, E, MICH), *2165* (W); *Taquet 2328* (B, E), *3540* (E, K), *3684* (BM, S-PA).

JAPAN. Honshu: *Tagawa 7149* (E, GH, K, L, Pic-Ser, U, US): *Togashi 363* (E, K, L, U); *Ohwi & Okuyama NSM 191* (B, BM, E, L, S-PA); *Togasi NSM 433* (B, BM, E, K, L, MICH, S-PA, US) — Kyushu: *Maximowicz* s.n. (BM, SING, S-PA, W); *Schottmüller 155* (B, S-PA); *Engler 7171* (B); *Ichikawa 200140* (GH). — Goto I.: *Warburg* s.n. (B). — Shikoku: *Tagawa 6862* (US); *Beattie & Kurihara 10135* (US); *Faurie 4610* (B). — Hachijo Jima: *Oldham 108* (GH). — Nakashima: *Schwarz 162* (Pic-Ser). — Oshima: *Faurie 4607* (B); *Kurihara, Kurihara & Ohba 361* (U). — Ryukyu. Yakushima: *Furuse* s.n. (TOFO). Amami Oshima: *Iwatsuki 4927* (E, K, L, U). Iheya: *Suzuki* s.n. (US). Okinawa: *Field & Loew 23 h* (SING); *Walker, Sonohara, Tawada & Amano 6052* (K, MICH, US); *Conover 948, 971, 1013, 1799* (US). Iriomote: *Nishida 653* (US); *Walker & Tawada 6745* (US). Yaeyama Retto: *Unger's coll. 8* (B).

TAIWAN: *Tanaka & Shimada 13523* (BM, L, MICH, US); *Gressitt 221* (B, BM, K, S-PA, U); *Faurie 620* (B, BM, W); *Warburg 9477* (B, E), *9584, 10924* (B).

CHINA. Kiangsu: *Chavel 596* (E). — Anhwei: *Ching 8743* (GH, US). — Hupeh: *Wilson 2663* (B, BM, E, HBG, K, US, W); *Henry 4373* (B, BM, US). — Chekiang: *Ching 1370* (B, BO, E, US), *1816* (BO, E, GH, K, US); *Steward 2375* (E, K, US); *Chiao 14104* (K, US), *14543* (BRI, SING, US). — Kiangsi: *Schindler 375* (B, BM, E, K, W); *Handel-Mazzetti 213* (W). — Hunan: *Fan & Li 12* (BO, L, W), *685* (A, BO, L); *Tsang 23756* (A, L). — Szechuan: *Chow 4668* (E, US); *Fang 2108* (E, GH, K, US), *3818, 4671* (E, K), *5795* (E, GH, K, US), *9931* (E, SING); *Wilson 5307* (BM). — Kweichow: *Cavalerie 1373* (E); *Tsiang 6256* (GH); *DeVol 563* (GH). — Fukien: *Chung 2137* (BO, K), *2857* (E, GH, K, W); *Tang 6916* (BM, MICH), *7101* (SING, S-PA); *Norton 1081, 1082 1083, 1084* (US); *Metcalf & Tang 543* (US), *6097* (BM). — Kwangtung: *Tsang 16574* (S-PA, US), *20001* (K, MICH), *20579* (BO, K, MICH, W), *20708* (B, BO, K, L, MICH, SING, W), *21243* (A, K, MICH, S-PA), *26201* (A, MICH); *Lau 684* (GH, MICH), *20135* (K, US); *Levine 511* (BO, GH); *Gressitt 1235, 1314* (BM, E). — Kwangsi: *Tsang 23069* (GH), *28175* (A, SING, US). — Yünnan: *Rock 7698* (GH, K, US); *Wang 66809, 71825, 71871, 71962, 73922, 74146, 77198* (A); *Handel-Mazzetti 5935* (K, US, W); *Forrest 18840* (BM, E, K), *26019* (E, K); *Henry 9018 A* (E, K, US); *Cavalerie 1373, 4023* (E, K); *Maire 2744* (E, K). — Tibet: *Ludlow, Sheriff & Taylor 6728* (BM, MICH). — Hainan: *Tsang 16778* (B, BO, K, US); *Gressitt 1030* (E, GH); *Eryl Smith 1452* (BM, K), *1453* (K, SING, S-PA, US). — Hong Kong: *Fortune 16* (B, E, L); *Taam 1336* (US), *1448* (BO, US), *2023* (MICH US); *Jelinek 31* (B, W); *Palmer & Bryant 41* (US); *Eryl Smith 1456* (SING). — Macau: *Warburg 5490* (B).

INDO-CHINA. Tonkin: *Tsang 27256, 30152* (K); *Chevalier 29327, 29495* (SING). — Laos: *Poilane 16926* (K). — Annam: *Clemens 3565* (BM, U); *Poilane 1617* (K, SING). — Cochin-China: *Gaudichaud* s.n. (B).

THAILAND. *Eryl Smith 585* (BM, K, SING), *398, 1214, 2292* (K); *Smitinand 417* (K); *Tagawa, Iwatsuki & Fukuoka T 588* (L, U), *T 1273* (U).

BURMA. *Dickason 6721* (A, E), *9105* (A, E, L); *Rock 2078* (US), *2152* (S-PA, US); *Forrest 52394* (K); *McKee 6018* (BM).

BANGLA DESH. *Wallich* s.n. (K).

BHUTAN. *Griffith* s.n. (B, K).

SIKKIM. *Meebold 2224* (B); *Hope* s.n. (K, L, US); *Gamble 7019* (K); *Hooker* s.n. (GH, B); *Engler 3543* (B).

NEPAL. *Stainton, Sykes & Williams 5189* (BM, E, GH, Pic-Ser), *8917* (BM, E); *Fleming 893, 905, 915* (BM).

INDIA. Assam: *Mann* s.n. (BO, E, HBG, L, SING, S-PA, US); *Schlagintweit* s.n. (B, BM, S-PA); *Hooker & Thomson* s.n. (B, BM, E, GH, K, S-PA, U, W); *Watt 10322* (L, US); N.E.F.A., *Panigrahi 17045* (K). — Manipur: *Watt 6050* (B, E). — West Bengal: *Schelpe 3670* (BM); *Bir* s.n. (U, US); *Warburg 989* (B); *Gamble 6856 A, 7325* (K), *7307* (E, K). — Bihar: *Haines 652* (K); *Mooney 138* (K.) — Uttar Pradesh: Kumaon, *Strachey & Winterbottom 2* (BM, GH, K); *Stewart 320* (BM). — Himachal Pradesh: *Bliss 95, 168* (K); *Trotter 255* (K). — Orissa: *Mooney 695, 3869* (K). — Pondicherry: *Perrottet 591* (B, L), *1397* (B). — Madhya Pradesh: *Mooney 1296* (K). — Madras: *Perrottet 591, 1171, 1172* (W); *Bourne 4843, 4998, 5139* (K); *Hohenacker-exsicc. 1260* (B, BM, E, L, S-PA, W); *Thomson* s.n. (B, BM, E, MICH, SING, S-PA, U, US, W); *Hügel 3176* (W); *Engler 3636, 3641* (B). — Mysore: *Meebold 9621* (B); *Blanford* s.n. (US). — Kerala: *Wallich '245'* (US).

CEYLON; *Thwaites CP 983* (B, BM, BO, E, SING, S-PA, W); *Pfaeltzer & Abeyguna Wardena 35* (U); *Freeman 17, 42* (BM); *Gardner 20* (W); *Schmid 1039* (BM): *Naylor Beckett 202* (B, E, K).

Not seen from the Andaman and Nicobar Islands.

DOUBTFUL AND INSUFFICIENTLY KNOWN SPECIES

Sphenomeris gracilis (Tagawa) Kurata J. Geob. 13 (1965) 101. — *Stenoloma gracile* Tagawa Acta Phytotax, Geob. 6 (1937) 227. Type: *Koidzumi* s.n., Iriomote, Ryukyu (KYO, not seen); one other collection cited from the same island.

No authentic material seen. Judging from the description it seems to fall within the variability of *Sph. chinensis*, except for the arrangement of the leaves with are described as subremote. The author compared it with *Stenoloma eberhardtii*, in the present author's opinion a *Lindsaea* (*L. dissectiformis*, see below), but the description of the scales of *St. gracile* shows that it is a Sphenomeris and not related to the group of *L. dissectiformis*.

Sphenomeris minutula Kurata J. Geob. 13 (1965) 101. Type: *M. Satô 4243*, Amami Oshima, Ryukyu (TOFO, not seen).

The original description, in a journal which is perhaps not very widespread, is as follows:

> Rhizoma repens, ca. 1 mm crassum, squamis setaceis fuscobrunneis cylindricis articulatis ca. 1 mm longis dense obtectum; frondibus subremotis. Stipites straminei deorsum subcastanei, glabri, graciles, 5-10 mm longi, supra sulcati. Lamina ovata vel oblongo-ovata, apice in ambitu obtusa, 1-1.5 cm longa, 0.7-1 cm lata, bipinnata vel tripinnatifida, chartacea, utrinque glabra; rachi gracili leviter flexuosa; pinnis 2-4 jugis, ascendentibus, alternatis, inferioribus oblique flabelliformibus, usque ad 5 mm longis 5 mm latis, costis supra late sulcatis, segmentis ultimis cuneatis apice dilatatis truncatis, 1.5-2 mm longis 0.5-1 mm latis, venulis in segmentis ultimis 1-2. Sori marginales, indusiis submembranaceis subintegris, pallide griceis [sic] interdum brunnescentibus, ca. 0.5 mm longis, 0.3-0.9 mm latis ... This is the tiniest species of the genus Sphenomeris. Notwithstanding the minuteness, it abundantly produces perfectly developed sori on the terminal margin of ultimate lobes ...

Through Prof. Kurata's courtesy a specimen identified by him as belonging to this species was deposited in the Utrecht herbarium: *Sako 5214*, Amami Oshima. I am not satisfied that it is specifically distinct from *Sph. chinensis*, nor can I at present decide its status. It may be a juvenile, yet fertile form of that species; the specimens were collected on mossy rocks, like *L. odorata* var. *japonica*, which I think is also a permanently (phenotypically or genotypically ?) juvenile form.

2. Tapeinidium

(Presl) C. Christensen Ind. Fil. (1906) 631; Tardieu-Blot & Christensen Fl. Gén. I.-C. 7 (1939) 133; Ching Fl. Reip. Pop. Sin. 2 (1959) 278; Kramer Blumea 15 (1968) 545.

For further synonymy and description see Fl. Mal. (gen. 2).

A genus of seventeen species, almost confined to the Malesian-Melanesian area.

KEY TO THE SPECIES

(1) Petiole, at least in the upper part, and rachis dark, pale-angled .... 1. **T. gracile**

(1) Petiole concolorous, usually quite pale.

  (2) Lamina pinnate & pinnatifid or more dissected .... 2. **T. luzonicum**

  (2) Lamina simply pinnate, with serrate or crenate pinnae .... 3. **T. pinnatum**

1. **Tapeinidium gracile** (Blume) v.A.v.R. Handb. (1909) 315; Kramer Blumea 15 (1968) 551. — *Davallia gracilis Blume* En. Pl. Jav. (1828) 233. Type: *Blume 1731* or s.n., Java (L). — ? *Tapeinidium lineare* (Cav.) C. Chr. Dansk Bot. Ark. 9 (1937) 26; Tardieu-Blot & Christensen Fl. Gén. I.-C. 7 (1939) 133. — *Dicksonia linearis* Cavanilles Descr. (1802) 274. Type: *Née* s.n., Philippines (MA, not seen; photogr. in U).

For notes on the synonymy see Kramer, loc. cit., and for the description Fl. Mal. (gen. 2 sp. 8).

A West Malesian species extending to the Moluccas, known from the present area by two collections.

TAIWAN. Orchid I, *Huang & Kao 7525* (U).

INDO-CHINA. Annam: Nhatrang, *Poilane 3400* (BM, K, P).

2. **Tapeinidium luzonicum** (Hooker) Kramer Blumea 15 (1968) 552. — *Davallia luzonica* Hooker Sp. Fil. 1 (1846) 174, pl. 60 B 2, 3, 5. Type: *Cuming 139*, Luzon (isotypes B, L). — *T. biserratum* auct. non (Blume) v.A.v.R.; Holttum Rev. Fl. Mal. 2 (1954) 339, fig. 197.

For further synonymy and description see Fl. Mal. (gen. 2 sp. 11).

A West and Central Malesian species recently collected in southern Peninsular Thailand.

THAILAND. *Tagawa, Iwatsuki & Fukuoka T 4830* (U, US).

3. **Tapeinidium pinnatum** (Cav.) C. Christensen Ind. Fil. (1906) 631; Ogata Ic. Fil. Jap. 1 (1928) pl. 44; Ito Fil. Jap. Ill. (1944) pl. 15; Holttum Rev. Fl. Mal. 2 (1954) 339, fig. 196; Ching Fl. Reip. Pop. Sin. 2 (1959) 278, pl. 25 fig. 7–11; Kramer Blumea 15 (1968) 553. — *Davallia pinnata* Cavanilles Descr. (1802) 277; Hooker Sp. Fil. 1 (1846) 173, pl. 60 B. Type: *Née* s.n., Philippines (MA, not seen; photogr. U).

For further synonymy and description see Fl. Mal. (gen. 2 sp. 12).

Western and Central Malesia, extending sporadically to Continental Asia and Japan. Reports from elsewhere are due to confusion with other species.

JAPAN. Ryukyu: Okinawa, *Amano 6297* (US). Ishigaki, *Masamune & Suzuki* s.n. (US); *Tagawa & Iwatsuki 4480* (US); *Nishida 447* (US); *Fosberg 37391* (L, US). Iriomote, *Tagawa & Iwatsuki 4566* (K, L, U, US), *4657* (US); *Walker & Tawada 6705* (BISH, K, MICH, US); *Ogata 273* (BM); *Oka 13751* (TOFO).

TAIWAN. *Tagawa 990* (K).

THAILAND. *Eryl Smith 1656* (BM), *1566, 1912, 1913, 2190* (K); *Marcan 1241* (SING), *1332* (BM, SING); *Kerr 6803, 9299* (K); *Smitinand 2164* (K); *Murton 8* (K).

INDIA. Kerala: Palghat Hills, Gen. *Johnston* s.n. (K).

The single old collection from India, which I did not find cited in the literature, and the absence of the species from Ceylon are quite remarkable.

3. Lindsaea

Dryander in J. E. Smith Mém. Ac. Turin 5 (1793) 401; Trans. Linn. Soc. 3 (1797) 39; Beddome Ferns S. India (1863/64; 1873) 39; Handb. Ferns Br. India (1892) 72; Tagawa Acta Phytotax. Geob. 6 (1937) 24; Tardieu-Blot & Christensen Fl. Gén. I.-C. 7 (1939) 118; Holttum Rev. Fl. Mal. 2 (1954) 321; Ching Fl. Reip. Pop. Sin. 2 (1959) 257; Tagawa Col. Ill. Jap. Pteridoph. (1959) 52, 226; Ohwi Fl. Jap. (1965) 39; Kramer Blumea 15 (1968) 557. — *Schizoloma* Gaudichaud Ann. Sc. Nat. 3 (1824) 507; p.p.; Beddome loc. cit. (1863/64, 1873) 9; loc. cit. (1892) 77, p.p.; Tardieu-Blot & Christensen loc. cit. (1939) 128; Holttum loc. cit. (1954) 342; Ching loc. cit. (1959) 272. — *Stenoloma* Fée sensu Tardieu-Blot & Christensen loc. cit. (1939) 130, p.p.; Ching loc. cit. (1959) 275 p.p.

For further synonymy and description see Fl. Mal. (gen 4).

About 150 species, pantropic and subtropic. For the subdivision of the genus see Kramer (1968, loc. cit. and Fl. Mal.).

KEY TO THE SPECIES*

(1) Lamina bipinnate, the secondary rachises at least in the adaxial groove with short pubescence (SECT. **Aulacolindsaea**) .... 25. **L. caudata**

(1) Secondary rachis glabrous; or lamina not bipinnate.

  (2) Rhizome epiphytic, long-scandent, with broad, triangular scales and strongly dorsiventral stele; leaves remote (SUBGEN. **Odontoloma**).

    (3) Lamina of full-grown plants bipinnate .... 35. **L. parasitica**

    (3) Lamina simply pinnate.

      (4) Sori continuous; rhizome scales chocolate brown .... 34. **L. oblanceolata**

      (4) Sori interrupted; rhizome scales golden brown.

        (5) At least some of the fertile lobes of the pinnules erose-denticulate .... 33. **L. merrillii**

        (5) Fully fertile lobes of pinnules not erose-denticulate.

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* The reader is reminded that in the present author's terminology the term *pinnule* always designates a free ultimate segment, regardless of the degree of dissection of the lamina.

(6) Larger pinnules 10–12 mm long; pinnules incised to ⅓ or ½, the lobes evenly narrowed from base to apex .... 31. **L. glandulifera**

(6) Larger pinnules 15 mm or more long, with truncate lobes, much less deeply incised, the lobes about parallel-sided .... 32. **L. repens**

(2) Rhizome terrestrial, mostly short-creeping and with clustered leaves, rarely more long-creeping and with remote leaves, but then the scales narrow; stele radially symmetric or nearly so (SUBGEN. **Lindsaea).**

(7) Lamina bipinnate or more dissected, with gradually reduced upper (primary) pinnae; or at least the basal pinnules of the almost conform terminal pinna enlarged, lobed (SECT. **Schizoloma**). (p. 12)

(8) Veins scantily to freely anastomosing .... 13. **L. heterophylla**

(8) Veins quite free.

(9) Pinnules not or hardly dimidiate, deeply incised, consisting of cuneate or flabellate, ± divaricate lobes.

(10) Rhizome not very short-creeping, the petioles not clustered, several mm apart; sori various.

(11) Sori on 1 or 2 veins; all ultimate lobes linear-cuneate .... 11. **L. schizophylla**

(11) Sori rarely on 1, mostly on 2–5 veins; very few or no ultimate lobes linear-cuneate .... 12. **L. cambodgensis**

(10) Rhizome very short-creeping, with clustered petioles; sori uni- to quadrinerval.

(12) The greater part of the lamina fully tripinnate; ultimate lobes abruptly spathulately broadened at the sorus, there much broader than the wings that connect them .... 1. **L. dissectiformis**

(12) Lamina fully tripinnate only at the base; ultimate lobes gradually broadened to the sorus, there not much wider than the wings connecting them, or scarcely broadened.

(13) Sori on 1 or 2 veins; larger ultimate lobes 1 mm wide at the apex **(fig. 4)** ...... 2. **L. kawabatae**

(13) Sori on 1–4 veins; larger ultimate lobes 3–5 mm wide at the apex **(fig. 5)** ..... 3. **L. annamensis**

(9) Pinnules distinctly dimidiate, or, if only indistinctly or not at all so, not deeply dissected into cuneate or flabellate lobes.

(14) Larger, dimidate pinnules incised to the middle or beyond, the lobes not broadened at the sorus and not apiculate .... *see 10.*

(14) Larger, dimidiate pinnules incised to ⅓, occasionally to the middle; some or most lobes broadened at the sorus and apiculate **(fig. 6)** .... 9. **L. chingii**

(14) Larger, dimidiate pinnules not or much more shallowly incised.

(15) Petiole and basal half of the primary rachis abaxially terete **(fig. 9)** .... 7. **L. austro-sinica**

(15) Petiole and basal half of the rachis abaxially bi-angular, often pale-margined.

(16) Sori strongly interrupted, even though the incisions of the margin do not, or some just barely, reach the level of the receptacle; indusium reaching and often here and there surpassing the margin; receptacle sometimes seemingly decurrent onto some of the veins supporting it; texture often subcoriaceous .... 6. **L. repanda**

(16) Sori less strongly interrupted, or some or all incisions reaching to beyond the receptacle, or the indusium remote from the margin.

(17) Lamina simply pinnate, with suborbicular-flabellate, scarcely or not incised larger pinnules, or bipinnate, the unipinnate apical portion relatively very long, at the base with suborbicular-flabellate pinnules .... 5. **L. orbiculata**

(17) Pinnules not suborbicular-flabellate, or, if some approach this shape, the lamina bipinnate with the unipinnate leaf-apex relatively less predominant.

(18) Terminal pinnule of lateral pinnae very large, asymmetrically deltoid, much larger than any of the (paucijugate) lateral pinnules of the same pinna .... 8. **L. javanensis**

(18) Terminal pinnule or segment of lateral pinnae lanceolate, rhombic, subelliptic, or, if deltoid, in size comparable to the larger lateral pinnules in the same pinna; or lamina simply pinnate.

(19) Pinnules in the basal portion of the simply pinnate leaf-apex (but above those that are transitional in shape between pinnate pinnae and non-pinnate pinnules) rhombic, with ± protracted apex, their sori broken by incisions reaching considerably beyond the receptacle.

(20) Terminal pinnule/segment large, well-developed, free or nearly so; no upper pinnules of lateral pinnae (if any) so strongly reduced as to be denticuliform; indusium mostly close to the margin; lamina not rarely unipinnate .... 8. **L. javanensis**

(20) Terminal segment narrowly triangular, in lateral pinnae (if any) mostly at the base confluent with some denticuliform reduced upper pinnules; pinnule-lobes (except sometimes the outer ones) with little or not convex outer margin; indusium strongly intramarginal; rarely unipinnate **(fig. 7)** .... 4. **L. chienii**

(20) Terminal segment as in the preceding species; lobes of fertile pinnules convex on the outer margin; indusium almost or quite reaching the margin; bipinnate, rarely more dissected .... 10. **L. bouillodii**

(19) Pinnules in the basal portion of the leaf-apex (but above those that are transitional from pinnate pinnae to non-pinnate pinnules) parallelogrammoid, rectangular, or flabellate, not rhombic with protracted apex, their sori continuous or with very few incisions that scarcely reach beyond the receptacle or do not reach its level **(fig. 8)** .... 5. **L. orbiculata**

(7) Lamina simple, simply pinnate, or, if bipinnate, without gradual transition from pinnae to pinnules, and with conform terminal pinna without larger, lobed basal pinnules.

(21) Lamina simply pinnate (rarely simple), with non-dimidiate, lanceolate or linear pinnules, with conform terminal one, and reticulate venation ....14. **L. ensifolia**

(21) Lamina simply pinnate, with lanceolate pinnules, without free conform terminal one, and with irregularly reticulate venation .... 13. **L. heterophylla**

(21) Lamina simply pinnate with free veins or bipinnate with dimidiate pinnules, or simply pinnate with reticulate veins and dimidiate pinnules.

(22) Veins sparingly to copiously anastomosing (SECT. Synaphlebium). (p. 15)

(23) Veins of larger fertile pinnules irregularly anastomosing, sometimes in some of the pinnules nearly or quite free.

(24) Sori continuous, or, if interrupted, the incisions not deeper than 1 mm.

(25) Sori continuous or interrupted; pinnules 10–12 mm long, 3–4 mm wide; petiole pale, abaxially flat or convex, bi-angular, the angles evanescing downward; sterile pinnules broadly crenate-sinuate ...... 16 **L. napaea**

(25) Sori interrupted; pinnules 10–20 mm long, 4–6 mm wide; petiole pale, abaxially angular to the base, sulcate at least near the apex; sterile pinnules bicrenate .... 15. **L. malayensis**

(24) Sori interrupted, the larger incisions 2 mm deep or more .... 17. **L. malabarica**

(23) Veins of larger fertile pinnules regularly anastomosing, at least in the basal $\frac{2}{3}$.

(26) Sori of larger, fully fertile pinnules continuous.

(27) Pinnules twice as long as wide; petiole usually reddish brown .... 21. **L. integra**

(27) Pinnules $2\frac{1}{2}$–3 × as long as wide; petiole stramineous .... 20. **L. cultrata**

(26) Sori of larger, fully fertile pinnules interrupted by incisions of the margin.

(28) Incisions of pinnules going to or slightly beyond the level of the receptacle; outer or all sori short, on 1–3 vein-ends; indusium falling short of the margin by less than its width to slightly surpassing it **(fig. 2)** .... 23. **L. venusta**

(28) At least most incisions of the pinnules deeper; sori usually on more than 3 veins, and/or the indusium more strongly intramarginal.

(29) Pinnules opaque, hardly narrowed to the obliquely truncate apex; outer margin distinct, with an incision; pinnae rather abruptly narrowed below the ± caudate, pinnatifid apex; pinnule-bearing rachises abaxially brown, sulcate and pale-margined .... 19. **L. parallelogramma**

(29) Pinnules with subacute or rounded apex and/or distinctly narrowed to the apex; or, if truncate, the outer margin not incised; pinnules often translucent; pinnae more gradually narrowed; pinnule-bearing rachises various.

(30) All pinnule lobes and receptacles distinctly convex towards the margin; indusium reaching to the margin or nearly so **(fig. 1)** .... 22. **L. lobata**

(30) These characters not combined, at least the inner pinnule lobes with straight outer margin.

(31) Pinnules with a distinct outer margin joining the upper at an angle of less than 90°, its sorus sometimes continuous with that of the upper; at least the inner incisions reaching considerably beyond the level of the receptacle .... 20. **L. cultrata**

(31) Pinnules without a distinct outer margin, this rounded into the upper; most or all incisions reaching considerably beyond the level of the receptacle .... 18. **L. obtusa**

(31) Pinnules without a distinct outer margin, this rounded into the upper; incisions reaching to the level of the receptacle, or shallower .... 16. **L. napaea**

(22) Veins quite free.

(32) Pinnules not dimidiate.

(33) Pinnules at least 6 × as long as wide; rachis dark-sclerotic, abaxially terete.

(34) Pinnules articulate at their insertion .... 29. **L. divergens**

(34) Pinnules not articulate at their insertion ... . 28. **L. walkerae**

(33) Pinnules relatively much shorter; rachis abaxially bi-angular, dark or not. *see 7* (SECT. **Schizoloma).**

(32) Pinnules dimidiate.

(35) Rachis abaxially terete, except near the apex.

(36) Pinnules incised, or, if entire, less than 12 mm long; simply pinnate; spores monolete.

(37) Pinnules herbaceous to subcoriaceous, without a distinct outer margin; rachis not dark-sclerotic ...... 26. **L. odorata**

(37) Pinnules subcoriaceous or coriaceous, with a distinct outer margin; at least the basal half of the rachis dark-sclerotic **(fig. 3)** ...... 27. **L. himalaica**

(36) Pinnules entire (except if incompletely fertile), usually 15–20 (–35) mm long; spores trilete; simply pinnate or bipinnate .... 24. **L. doryphora**

(35) Rachis abaxially bi-angular.

(38) Pinnules erose; indusium 0.5 mm wide .... 5. **L. orbiculata**

(38) Pinnules not erose; indusium narrower.

(39) Lamina simply pinnate, with reduced and somewhat remote basal pinnules; most incisions of the pinnules reaching to about the level of the receptacle ... . 30. **L. lucida**

(39) Lamina bipinnate, or, if simply pinnate, the basal pinnules not reduced and little or not remote; incisions of pinnules reaching considerably beyond the level of the receptacle ... 17. **L. malabarica**

SECTION **Schizoloma** (Gaud.) Kramer

1. **Lindsaea dissectiformis** Ching Sinensia 1 (1930) 52. Type: *McClure 18312*, Hung Mo Shan, Hainan (isotype A). — *Odontosoria eberhardtii* Christ Journal de Bot. 21 (1908) 235, 266, nom. nud.; Merrill Lingn. Sc. J. 5 (1927) 12. — *Stenoloma eberhardtii* Ching Sinensia 3 (1933) 338; Tardieu-Blot & Christensen Fl. Gén. I.-C. 7 (1939) 132, fig. 16 1/2; Ching Fl. Reip. Pop. Sin. 2 (1959) 277, pl. 24 fig. 1/2; Chun, Chang & Chen Fl. Hain. 1 (1964) 58, fig. 26. — *Lindsaea eberhardtii* Kramer Acta Bot. Neerl. 6 (1957) 135. Type: *Eberhardt 115, 116*, Annam (P).

Rhizome very short-creeping, 1–1½ mm in diam.; scales castaneous, very narrowly triangular, the cell partitions laterally somewhat protruding, almost the whole apical half uniseriate, to 6-seriate at the base, to 2⅓ mm long. Leaves clustered; petioles ca. 10–25 cm long, slightly exceeding the lamina to 1½ × as long, castaneous to atropurpureous, scarcely lustrous, quadrangular with subterete base, upward pale-margined. Lamina deltoid to oblong, acute, ca. 8–15 cm long, at the base tri- or quadripinnate & pinnatifid, upward gradually of simpler structure, with up to 10 primary pinnae to a side that are more than once pinnate & pinnatifid; colour dark or olivaceous green when dry, texture herbaceous. Primary rachis like the petiole, upward gradually stramineous. Primary pinnae slightly ascending, contiguous, the largest (basal) ones 4–7 cm long, 2½–3½ cm wide; upper pinnae gradually shorter; at least the basal pinnae distinctly inequilateral, basally broader; secondary rachises abaxially narrowly sulcate, bi-angular at the base, upward gradually green-marginate. Secondary pinnae up to 10 to a side, slightly ascending. Penultimate divisions ascending, variously once or twice bifid, the ultimate lobes obcuneate-spathulate, uni- or the largest binerval, 3–5 mm long if almost free, the base ca. 0.4–0.5 mm wide, upward gradually cuneately, then at the sorus abruptly spathulate-broadened, there ½–1½ mm wide, their apices triangular-acute, obliquely truncate, or rarely rounded, in addition erose-denticulate. Upper lobes/segments gradually confluent into pinnatifid pinna-apices. Sterile segments narrower, lanceolate, acute. Veins immersed, scarcely evident. Sori uni- or less often binerval; indusium pale, ½–2 mm long, not rarely not at right angles with its vein, its base straight or faintly concave or convex, laterally free, its outer edge sinuate-erose, 0.4–0.5 mm wide, not reaching the margin by an equal or often considerably larger distance, rarely by only about half its width. Spores light yellowish brown, trilete, verruculose, ca. 27 μ.

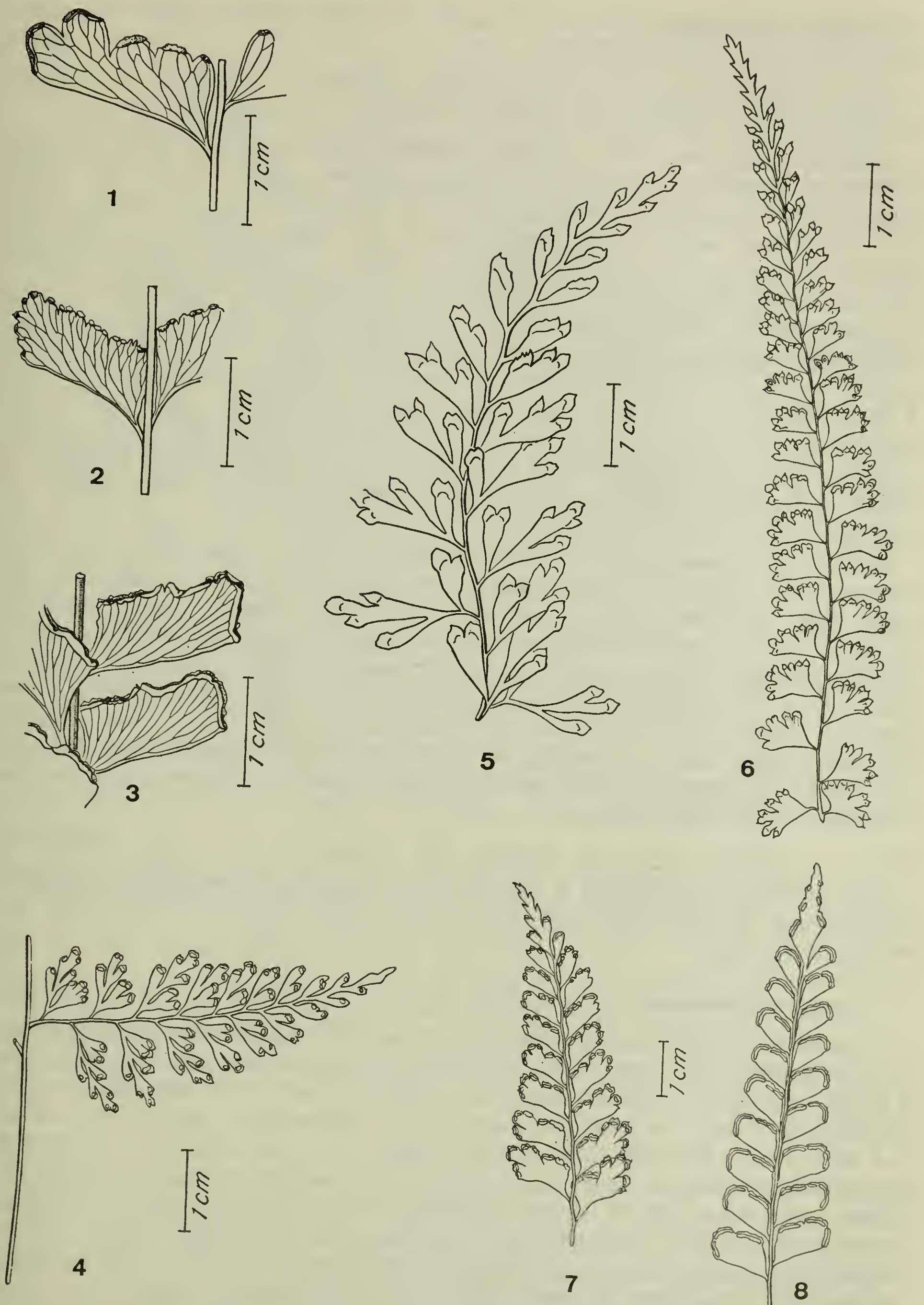
Ecology: In moist forests. ca. 1500 m alt.; very few data.

Distribution: Confined to Annam (Central Viet-Nâm) and Hainan.

INDO-CHINA. Annam: *Eberhardt 115, 116* (P, type of *S. eberhardtii*); *Poilane 3692* (BM, BO, K, MICH), *4156* (SING), *4360* (K, P), *22047* (GH); *Jacquet* s.n. (BO, P).

CHINA. Hainan: *Eryl Smith 1457* (BM, K); *McClure 778* (Lingnan Univ. *18312*) (A, isotype).

Notes. Closely related to the Japanese *L. kawabatae* and the Madagascan *L. millefolium;* see also Kramer (1957, loc. cit.). The basionym of *Stenoloma eberhardtii*, the name most often used for this species, was published as a nomen nudum and the first description did not appear until 1939 in the Flore Générale de l'Indo-Chine. Therefore Ching's name *L. dissectiformis* takes precedence.



Figs. 1–8. Lindsaea

1. Lindsaea lobata var. *hainaniana*. Detail of pinna (*Liang 63789*, US). *2. L. venusta*. Detail of pinna (*Wall 20.37*, GH). *3. L. himalaica*. Detail of pinna (*Griffith* s.n., Assam, K). *4. L. kawabatae*. Basal pinna (holotype KYO). *5. L. annamensis*. Lower pinna (*Poilane 3567*, P). *6. L. chingii*. Basal pinna (*Tsang 29330*, P). *7. L. chienii*. Lamina apex (*Kurata* s.n., Honshu, TOFO). *8. L. orbiculata* var. *commixta*. Lamina apex (*Kawabata 807*, TOFO).

2. **Lindsaea kawabatae** Kurata J. Geobot. 13 (1965) 100. — Type: *Kawabata 991*, Yakushima, Japan (TOFO). **Fig. 4**

As the journal in which this species was described is not likely to be found in many smaller libraries, the original description is here quoted verbatim.

Rhizoma breviter repens, squamis minutis lineari-lanceolatis dilute castaneis obtectum; frondibus approximatis. Stipites graciles, usque ad 14 cm longi, rufo-castanei vel sursum brunneo-straminei, quadrangulares, supra sulcati. Lamina 8–11 cm longa, basi 5–9 cm lata, deltoidea vel ovata, acuminata, tripinnata sursum bipinnata vel simpliciter pinnata; pinnis ca 10-jugis, erecto-patentibus, breviter petiolatis, alternatis vel inferioribus suboppositis, inferioribus inter se 1–2 cm remotis, deltoideo-lanceolatis, acuminatis; pinnulis 5–7 jugis, distincte anadromice dispositis, infimis posterioribus longioribus, subdimidiato-lanceolatis, ad 1.2 cm longis 5 mm latis, pinnatis, segmentis 2–3-jugis, anguste cuneatis ad 3 mm longis, ad 1.5 mm latis, apice acute denticulatis, segmentis infimis anterioribus flabellato-cuneatis, pauci-incisis, pinnulis superioribus et anterioribus omnibus dimidiato-rhomboideis vel oblique flabellato-cuneatis, venulis in segmentis ultimis 1–2; textura herbacea, viridi. Sorus unus pro lobulo ultimo, venas 1–2 occupans, indusio griceo [sic] e margine magis remoto.

To this good description the following points may be added: Major, bipinnate pinnae 3 to a side, the upper ones very gradually of simpler structure, the uppermost confluent into a pinnatifid leaf-apex. Primary rachis abaxially bi-angular like the petiole; secondary rachises abaxially narrowly sulcate, narrowly green-marginate. Ultimate divisions apically erose or denticulate, the narrower with convex outer margin, the broader ones sometimes subtruncate. Sori $\frac{1}{3}$–1 mm long, the longer ones basally concave; indusium pale, delicate, ± erose, laterally free, 0.3–0.4 mm wide, not reaching the margin by an approximately equal distance, not reflexed at maturity. Spores as in *L. chienii*, q.v. Only known from the type collection; no ecological data.

Notes. As already noted by Kurata, this species is very closely related to *L. dissectiformis* (*"eberhardtii"*), with which it shares i.a. the inequilateral, basitonic basal pinnae. For the differences see the key; more material may show the two species to be one.

3. **Lindsaea annamensis** Kramer, **spec. nov.** **Fig. 5**

Rhizoma breviter repens, squamis ferrugineis, angustissime triangularibus, acuminatissimis obtectum. Folia approximata; petiolus badius, quadrangularis. Lamina triangularis, basi bipinnata et pinnatifida vel tripinnata, chartacea vel subcoriacea. Pinnae majores pro latere 6–10, adscendentes, triangulares, acutae vel acuminatae. Pinnulae majores pro latere 3–6, adscendentes, ± profunde pinnatifidae, acroscopice segmentis 1–3, basiscopice segmento unico vel nullo; lobi ultimi valde adscendentes, cuneato-flabellati, majores bifidi, minores simplices, usque ad 8 × 5 mm, basi ca 1 mm lati, apice eroso-denticulati. Apices laminae pinnarumque sensim angustati et structura simpliciore, pinnatifidi; saepe acuminati vel caudati. Venae binae ad quaternae vel in lobis minoribus singulae. Sori venis 1–4 insidentes, majores basi saepe concavi. Indusium marginem non attingens. Sporae tetraëdricae.

Rhizome short-creeping, ca. 2½ mm in diam.; scales reddish brown, very narrowly acuminate-triangular, with a considerable uniseriate apical portion, to 6-seriate at the base, to 2½ mm long. Leaves close; petioles castaneous, somewhat shining, quadrangular, upward ± pale-margined, adaxially sulcate, 10–30 cm long, equaling to almost twice as long as the lamina. Lamina ca 10–22 cm long, triangular, bipinnate & pinnatifid at the base, or in large leaves there tripinnate and otherwise bipinnate & pinnatifid; colour medium green or olivaceous when dry, texture chartaceous to subcoriaceous. Rachis like the upper part of the petiole, upward gradually green. Major pinnae 6–10 to a side, (subfalcately) ascending, contiguous, triangular, acute or acumimate, subsessile, to 8 × 3 cm; secondary rachises stramineous, abaxially shallowly sulcate, upward gradually narrowly green-marginate. Pinnules ascending, ± continguous, 3–6 larger ones to a side; larger pinnules asymmetrically ovate to trapeziform in outline, ca. 15–20 × 5–7 mm, ± deeply pinnatifid, with 1–3 segments on the acroscopic side, the largest also with one on the basiscopic side, in the largest incised to a narrow costal wing; basal pinnae sometimes with 1 or a few basiscopic fully pinnate & pinnatifid pinnules. Ultimate lobes strongly ascending, cuneate-flabellate, the larger ones bifid, the smaller ones entire, the largest ca 8 × 5 mm, ca 1 mm wide at the base, the apical margin protracted into 1 or several apiculi separated by incisions, or in broader lobes coarsely erose. Upper pinnae, pinnules, etc., gradually and strongly reduced, confluent into narrow, lobed, lanceolate, often acuminate or caudate lamina and pinna apices. Veins immersed, evident, 2–4 per lobe, single in the smallest. Sori on 1–4 vein-ends, usually basally concave if long; receptacle often laterally exceeding its veins, not rarely not at right angles with them; indusium delicate, pale, subentire to erose, laterally free, ½ mm wide, falling short of the margin by an at least equal, often larger distance. Spores medium brown, trilete, slightly verruculose, ca. 25–28 μ.

Type and only known collection: *Poilane 3567*, Nhatrang, Annam, Viet-Nâm (P, 2 sheets), on poor sandy soil in forest, 1800 m. "Bia di" (Moïs).

Note. This species combines characters of *L. chingii*, *L. dissectiformis*, and *L. chienii* but is probably closest to the last-named species. Its spores seem to be normally developed, but it might, of course, still have originally arisen by hybridization.

4. **Lindsaea chienii** Ching Sinensia 1 (1929) 4; Hu & Ching Ic. Fil. Sin. 1 (1930) pl. 19; Tagawa Acta Phytotax. Geob. 6 (1937) 34, fig. 3 A-C; Col. Ill. Jap Pterid. (1959) 53, 226, fig. 86; Ching Fl. Reip. Pop. Sin. 2 (1959) 270; Kurata, Satake & Mashiko Pterid. Idzu Penins. (1960) 23, map II. — *L. tenera* Dryander var. *chienii* (Ching) Tardieu-Blot & Christensen Fl. Gén. I.-C. 7 (1939) 127; Iwatsuki Acta Phytotax. Geob. 19 (1961) 5. — *L. orbiculata* (Lam.) Mett. ex Kuhn var. *chienii* (Ching) Ohwi Fl. Jap. Pteridoph. (1957) 35 (not seen). — *Schizoloma chienii* (Ching) Tardieu-Blot Am. Fern J. 48 (1958) 34. Type: Ching 7184, Yao-mar Shan, N.W. Kwangsi, China (isotype US). — *L. orbiculata* auct. non (Lam.) Mett. ex Kuhn; Ito Fil. Jap. Ill. (1944) pl. 20; Ohwi Fl. Jap. (1965) 40, p.p. **Fig. 7**

Rhizome short- to very short-creeping, 1½–2 mm in diam.; scales castaneous, narrowly lanceolate, the upper ½ or ⅓ uniseriate, up to 3-seriate at the base but some entirely uniseriate, to ca. 1⅓ mm long. Leaves clustered to a few mm apart; petioles reddish brown to castaneous, lustrous, slender, upward gradually quadrangular with narrow, pale edges, not or only adaxially sulcate, ca. 10–30 cm long, equaling the lamina to almost twice as long. Lamina herbaceous or firmly herbaceous, dark green when dry, especially above, ca. 10–20 cm long, bipinnate, or tripinnate at the extreme base, deltoid, oblong (or rarely linear and simply pinnate in juvenile but already fertile plants), with 1–6 pairs of major (fully pinnate) pinnae to a side, without a conform terminal one; rachis like the upper part of the petiole, upward gradually entirely pale. Pinnae narrowly triangular, acute or shortly acuminate, very shortly petiolulate to subsessile, the lower ones about their width apart but ascending and therefore often ± contiguous, the larger ones 5–10 cm long, 2–3 cm wide; secondary rachises pale to greenish, abaxially flat or narrowly sulcate, at least above narrowly alate. Lower pinnae with ca. 4–8 free pinnules to a side; pinnules ascending or the basal ones spreading, of variable size and shape, depending on the place in the lamina, the larger ones of basal pinnae in outline $\frac{1}{4}$-elliptic, rhombic, or trapeziform, strongly dimidiate, often ca. 8 × 4–12 × 6 mm, obtuse, incised, with 1–3 oblique incisions on the upper and 1 or 2 on the outer side, these very oblique, of very unequal depth, the basal pinnules often deeply pinnatipartite, with a few very unequal segments on the anterior side, or less often fully pinnate, with a few flabellate pinnules on both sides. Upper pinnules of lower pinnae and many or all of upper pinnae cuneate-flabellate, gradually reduced to the pinna-apex, some confluent with it, or sometimes, especially in larger pinnae, the pinna-apex basally pinnatilobate but ± distinct, rhombic to lanceolate, of variable size, acute or shortly acuminate, ± distinctly serrato-lobate or basally pinnatifid, in size comparable to the larger pinnules of the pinna or larger. Basal acroscopic pinnule cuneate-flabellate. A few upper pinnae pinnatifid or only basally pinnate, transitional to the non-pinnate pinnules in the base of the pinna-apex, these rhombic or trapezoidal, with several incisions that go well beyond the receptacle, none, or only the uppermost that are already connected with the pinnatifid leaf-apex not incised and with continuous sori. Veins immersed, scarcely evident except in transmittent light, once or twice, rarely 3 ×, forked, $\frac{1}{2}$–$\frac{2}{3}$ mm apart, a costa scarcely or not developed. Incisions of the margin acute, the lobes with parallel, straight or slightly convex-convergent sides, their outer margin straight or convex in outer lobes, distinctly erose, usually also slightly crispate; dimensions of lobes very variable. Sterile pinnules sharply dentate; sterile leaves of simpler structure sometimes present with the fertile ones but much less regularly so than in *L. orbiculata.* Sori extending to the terminal segments, interrupted by the incisions of the margin, of variable length, often 1–3 mm long and on 2–5 vein-ends (rarely uninerval), strongly intramarginal, with straight or, especially in outer lobes and smaller pinnules, basally concave receptacle; indusium pale to brownish, ± erose and/or crispate, 0.4–0.5 mm wide, not reaching the margin by an equal or larger (rarely smaller) distance, not reflexed at maturity. Spores light yellowish brown, trilete, verruculose, ca. 25 μ.

Ecology. In shaded places, on rich soil, mostly at lower elevations but in the tropics to above 1000 m. Apparently not rare in Japan.

Distribution. See below.

Geographically selected citations:

JAPAN. Honshu: Tagawa Fl. Jap. 6199 (US); *Kurata 82, 1175a* (TOFO). — Shikoku: *Inada 4194* (TOFO). — Kyushu: *Otomasu 4928* (TOFO); *Kurata 8875* (TOFO). — Hachijo Jima: *Sakurai* s.n. (B, E). — Ryukyu: Yakushima, *Iwatsuki 3427* (E, K, L, U, US); *Arakane 136* (KYO); *Hamaya 2784* (TOFO). Amami Oshima, *Hutch 21015* (TOFO). Tokara Gunto (Linschoten Is), *Kawagoe* s.n. (US). Okinawa, *Sonohara, Tawada & Amano 6293* (BISH, K, MICH, US); *Conover 960, 1134, 1757* (US). Ishigaki, *Oka 14720* (TOFO); *Hatusima 22917* (TAI).

TAIWAN. *Ogata 190* (BM); *Hancock 71* (K); *Suzuki 7442* (TAI); *DeVol c.s. 4475* (TAI).

CHINA. Kwangsi: *Ching 7184* (US, isotype). — Hainan: *Eryl Smith 1478* (K, SING). — Also reported from Kwangtung and Yünnan by Ching (1959).

INDO-CHINA. Annam: *Chevalier 30685* (K, MICH, P).

THAILAND. *Hennipman 3937* (L); *Tagawa, Iwatsuki & Fukuoka T 1259* (L), *T 4808* (L, U, US).

Notes. The isotype seen by the author is less incised than most other specimens but otherwise not atypical.

L. chienii is very closely related to, and probably to a certain degree interfertile with, *L. orbiculata* var. *commixta.* There are a few intermediates, but relatively so few that *L. chienii* is treated here as a distinct species.

5. **Lindsaea orbiculata** (Lamarck) Mett. ex Kuhn Miq. Ann. Mus. Bot. Lugd.-Bat. 4 (1869) 279; Merrill Lingn. Sc. J. 5 (1927) 13; Ogata Ic. Fil. Jap. 1 (1928) pl. 34; Tagawa Acta Phytotax. Geob. 6 (1937) 33; Tardieu-Blot & Christensen Fl. Gén. I.-C. 7 (1939) 125; Ching Fl. Reip. Pop. Sin. 2 (1959) 264; Chun, Chang & Chen Fl. Hain. 1 (1964) 54; Iwatsuki Acta Phytotax. Geob. 19 (1961) 8; Ohwi Fl. Jap. (1965) 40, p.p. — *Adiantum orbiculatum* Lamarck Encycl. 1 (1783) 41. Type: *Sonnerat* s.n., Malacca (P). — *L. flabellulata* Dryander Trans. Linn. Soc. 3 (1797) 41, pl. 8 fig. 2; Beddome Ferns S. India (1864/65) 72, pl. 216 (poor); Dunn & Tutcher Kew Bull. Add. Ser. 10 (1912) 337; Gibbs Common Hongkong Ferns (1927) 10, pl. 15. Lectotype: *Nelson* s.n., Macao (BM). — *L. longipes* Tardieu-Blot & Christensen Fl. Gén. I.-C. 7 (1939) 125, fig. 15. Type: *Poilane 8208*, Ninh-Hoa, Annam (P, 2 sh.; dupl. in BM, K). — ? *L. simulans* Ching Fl. Reip. Pop. Sin. 2 (1959) 265, 371, nom. invalid. (see notes at the end of the genus).

For further synonymy and description see Fl. Mal. (sp. 3).

KEY TO THE VARIETIES

Plants usually (always ?) with simply pinnate sterile leaves beside the fertile ones; fertile leaves simply pinnate, or, if bipinnate, at least some pinnules at the base of the terminal pinna, above the uppermost pinnate pinnae, suborbicular; the lamina not gradually passing from the bipinnate condition at the base to the simply pinnate apex but with a rather abrupt transition .... var. *orbiculata*

Sterile simply pinnate leaves usually wanting; no pinnules suborbicular; larger laminas upward gradually of simpler structure, with a gradual transition from the bipinnate base to the simply pinnate apex. .... var. *commixta*

a. Var. **orbiculata**

Distribution. As given below, and extending to the Philippines and Java.

Geographically selected citations:

JAPAN. Shikoku: *Okamura* s.n. (GH). — Ryukyu: Amami Oshima, *Tokashiki* s.n. (TOFO); *Hutch 21150* (TOFO). Yoronjima, *Ugehara* s.n. (US). Okino Erabu, *Tagawa & Iwatsuki 2118* (E, K, L, U. US), *2157* (US); *Hatusima & Sako 21402, 21507* (TOFO). Okinawa, *Teruya 168* (SING); *Walker 5923a* (BISH, K, US).

TAIWAN. *Tanaka & Shimada 13522* (BM, E, GH, L, MICH, SING, S-PA, US, W, Z); *Hancock 70* (BM, K, US); *Faurie 619* (B, BM, W); *Ream 477* (GH. MICH); *DeVol & Huang 1213* (TAI, US); *Kao 3485* (TAI).

CHINA. Hunan: *Fan & Li 355* (A, BO, L, W). — Fukien: *Tang S. G. 7065* (BM, S-PA); *Schindler 421* (B, BM, E, K). — Kwangsi: *Morse 47* (US); *Tsang 24497* (A, MICH). — Kweichow: *Cavalerie 3563* (E). — Kwangtung: *Tsang 21753* (A, BO, E, K, L, MICH, W, Z); Canton Chr. College *12201* (E, US); *Delavay* s.n. (P). — Hainan: *Eryl Smith 1465* (BM, K, SING, US, p.p.); Mrs. *Hancock 70, 71* (US); *Lau 1491, 4950* (MICH). — Prov.?: *Osbeck* s.n. (S-PA); *Meyen* s.n. (B). — Hong Kong: many coll., e.g. *Eryl Smith 1468* (K, SING); *Matthew 308, 309* (E); *Taam 1415* (US), *1882* (MICH, US); *Faurie 15762* (E); *Wright* s.n. (GH, K, US). — Macau: *Nelson* s.n. (BM, lectotype of *L. flabellulata*). — Reported from Szechuan and Yünnan by Ching (1959); no material seen.

INDO-CHINA. Tonkin: *Tsang 30149* (A, E, K), *30752* (A, K). — Annam: *Squires 344* (BO, BRI, E, SING, W); *Pételot 3424, 3511* (P, US); *Poilane 1094* (K, MICH, P), *2698* (GH, HBG, MICH, P), *5242* (GH, MICH, P), *8208* (BM, K, P, type of *L. longipes*). — Cochin China: *Gaudichaud* s.n. (B, K).

THAILAND. *Marcan 1228* (BM, SING); *Kerr 2179* (BM K).

BURMA. Reported by Dickason (1946), no material seen.

INDIA. Assam: *Clarke 45642 A, B* (K). — Kerala: *Ferguson* ? (BM).

b. Var. **commixta** (Tagawa) Kramer Fl. Mal. II 1, 3 (1971) 207. — *Lindsaea commixta* Tagawa Acta Phytotax. Geob. 6 (1937) 37, fig. 3 H-J; Ching Fl. Reip. Pop. Sin. 2 (1959) 268; Tagawa Col. Ill. Jap. Pterid. (1959) 54, 226, fig. 87. — *L. tenera* Dryander var. *commixta* (Tagawa) Iwatsuki Acta Phytotax. Geob. 19 (1961) 6. Type: *Hidaka* s.n., Tanage-Shima, Kyushu (KYO, not seen; photogr. in U). — *L. bonii* Christ Not. Syst. 1 (1910) 187. Type: *Bon 8*, S. Tonkin (P). — *L. hainanensis* Ching Bul. Fan Mem. Inst. Biol. N.S. 1 (1949) 298; Acta Phytotax. Sin. 8 (1959) 141, fig. 16; Fl. Reip. Pop. Sin. 2 (1959) 267; Chun, Chang & Chen Fl. Hain. 1 (1964) 54. Type: *Lau 6149*, Hainan (A, MICH, isotypes). — *L. tenera* auct. non Dryander; Beddome Ferns S. India (1863/64, 1873) 7, pl. 24. **Fig. 8**

For further synonymy and description see Fl. Mal. loc. cit.

Distribution. See below; sporadically extending to Malesia.

JAPAN. Kyushu: Koshiki Jima, *Ohyo 8913* (KYO, paratype). — Ryukyu: Tanegashima, *Tasiro* s.n. (KYO, paratype). Yakushima, *Ohtani* E.*12* (U); *Ohba 662674* (US); *Kawanabe 5346* (TOFO); *Hutch 19108* (TOFO); *Kawabata 807, 808* (TOFO); *Kudo* s.n. (KYO, paratype). Nakanoshima, *Hatusima 15720* (US). Amami Oshima, *Faurie 4599* (B, KYO, W, paratypes; p.p., with *L. chienii*); *Hutch 21018, 21639, 21704* (TOFO); *Koidzumi* s.n. (KYO, paratype). Okinawa, *Walker* c.s. 6086 (US); *Teruya 98, 166, 167* (SING); *Ito* s.n. (KYO, paratype); *Sonohara, Tawada & Amano 6294* (MICH, US); *Conover 978, 1056, 1070, 1757, 1800* (US); *Ogata 191* (BM). Ishigaki, *Oka 13348* (TOFO); *Kawagoe* s.n. (US). Iriomote, *Nishida 542* (US); *Warburg* s.n. (B). Yonaguni, *Koidzumi* s.n. (KYO, paratype).

TAIWAN. *Sagae* s.n. (TOFO); *Hancock 71* (US); *Ito* s.n. (KYO, paratype); *Huang 1052* (TAI); *Murphy* s.n. (K); Botel Tobago, *Chuang & Hsu 2448* (TAI); Orchid I., *Huang & Kao 7534* (TAI, U).

CHINA. Hainan: *Lau 6149* (A, MICH, isotypes of *L. hainanensis*), *1491* (GH); *Tsang & Fung L. U. 18141* (GH, K); *Eryl Smith 1465* (BM, p.p.). — Hong Kong: *Lorrain 18* (K, p.p.).

INDO-CHINA. Tonkin: *Bon 8* (P, type of *L. bonii*). — Annam: *Evrard 1280* (MICH, P); *Hayata 582* (P); *Chevalier 30640* (P); *Cadiére 48* [68] (BM). — Cambodia: *Bouillod 59* (P). Cochin China: *Gaudichaud* s.n. (B).

THAILAND. *Tagawa, Iwatsuki & Fukuoka T 1259* (US), *T 637, 7153* (L, U, US); *Tagawa T 3939* (L, U, US); *Sörensen, Larsen & Hansen 2269* (E).

BURMA. *Lace 4746* (E).

NEPAL. *Ghose 10* (P).

INDIA. Assam: *Godwin Austen* s.n. (P); *Clarke 45642* A, B (K); Wenger 15, 169 (K). — Uttar Pradesh: *Fleming 864* (BM). — Kerala: coll.? (BM).

CEYLON. *Thwaites CP 3311* (B, BM, BO, E, K, P, SING, W), *CP 1381* (B, BM, BO, E, GH, K, L, P, SING, W); *Wall* s.n. (B, E, GH, K, P, US); *Walker* s.n. (B, E, GH, P, S-PA, U, W); *Sledge 1381* (K, U); *Hutchison* s.n. (E).

Notes. Many, not all, Ceylonese specimens have longer rhizomes, narrower terminal segments, and more interrupted sori than typical specimens. This is presumably due to introgression by *L. schizophylla.*

As stated under *L. chienii,* there are some intermediates between that species and *L. orbiculata* var. *commixta* which may be of hybrid origin, e.g., *Ohtani* s.n. from Yakushima (U). They have more strongly intramarginal and interrupted sori and more incised subapical pinnules than typical var. *commixta.* On the other hand, the number of intermediates between var. *commixta* and var. *orbiculata* is considerably larger, and the differences between the two are more gradual and not very easy to define. Therefore the two are treated as varieties of one species, whereas *L. chienii* is retained as specifically distinct.

The type collection of *L. hainanensis* consists of large, atypical plants with an almost conform terminal pinna, but in the absence of further material they do not seem to represent more than an extreme form of var. *commixta,* typical specimens of which have also been collected in Hainan.

6. **Lindsaea repanda** Kunze Bot. Zeit. 6 (1848) 541; Tagawa Acta Phytotax. Geob. 6 (1937) 38, fig. 4 A — C. Type: Mertens s.n., Bonin Is. (LE; dupl. in L).

Rhizome short-creeping, ca. 2 mm in diam.; scales castaneous, very narrowly triangular, about the apical $\frac{1}{3}$ uniseriate, to ca. 5-seriate at the base, to ca. $1\frac{1}{2}$ mm long. Leaves close to clustered; petioles quadrangular almost to the base, medium or more often dark brown to blackish or adaxially paler, abaxially the greater part pale-angled and scarcely sulcate, ca. 8 — 22 cm long, equaling to almost twice as long as the lamina. Lamina olivaceous to brownish when dry, herbaceous or usually subcoriaceous, ca. 8 — 13 cm long, bipinnate or subbipinnate, rarely almost simply pinnate when fertile, with 1 — 6 well-developed pinnae to a side, rarely only the basal divisions subpinnate; no conform terminal pinna present. Primary rachis like the petiole, abaxially largely or entirely dark and pale-angled. Pinnae subsessile, spreading to ascending, the larger ones ($1\frac{1}{2}$-) 3 — 5 cm long, $\frac{3}{4}$ — $1\frac{1}{2}$ cm wide; secondary rachises pale, abaxially bi-angular to sulcate. Pinnules of well-developed pinnae 3 — 7 to a side, ± narrowly and asymmetrically obovate to flabellate-subrhombic, not very distinctly dimidiate, cuneate at the base, sessile, ± contiguous; larger fertile ones ca. 6 — 10 mm long, 5 — 6 mm wide; pinnules of small pinnae and of the leaf-apex trapezoid, distinctly dimidiate, to 12 x 6 (- 10) mm. Upper pinnules of lateral pinnae and of the leaf-apex somewhat reduced, more narrowly cuneate, none or 1 or 2 connected with the relatively large, rhombic to lanceolate, often lobed, obtuse to shortly acuminate terminal segment (pinnule); upper (primary) pinnae rather abruptly reduced, some transitional between pinnae and pinnules, ± pinnatifid, very obtuse. Veins immersed, not evident, free, 1 — 3 x forked, close, $\frac{1}{2}$ — $\frac{2}{3}$ mm apart. Upper/outer margin of sterile pinnules coarsely erose-denticulate or more often irregularly and sharply dentate; this margin in fertile pinnules with a few irregular, shallow incisions ca. $\frac{1}{2}$ mm deep, otherwise erose or not rarely sharply erose-denticulate. Sori on the upper/outer margin, strongly interrupted even by quite shallow incisions, on (1 —) 2 — 5 vein-ends, basally not rarely concave, their interior edge usually irregular, seemingly slightly decurrent onto the apices of the veins supporting them (see Tagawa's figures); indusium pale, rigid, 0.4 — 0.5 mm wide, its edge erose-denticulate, reaching, and, with its small lobes mostly here and there slightly exceeding the margin, scarcely bulging at maturity. Spores yellowish, trilete, verruculose, ca. 27μ.

Ecology. No data extant.

Distribution. Confined to the Bonin Is.

JAPAN. Bonin Is: Hahashima, *Hisauchi* s.n. (KYO); *Tuyama* s.n. (KYO). Ototoshima, *Tuyama* s.n. (KYO). Chichishima, *Tuyama* s.n. (KYO). Island?, *Hattori 272* (P); *Mertens* s.n. (L,LE, type); *Toshima* s.n. (KYO); *Warburg* s.n. (B); Imp. Acad. Petersb. *43* (K, isotype ??).

Notes. A distinct species but evidently quite close to *L. orbiculata* var. *commixta.* Among the species with sufficiently known range this is perhaps the most narrowly distributed.

7. **Lindsaea austro-sinica** Ching Bull. Fan Mem. Inst. Biol. N.S. 1 (1949) 297; Fl. Reip. Pop. Sin. 2 (1959) 266. Type: *Tsang 22638,* Shang-sze Hsien, Kwangsi, China (GH, P, Pic-Ser, isotypes). — *L. scandens* auct. non Hooker; Tardieu-Blot & Christensen Fl. Gen I.-C. 7 (1939) 121, p.p.mai — *L. longipes* Tardieu-Blot & Christensen. loc. cit. 125, quoad specim. citat., p.p.,excl. typ. **Fig.9**

Rhizome rather short- to short-creeping, 2 — 4 mm in diam.; scales reddish brown, very narrowly triangular, the apical $\frac{1}{2}$ or $\frac{1}{3}$ uniseriate, up to 4-seriate at the base, to 2$\frac{1}{3}$ mm long. Leaves close to a few mm apart; petioles lustrous, castaneous to blackish, abaxially entirely terete and concolorous, adaxially sulcate and upward usually narrowly pale-margined, 15 — 40 cm long, about equaling to 1$\frac{1}{2}$ x as long as the lamina. Lamina oblong, ca. 15 — 35 cm long, medium to dark or olivaceous green when dry, herbaceous or chartaceous, bipinnate (rarely tripinnate at the base), with 1 — 7, mostly 3 — 5 pinnae to a side, the terminal pinna almost conform or passing rather abruptly into the bipinnate part; primary rachis like the petiole or upward paler and ± sulcate, sometimes the uppermost part pale-margined. Pinnae very narrowly triangular, shortly acuminate, or in small leaves oblong and acute or obtuse, often distinctly petiolulate, 6 — 13 cm long, 2$\frac{1}{2}$ — 4 cm wide, relatively broadest in paucijugate leaves. 1$\frac{1}{2}$ — 5 x as long as wide, ascending, several cm apart but sometimes contiguous through being ascending, with 2 — 13 pinnules to a side, the basal posterior pinnule of the lowermost pinnae sometimes pinnate.

a few cm long, and a few pinnules next to it pinnatifid; secondary rachises abruptly pale at their insertion, stramineous to pale brown, or the basal ones of large leaves basally concolorous, abaxially terete at the base, upward gradually biangular, sometimes shallowly sulcate, near the apex narrowly green-margined. Pinnules less than half their width apart to contiguous, spreading or somewhat ascending, dimidiate, otherwise variable in shape, the larger ones of paucijugate, usually small laminas rhombic or subrectangular, 12 — 20 mm long, 9 — 15 mm wide, less than 1½ x as long as wide, often widest at the base, often with one incision a few mm deep in the upper and another in the outer margin, the lobes separated by them ± convex; in plurijugate, mostly larger laminas, and upper pinnules of some paucijugate ones, rounded-rectangular to ligulate (resembling those of *L. lancea* and *L. doryphora*), 11 — 14 mm long, 6 — 7 mm wide, 1½ — 2 x as long as wide, scarcely narrowed to the apex, the upper margin rounded into the outer, the larger pinnules with 1 or 2 incisions up to ½ mm deep in the upper and one in the outer margin, the smaller ones entire; transitions between these two shapes not rare. Lobes of smaller pinnules with straight or laterally slightly protracted margin, scarcely erose. Upper pinnae little reduced, the terminal pinna with larger pinnules of the shape described first and then almost conform to the lateral pinnae, or very few pinnae more strongly reduced, with a few transitions from pinnate pinnae to incised pinnules. Upper pinnules of lateral pinnae little reduced, not less than ⅔ the size of the larger ones, the pinna-apex triangular, acuminate, or rhombic and sometimes subobtuse in paucijugate leaves, narrowly connected with one of the uppermost pinnules, asymmetric, broadly cuneate or subtruncate at the base, there lobed, upward crenate, soriferous, with interrupted sori. Sterile pinnules shallowly crenate (not sharply dentate). Veins immersed or slightly raised, ± evident, free, 2 — 4 x forked, ¾ — 1 mm apart. Sori continuous in entire, interrupted in incised pinnules, on 2 — 12 vein-ends; indusium pale, 0.3 mm wide, entire, almost or quite reaching the margin, rarely to 0.5 mm wide and not reaching the margin by about half its width, not reflexed and scarcely bulging at maturity. Spores yellowish, verruculose, trilete, ca. 27 μ.

Ecology. Terrestial in thickets and forests, on sand or clay, 700 — 1100 m. *Distribution.* Southern China and Indo-China.

CHINA. Kwangsi: *Tsang 22638* (GH, P, Pic-Ser, isotypes).

INDO-CHINA. Annam: *Vincens* s.n. (BO, K, MICH, P, SING; several coll.); *Cadière 11* (P); *Poilane 3378* (BISH, BO, MICH, P), *3412* (HBG, MICH), *4413* (GH, HBG), *4614* (P); *Fleury* (*Chevalier 38646*) (P); *Chevalier 38819, 38834* (P). — Cambodia: *Bouillod 69* (P).

Notes. A distinctive species, and in spite of the great variability of the foliage readily recognized by its dark, abaxially quite terete axes. Ching (1959) completely misunderstood its affinity. The type of *L. hainanensis* bears some resemblance to *L. austro-sinica* (see under *L. orbiculata* var. *commixta*); there may be some hybridization, but *L. austro-sinica* does not seem to have been found in Hainan.

8. **Lindsaea javanensis** Blume En. Pl. Jav. (1828) 219; Tardieu-Blot & Christensen Fl. Gen. I.-C. 7 (1939) 124. — *Schizoloma javanense* (Blume) Holttum Rev. Fl. Mal. 2 (1954) 349, fig. 202.

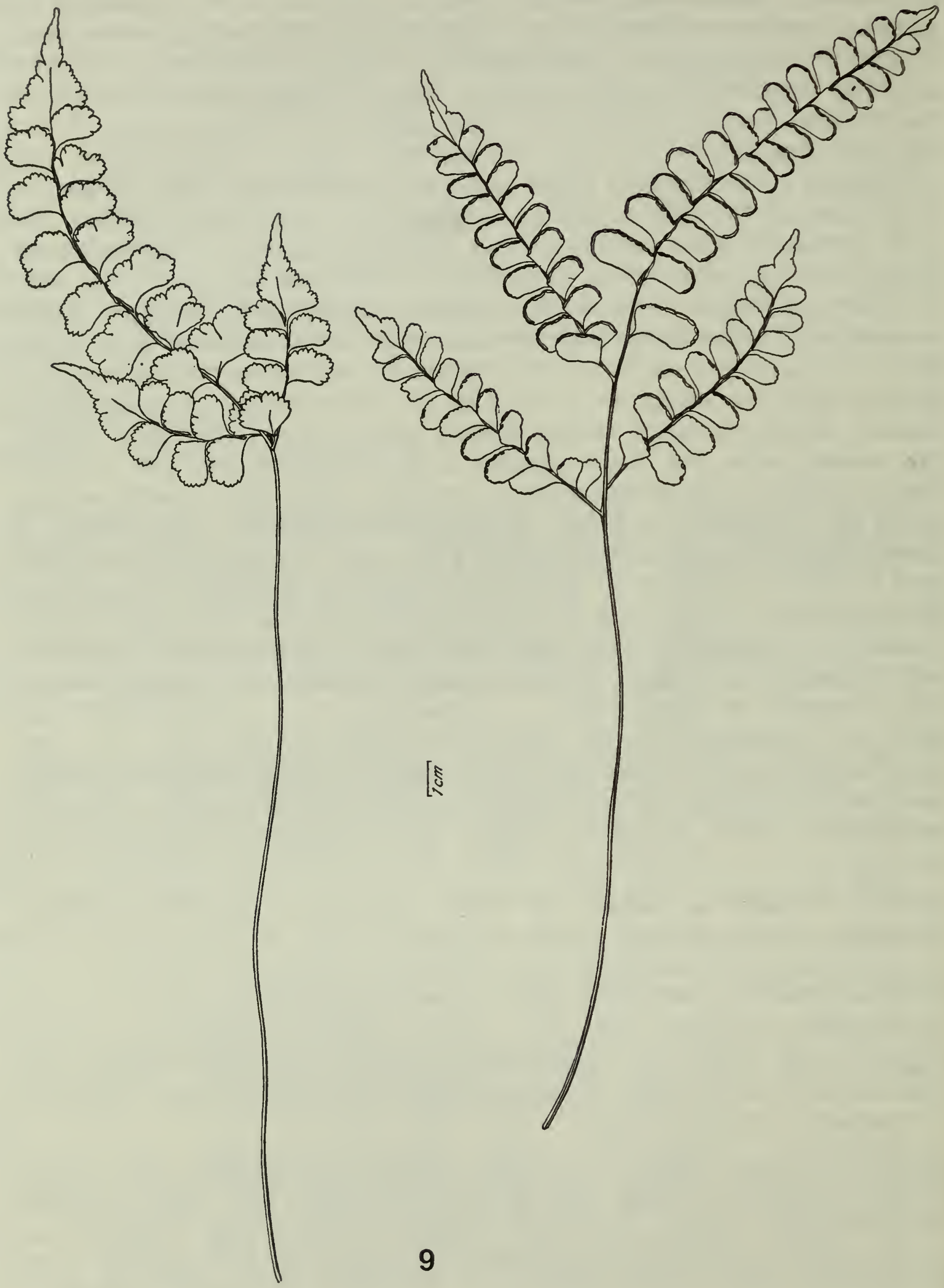


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Fig. 9. *L. austro-sinica. Left:* sterile lamina (*Vincens* s.n., Annam, P). *Right:* fertile lamina (*Bouillod 69,* P).

TYPE: Blume s.n., Java (L.) — *L. flabellulata* Dryander var. *gigantea* Hooker Sp. Fil. 1 (1846) 211, pl. 63 c. — *L. orbiculata* (Lam.) Mett. ex Kuhn var. *gigantea* (Hooker) Mett. ex Kuhn Miq. Ann. Mus. Bot. Lugd.-Bat. 4 (1869) 279. — *L. tenera* Dryander var. *gigantea* (Hooker) Holttum Gard. Bull. S.S. 5 (1930) 65. — *L. gigantea* (Hooker) C. Christensen Bot. Jahrb. 66 (1933) 53. TYPE: Griffith s.n., Assam & Khasya Hills (K). — *L. orbiculata* (Lam.) Mett. ex Kuhn var. *deltoidea* Wu Bull. Dep. Coll. Sci. Sun Yatsen Univ. 3 (1932) 134, pl. 52. — *L. chienii* Ching var. *deltoidea* (Wu) Tagawa Acta Phytotax. Geob. 6 (1937) 37; Col. Ill. Jap. Pterid. (1959) 54, 226. Type: Sin 180, Kwangsi, China (not seen), — *L. liangkwangensis* Ching Fl. Reip. Pop. Sin. 2 (1959) 269, 372, ex char. et synon. Type: *Hsu 00813,* Kwangtung, China (not seen).

For further synonymy and description see Fl. Mal. (sp. 5).

Distribution. From S. Japan and S.E. China to Assam and W. Malesia; reported by Ching (1959) from the Chinese provinces of Kwangsi and Kwangtung.

Geographically selected citations:

JAPAN. Ryukyu: Yakushima, *Kawabata 834, 973* (TOFO), *13890* (US). Amami Oshima, *Hutch 21266, 21606* (TOFO). Okinawa, *Tawada 34* (TAI); *T. Ito* s.n. (TAI); *Naito* s.n. (KAG).

TAIWAN: *Ream 478* (MICH); *Nakamura 527* (TAI); *Simizu 3801* (TAI).

INDO-CHINA. Tonkin: *Pételot 3422* (BM, US), *3646* (P). — Annam: *Poilane 4375* (P); *Cadière 137* (P).

THAILAND: *Hennipman 937* (L); *Tagawa, Iwatsuki & Fukuoka T 1259* (U), *1514* (L,U); *Smitinand 1262* (K).

BURMA: *Sidney* s.n. (US).

INDIA. Assam: *Griffith* s.n. (K, S–PA, type of *L. flabellulata* var. *gigantea); Mann* s.n. (B, BO, HBG, K, L, MICH, P, SING, S–PA); *Jerdon* s.n. (K); *Godwin Austen* s.n. (P).

Notes. As noted in Fl. Mal., the Continental-Asiatic and Japanese specimens of this species are not in all respects like the Malesian ones. They are as a rule more amply bipinnate, the large, asymmetric, terminal segment forming a relatively smaller portion of the pinna; the two forms are sometimes present together on one rhizome, e.g., *Cadière 137* from Annam (P). The continental form often — but not always — has more strongly intramarginal indusia. There is probably some hybridization with *L. chienii.*

9. **Lindsaea chingii** C. Christensen Ind. Fil. Suppl. III (1934) 121, based on: *L. chinensis* Ching Sinensia 1 (1929) 5, non (L.) Mettenius ex Kuhn (1868) (= *Sphenomeris ch.*); Hu & Ching Ic. Fil. Sin. I (1930) pl. 20; Ching Fl. Reip. Pop. Sin. 2 (1959) 263. Type: *Ching 7968,* Tsing Lung Shan, Kwangsi, China (not seen). **Fig. 6**

Rhizome short- to very short-creeping, 1½–2 mm in diam,; scales castaneous, very narrowly triangular, about the apical ⅓ uniseriate, up to 6-seriate at the base, up to 2⅓ mm long. Leaves close to clustered; petioles ca. 12–20 cm long, ½–1 × as long as the lamina, medium to dark brown or paler in the upper part, adaxially broadly sulcate and green-margined above, abaxially in the upper part obtusely bi-angular, ± convex, scarcely marginate. Lamina oblong, ca. 15–22 cm long, bipinnate, with ca. 6–10 well-developed pinnate pinnae to a side, without a conform terminal one; colour olivaceous when dry, texture herbaceous; primary rachis abaxially bi-angular, reddish brown or mottled, upward stramineous. Pinnae subsessile, laxly ascending, very narrowly lanceolate, acuminate, the larger ones 3–10 cm long, 1–1½ cm wide, with ca. 8–18 well-developed pinnules to a side, the lower ones not, the upper ones ± contiguous; secondary rachises slender, pale, greenish, abaxially flat, upward gradually narrowly marginate. Pinnules spreading or slightly ascending, dimidiate, sub-quadrangular or ¼-elliptic in outline, the larger ones 4–7 mm long, 4–5 mm wide, as long as wide to almost 1½ × as long as wide, cuneately subpetiolulate at the base. Larger pinnules with straight or slightly concave lower margin, often little narrowed to the apex, irregularly incised from the upper and outer edge, the incisions oblique, usually one major one halfway the upper margin, reaching down to ⅓ or $\frac{2}{5}$, in addition 1 or 2 shallower ones on the outer and a few on the upper margin on both sides of the deeper one; lobes subdigitately divergent, ¾–1½ mm wide, ½–2 mm long, the basal part parallel-sided, at least some subspathulately broadened at the sorus, with convex sides, the outer edge with one or two apiculi to ca. ⅓ mm long, less often only erose and rounded or subtruncate. Upper pinnae gradually reduced with transitions to the pinnules of the leaf-apex; upper pinnules gradually and strongly reduced, cuneate and pluri-, then uni-apiculate, some denticuliform ones confluent with the pinnatifid, narrowly lanceolate, acute pinna-apex of ca. 1 cm. Veins immersed, ± evident, simple or once forked, 1 or 2 running to each lobe. Sori single in the lobes, uni- or binerval; indusium pale, ¼–1 cm long, 0.3–0.4 mm wide, with straight or convex or in binerval sori often somewhat concave base, free at the sides, erose, overtopped by the apiculus, otherwise almost reaching the outer margin of its segment. Spores like those of *L. chienii*, ca. 23–25μ.

Distribution. Tonkin; described from Kwangsi, China, and not reported from other provinces by Ching (1959).

Ecology. In thickets on dry sand or clay; altitude not noted.

INDO-CHINA. Tonkin: *Tsang 27183* (E,K), *29330* (A,E,K,P); *Balansa 121* (BM).

Notes. I have not seen the type of *L. chingii*, but Ching's good description and Hu & Ching's figure are not open to misinterpretation. The description was evidently based on a young specimen. The description given above was newly made from seven presumably full-grown specimens.

L. chingii is a well-marked species and is apparently rather closely related to the following.

10. **Lindsaea bouillodii** Christ Not. Syst. 1 (1909) 59. Type: *Bouillod 48*, Cambodia (P). — *L. tenera* auct. non Dryander; Tardieu-Blot & Christensen Fl. Gén.I.-C. 7 (1939) 126, and of other authors. — *Schizoloma tenerum* auct. non (Dryander) Holttum Rev. Fl. Mal. 2 (1954) 348, fig. 201. — *L. cambodgensis* auct. non Christ; Kramer *Blumea 15* (1968) 563.

For further synonymy and description see Fl. Mal. (sp. 2).

Distribution. Indo-China to Java and Borneo.

CHINA. Hainan: *Eryl Smith 1478* (SING).

INDO-CHINA. Tonkin: *Sollet 3512*. — Annam: *Pételot 3512* (US). — Cambodia: *Pierre 5767, 5787* (P); *Bouillod 48* (P, type); *Eryl Smith 2303* (BM,K,P), *2304* (K); Kerr *7582(K), 15485* (BM, K).

THAILAND. *v. Beusekom 789, 791* (L, p.p. min.); *Smitinand 5469* (K); *Eryl Smith 1878* (K).

Notes. A specimen labelled "China, *Forbes 506*" (p.p.) in BM is perhaps from elsewhere.

See also under *L. tenera* among the insufficiently known species.

11. **Lindsaea schizophylla** (Baker) Christ Journal de Bot. 21 (1908) 234.— *Davallia schizophylla* Baker Syn. Fil. 2nd ed. (1874) 468. Type: *Thwaites CP 3903,* Ceylon (BM; specimens with the same number but prob. from several collections in B, BO, P, W). — *Davallia trichomanoides* auct. non (Dryander) Beddome; Beddome Ferns Br. India 2 (1868) pl. 178. — *L. orbiculata* auct. non (Lam.) Mett. ex Kuhn; Beddome Ferns Br. India (1892) 75, in part.

Rhizome rather short-creeping, 1½ — 2 mm in diam.; scales castaneous to fuscous, narrowly triangular, shortly uniseriate at the apex, up to ca. 8-seriate at the base, to 2 mm long. Leaves not clustered, a few mm to 1 cm apart; petioles ca. 12 — 25, often about 20 cm long, brown, dark at the base, reddish or pale brown to stramineous near the apex, adaxially sulcate and sometimes pale-margined upward, abaxially at least in the upper part acutely bi-angular but scarcely sulcate. Lamina oblong or narrowly oblong, sometimes subtriangular, 12 —20 cm long, half as long as to equaling the petiole, dark or olivaceous green when dry, herbaceous (mostly thinly), bipinnate & bipinnatifid, less often at the base tripinnate & pinnatifid, or in small plants bipinnate & pinnatifid; primary rachis stramineous or pale brown at the base, abaxially bi-angular, adaxially deeply sulcate. Major pinnae 1 — 4 to a side, ascending or arcuately ascending, with a petiolule of a few mm, 5 — 10 cm long, 1½ — 2 cm wide, acuminate, often slightly narrowed at the base; secondary rachises abaxially flattened, greenish, upward gradually marginate. Secondary pinnae (pinnules) slightly ascending, the lower ones not contiguous, shortly petiolulate, up to 8 major ones to a side, pinnate & pinnatifid or only pinnatifid, or the basal ones of basal pinnae & bipinnatifid; segments cuneate, bifid, twice bifid, or simple, those on the anterior side larger and more numerous than on the posterior side, the pinnules strongly anadromous. Ultimate divisions mostly 2 — 5 mm long, at the base 0.3 — 0.5 mm wide, cuneately broadened from the base, 0.5 — 1 mm wide just below the sorus, at the sorus again and usually ± spathulately broadened, there 1 — 1⅓ mm wide, outer margin rounded to acute, usually erose, sometimes truncate and then not at right angles to the vein. Upper pinnae rather abruptly reduced, pinnate and twice bifid, those above again simpler and, like the upper pinnules, etc., gradually confluent into the pinnatifid, acute lamina-, pinna-, etc., apices. Sterile leaves sometimes only with short, pinnate & twice bifid pinnae, then linear; sterile lobes subacute or acute, not spathulately broadened. Veins immersed, single or rarely paired in the lobes, evident, especially their clavate ends on the adaxial side. Sori uni-, less often binerval; indusium yellowish, delicate, subentire or lobulate-erose, if short with convex base and adnate at the narrowed sides (not pouch-shaped), if longer often with concave base and free at the rounded sides, ⅓ — 1 mm long, ⅓ — ½ mm wide, not reaching the margin by its width or more, scarcely bulging at maturity. Spores pale brown, trilete, smooth, ca. 22μ.

Ecology. Terrestrial in montae forests, ca. 1600 — 2000 m.

Distribution. Endemic in Ceylon; most collections with data on exact provenance from Adam's Peak, only *J. Smith* s.n. marked "Südspitze".

CEYLON. *Ferguson* s.n. (GH, US); *Robinson 113a* (K); *Matthew s.n.* (K); *Alwis* s.n. (Z); *Thwaites CP 3903* (BM, type; dupl.? in B, BO, E, K, P, W); *Wall 1012* (P, S-PA); *J. Smith* s.n. (P. S-PA); *Sledge 608* (K, U); *Skinner* s.n. (K); *Hutchinson* s.n. (E).

Notes. The closest relative of this species is probably *L. orbiculata* var. *commixta,* with which it seems to be interfertile to a certain degree. Putative hybrids are reported under that taxon.

12. **Lindsaea cambodgensis** Christ Not. Syst. 1 (1909) 58; not of Kramer Blumea 15 (1968) 563. Type: *Bouillod 61,* Cam-Chay Mts., Cambodia (P). — *L. parvipinnula* K. Iwatsuki Acta Phytotax. Geob. 19 (1961) 6, fig. 13. Type: *Tagawa & Iwatsuki 3204,* Yakushima, Japan (KYO, not seen; photogr. in U).

For a description the reader is referred to the very complete original one of *L. parvipinnula* to which only a few points are added here.

Rhizome scales castaneous, very narrowly lanceolate, rather shortly uniseriate at the apex, up to 5-seriate at the base, to almost 2 mm long. Petioles to 22 cm long. Lamina to 15 x 8 cm, not rarely subtripinnate & pinnatilobate at the base, i.e., the basal pair(s) of pinnae with one or a few pinnate pinnules on both sides. Pinnae subsessile. Pinnules scarcely dimidiate, the basal ones of larger pinnae always with at least one incision going well beyond the receptacle, sometimes with more and deeper incisions, especially if they are transitional between pinnate secondary pinnae and non-pinnate pinnules; upper pinnules entire, flabellate-cuneate, gradually reduced, usually one connected with the very obtuse, cuneate-flabellate, often cleft or lobed terminal segment. Sori on (1 —) 2 — 5 vein-ends, basally convex if very short, often concave if longer, $\frac{3}{4}$ — 3 mm long. Indusium greenish, subentire or slightly erose, 0.3 — 0.4 mm wide, not reaching the erose margin by the same distance or a little less. Spores yellowish, trilete, nearly smooth, ca. 25μ. Juvenile, sterile plants with unevenly digitate-crenate pinnules.

Ecology. According to Iwatsuki (loc. cit.) terrestrial on the floor of light forest at lower elevation.

Distribution. Yakushima and Okinawa, Japan; Cambodia. Also reported from Amami-Oshima by Iwatsuki (loc. cit.); no material seen by the present author.

JAPAN. Ryukyu: Yakushima, *Saiki* s.n. (KYO, paratype of *L. parvipinnula*); *Iwatsuki 2978* (KYO, id.); *Ohtani E-12* (U); *Furuse* s.n. (TOFO); *Satake* s.n. (TOFO); *Kawabata 988* (TOFO); *Hutch 18970* (TOFO); *Yamaguchi 6* (TOFO); *Kawanabe 5045* (TOFO, isoparatype of *L. parvipinnula*), *4960* (KYO, TOFO, paratypes of *L.p.*); *Ohba 66727* (U). Okinawa, *Tawada 1556* (KYO, TAI, iso-paratypes of *L.p.*), *114* (KYO, paratype of *L.p.*); *Tamaki 723* (KYO, id.); *Ito* s.n. (KYO),

INDO-CHINA. Cambodia: *Eryl Smith 2304* (K); *Bouillod 61* (P, type).

Notes. The disjunct distribution of this species is remarkable. The Cambodian specimens are a little coarser in texture and dissection than the Japanese ones which may be infraspecifically distinct.

The rather long-creeping rhizome, the small, cleft pinnules and the delicate lamina characterize this species rather well.

13. **Lindsaea heterophylla** Dryander Trans. Linn. Soc. 3 (1797) 41, pl. 8 fig. 1; Beddome Ferns S. India (1863/64) 70, pl. 206; Dunn & Tutcher Kew Bull. Add. Ser. 10 (1912) 338; Gibbs Common Hongkong Ferns (1927) 14, pl. 7; Tagawa Acta Phytotax. Geob. 7 (1938) 197; Ito Fil. Jap. III. (1944) pl. 22; Iwatsuki Acta Phytotax. Geob. 19 (1961) 3. — *Schizoloma heterophyllum* (Dryander) J. Smith Hook. J. Bot. 3 (1841) 414; Beddome Ferns S. India (1863/64) 9, pl. 26; Blatter & d'Almeida Ferns of Bombay (1922) 55, fig. 18; Merrill Lingn. Sc. J. 5 (1927) 13; Ogata Ic. Fil. Jap. 3 (1930) pl. 148; Ching Fl. Reip. Pop. Sin. 2 (1959) 273, pl. 23 fig. 7 — 11; Chun, Chang & Chen Fl. Hain. 1 (1964) 57. Type: *Robertson* s.n., Malacca (BM). — *Schizoloma intertextum* Ching Fl. Reip. Pop. Sin. 2 (1959) 274, 374. Type: Herb. Biol. Kwangsi Univ., Kwangsi, China (not seen).

For further synonymy and description see Fl. Mal. (sp. 7).

Distribution. Madagascar and Mascarenes, S. India and Ceylon to Ryukyu and Central Malesia.

Geographically selected collections:

JAPAN. Ryukyu: Okinawa, *Conover 958, 1173* (US); *Sonohara 65* (US); *Ogata 195* (BM); *Tawada 130* (U); *Tagawa & Iwatsuki 4845* (US). Iriomote, *Nishida 540* (US); *Walker & Tawada 6635* (MICH, US). Yonaguni, *Hatusima 24424* (TOFO).

TAIWAN. *Steere* s.n. (MICH); *A. M. Evans 089* (TENN).

CHINA. Kwangtung: Canton Chr. Coll. Herb. 1573 (US); *Tsang 26045* (A); *Gressitt 1213* (BM, E, GH); *Petersen* s.n. (L). — Kwangsi: *Morse 6* (US); *Ching 7758* (US; paratype of *Sch. intertextum*); *Tsang 22106* (GH, Pic-Ser; id.), *23909* (MICH). — Hainan: *Eryl Smith 1500* (K, SING, US); *Gressitt 966* (E, GH); *Hancock 4* "p. p." (BM). — Hong Kong: *Cadière 92* (MICH, SING); *Eryl Smith 1479* (K, SING); *Taam 2210* (US); *Wright* s.n. (GH, K, US); *Matthew 311, 312* (E); *Hance & Simson 667* (W). — Reported from Yünnan by Ching (loc. cit., as *Sch. intertextum*).

INDO-CHINA. Tonkin: *Bourret 7* (MICH); *Balansa 125* (K), 1972 (K, MICH); *Tsang 29370* ((A, p.p.). — Laos: *Poilane 2117* (GH, MICH, S-PA). — Annam: *Poilane 5241* (GH, MICH); *Cadière 49* (GH). — Cambodia: *Eryl Smith 2306* (K).

THAILAND. *H. M. Smith 202, 212* (US); *Tagawa, Iwatsuki & Fukuoka T 592* (U, US), *T 1311, 1831* (U); *Tagawa 3951* (U);*Hennipman 3588, 3937a* (L); *Kerr 779, 2372, 6841* (K).

INDIA. Bombay: *Meebold 9613* (S-PA). — Mysore: *Blanford* s.n. (E); *Law* s.n. (GH); *Meebold 9614* (S-PA). — Madras: *Beddome* s.n. (BM, E, K); *Faucheux* s.n. (BM). — Kerala: *Beddome* s.n. (BM).

CEYLON. *Thwaites CP 3861* (B, BM, E, K); *J. Smith* s.n. (S-PA); *Wall* s.n. (B, GH).

Note. The Chinese specimens have mostly broader, more rigid and erose indusia, but are connected with the typical form by intermediates.

14. **Lindsaea ensifolia** Swartz Schrader, J. Bot. 1800 (1801) 77; Dunn & Tutcher Kew Bull. Add. Ser. 10 (1912) 338; Gibbs Common Hongkong Ferns (1927) 12, pl. 6; Tagawa Acta Phytotax Geob. 7 (1936) 197, 198; Ito Fil. Jap. III. (1944) pl. 23; Iwatsuki Acta Phytotax. Geob. 19 (1961) 2; Kramer Blumea 15 (1968) 564. — *Schizoloma ensifolium* (Swartz) J. Smith Hook. J. Bot. 3 (1841) 414; Beddome Ferns S. India (1863/64, 1873) 9, pl. 25; Ferns Br. India (1892) 80, pl. 41; Blatter & d'Almeida Ferns of Bombay (1922) 53, fig. 17; Merrill Lingn. Sc. J. 5 (1927) 13; Ogata Ic. Fil. Jap. 6 (1935) pl. 293; Tardieu-Blot & Christensen Fl. Gén. I.-C. 7 (1939) 129, fig. 15 1–2; Ching Fl. Reip. Pop. Sin. 2 (1959) 273, pl. 23 fig. 1–6; Chun, Chang & Chen Fl. Hain. 1 (1964) 56, fig. 24. Type: coll. unknown, Mauritius (S-PA). — *L. griffithiana* Hooker Sp. Fil. 1 (1846) 219, pl. 68 B. — *Schizoloma griffithianum* (Hooker) Fée Gen. Fil. (1852) 108. Type: *Griffith* s.n., Mergui, Burma (K).

For further synonymy and description see Fl. Mal. (sp. 8).

Of the three subspecies recognized by Kramer (loc. cit.) only one occurs in the area of the present paper, viz. ssp. *ensifolia*.

Distribution. Old World tropics to Malesia, western Melanesia, and tropical Australia.

Geographically selected citations:

JAPAN. Ryukyu: Iriomote, *Nishida 534* (US).*.

TAIWAN. *Henry 1497* (E), *1502* (B); *Faurie 130* (S-PA).

CHINA. Kwangsi: *Tsang 24699* (A, MICH). — Kwangtung: *Lau 20178* (A); *Merrill 10899* (GH); *Dalziel s.n.* (E). — Yünnan: *Wang 81126* (*A*). — Hainan: *Lau 6369* (MICH); *Wang 34040* (E, GH), *34261* (MICH. — Hong Kong: many coll., e.g., *Eryl Smith 1501* (SING, US); *Taam 1409* (MICH, US), *2211* (US); *Topping 605* (GH, US), *608* (US); *Fortune 3* (BM, E), *27* (E, L); *Matthew 304* (E).

INDO-CHINA. Tonkin: *Balansa 107* (K). — Laos: *Colani 4111* (BM); *Poilane 2116* (*BM, HBG, MICH*). — Annam: *Cadière* 50 [67] (K). — Cambodia: *Pierre 5794* (BM, HBG, K). — Cochin China: P. Condor, *Harmand 875* (MICH, SING); Pierre *5743, 5801, 5802* (MICH), *5794* (E, HBG).

THAILAND. *Eryl Smith 1236, 1879, 1880, 1904* (K, SING); *Molesworth-Allen 2154* (S-PA); *H. M. Smith 599* (GH, MICH, US); *Tagawa 3937* (U); *Tagawa, Iwatsuki & Fukuoka T 594, 1262, 1309* (*L, U*); *v. Beusekom 316* (*L*); *Larsen, Smitinand & Warneke 659, 896* (L).

BURMA. *H. M. Smith 575* (US); *Dickason 8007, 8020* (A); *Sidney 33* (BM, US); *Brandis 274* (K); Mergui, *Griffith* s.n. (K, type of *L. griffithiana*).

SIKKIM. *Gamble 347 A* (E); *Clarke 36796 B* (E).

NEPAL. *Wallich 93* or s.n. (B, L, US).

BANGLA DESH. *Gamble 7909* (E, K, US); *Cowan 924* (E); *Hooker & Thomson* s.n. (B, GH, K, W); *Thomson* s.n. (B, E, S-PA, U).

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* A specimen labelled "Yokohama", *Schottmueller 122* "p.p." (B), is probably mislabelled; the species was not reported from Honshu by Tagawa (1959).

INDIA. Assam: *Mann s.n.* (B. E, HBG, K, L, SING, S-PA, US); *Clarke 42947 B* (K, US); *Meebold 7390* (K); *Hooker* s.n. (B). — Rajasthan: *Gamble 2387* A (K). — West Bengal: *Gamble 409 A* and s.n (K), *409 B* (E). — Madras: *Gamble 15974* (K, US). — Kerala: *Wight 214* (B).

CEYLON.*Thwaites CP 1382* (B, BM, E, GH, S-PA, U, W); *Hance* 32 (W); *Walker* s.n. (B, BM, GH, K, W); *J. Smith* s.n. (S-PA); *Naylor Beckett 61* (E, GH); *Koenig* s.n. (L); *Freeman 51, 52, 89* (BM); *F. Schmid 1090 1125* (BM); *Macrae* s.n. (E).

PUTATIVE HYBRIDS IN SECTION SCHIZOLOMA

Four specimens in herb. TOFO combine characters of two species each of section Schizoloma and are presumably of hybrid origin. *Yamaguchi 14* from Yakushima has a short rhizome and the leaf pattern of *L. orbiculata* var. *commixta* but pinnules rather like *L. cambodgensis;* its spores are abortive. *Yamaguchi 9* from the same island is somewhat like the preceeding but looks more like a hybrid between *L. chienii* and *L. cambodgensis;* it also has abortive spores. *Satake* s.n., also from Yakushima, is about midway between *L. kawabatae* and *L. chienii. Oka 13890* from Iriomote has very irregularly dissected subbipinnate leaves with features of both *L. orbiculata* and *L. heterophylla.* The spores of the two last-named collections are well-developed.

For supposed hybrids between *L. orbiculata* var. *commixta* and *L. schizophylla* see under the former.

SECTION **Synaphlebium** (J. Smith) Diels

15. **Lindsaea malayensis** Holttum Gard. Bull. S. S. 5 (1930) 69, fig. 8; Rev. Fl. Mal. 2 (1954) 335, fig. 194. Type: *Md. Haniff 4032,* G. Kerbau, Perak, Malaya (SING).

For description see Fl. Mal. (sp. 15).

Distribution. Malay Penisula: Malaya and southern Peninsular Thailand.

THAILAND. *Tagawa, Iwatsuki & Fukuoka T 4781* (U).

16. **Lindsaea napaea** v.A.v.R. Bull. Jard. Bot. Btzg. II. 20 (1915) 19, pl. 3; Holttum Gard. Bull. S. S. 5 (1930) 66; Rev. Fl. Mal. 2 (1954) 330, fig. 189. Type: *Teijsmann 16616,* Mt. Dai, Lingga Is. (BO).

For description see Fl. Mal. (sp. 16).

Distribution. Sumatra, Malaya, and adjacent islands; southern Peninsular Thailand.

THAILAND. *Kerr 15227* (K).

17. **Lindsaea malabarica** (Beddome) Baker ex Christensen Contr. U. S. Nat. Herb. 26 (1931) 295; Baker Syn. Fil. 2nd ed. (1874) 545 (in indice; invalid combination, species not accepted). — *Schizoloma malabaricum* Beddome Ferns Br. India (1868) pl. 268, with descr. — *Sch. lobatum* (Poiret) Beddome var. *malabaricum* (Beddome) Beddome Ferns Br. India (1883) 79, (1892) 79, pl. 39 (err. '*malabarica*'). Type: Beddome s.n., South Canara, Mysore, India (K).

Rhizome short-creeping or rather so, 1–1½ mm in diam.; scales not seen. Leaves close to almost 1 cm apart; petioles stramineous to pale reddish brown, quadrangular except at the extreme base, scarcely sulcate except adaxially, ca. 10–20 cm long, ⅔ to about as long as the lamina. Lamina simply pinnate or bipinnate with one or two pairs of lateral pinnae and a conform terminal one, medium green when dry, herbaceous, ca. 15–35 cm long; pinnule-bearing rachises like the upper part of the petiole. Pinnules ca. 20–35 to a side, ½–1 × their width apart or the upper ones closer, ascending (often strongly) or the lower ones almost spreading, parallelogrammoid or subtrapezoid, the major ones 10–12 mm long, 3½–5 mm wide, 2–3 × as long as wide; margins straight or the upper and/or lower outward somewhat convex, a distinct outer margin developed or not; basal pinnules sometimes a little reduced, upper pinnules gradually and strongly reduced, a few denticuliform ones connected with the almost linear terminal segment. Veins immersed, ± evident, once or twice forked, rather close, ½–¾ mm apart, free or usually the inner ones here and there connivent, rarely truly anastomosing but never regularly so. Upper margin with 3 or 4 oblique incisions to ¾ mm deep, reaching or slightly surpassing the level of the receptacle, the lobes laterally narrowed, usually with convex outer margin. Sterile lobes subacute. Sori interrupted, on 2–3 (— 5) vein-ends, with straight or laterally slightly convex, or in the outer sori slightly concave receptacle; indusium pale or greenish, rigid, entire or crenulate, 0.3 mm wide, reaching the margin or nearly so, scarcely reflexed at maturity. Spores not seen.

Distribution. Southern India; recorded from Burma by Christensen (1931) and Dickason (1946), probably in error.

INDIA. Madras: *Ghatak 440* (K). — Mysore: *Beddome* s.n. (K, type).

Notes. With the very limited material at hand I feel uncertain about the status of this species. Yet it does not seem to fit any of the others of the present section. It might be taken for a juvenile form of *L. venusta,* but the juvenile specimens of that species I saw which were in size comparable to the material of *L. malabarica* have more regularly crenate pinnules, shorter sori, and much less rarely anastomosing veins. More material is required in order to establish the variability of *L. malabarica.*

A collection that may represent the mature form is *Thomson* s.n., "Mt. Nilghiri & Kurg" (B, E, GH, K, S–PA, U, US, W). It has uni- or bijugate-bipinnate leaves, larger pinnules (up to 16 × 7 mm), ± parallel-sided lobes with straight outer margin, incisions to 3 mm deep going to ⅓ or in the apical half to the middle of the pinnule, and in the basal half of larger pinnules more or less regularly, elsewhere irregularly anastomosing veins. In some characters it is quite divergent from the material on which the above discription is based, but part of the material in S–PA is incompletely fertile and much more like it. It bears some resemblance to *L. lobata* var. *epirotes* but has more deeply and irregularly incised, less elongate, more truncate pinnules and much less regularly anastomosing veins that are closer in the pinnule lobes.

18. **Lindsaea obtusa** J. Smith in Hooker Sp. Fil. I (1846) 224, Type: *Cuming 394,* Malacca (K; dupl. in B, GH, W). — *L. davallioides* auct. non Blume; Ito Fil. Jap. Ill. (1944) pl. 21.

For further synonymy and description see Fl. Mal. (sp. 18).

Distribution. Taiwan and Malesia to western Melanesia; to be expected in southern Thailand.

TAIWAN. *Faurie 245* (S–PA); *Suzuki* s.n. (TAI 6179); *Sasaki* s.n (TAI 6183).

ANDAMAN IS. South Andaman, *Mann* s.n. (P, S–PA); *Kurz* s.n. (K).

Notes. The specimens from South Andaman are not typical, having smaller and more shallowly incised pinnules than usual. They may represent a local form, but *L. obtusa* is as a whole very variable. —— See also the note after *L. lobata* var. *epirotes,* p. 36.

19. **Lindsaea parallelogramma** v.A.v.R. Bull. Jard. Bot. Btzg III. 5 (1922) 212; Holttum Gard. Bull. S. S. 5 (1930) 70, fig. 9; Rev. Fl. Mal. 2 (1954) 335, fig. 193.

Type: *Bünnemeijer 7359,* P. Singkep, Lingga Is (BO; dupl. in L).

For further synonymy and description see Fl. Mal. (sp. 22).

Distribution. S. Peninsular Thailand and Malesia.

THAILAND. *Kerr 14497* (K).

20. **Lindsaea cultrata** (Willdenow) Swartz Syn. Fil. (1806) 119; Kramer Blumea 15 (1968) 565; not of other authors. Type: coll.?, "Malabaria" (B, herb. Willdenow). —— *L. decomposita* Willdenow Sp. Pl. (1810) 425; Holttum Gard. Bull. S. S. 5 (1930) 66, fig. 5; Rev. Fl. Mal. 2 (1954) 333, fig. 192, and of other authors, at least in part. Type: coll.? "India" (B. herb. Willdenow). —— *L. recurvata* Hooker Sp. Fil. 1 (1846) 222, pl. 70 A. —— *Synaphlebium recurvatum* (Hooker) J. Smith Hook. J. Bot 3 (1841) 415; Hist. Fil. (1875) 268, pl. 18 c. Type: prob. *Wallich* sin. dat. (K).

For further synonymy and description see Fl. Mal. (sp. 23).

Distribution. Southern India (?), Ceylon; southern Thailand; Malesia; Orchid I. and Botel Tobago; ? Hainan.

TAIWAN. Botel Tobago, *Chuang & Hsu 2453* (TAI); *C. C. Hsu* s.n. (U). Orchid I., *Huang & Kao 7532* (TAI, U); *Fukuyama* s.n. (TAI 6178, 6184); *Sasaki* s.n. (TAI 6181).

CHINA. Hainan: *Hancock* (Kew no. 119) (K; mislabelled ?).

THAILAND. *Eryl Smith 2301* (BM, K), *2301 B* (K); *Hennipman 3937b* (L); *v. Beusekom 791* (L).

INDIA. S. India, without exact loc., *Gough* s.n. (K, poor, uncertain). —— The exact provenance of the types of *L. cultrata* and *L. decomposita,* as cited above, is uncertain.

CEYLON. *Thwaites CP 982* p.p. (with *L. venusta*) (B, BM, E, GH, K, L, P, S–PA, W); *Sledge 543, 619, 1229* (K); *Holttum S.F. 39201* (SING); *Henderson* s.n. (K); *Freeman 47, 49* (BM), *50* (BM, prob.); *Gardner 1122* (BM, E, K), *1260, 1261* (B, K); *Ballard 1077* (K); and others.

Notes. Not all Ceylonese specimens agree with the Indo-Malayan ones. Some are quite typical, others have more strongly reduced upper pinnules, and in many the outermost sorus of the upper margin is not or only in some pinnules, continuous with that of the outer, a fairly constant character in Malesia. As some Ceylonese collections are not divergent, it does not seem advisable to treat the local from as infraspecifically distinct. There may be some introgression of *L. venusta.* The specimens from the islets near Taiwan are very similar; they can be told apart from *L. lobata* var. *epirotes* by i.a. less elongate pinnules, from var. *hainaniana* by less deeply incised pinnules and straighter outer edges of pinnule lobes.

21. **Lindsaea integra** Holttum Gard. Bull. S. S. 5 (1930) 67, fig. 6. Type: *Holttum 20934,* Pahang, Malaya (SING; dupl. in BM, BO, K, US). — *L. nitida* auct. non Copeland; Holttum Rev. Fl. Mal 2 (1954) 333, fig. 191.

For description see Fl. Mal. (sp. 25).

Distribution. Malay Peninsula, Sumatra, Borneo; southern Peninsular Thailand.

THAILAND. *Eryl Smith 1877, 1878* (K), *2298, 2299* (BM, K).

22. **Lindsaea lobata** Poiret in Lamarck Encyl. Suppl. 3 (1813) 448; Kramer Blumea 15 (1968) 565. Type: Commerson s.n. Java (P.) — *L. davallioides* Blume En. Pl. Jav. (1828) 218; Hooker Sp. Fil. 1 (1846) 224, pl. 68 A; Tardieu-Blot & Christensen Fl. Gén. I.-C. 7 (1939) 127; Ching Fl. Reip. Pop. Sin. 2 (1959) 271; Chun, Chang & Chen Fl. Hain. 1 (1964) 56; not of Ito Fil. Jap. Ill. (1944) pl. 21. Type: *Blume* s.n., Java (L).

For further synonymy and description see Fl. Mal. (sp. 21).

Distribution. Malesia to western Melanesia and Micronesia. Two continental groups of plants seem referable to this species, but they differ decidedly from the Malesian material and are therefore here described as new varieties. They may prove to be distinct species, although they are certainly very close to *L. lobata.*

a. Var. **epirotes** Kramer **var. nov.**

Petiolus brunneus vel raro nigrescens. Lamina unijugo-bipinnata vel unipinnata. Pinnulae herbaceae, pellucidae, parallelogrammoidales vel paulo angustatae et subtrapezoidales, 11–16 mm longae, 3–5 mm latae, margine exteriore saepe distincto. Margo anterior/exterior incisus, incisionibus basalibus minime duplum spatii a receptaculo ad marginem aequantibus, exterioribus plerumque sensim profundioribus. Lobi basales margine exteriore receptaculoque rectis. Indusium ¼ mm latum, marginem attingens vel fere.

Type: *Tsang 29002,* Taai Wong Mo Shan, Tonkin (A; dupl. in E, P).

Petiole medium to dark reddish brown, rarely black, occasionally stramineous. Lamina unijugate-bipinnate or unipinnate, drying medium green. Pinnules herbaceous, translucent, parallelogram-shaped or usually somewhat narrowed to the apex and then subtrapezoidal, 11–16 mm long, 3–5 mm wide, 2½–3½ (–4) × as long as wide; a distinct outer margin usually developed. Inner incisions of the pinnules at least twice as deep as the distance from the receptacle to the margin, outer ones as deep or usually progressively deeper; inner lobes hardly, outer ones somewhat or very little divergent. Inner lobes with straight outer margin and straight receptacle, outer ones usually with weakly convex margin and receptacle. Upper pinnules strongly and gradually reduced. Veins mostly regularly anastomosing, occasionally with an incomplete second series of areoles. Indusium ¼ mm wide, nearly or quite reaching the margin.

Ecology. Terrestrial in thickets and woods, 700–1500 m.

Distribution. Indo-China; to be expected in S. E. China.

INDO-CHINA. Tonkin: *Tsang 27107* (A, K), *29002* (A, E, P, type), *27310* ? [sic] (E). — Annam: *Poilane 1525* (GH, MICH), *3384* (GH. MICH, SING), *7006* (US), *7169* (BO, K, MICH).

Notes. In many respects close to the Malesian form. The most important difference is in the margin of the lobes and the receptacle which are straight at least in the proximal lobes; the petioles are usually darker and there is often a distinct outer margin. Certain forms of *L. obtusa* are also not unlike this variety; they have wider indusia (0.4–0.7 mm) which are more strongly intramarginal, and usually dry blackish.

b. Var. **hainaniana** Kramer **var. nov.** — **L. decomposita** auct. non Willdenow; Merrill Lingn. Sc. J. 5 (1927) 12. — *L. cultrata* auct. non (Willd.) Swartz; Merrill loc. cit. 13 (prob.). **Fig. 1.**

Petiolus stramineus. Lamina unijugo-bipinnata vel unipinnata. Pinnulae herbaceae, paulo pellucidae, subligulato-parallelogrammoidales, parce vel haud angustatae, margine exteriore saepe distincto, majores 12–15 mm longae, 5–6 mm latae. Margo anterior/exterior incisus, incisionibus minime triplum spatii a receptaculo ad marginem aequantibus, Lobi margine exteriore et receptaculo parce sed distincte convexis, etiam basales divergentes. Indusium $\frac{1}{5}$–$\frac{1}{4}$ mm latum, marginem attingens vel fere.

Type: *Liang 63789*, Hainan (US; dupl. in K).

Petiole stramineous. Lamina unijugate–bipinnate or unipinnate, drying bright to dark green. Pinnules herbaceous, little translucent, subligulate-parallelogrammoid, little or not narrowed to near the apex, a distinct outer margin usually developed; major pinnules 12–15 mm long, 5–6 mm wide, over 2 to 2½ × as long as wide. Incisions going to ⅓ of the width, rarely less but at least 3 × the distance from the margin to the receptacle. Lobes somewhat narrowed, even the inner ones distinctly divergent, most or all, including the inner ones, with weakly but distinctly convex outer margin and receptacle. Veins regularly anastomosing, not rarely with an incomplete second series of areoles. Indusium $\frac{1}{5}$ or ¼ mm wide, almost or quite reaching the margin.

Ecology. Terrestrial in forests, sometimes on rocks, in moist places, ca. 1000 m.

Distribution: Hainan.

CHINA. Hainan: *Lau 3817* (BISH, GH, S-PA), *5227* (A, MICH); *Eryl Smith 1469* (K, SING); *McClure* Canton Chr. Coll. *9482* (BISH, BM, K); *Wang 35711* (GH); *Liang 63789* (K, US, type).

Notes. In general appearance not unlike *L. cultrata*, especially the Ceylonese form. It differs in the more deeply incised pinnules with convex outer margin and receptacle, all typical features of *L. lobata*. In most specimens the upper pinnules are less gradually and strongly reduced than in var. *lobata* and var. *epirotes*, but more so than in typical *L. cultrata*. — See also the notes after the last-named species.

23. **Lindsaea venusta** Kaulfuss ex Kuhn Linnaea 36 (1869) 79. Type: *Thwaites CP 982*, Ceylon '[dupl. (all?) in B, BM, BO, E, GH, K, SING, S-PA, W]. — *Schizoloma recurvatum* auct. non (Wall. ex Hooker) Moore; Beddome Ferns S. India (1863/64; 1873) 9, pl. 27. **Fig. 2.**

Rhizome slender, 1–2 mm in diam., not very short-creeping, soon almost scaleless; scales light brown, lanceolate, relatively shortly uniseriate at the apex, up to ca. 7-seriate at the base, up to 1⅓ mm long. Leaves not close, up to 2½ cm apart; petiole stramineous to pale or reddish brown, below obtusely, above acutely quadrangular, adaxially upward sulcate, 8–30 cm long, in small, usually simply pinnate leaves $\frac{2}{5}$, in large, bipinnate ones up to almost 1½ × as long as the lamina. Lamina ca. 10–25 cm long, bright medium or dark to olivaceous green when dry, chartaceous, simply pinnate or more often bipinnate, with 1 or 2 pairs of lateral pinnae and a conform terminal one; primary rachis stramineous or pale reddish brown, abaxially bi-angular. Pinnae (if any) or simply pinnate lamina 10–20 cm long, 1½–2½ cm wide (the terminal sometimes larger), ascending or spreading, subsessile, the lateral pairs (if any) several cm apart, not contiguous, acuminate; secondary rachises stramineous, abaxially bi-angular, shallowly sulcate. Pinnules ca. 25–35 to a side, spreading or slightly ascending, almost their width apart to subcontiguous, parallelogrammoid, trapezoid, or less often subligulate, mostly with ± parallel upper and lower margins, i.e. hardly narrowed to the apex, both margins straight, or the uper slightly convex, the lower slightly concave, the inner straight, the outer distinct, straight or a little convex, meeting the upper at right angles or at a smaller angle; major pinnules 10–15 mm long, 5–6 mm wide, 2–2½ (– 3) × as long as wide. Upper and outer margin very shallowly crenate, regularly so if sterile, less so if fertile, with rounded to subacute, uninerval lobes, the incisions up to 1 mm deep but usually only ¼ or ½ mm, reaching or slightly surpassing the level of the receptacle. Lobes with slightly convex or straight outer margin. Upper pinnules gradually and strongly reduced, one or a few ± denticuliform ones connected with the small, narrowly lanceolate terminal segment. Veins immersed, ± evident, mostly twice forked, rather regularly anastomosing, forming a series of areoles ½–1 mm wide. Sori interrupted by the incisions, on (1 -) 2–4 (—5) vein-ends; indusium with at least laterally convex base, pale, entire, ¼ mm wide, not reaching the margin by a smaller distance to equaling or slightly surpassing it, scarcely reflexed at maturity, the laminal lobe oppsite it often pale on the adaxial side, Spores pale browish, trilete, smooth, ca. 21 μ.

Ecology. Terrestrial in forests, 200 — 700 m (very few data).

Distribution. Ceylon, apparently not rare; southern Peninsular India.

INDIA. Madras: *Beddome 40* (E, K), s.n. (BM, K). — Kerala: *Beddome* s.n. (K).

CEYLON. *Thwaites CP 982* p.p. (B, BM, BO, E, GH, K, SING, S-PA, W, some or all isotypes); *Moon* s.n. (BM); *Lenormand* s.n. (B, fragm.); *F. Schmid 1110, 1116, 1133* (BM); *Wall* s.n. (BO, GH, S-PA); *Rawson 554a 3320* (BM); *Ferguson 36* (GH), *44* p.p. (US); *v. Fridau* s.n. (HBG); *Sledge 997* (K), *1377* (K, U); *Robinson 116* p.p. (K); *Naylor Beckett* s.n. (K); *Haycock* s.n. (BM); *Randall* s.n. (BM); *Bradford* s.n. (BM); *Emerson* s.n. (E); *Koenig* s.n. (L).

Notes. In spite of the excellent original description, the wide distribution of the type collection, and the distinctness of the species, *L. venusta* almost fell into oblivion, the name appearing on hardly any herbarium label. The short, submarginal sori and regularly crenate sterile margin are unique in the section but are reminiscent of *L. repanda* of the Bonin Islands (sect. Schizoloma), and also of *L. kirkii* of the Seychelles, a similarity already noted by Kuhn (loc. cit.). The affinities of *L. venusta* in section Synaphlebium are not clear.

SECTION **Lindsaea**

24. **Lindsaea doryphora** Kramer Blumea 15 (1968) 566. TYPE: Alston 13358, Permantang, Kalimantan, Borneo (U; dupl. in BM). — *L. scandens* Hooker var. *terrestris* Holttum Rev. Fl. Mal. 2 (1954) 327, nom. invalid. (not typified). — *L. lancea* auct. non (L.) Beddome of various authors, as to Asiatic material, at least in part.

For description see Fl. Mal. (sp. 32).

Distribution. Malay Peninsula to Borneo and the Philippines.

THAILAND. *Kerr 14458* (K); *Eryl Smith 463* (K, SING), *1874* (K), 1875 (K, SING), *2269, 2295, 2296* (K).

BURMA. Tenasserim: *Wallich* s.n. (K); *Wight 219* (B).

SECTION **Aulacorhachis** Kramer, **sect. nova.**

Squamae rhizomatis nodulis corticis oblongis insidentes; lamina bipinnata, rhachides saltem sulco adaxiali tomentum perbrevem sed sine lente manifestum gerentes; pinnulae dimidiatae, haud incisae, venulis liberis, soris continuis. Species typica (adhuc unica): *Lindsaea caudata* Hooker.

25. **Lindsaea caudata** Hooker Sp. Fil. 1 (1846) 215; Beddome Ferns S. India (1863/64) 73, pl. 217. — *L. trapeziformis* Dryander var. *caudata* (Hooker) Cesati Atti Ac. Sc. Fis. Mat. Napoli 7 (1877) 14. — *L. lancea* (L.) Beddome var. *caudata* (Hooker) v.A.v.R. Handb. 1 (1908) 273. Type: Mrs. *Walker* s.n., Adam's Peak, Ceylon (K). — *L. lancea* auct. non (L.) Beddome; Beddome Ferns Br. India (1892) 75.

Rhizome terrestrial (prob. short-creeping, only small pieces seen), up to 4 mm in diam.; scales medium brown, narrowly triangular, long-acuminate to the rather shortly uni-bi-seriate apex, to 3 mm long, inserted on oblong mounds of cortical tissue from which they are not quite sharply differentiated at the ca. 6-seriate base. Leaves presumably close; petioles dark brown to blackish, ± lustrous, rather stout, up to 3 mm in diam. at the apex, abaxially terete, adaxially flattened but scarcely sulcate, ca. 25 — over 60 cm long, about as long as to 1½ x as long as the lamina. Lamina usually dark olivaceous to blackish when dry, herbaceous or chartaceous, ca. 25 — 50 cm long, bipinnate, with 3 — 9 pinnae to a side and a conform terminal one; primary rachis like the petiole, occasionally laterally ± puberulent just below the pinna bases or rarely throughout, adaxially sulcate, in the groove persistently or fugaciously puberulent. Pinnae laxly ascending, often alternate throughout, with a petiolule of a few mm to 2 cm, ca. 10 — 25 cm long, 2½ — 4½ cm wide, basally not or only anteriorly slightly narrowed, rather abruptly and strongly narrowed near the apex, with ca. 15 — 25 well-developed pinnules to a side; upper pinnae little or not reduced; secondary rachises dark reddish brown or occasionally darker or pale, mostly abruptly discolorous at their insertion, abaxially terete, adaxially sulcate, permanently puberulent in the groove, in the basal part often also laterally, sometimes the posterior pinnule-bases also slightly puberulent; hairs 0.2 — 0.4 mm long, with up to 5 cells, the terminal cell rounded; rachis of the terminal pinna not or not abruptly discolorous. Pinnules spreading or slightly ascending, close to contiguous or slightly overlapping, not rarely touching or overlying the rachis with their inner margin, ¼-elliptic to subligulate, in shape very much like those of *L. parasitica, L. doryphora,* and *L. lancea,* cuneate-subpetiolulate at the base, the inner margin straight, the lower straight or basally concave or apically convex, the upper margin outward increasingly convex, broadly rounded into the outer which is not truly distinct, transition between outer and lower margin shortly rounded to subacute; larger pinnules 13 — 22 mm long, 7 — 10 mm wide, 2 (- 2½) x as long as wide. Upper pinnules rather abruptly reduced, a few denticuliform, one or a few connected with the small, narrowly lanceolate, in herbarium specimens often lost pinna-apex (but one specimen, Fendler s.n., GH, with scarcely reduced upper pinnules and a large, flabellate, free terminal pinnule, the terminal pinna with a normal apex). Upper/outer edge of pinnules shallowly and regularly crenate in sterile, quite entire in fertile pinnules; lower base usually pale and distinctly sclerotic. Veins evident, abaxially elevated at the base or throughout, free, 1 — 3 x forked, rather close, ca. ¾ mm apart. Sori continuous around the upper and outer margin (except in incompletely fertile pinnules), with abundant filiform pluricellular paraphyses; indusium brownish, rigid, entire, narrow, 0.2 — 0.3 mm wide, almost or quite equaling the margin, strongly reflexed and quite concealed at maturity. Spores medium brown, trilete, minutely granulate, ca. 35 — 40 μ.

Ecology and distribution. Confined to Ceylon; hardly any data on habitat and distribution on the island. Probably only in the mountains of the central massif; very few recent collections, perhaps now very rare through destruction of forests.

CEYLON. *Thwaites CP 1380* (B, BM, BO, E, GH, L, P, SING, W), s.n. (K, W); *Ferguson 37* (GH); *Beddome* s.n. (K); *Thomson* s.n. (B, GH, P); *Hooker & Thomson 302* (BM); *Gardner 22* (P.W.), s.n. (BM, K); *Wall* s.n. (B, BO, K, S-PA); *Finlayson* s.n. (BM); *Nietner* s.n. (HBG); Mrs. *Walker* s.n. (K, type); *J. Smith* s.n. (S-PA); *Robinson* s.n. (K); *v. Fridau* s.n. (HBG); *Sledge 821* (U); *Emerson* s.n. (E); *Gower* s.n. (E); *Wight 1916* (E).

Notes. In spite of its similarity to *L. parasitica, L. doryphora,* and *L. lancea, L. caudata* is readily distinguishable by the pubescence in the adaxial grooves of the leaf axes. It is surprising that this character has not been described before. It is almost unique in the Lindsaeoid ferns, being otherwise only found in the Antillean *Odontosoria uncinella.*

SECTION **Osmolindsaea** Kramer

26. **Lindsaea odorata** Roxburgh Calc. J. Nat. Hist. 4 (1846) 511; Kramer Blumea 15 (1968) 567. Type: a plant from the Garrow Hills, India; no specimen extant, Plate 2578 of Icones Roxburghianae (K) to be regarded as type. — *L. cultrata* (Willd.) Swartz var. *minor* Hooker Sp. Fil. 1 (1846) 204 in part, excl. lectotype. — *L. cultrata* (Willd.) Swartz var. *pallens* Hooker Sp. Fil. 1 (1846) 204; Kunze Linnaea 24 (1851) 276. Lectotype: *de Silva 151* or s.n., Silhet, Assam (K). — *L. cultrata* (Willd.) Swartz var. *attenuata* Hooker Sp. Fil. 1 (1846) 204. Lectotype: *Griffith 862,* Assam (K). — *L. neocultrata* Ching & Wang Acta Phytotax. Sin. 8 (1959) 165, pl. 19 fig. 15; Ching Fl. Reip. Pop. Sin. 2 (1959) 260, pl. 22 fig. 8–9; Chun, Chang & Chen Fl. Hain. 1 (1964) 54, fig. 23. Type: E. Hainan Exped. 893, Tia-lo Shan, Hainan (not seen). — *L. cultrata* auct. non (Willd.) Swartz of nearly all authors, e.g., Beddome Ferns S. India (1863/64, 1873) 7, pl. 23; Nakai J. Coll. Sc. Imp. Un. Tokyo 31 (1911) 403; Ogata Ic. Fil. Jap. 2 (1929) pl. 79; Tagawa Acta Phytotax. Geob. 6 (1937) 26, fig. 1 A-C; Tardieu-Blot & Christensen Fl. Gén. I.-C. 7 (1939) 120; Ito Fil. Jap. Ill. (1944) pl. 16; Holttum Rev. Fl. Mal. 2 (1954) 328, fig. 188; Ching Fl. Reip. Pop Sin. 2 (1959) 260, pl. 22 fig. 1–7; Tagawa Col. Ill. Jap. Pterid. (1959) 53, 226, fig. 84; Chun, Chang & Chen Fl. Hain. 1 (1964) 55.

For further synonymy and description see Fl. Mal. (sp. 33). Two varieties in the present area: *

a. Var. **odorata.**

Pinnules incised, sori interrupted; upper pinnules gradually and strongly reduced.

Distribution. Tropical and subtropical Asia from Ceylon, Tibet, and Japan to western Melanesia, Rhodesia and Madagascar. Very common in many parts of Asia.

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* A third variety, var. *darjeelingensis* Sen & Sen, was recently described from West Bengal [Am. Fern J. 61 (1971) 14].

Geographically selected citations:

JAPAN. Honshu: *Tagawa 7385* (E, GH, K, L, U); *Tagawa & Iwatsuki 718* (E, GH, K, L, Pic-Ser, U, US); *Ito 82* (SING). — Kyushu: *Sugimoto* s.n. (A). — Hachijo Jima: *Ohba* s.n. (TOFO). — Ryukyu: Yakushima, *Tagawa 789* (K, SING); *Faurie 4596, 4597* (B, BM, W); *Togasi TNS 1479* (E, K, S-PA, US).

TAIWAN, *Ream 461* (MICH); *Hancock 6* (B, BM, K, US); *Oldham* s.n. (GH, K, W); *Faurie 618, 619* (S-PA); *Kao 4116* (TAI).

CHINA. Szechuan: *Wilson 2671* (BM, E, HBG, K, US, W); *Fang 3233* (E, GH, US), *3918, 7998* (E, K); *H. Smith 2065* (S-PA). — Yünnan: *Delavay 21* (K); *Handel-Mazzetti* s.n. (K); *Cavalerie 1769, 7060* (E, K); *Forrest 9358* (E, K), *11756* (BM, E, K, W); *Rock 7189, 7359* (US); *Tsai 52429* (US), *55242* (GH, US), *58989* (GH), *60747* (GH, S-PA); *Maire 66* (S-PA), s.n. (SING, US, W, Z). — Kweichow: *Tsiang 4584* (E, GH, SING, S-PA, US), *4726* (GH, SING). — Kwangsi: *Ching 5787* (US); *Tsang 22715* (A, W). — Kwangtung: *Tsang 20226* (A, K, US, W), *25219, 25385 25475* (A); *Metcalf 17512, 17738* (MICH); *Merrill 1607* (GH).

TIBET. *Forrest 19953* (E); *Ludlow, Sheriff & Taylor 7032* (BM).

INDO-CHINA. Tonkin: *Pételot 581* (US), *5401* (GH). — Annam: *Chevalier 30690* (K), *30776* (SING).

THAILAND. *Sörensen, Larsen & Hansen 2335* (E, K); *Smitinand 395* (K); *Floto 7405* (K); *Tagawa, Iwatsuki & Fukuoka T 595* (L, U).

BURMA. *Kingdon Ward 21160* (BM, GH); *Parish* s.n. (E); *Buchanan* s.n. (E); *Toppin 4294* (E).

BHUTAN. *Ludlow & Sheriff 997* (BM, E); *Griffith* s.n. (B, K, W); *Cooper 2828* (BM).

SIKKIM. *Bor & Ram 19730* (BM, SING); *Meebold 2117* (B); *Gamble 6998* (E), *9961* (K); *Engler 5483* (B).

NEPAL. *Wallich 148* or s.n. (B, BM, E, GH, K, US); *Bonner 134* (BM); *Stainton, Sykes & Williams 6941* (BM, E, Pic-Ser).

BANGLA DESH. *Clarke 19626* (BM).

INDIA. Assam: many coll., e.g., *Sinclair 2950* (E); *Kingdon Ward 18663* (BM), *18794* (A, BM); *Hooker & Thomson* s.n. (B, BM, E, GH, K, S-PA, U, US, W); *Mann* s.n. (BO, SING, S-PA); *Biswas 4101* (GH). — West Bengal: *Gupta 17* (SING); *Bir* s.n. (U, US); *Pichi-Sermolli 4604, 4635* (Pic-Ser). — Mysore: *Thomson* s.n. (B, BM, E, S-PA, U, W). — Madras: *Ysander* s.n. (S-PA); *Wight 220* (E); *Bembower 3* (MICH); *Gamble 17365* (E); *Noyes* s.n. (GH); *Faucheux* s.n. (BM). — Kerala: *Meebold 13334* (B, S-PA).

CEYLON. *Holttum* SFN *39212* (SING); *Wall* s.n. (BO, E, GH); *Freeman 43, 44, 45* (BM); *Thwaites* CP *3070* (B, BM, BO, E, GH, L, W); *Hance 47* (W); *Nietner* s.n. (B, HBG); *Parish* s.n. (E); *Gardner 1121* (E).

Notes. Some of the Chinese and Japanese specimens have more widely creeping rhizomes than usual but are not otherwise divergent.

As noted in Fl. Mal., freshly dried leaves of *L. odorata* have a distinct coumarin-like odour. I am much indebted to Dr. K. Iwatsuki, Kyoto, for the following information otherwise not accessible to me. According to Shimada, Sawada, Kozuka, and Kojima (Jap. J. Pharmac. 22, 1968, 37–38; Japanese) coumarin (I) was found in the methanol extract of *L. odorata* (*"cultrata"*) from the Kii Peninsula, Honshu. It is supposed to be present in the living plant [which lacks the odour] as a glycoside of coumaric acid.

b. Var. **japonica** (Baker) Kramer **comb. nov.** Basionym: *L. cultrata* (Willd.) Swartz var. *japonica* Baker Syn. Fil. 1st ed. (1867) 105. — *L. japonica* (Baker) Diels in E. P. Pfl. Fam. I^4 (1899) 221; Tagawa Acta Phytotax. Geob. 6 (1937) 27, fig. 1 d–e; Ito Fil. Jap. Ill. (1944) pl. 17; Tagawa Col. Ill. Jap. Pterid. (1959) 53, 226, fig. 85; Ching Fl. Reip. Pop. Sin. 2 (1959) 259. Type: *Oldham* s.n., Nagasaki, Japan (K; dupl. in GH).

Rhizome not very short-creeping, $\frac{2}{3}$–1 mm in diam.; scales not seen. Petioles at least in the basal half, often throughout, castaneous, abaxially terete, 2–7 cm long, mostly shorter than the lamina. Lamina 2–9 cm long, 1–2$\frac{1}{2}$ cm wide, with 3–15 pinnules to a side, these their width apart to subcontiguous, spreading, herbaceous, mostly olivaceous when dry, asymmetrically triangular to dimidiate-ovate, obtuse or less often subacute, 4 × 3 to 11 × 5 mm, the basal ones slightly or not reduced, sterile and crenate or with a short sorus near the apex, the middle ones entire, with an unbroken sorus, or rarely with one shallow incision interrupting the sorus. Upper pinnules little reduced, about half as long as the lower ones, the leaf-apex consisting of a cuneate-flabellate, distally always truncate, free or almost free pinnule; or in larger specimens more strongly reduced, some denticuliform ones confluent with the narrow, lobed leaf-apex. Indusium as in var. *odorata*, or in small specimens a little narrower; spores as in var. *odorata*.

Distribution. See below.

KOREA, Cheju Dô (Quelpaert I): *Faurie 90* (B, BM, E, MICH); *Taquet 51* (E, W), *2339 4754* (E, K), *3542* (E, S-PA), s.n. (GH, MICH, W).

JAPAN. Honshu: *Ito 82* (SING). — Hachijo Jima: *Ohsuga* s.n. (TOFO). — Kyushu: *Maximowicz 120* (B, BM, GH, K, L, S-PA, W); *Oldham* s.n. (GH, K, type), *477* (B); *Kido 2663* (TOFO); *Tagawa & Iwatsuki 1077* (E, GH, K, L, U); *Namegata 11560* (TENN), *11796* (US). — Ryukyu: Yakushima, *Ohba 66182* (U); *Ito 83* (SING). Amami Oshima, *Hosoyamada* s.n. (US). Okinawa, *Sonohara, Tawada & Amano 7096* (BISH, MICH, US); *Conover 931* (US), *1798* (BISH, US); *Ito* s.n. (US); *Tashiro* s.n. (US); *Ogata 194* (BM). Ishigaki, *Walker & Tawada 7283* (US). — Iriomote, *Nishida* s.n. (US); *Walker & Tawada 6757* (US); *Ito* s.n. (US); *Hatusima 23046* (TAI).

TAIWAN. *Ito* s.n. (BM, GH); *Swinhoe* s.n. (B); *Oldham* s.n. (BM, W, p.p.); *Wilford 466* (K); *Faurie 254* (S–PA); *Ford* s.n. (K).

CHINA. Szechuan: *H. Smith 13614* (BM, E, S–PA).

Notes. At first sight this might be taken for a small phenotypic form of *L. odorata*, and I am not quite sure that this is not the case, i.a. in view of the disjunct occurrence in western China. After comparison with a large series of typical *L. odorata* it seemed that the combination of small size, dark petiole, unbroken sori, reduced and quite or almost sterile basal pinnules could serve for distinguishing a taxon, but, especially in view of the great variability of *L. odorata* proper, at the varietal level. Small specimens of *L. odorata* from the Philippines look very much like var. *japonica* but have paler axes, broken sori, or both.

27. **Lindsaea himalaica** Kramer spec. nov. — *L. cultrata* (Willd.) Swartz var. *minor* Hooker Sp. Fil. 1 (1846) 204, p.p., excl. lectot. — *L. cultrata* (Willd.) Swartz var. *assamica* Hooker loc. cit., ex char. (no material cited). **Fig. 3**

L. odoratae valde affinis, differt petiolo et saltem dimidio basali rhachidis obscuris, pinnulis margine exteriore distincto, incisionibus tantum singulis vel binis. Type: *Simons* s.n., Bhutan (BM).

Rhizome short-creeping, 1½ mm in diam.; scales reddish brown, very narrowly triangular, the basal half or less biseriate, the apical half uniseriate, up to 4-seriate at the extreme base, up to 1½ mm long. Leaves close to clustered; petiole atropurpureous to blackish, ± lustrous, abaxially rounded, shorter than the lamina. Lamina linear, simply pinnate, ca. 15–35 cm long, slightly longer than to ca. 3 × as long as the petiole, 2–3½ cm wide, with (10–) 20–40 pinnules to a side; rachis abaxially rounded or narrowed-rounded, at least in the basal half dark reddish brown to blackish. Pinnules spreading or little ascending, half their width apart to contiguous, subcoriaceous to coriaceous and olivaceous when dry, subtrapezoidal or subparallelogrammoid, little or not narrowed to the truncate or very shortly rounded apex, the base cuneiform-subpetioluliform, abruptly pale-offset from the rachis; larger pinnules 10–18 mm long, 4½–9 mm wide, 2–2½ × as long as wide. Lower margin straight, upper margin straight or slightly convex towards the apex, meeting the outer margin at right angles or very shortly rounded into it. Upper margin with 1 or 2 very shallow incisions to ½ mm deep; outer margin entire, its sorus continuous with the outermost of the upper margin. Veins immersed, scarcely visible even in transmittent light, free, close, ½–¾ mm apart, 1–3 × forked. Upper pinnules gradually and ± strongly reduced, one or a few denticuliform ones connected with the small, narrow, lobed, lanceolate-linear leaf-apex; sometimes a few basal pinnules ± remote and reduced. Sori 2 or 3 per pinnule, usually somewhat convex on the inner margin near the incision(s) of the pinnule; indusium brownish, rigid, entire or nearly so, scarcely narrowed at the ends, 0.4–0.5 mm wide, almost or quite reaching the margin. Spores medium brown, monolete, bean-shaped, smooth, ca. 40 × 25 μ.

Ecology. No data.

Distribution. See below.

BHUTAN. *Griffith 135* or s.n. (B, GH, K, MICH, syntype of *L. cultrata* var. *minor*); *Simons* s.n. (BM, type).

INDIA. Assam: *Simons* s.n. (BM); *Griffith* s.n. (K, type of *L. cultrata* var. *assamica* ?); *March* s.n. (K). N.E.F.A., *R. S. Rao 17471* (K).

Notes. Two specimens from N.E. India, *Meebold 4787 from* Manipur (B) and *Watt 11039* from Assam (GH), approach *L. himalaica* in texture and in outline of pinnules, but have only basally dark rachises and more interrupted sori. They are better regarded as an extreme form of *L. odorata*. With the material at hand *L. himalaica* seems sufficiently distinct to merit specific rank.

SECTION **Psammolindsaea** Kramer

28. **Lindsaea walkerae** Hooker Sp. Fil. 1 (1846) 209, pl. 69A; Beddome Ferns S. India (1863/64) 72, pl. 215; Ferns Br. India (1892) 76; Kramer Blumea 15 (1968) 560, 17 (1970) 177. — *Schizoloma walkerae* (Hooker) Kuhn Chaetopt. (1882) 346; Tardieu-Blot & Christensen Fl. Gén. I.-C. 7 (1939) 128; Holttum Rev. Fl. Mal. 2 (1954) 344. Type: Mrs. *Walker* s.n., Ceylon (K; dupl. in B).

For further synonymy and description see Fl. Mal. (sp. 35).

Distribution. Ceylon and Indo-China to Malesia, Queensland, and Micronesia.

INDO-CHINA. Tonkin: *Balansa* s.n. (P). — Cochin China: *Talmy* s.n. (P); *Bois 2226* (BM, P).

CEYLON. *Thwaites CP 1379* (B, BM, BO, E, GH, K, S-PA, U, W); Mrs. *Walker* s.n. (B, K, type); *McKenzie* s.n. (K); *Ferguson 43* (US); *Walker* s.n. (GH); *Fendler 2028* (GH); Mrs. *McDonnell* s.n. (K); *Wall* s.n. (BO, GH); *Gardner 1379* (K); *Sledge 1376* (K); *Wight 105* bis (E); *Emerson* s.n. (E).

SECTION **Isoloma** (J. Smith) Kramer

29. **Lindsaea divergens** Hooker & Greville Ic. Fil. (1831) pl. 226; Beddome Ferns Br. India (1892) 76, fig. 38. — *Isoloma divergens* (Hooker & Greville) J. Smith Hook. J. Bot. 3 (1841) 414; Holttum Rev. Fl. Mal. 2 (1954) 337, fig. 195. Type: a *Wallich* collection from herb. Roxburgh (K, herb. Hooker, ?).

For further synonymy and description see Fl. Mal. (sp. 41).

Distribution. Malay Peninsula, Malesia to Borneo and Palawan.

THAILAND. *Kerr 15935* (K).

SECTION **Stenolindsaea** Kramer

30. **Lindsaea lucida** Blume En. Pl. Jav. (1828) 216; Tardieu-Blot & Christensen Fl. Gén. I-C.7 (1939) 122; Holttum Rev. Fl. Mal. 2 (1954) 328, fig. 187; Ching Fl. Reip. Pop. Sin. 2 (1959) 263; Chun, Chang & Chen Fl. Hain. 1 (1964) 55; Kramer Blumea 15 (1968) 567. Type: *Blume* s.n., Java (L). — *L. gracilis* Blume En. Pl. Jav. (1828) 217. Type: *Blume* s.n., Java (L). — *L. concinna* J. Smith Hook. J. Bot. 3 (1841) 415, nom subnud.; Hooker Sp. Fil. 1 (1846) 205, pl. 61 B; Tagawa Acta Phytotax. Geob. 6 (1937) 29, fig. G-I; Ito Fil. Jap. Ill. (1944) pl. 19; Ching Fl. Reip. Pop. Sin. 2 (1959) 262. Type: *Cuming 198*, Luzon (K; dupl. in B, E, GH, HBG, L, SING, W). — *L. lobbiana* Hooker Sp. Fil. 1 (1846) 205, pl. 62 C. Type: *Lobb* s.n., Java (K). — *L. kusukusensis* Hayata Ic. Pl. Form. 4 (1914) 211, fig. 143; Ching Fl. Reip. Pop. Sin. 2 (1959) 262. — *L. concinna* J. Smith var. *kusukusensis* (Hayata) Tagawa Acta Phytotax. Geob. 6 (1937) 30. Type: *Hayata & Sasaki* s.n., Kusukusu, Taiwan (not seen), — *L. minima* Ching Sinensia 1 (1930) 52, non Copeland (1929). — *L. changii* C. Christensen Ind. Fil. Suppl. 3 (1934) 121; Ching Fl. Reip. Pop. Sin. 2 (1959) 261. Type: *Chang* s.n., Kuling, Kiangsi, China (dupl. in K). — *L. cultrata* (Willd.) Swartz var. *attenuata* Hooker Sp. Fil. 1 (1846) 204, p.p., excl. lectot.

For further synonymy and description see Fl. Mal. (sp. 42).

Distribution. In continental Asia etc. only ssp. *lucida*, which occurs East to Malesia and the Palau Is.

JAPAN. Ryukyu: Ishigaki, *Walker & Tawada 7182* (MICH, US); *Nishida 312* (US); *Tagawa & Iwatsuki 4486* (US), *4761* (E, K, L, U). Iriomote, *Hatusima 18532* (US); *Bandai* s.n. (TOFO); *Koidzumi* s.n. (US).

CHINA. Kiangsi: *Chang* s.n. (K, isotype of *L. minima* = *L. changii*). — Kwangtung: *Tsang 26755* (A, K). — Hainan: *Eryl Smith 1466* (K, SING, US); *Lau 3596* (BISH, GH, MICH, S-PA), *5107* (MICH); *How 72036, 72725* (GH); *Wang 34571* (E. GH, MICH).

INDO-CHINA. Tonkin: *Pételot s.n.* (BM); *Tsang 29900* (A, E, K, TAI), *30036, 30236* (A, E, K). — Annam: *Sallet 5* (BO); *Cadière 51* (MICH); *Matthew 25* (K), s.n. (BM). — Cochin China: *Gaudichaud* s.n. (B).

THAILAND. *H. M. Smith 602* (GH, MICH, US); *Hansen & Smitinand 12264* (L); *Eryl Smith 922* (K), *1701* (SING), *1559, 1876* (K), *2279* (BM, K); *Kiah 24297* (K. SING); *Marcan 1260, 1264* (BM); *Kerr 9235, 17029* (K); *Sörensen, Larsen & Hansen 182* (E, K); *Murton 7* (K); *Iwatsuki & Fukuoka T 7389* (U).

BURMA. *Rock 750* (BM, US); *Sidney 32* (U, US). Tenasserim, *Falconer* s.n. (BO, L); *Wight 220* (US); *Parish* s.n. (BM).

BHUTAN. *Griffith 1670* (E).

BANGLA DESH. *King 61* (US).

INDIA. Assam: *Mann* s.n. (E, HBG, L, S-PA, US); *Griffith* s.n. (B, K); *Day* s.n. (GH); *Barnard 41 A* (BM); *Wenger 167* (K). — Manipur: *Watt 6925* (E). — West Bengal: *Thomson* s.n. (B). — Madras: *Gamble 17365* p.p. (US). — Andaman Is: *Kunstler* s.n. (B). — Not seen from Taiwan. To be looked for in Ceylon.

SUBGENUS **Odontoloma** (Hooker) Kramer

SECTION **Odontoloma**

31. **Lindsaea glandulifera** v.A.v.R. Bull. Jard. Bot. Btzg II. 1 (1911) 9. Type: *Koorders 15415* B, Besuki, Java (BO; dupl. in K, L). — *L. repens* (Bory) Thwaites f. *minor* Thwaites En. Pl. Zeyl. (1864) 388. — *L. repens* (Bory) Thwaites var. *minor* (Thwaites) Beddome Ferns S. India (1863/64) 72, pl. 214. Type: *Thwaites CP 1389* p.p mai., Ceylon [K; dupl. (all?) in B, BM, BO, E, GH, W].

For further synonymy and description see Fl. Mal. (sp. 44).

Distribution. East Java and Lesser Sunda Is.

CEYLON. *Thwaites CP 1389* p.p. mai. (B, BM, BO, E, GH, K, W, type coll. of *L. repens* f. or var. *minor*); *Hooker & Thomson* s.n. (BM); *Robinson 110a* (K); *Skinner* s.n. (K); *J. Smith* s.n. (S-PA).

Note. The strongly disjunct distribution is of an unusual pattern. The two populations do not seem to be even infraspecifically distinct.

32. **Lindsaea repens** (Bory) Thwaites En. Pl. Zeyl. (1864) 388; Beddome Ferns S. India (1863/64) 72, pl. 209; Ogata Ic. Fil. Jap. 5 (1933) pl. 232, as to plant depicted; Tardieu-Blot & Christensen Fl. Gén. I.-C. 7 (1939) 120; Kramer Blumea 15 (1968) 568, 17 (1970) 180. — *Dicksonia repens* Bory Voy. 2 (1804) 323. Type: *Bory* s.n., Réunion (P). — *L. macraeana* auct. non (Hooker & Arnott) Copeland of later authors, e.g., Holttum Rev. Fl. Mal. 2 (1954) 324, fig. 185; not of Ching Fl. Reip. Pop. Sin. 2 (1959) 266.

For further synonymy and description see Fl. Mal. (sp. 46). In our area this species is only represented by var. **pectinata** (Blume) Mettenius ex Kuhn Miq. Ann. Mus. Lugd. -Bat. 4 (1868) 277; Kramer Blumea 15 (1968) 568. — *L. pectinata* Blume En. Pl. Jav. (1828) 217; not of Holttum Rev. Fl. Mal. 2 (1954) 324. Type: *Blume* s.n., Java (L).

For further synonymy and description see Fl. Mal. (sp. 46, 3).

Distribution. Assam and Indo-China to the Greater Sunda Is. and the Philippines.

INDO-CHINA, Annam: *Evrard 1872* (BO, GH, K), *Poilane 3513* (MICH), *3533* (SING), *21852* (BO, GH, K, MICH, SING), *22343* (MICH); *Fleury* (*Chevalier 38797*) (K); *Vincens* s.n. (GH, K, MICH, SING); *Anet 1919* (BO) — Cochin China: *Pierre 5707* (BO, E, GH, HBG, K, MICH, SING), *5707 A* (E, K, MICH). — Cambodia: *Poilane 15175* (K, MICH, SING).

THAILAND. *Smitinand 860* (K); *Eryl Smith 634* (BM, K, SING), *2305* (K).

SIKKIM. *Clarke 36800 C, E, F, 37002 G, M* (E).

INDIA. Assam: *Mann* s.n. (B, BO, BRI, E, HBG, L, SING, S-PA, US); *Gammie 68* (B, W).

CEYLON. *Wall 1012* (S-PA); *Thwaites CP 1389* p.p. min. (E), *3389* (B, BM, BO, E, GH, K, S-PA, W); *Ferguson 29* (GH, US).

Not seen from Burma. A specimen marked "Hongkong in locis umbrosis silvaticis Dec. 67 Dr. M. . . [?]" in herb. P probably mislabelled.

33. **Lindsaea merrillii** Copeland Perkins Fragm. (1905) 181; Tagawa Acta Phytotax. Geob. 6 (1937) 33, fig. 2 E, F. Type: *Merrill 1774*, Mindoro, Philippines (MICH; dupl. in B, GH, K, US).

The typical subspecies is confined to the Philippines. In the present area only ssp. yaeyamensis is found.

Ssp. **yaeyamensis** (Tagawa) Kramer **stat. nov.** Basionym: *Lindsaea yaeyamensis* Tagawa Acta Phytotax. Geob. 6 (1937) 31, fig. 2 C, D; Ito Fil. Jap. I11. (1944) pl. 18. Type: *Koidzumi* s.n., Iriomote, Ryukyu (KYO, not seen; dupl. in US). — *L. macraeana auct.* non (Hooker & Arnott) Copeland; Ching Fl. Reip. Pop. Sin. 2 (1959) 266.

In most respects similar to ssp. *merrillii* (see Fl. Mal. sp. 48). The petioles tend to be more rounded abaxially and are sometimes a little longer. The main difference is in the teeth of the fertile pinnule lobes, which in typical ssp. *yaeyamensis* have a minutely erose to subentire apical margin with a tooth at each end, whereas they are protracted and ± dentiform in the middle in ssp. *merrillii*. This was described and very clearly illustrated by Tagawa (loc. cit.). The sori of ssp. *yaeyamensis* are more often binerval, and the indusia may almost reach the margin. Some of the specimens from Taiwan are very close to ssp. *merrillii*.

JAPAN. Ryukyu: Ishigaki, *Nishida 374* (US); *Kawagoe* s.n. (US); *Fosberg 37409* (L); *Masamune & Suzuki* s.n (TAI 6198). Iriomote, *Walker & Tawada 6733* (BISH, K, L, MICH, US) *6871* (US); *Gressitt 580* (B, BM, GH, U); *Tagawa & Iwatsuki 4762* (E,K,L,U); *Masamune* s.n. (TAI); *Oka 13743* (TOFO); *Bandai* s.n. (TOFO); *Koidzumi* s.n. (US, isotype).

TAIWAN. *Beattie & Kurihara 10391a* (US); *Ogata 196* (BM); *Tagawa 955* (BM), *976* (K, paratype); *Henry 1362* (B); *Simizu 2789* (TAI); *Hukuyama 664* (TAI); *Kudo & Mori s.n.* (TAI 6169); *Chuang & Kao 3409* (TAI, U). Botel Tobago, *Hsu* s.n. (U); *Chuang & Hsu 2452* (TAI); *Yamamoto* s.n. (TAI 6162). Orchid I., *Sasaki* s.n. (TAI 6161); *Huang & Kao 7533* (TAI,U).

SECTION **Pseudolancea** Kramer

34. **Lindsaea oblanceolata** v.A.v.R. Bull. Jard. Bot. Btzg II. 23 (1916) 15. Type: *Ajoeb 100*, Sumatra (BO; dupl. in L). — *L. pectinata* auct. non Blume; Holttum Rev. Fl.Mal. 2 (1954) 324.

For further synonymy and description see Fl. Mal. (sp. 45).

Distribution. Malesia, East to the Philippines and the Moluccas.

INDO-CHINA. Annam: *Evrard 1295* (MICH, SING); *Fleury 38797* (BO).

THAILAND. *Eryl Smith 1871* (K, SING); *Kerr 7541* (K), *13287* (K); *Tagawa, Iwatsuki & Fukuoka T 4781* bis (U); *Smitinand 875* (K, doubtful).

35. **Lindsaea parasitica** (Roxburgh ex Griffith) Hieronymus Hedwigia 62 (1920) 14; Kramer Blumea 15 (1968) 570. — *Vittaria parasitica* Roxburgh ex Griffith Calc. J. Nat. Hist, 4 (1844) 510. Type: *Roxburgh* s.n. Pulau Penang, Malaya (not seen). — *L. scandens* Hooker Sp. Fil. 1 (1846) 205, pl. 63 B; Beddome Ferns Br. India 2 (1868) pl. 298; id. (1892) 74, fig. 37; Holttum Rev. Fl. Mal. 2 (1954) 325, fig. 186; not of Tardieu-Blot & Christensen Fl. Gén. I. – C. 7 (1939) 121. Lectotype: *Cuming 405*, "Luzon" (K). — *L. lancea* auct. non (L.) Beddome of various authors, as to Asiatic material, at least in part.

For further synonymy and description see Fl. Mal. (sp. 52).

Distribution. Malay Peninsula, Sumatra, Borneo.

THAILAND. *v. Beusekom 804* (L); *Tagawa, Iwatsuki & Fukuoka T 5277* (L. U); *Eryl Smith 780, 1873* (K); *Kerr 7909* (K).

Doubtful and Insufficiently Known Species

Lindsaea conformis Ching Fl. Reip. Pop. Sin.2 (1959) 372 269. Type: *Tsang 24950*, Kwangtung, China (not seen). — judging from the description this is a form of *L. chienii*.

Lindsaea longipetiolata Ching Sinensia 1 (1930) 51; Bull. Fan Mem. Inst. Biol. Bot. Ser 10 (1940) 174; Fl. Reip. Pop. Sin.2 (1959) 270. Type: *C. C. Chang* s.n., Kiangsi, China (not seen). — This is presumably *L. orbiculata* var. *commixta*.

Lindsaea recedens Ching Fl. Reip. Pop. Sin.2 (1959) 373, 269. Type: *K. L. Ling 197*, Fukien, China (not seen); also reported from Kwangsi and Japan. — The citation of Ito's plate (Ic. Fil. Jap. pl.20) and the description show that this is almost certainly *L. chienii*.

Lindsaea simulans Ching Fl. Reip. Pop. Sin.2 (1959) 371, 265. Type: several syntype collections cited from Kwangsi, Kwangtung, and Yünnan. In the absence of a designated holotype the name is not validly published. One syntype seen: *Lau 2130* from Kwangtung (MICH), which is *L. orbiculata*.

Lindsaea taiwaniana Ching Fl. Reip. Pop. Sin. 2 (1959) 327, 267. Type: *Hancock 10*; also *128* (paratype), Taiwan (not seen). — Seems to be a form of *L. orbiculata*.

Lindsaea tenera Dryander Trans. Linn. Soc.3 (1797) 42, pl.10; non Kaulfuss 1824, nor of later authors.—*Schizoloma tenerum* (Dryander) Holttum Rev. Fl. Mal. 2 (1954) 348, as to type only. Type: "Habitat in India Orientali: Missionarii Societatis Unitatis Fratrum" (BM).

As stated before, the plants referred by all later authors to *L. tenera* do not match the type (Kramer 1968, where erroneously the name *L. cambodgensis* instead of *L. bouillodii* is adopted for them). The exact provenance of the material being unknown, it seemed that the identity of Dryander's type would remain a puzzle. Then three specimens came to the author's attention that seemed to shed some light on the problem, as they had several important characters in common with the type of *L. tenera*. They are *Kurz 26016* from the Nicobar Is. (K), *Kurz* s.n. (K) and *Parish* s.n. (E) from the Andaman Is. The differences between this material and what has always been called *L. tenera* (*L. bouillodii* in the present author's concept) may be summed up as follows: petiole stramineous to medium brown (not dark brown), texture thinly herbaceous with very lax venation (not chartaceous with venation of average density), pinnules rounded-rhombic, the incisions of very irregular depth (not rhombic-ovate or dimidiate-ovate and much more regularly incised), the upper pinnules very little incised, with long sori (this is not the case in *L. bouillodii*). The terminal segments are broader and more obtuse than those of *L. bouillodii* in the above-cited specimens but not in Dryander's type.

One of the collectors in the service of the "Societas Unitatis Fratrum" (= Moravian Brothers or Herrenhuters) was Koenig, as stated by Burkill (1965) *). As the Society had contact with the Nicobar Is. at a very early date, Dryander's specimens may very well have been collected by Koenig on that archipelago. As the material at hand is too scanty for a sound judgment of the status of the taxon and its variability, *L. tenera* is here kept among the insufficiently known taxa, although it may well be an endemic taxon, though not necessarily a species, of the Andaman and Nicobar Is.

Lindsaea yunnanensis Ching Fl. Reip. Pop. Sin. 2 (1959) 373, 271. Type: *K. M. Feng 13646*, Yünnan, China (not seen). — The description is unfortunately not accompanied by a figure. This may well be a distinct species, presumably related to *L. bouillodii* and/or *L. chingii*.

Vittaria resecta Roxburgh ex Griffith Calc. J. Nat Hist. 4 (1844) 510. Type: no specimen cited; said to be "nat. of Chittagong". The extremely brief description is vaguely reminiscent of *L. javanensis* which I saw from nearby Assam. It seems fairly certain that it applies to a species of *Lindsaea*, Roxburgh having described several other, mostly equally obscure species of *Lindsaea* under *Vittaria*.

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*I am indebted to Dr. F. M. Jarrett, Kew, for helpful advice and the bibliographic reference pertaining to this problem.

EXCLUDED SPECIES

Lindsaea lanuginosa Wallich ex Hooker Sp. Fil. 1 (1846) 210, pl. 69 B; Beddome Ferns Br. India (1892) 77, etc. = *Nephrolepis acutifolia* (Desv.) Christ.

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Notes on the Systematy of Malayan Phanerogams XI - XVII*

from

FOREST RESEARCH INSTITUTE, KEPONG, MALAYA

Abstract

Xylopia malayana var. *obscura* is a new variety.

The genus *Tabernaemontana* s.l. is preferred to its segregates.

New synonyms are proposed in *Leptopus australis, Glochidion brunneum, G. penangense, G. wallichianum, G. zeylanicum* var. *malayanum, Baccaurea motleyana, Blumeodendron tokbrai, B. borneense* and *Suregada multiflora. Glochidion trilobum* is a mixtum compositum. Three species are reduced to varieties:—*Austrobuxus nitidus* var. *montanus, Agrostistachys longifolia* var. *leptostachya* and *Trigonostemon verticillatus* var. *salicifolius. Endospermum diadenum* (formerly *malaccense*) has peltate leaves in youth. *Alchornea tiliifolia* is annotated.

Scaphocalyx parviflora is reduced to *S. spathacea,* making the genus monotypic.

Burkilliodendron was published 8 months earlier than *Alloburkillia* as a new name for *Burkillia* Ridley.

Glycosmis calcicola and var. *kelantanica* are new from limestone.

Pentace excelsa, P. grandiflora and *Schoutenia furfuracea* are new Tiliaceae from the east coast.

XI. Annonaceae (b)

K. M. KOCHUMMEN

Xylopia malayana Hk. f. et. Thoms. var. **obscura** Kochummen **var. nov.**

A varietas typica in folliis apice latiore breviore, subter nervis lateralibus et reticuliis obscuris differt.

TRENGGANU: Ulu Brang *FRI 12594* (holotype of var. KEP! ; A, K, L, SING).

PAHANG: Raub *KEP* 20309.

JOHORE: Rengam F. R. *FRI 2188*; G. Arong F. R. *FRI 2761.*

XII. Tabernaemontana (sens. lat.), Apocynaceae

T. C. WHITMORE

I follow Hallier (Bot. Jahrb., 49, 1913, 372–5), Merrill (Contrib. Arn. Arb. 8, 1934, 143–4) and Corner (Gdns' Bull. Str. Settl. 10, 1939, 276) in recognising *Tabernaemontana* L. in the broad sense and not its segregates *Ervatamia* (DC.) Stapf and *Pagiantha* Mgf.

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* Continued from Gdns' Bull. Sing. 24, 1969, 1–11; Fed. Mus. J. 13,1970,133–7.

I agree with these authors that there are species in the East, including Malaya, which transgress the differences between the segregate genera some of which are weak. There is also an important practical obstacle to the recognition of the segregates, that without careful re-examination of type material it is not clear to which segregate genus a species belongs; Markgraf (Notizbl. Berl. Dahlem 12, 1935, 540–52) who favours splitting has not himself seen all the types, few are represented in Singapore, and three species of *Ervatamia* (*E. curtisii* King & Gamble, *E. jasminiflora* Ridley and *E. pauciflora* Ridley) are not represented at all.

Malesian *Tabernaemontana* is clearly in need of revision and for the *Tree Flora of Malaya* only the trees can be satisfactorily described.

XIII. Euphorbiaceae

T. C. Whitmore

Minor adjustments to taxonomy which need no commentary appear in the text of the account in vol. 2 of *Tree Flora of Malaya.* More substantial changes and those needing discussion are made below. Other changes have been made by Airy Shaw and will appear in the series Notes on Malesian and other Asiatic Euphorbiaceae in the Kew Bulletin. The genera are in the sequence of the Pflanzenreich monograph.

Leptopus

Leptopus australis (Zoll. & Mor.) Projarkova Not. Syst. Herb. Inst. Bot. Acad. Sci. URSS 20 (270) 1960

L. hirta (Ridley) Projarkova *loc. cit.* 271 **syn. nov.**

L. calcareus (Ridley) Projarkova *loc. cit.* 271 **syn. nov.**

Andrachne hirta Ridley Kew Bull. 1923, 361 (type *Ridley 14883* ! K, ! SING)

Andrachne calcarea Ridley *loc. cit.* 362. (syntypes *Ridley 8203, Robinson 6201, Annandale 1835* ! K)

This genus has been known in Malaya as *Andrachne.* I am unable to distinguish Ridley's two species. The type of *L.* (*A.*) *hirta* is indeed very hairy (as the epithet implies) on leaf and twig but this condition merges via a long series of collections into the glabrous condition of *L. australis. L.* (*A*) *hirta* is also a small-leafed form; this is of no taxonomic significance. *L.* (*A*) *calcarea* has the leaves rather blunter at base and apex but I can see no sharp distinction against *L. australis.* I therefore formally propose the reduction of these optimistically proposed entities. Gage in J. & Proc. As. Soc. Beng. 75 (1936) 522–3 cited all the collections under *Andrachne fruticosa* Decne. (non Linn.) which is *L. australis* and Henderson (J. Mal. Br. Roy. As. Soc. 17, 1939, 68–9) doubted if Ridley's species could be maintained.

Glochidion

Too many species have been based on too few collections. The following rationalisations are possible.

Glochidion brunneum Hk. f. Fl. Brit. Ind. 5 (1887) 312.

G. goniocarpum Hk. f. *loc. cit.* **syn. nov.**, type King's Collector, Singapore (! SING).

G. pedunculatum Ridley Kew Bull. (1923) 364, non Merrill Philip. J. Sci. Bot. 11, 1916, 67 **syn. nov.**, type *Ridley 8952* (! SING); *8952 a* (! SING).

These two rare species both known from single collections come well within the range of variation of the commoner *G. brunneum.*

G. penangense (M.A.) Airy Shaw Kew Bull. 23 (1969) 6.

G. villicaule Hk. f. Fl. Brit. Ind. 5 (1887) 326 **syn. nov.**, syntypes *Griffith* (K.D.) *4842*, *Scortechini*, Perak (! K).

G. coronatum Hk. f. *loc. cit.* nomen illegit., see Airy Shaw *loc. cit.*, type *Wallich 1849* (! K).

I have compared the Perak syntype of *G. villicaule* with the type of *G. coronatum* Hk. f. and can see no difference.

G. trilobum Ridley Kew Bull. (1923) 364.

This is a *mixtum compositum*. The two syntypes on which the species is based are correctly placed as follows:

Ridley 8440, Singapore Garden, is *G. microbotrys* Hk. f., differing only from typical material of the latter in its densely pubescent fruits, which however is a condition approached by some of the many sheets of *G. microbotrys* at K. *Burkill SFN 7004*, Negri Sembilan, Tampin, is typical *G. wallichianum* M.A.

Baccaurea

Baccaurea motleyana (M.A.) M.A. in D.C. Prodromus 15 (1866) 461. *B. pubescens* P. & H. Pflanzenreich IV x V (1922) 251 **syn. nov.**

B. pubescens is known solely from *Wawra 297a*, Singapore. No one has ever found it since and the collection, at Berlin, is now burned. The description could well be of *B. motleyana*, as Ridley (Flora 3, 1924, 251) points out, which is a species found in cultivation throughout the Peninsula and offshore islands. I agree with Ridley and go one step further in reducing *B. pubescens* to synonymy. That Pax and Hoffmann put it in section Calyptroon, not Pierardia, is of no consequence, for the sections differ in the bracts of the male inflorescence and *Wawra 297a* was from a female tree.

Austrobuxus

Two species of *Austrobuxus* have been recognized in Malaya where they have been called *Longetia*. *L. malayana* (Benth.) P. & H. is a widespread species of the lowlands. *L. montana* Ridley was described from 3300 ft, on G. Tahan; it differs in having smaller, retuse, very leathery leaves and in its typical form is highly distinctive; I extend its range to G. Benom and G. Ulu Kachau, also in Pahang, and observe that on G. Jerai (Kedah), at 4000 ft, on G. Padang (Trengganu) and at 3400 ft in the Ulu Nenggiri (Kelantan) *L. malayana* grows, so *L. montana* does not replace the other in the mountains. Moreover *KEP 15085* from near the sea at Baloh F.R. Pahang approaches *L. montana* in leaf.

Austrobuxus is an earlier name than *Longetia* and a move to conserve the latter failed. *L. malayana* now becomes *A. nitida* Miq. For the first time I transfer *L. montana* to *Austrobuxus*, but because it differs solely in leaf characters which are to some extent overlapping I consider it to be merely a variety; a few specimens cannot clearly be placed in one taxon or the other.

Austrobuxus nitidus Miq. var. **montanus** (Ridley) Whitmore **stat. nov.**

Basionym — *Choriophyllum montanum* Ridley in J. Linn. Soc. Bot. 38. (1907) 322. Type *Robinson 5434*.

Synonym — *Longetia montana* (Ridley) P. & H. in Pflanzenreich XV (1922) 291.

Agrostistachys

Agrostistachys longifolia (Wight) Benth. Gen. Pl. 3 (1880) 303.

A. longifolia var. *malayana* Hk. f. Fl. Brit. Ind. 5 (1890) 407.

A. longifolia var. *latifolia* Hk. f. *loc. cit.*

A. borneensis Becc. Nelle foreste Borneo (1902) 331.
(1902) 331.

A. sessilifolia (Kurz) P. & H. Pflanzenreich IV 147 VI (1912) 100.

A. latifolia (Hk. f.) P. & H. *loc. cit.*

The full synonymy is given in the Planzenreich account. Hooker recognized two varieties and these were later raised to species by Pax & Hoffmann. The abundant Malayan material now to hand at Kepong and Singapore shows that there is a continuous range of variation, which also includes the Indian material at Kew including the type of *A. longifolia.*

A. longifolia var. **leptostachya** (P. & H.) Whitmore **stat. nov.**

A. leptostachya Pax & Hoffmann *loc. cit.* 102 **syn. nov.**

This is a very distinctive form with short filiform spikes, which tend to be in cauline tufts, these features being more marked on male trees. All intermediates to typical *A. longifolia* with long, stout, solitary, axillary spikes exist. I therefore reduce *A. leptostachya* but retain it as a variety to draw attention to the polymorphism of the species, which my forest observations indicate might correlate with geographical distribution, and tree construction. *KEP 94699* is almost exactly intermediate.

A. leptostachya was described from Sarawak and is well represented at Kew. Typical collections are:

MALAYA, PERAK: *FRI 625, 647, 671.*
PAHANG: *SFN 28763, FRI 4734, 4907, Wong & Wyatt-Smith 35, KEP 8955.*
KEDAH: *KEP 4641.*
Locality unknown: *KEP 98304.*

Trigonostemon

Trigonostemon verticillatus (Jack) Pax var. **salicifolius** (Ridley) Whitmore **stat. nov.** *Trigonostemon salicifolius* Ridley Kew Bull. (1923) 366 **syn. nov.** (type *Ridley* s.n. Selangor Batu Caves, ! K).

Ridley's species seems to be no more than a central Selangor form of *T. verticillatus* with leaves oblong (as opposed to elliptic) and often small, for we now have collections from Kanching, Bt. Lagong and Ulu Gombak as well as Batu Caves. It is interesting that two collections from the hills of Lower Perak have oblong (but big) leaves. Varietal status keeps this form in view, and a biosystematist might find it interesting to investigate it more closely, especially in view of its disjunct distribution. It grows on hills once lapped by the Pleistocene sea.

SELANGOR Batu Caves: *Ridley* s.n. (type) Bt. Lagong: *Poore 1062* (K): Kanching: *KEP 21258* (KEP) Ulu Gombak: *KEP 18167* (KEP, K), *Hume 9015* (SING) PERAK *Scortechini 702* (K) (locality?); Briah Larut: *Wray 4204* (K, SING); Telok Kopia F.R. *FRI 3112* (KEP).

Alchornea

Alchornea tilifolia (Benth.) M.A.

I reject *Evans* s.n. Aug 1917 Pahang, Labong, Endau but add *Kunstler* 166, mounted at Kew with *Scortechini* (received 1888), which is *A. villosa.* Thus the species is still known from one collection only. The label of the Kunstler sheet has no locality and merely says Flora of the Malay Archipelago, but is probably one of his first collections from Johore, G. Panti.

Blumeodendron

Blumeodendron tokbrai (Bl.) J. J. Smith Meded. Dept. Landbouw. 10 (1910) 12, 460.

Mallotus? vernicosus Hk. f. Fl. Brit. Ind. 5 (1890) 443.

B. vernicosum (Hk. f.) Gage Rec. Bot. Svy. Ind. 9 (1922) 244 **syn. nov.**

B. elateriospermum J. J. Smith Bull. Jard. Bot. Buitenz. sér. 3, 28 (1912) 56.

B. tokbrai is a widespread polymorphic species, first recorded for Malaya by Henderson (Gdns' Bull. Str. Settl. 7, 1933, 124) into which merges *B. vernicosum.* I can find no disjunctions in habitat or morphology amongst the abundant material at Kepong to justify retaining two species.

B. borneense Pax & Hoffmann in Engler Pflanzenreich IV 147 XIV (1919) 14.

B. concolor Gage Rec. Bot. Svy. Ind. 9 (1922) 244 **syn. nov.**

The latter is known in Malaya from only two collections, *Curtis 1368* Pangkor (type !K) and *Haniff 15472* Langkawi (!SING, !K). It differs from the type of *B. borneense* (*Beccari 2976* !K) in its slightly larger, more ovate, more strongly nerved leaves, but this is well within the range of *B. borneense* now abundantly represented at Kew from northern Borneo.

Endospermum

Endospermum diadenum (Miq.) Airy Shaw Kew Bull. 14 (1960) 395.

E. malaccense M.A. Flora 47 (1864) 469.

I am able amply to confirm Airy Shaw's suspicions that *Melanolepis diadena* Miq. Fl. Ind. Bat. Suppl. (Fl. Sum.) (1865) 455 is indeed none other than "an extreme, perhaps juvenile, form of *E. malaccense*", which has spreading straight hairs and no stellate hairs. The confirmation is based on four pieces of evidence:

(1) the, by now numerous, collections made by the Kepong staff of young *E. malaccense.*
(2) the rich collection at SING of juvenile *E. malaccense* made by Corner, and which Airy Shaw did not see and K has not got in duplicate.
(3) the thorough analysis by Corner in Gdns' Bull. Str. Settl. 10 (1939) 296 of variation with age of leaf hairiness, an analysis apparently not known to Airy Shaw when he wrote.
(4) two of the three Malayan collections of *E. diadenum* cited by Shaw are indeed from juveniles.

There is therefore no alternative but to rename the common well known sesendok of Malaya, and use a new name based on a single unattached leaf, a sterile specimen from a juvenile plant. The rigid application of the rule of priority in this case is distressing and in the account of Euphorbiaceae for the

Tree Flora I have no compunction in recommending Malayan foresters to continue to use the epithet well known for over half a century. My justification for this course is set out in full in the Prologue to the *Tree Flora,* vol. 1.

Over the years collections of *Endospermum* from the Peninsula with peltate leaves have accumulated. Corner stated that juvenile plants of *E. malaccense* never have peltate leaves and referred these collections to *E. moluccanum* Becc., an east Malesian species, from which they differ in not possessing hollow ant-inhabited twigs. None of these peltate-leaved collections is fertile, all are from saplings or poles or small to medium trees to 70 ft tall. I consider them merely a juvenile stage of *E. malaccense. FRI 770* from Slim Hills Perak, 50 ft tall, 2 ft girth, seems to clinch this conclusion, it too is sterile and possesses leaves strongly peltate, weakly peltate and apeltate. Forest observations show that *E. malaccense* usually but not always has peltate leaves in youth. At Kepong we have two seedling collections (FRI 29, 1005) and two collections of 20 ft saplings (*FRI 11, 4787*) which are not peltate and *FRI 336, 560, 768, 864, 2212, KEP 98546, 115652* which are strongly peltate.

In conclusion, there is no evidence that *E. moluccanum* or the peltate Borneo species *E. peltatum* Merr. occur in Malaya. Our material can most simply be accounted as juvenile *E. malaccense.*

Suregada

I am unable to detect any consistent differences between the four species referred to this genus (as *Gelonium*) by Ridley (Flora 3, 1924, 310–2).

In the first place, *Gelonium tenuifolium* Ridley must be reduced.

In the second place, the widespread continental species *G. multiflorum* Juss. merges into *G. glomerulatum* Hassk. of the Malesian archipelago here in Malaya where the ranges overlap.

In the third place, Corner (Gdns' Bull. Str. Settl. 10, 1939, 299) found *G. bifarium* Roxb. impossible to recognize in the Peninsula, and I agree.

I refer all collections made in Malaya to *S. multiflora* (Juss.) Baill., the earliest published species, but without study of types and material from the whole range of the complex can make no formal decision except:

Suregada multiflora (A. Juss.) Baill. Ét. Gén. Euphorb. (1858) 396.

Gelonium tenuifolium Ridley J. Roy. As. Soc. Str. Br. 59 (1911) 181 (type Ridley 15902 ! K,! SING) **syn. nov.**

In addition to the above, *S. angustifolia* (Miq.) Airy Shaw has once been collected in Malaya. It is quite distinct.

XIV. Flacourtiaceae

T. C. WHITMORE

Scaphocalyx

Scaphocalyx spathacea Ridley J. Bot. 58 (1920) 149.

S. parviflora Ridley *loc. cit.* **syn. nov.**

Most of the flowers at Kepong herbarium have been eaten by insects, but *KEP 99478* from the Bt. Lagong population retains a few buds; some are 3 mm long on 4 mm pedicels, on another cluster they are 23 mm long on 15 mm pedicels; the collection thus spans both Ridley's species and demonstrates that the flower size difference is accounted for by the different stages of development of the flowers when collected.

XV. Leguminosae (c)

T. C. Whitmore

Burkilliodendron Sastry Bull. Bot. Surv. India 10 (1969) 243.

Burkillia Ridley Fl. Mal. Pen. 5 (1925) 304, non *Burkillia* West & West (1907).

Alloburkillia Whitmore Gdns' Bull. Sing. 24 (1969) 4 **syn. nov.**

Burkilliodendron album (Ridley) Sastry loc. cit.

Burkillia alba Ridley loc. cit.

Alloburkillia album (Ridley) Whitmore loc. cit. **syn. nov.**

Sastry's new name for Ridley's genus was published on 3 Jan. 1969, my own on 9 Aug. 1969. Ridley describes the plant as a shrub, and the legitimate name is therefore a misnomer.

XVI. Rutaceae

B. C. Stone (University of Malaya)

Glycosmis

Glycosmis calcicola B. C. Stone, **sp. nov.** **Fig. 1**

G. parkinsonii var. *ovatofoliolis* Tanaka, in herb. KEP and SING. ? Ined.

Frutex inermis ad 1–2 m altis, ramis divaricatis, ramulis gracilibus, 1–2 mm crassis, juventute tomentellibus, trichomiis rufidulis 1–3-cellularibus acutis, maturitate rufo-brunneis glabratis minute striatis; *foliis* imparipinnatis, petiolo 9–20 mm longo, minute tomentello glabrescentio; *foliolis* 1–5, alternatis vel suboppositis, tenuiter coriaceis, ovalis vel obtuse-ellipticis, 1.7–7 cm long, 0.9–4.3 cm latis, apice obtuso, vel plerumque emarginato-retuso, base rotundato vel obtuso, dorso in costa puberulento, costa infra prominulento, supra subdepresso-canaliculato, nerviis lateralibus utrinque 4–7, lamina minute glanduloso-punctulato. *Inflorescentia* rufotomentella, axillaris, parvis, cymosis, 3–7-floriferis, pedunculo perbreve ad 2 mm longo, pedicellis 1 mm longis minute bracteolatis. *Calyx* 4-lobatus cupuliformis lobis 1.5 mm longis late deltoideis rotundato-obtusis. *Petala* 4 ovata utrinque acuminata alba dorso rufotomentella (plerumque in portione medio) et ciliolulata, intus glabra, 3.2 × 1.5 mm. Stamina inaequalia, 4 longiora (filamentis 3 mm longis) petalis aequantia, 4 breviora (filamentis 2.5 mm longis); filamentis oblongis complanatis apice abrupte acuminatis, distaliter (sub anthero) subsparse puberulo; antheris glabris late cordatis 0.7–0.9 mm longis. *Gynoecium* disco glabro albo 2 mm alto; ovario lente quadrangulato obclavato 1.7–1.8 mm longo subsparse glanduloso supra medium puberulento; stigma truncato non expanso 0.2–0.25 mm lato; loculis 4; ovulis elongatis solitariis pendulosis. *Fructus* baccatus parvus ad 1 cm longus ovoideus vel subellipsoideus apiculatus, pericarpio tenue, semina plerumque singulo, cotyledonis viridis crassiter plano-convexibus punctatis 6 mm longis, plumulo perminute albo-pilosulo.

Holotypus: MALAYA. Selangor: Kanching Distr., Gua Anak Takun, limestone hill near Templer Park, 500 ft. alt., 21 Sept. 1969, *B. C. Stone 8789* (KLU; isotypes A, BISH, K, L, SAR, SING, TNS).

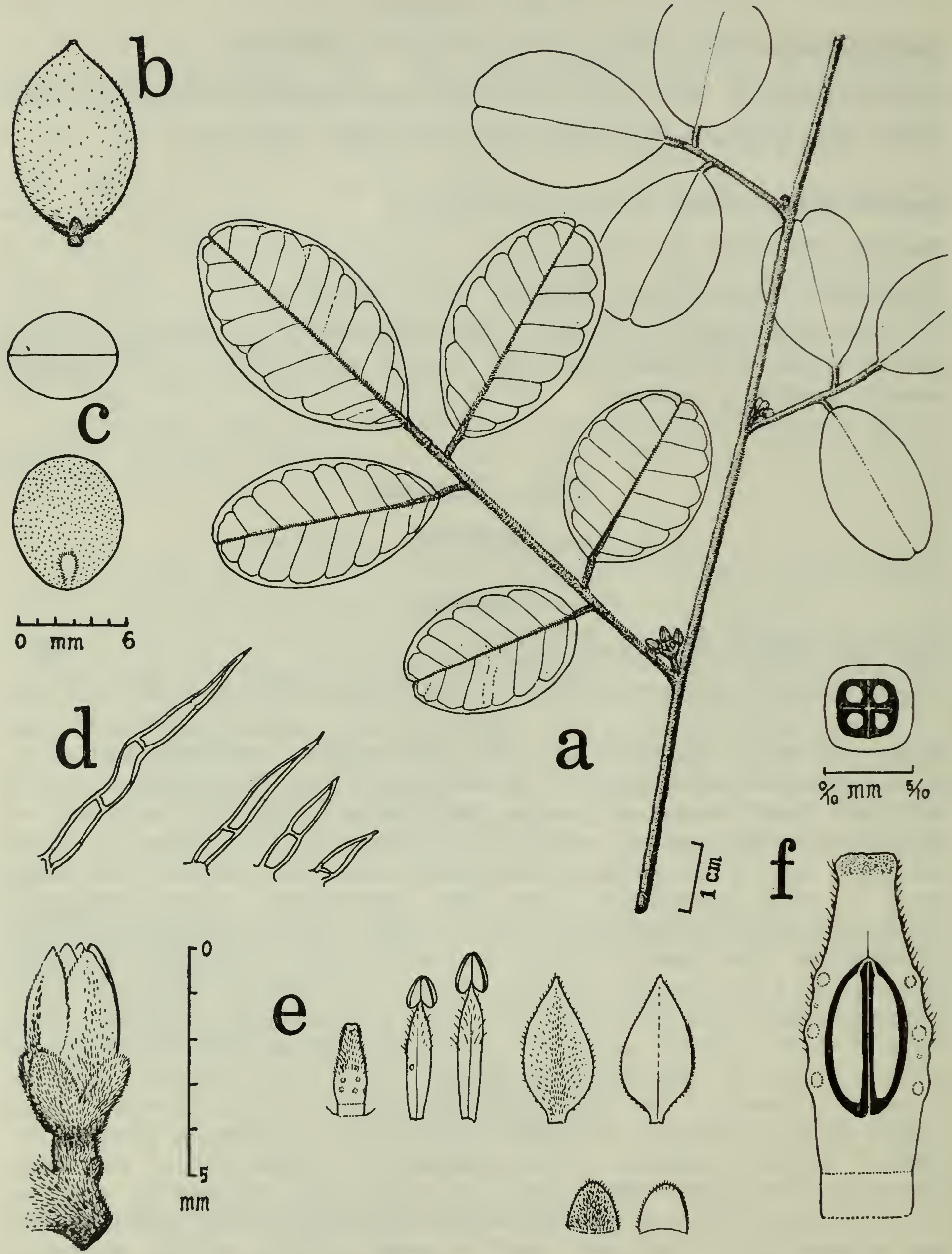

Fig. 1. *Glycosmis calcicola* Stone (BCS 8789, type); *a:* habit; *b:* fruit; *c:* seed; *d:* hairs; *e:* flower, bud and parts; *f:* ovary.

Further specimens examined: MALAYA: Selangor; Bukit Takun, 8 May 1925, *Symington KEP 39586* (KEP). Kanching, 16 March 1935, *Symington KEP 37407* (KEP); 5 Nov. 1940, *Reid KEP 51681* (KEP), 23 Dec. 1963, *Sow KEP 94745* (KEP). Bukit Takun, 18 Feb. 1937, *Symington & Henderson KEP 43289* (KEP). Bukit (Gua) Takun, limestone hill, 900 ft. alt., 11 July 1965, *B. C. Stone, Y. K. Wong, P. C. Lee & G. B. Evans BCS. 5907* (KLU). Gua Batu ("Batu Caves"), 28 Dec. 1969, *B. C. Stone & P. R. Wycherley* s.n. (KLU). Gua Anak Takun, 31 July 1968, *Whitmore FRI 12165* (KEP). Perak, Lenggong, G. Runta, 300 ft. 11 June 1930 *Henderson SFN 23819* (SING KEP). Kedah: Pulau Langkawi, Kuala Kelim, 4 May 1938, *Symington KEP 46792* (KEP), *46794* (KEP). Batu Ayam, 19 Nov. 1941, *Corner SFN 37838* (KEP).

This species appears to be distinct from most or all others in the genus by its small ovate-emarginate leaflets. It is similar in most floral details to *G. parkinsonii* Tanaka (of Burma), though the typical variety differs in its glabrous anthers; in addition, the usually more numerous leaflets and the emarginate or retuse leaflet tips and different leaflet shape, seem to confer specific rather than varietal status as concluded by Tanaka. The species apparently is restricted to limestone.

G. calcicola var. **kelantanica** B. C. Stone, **var. nov.**

A varietas typica in foliolis plerumque duplo vel triplo magnioribus, petalis latioribus, antheris pilosulis, differt; cetera simillima.

Holotypus: MALAYA: Kelantan; S. Nenggiri, Gua Jaya at Kuala Jenera, limestone hill, 27 July 1967, *T. C. Whitmore FRI 4255* (KEP).

Further specimen examined; Kelantan, Gua Musang, 15 Aug. 70, *Stone 9521* (KLU).

According to Tanaka, there is a variety of *G. parkinsonii* in Sumatra; I have not seen this and thus do not know whether it might belong to *G. calcicola*.

G. calcicola is not uncommon where it occurs. It is probably to be found on some if not all of the other limestone hills in the country, but many of these have never been botanized or perhaps even climbed.

The specific epithet *calcicola* indicates the occurrence of this plant exclusively on limestone.

Tanaka, who was apparently in control of much information concerning *Glycosmis*, published *G. parkinsonii* Tan. in Studia Citrologica 2: 25, 1928, and in the Journal of Botany (ed. Rendle) 68: 227, 1930. In both the herbaria of Kepong and Singapore a number of sheets of the species described above are named with tickets reading "*Glycosmis parkinsonii* Tan. var. *ovatofoliolis* Tanaka" but nowhere can I find any publication of this name. It is not listed in the exhaustive "Catalog of Genera, Species and subordinate taxa in the Orange subfamily Aurantoideae (Rutaceae)" by Carpenter and Reece (Crops Research, Agricultural Research Service, U.S. Dept. of Agriculture ARS 34–106, May 1969). In the Jour. Bot. paper mentioned above, Tanaka says: "A trifoliolate variety occurs in Sumatra, which will be described elsewhere." However, the Malayan plants are not mentioned. It appears that the variety *ovatofoliolis* is a *nomen nudum* appearing only on herbarium labels.

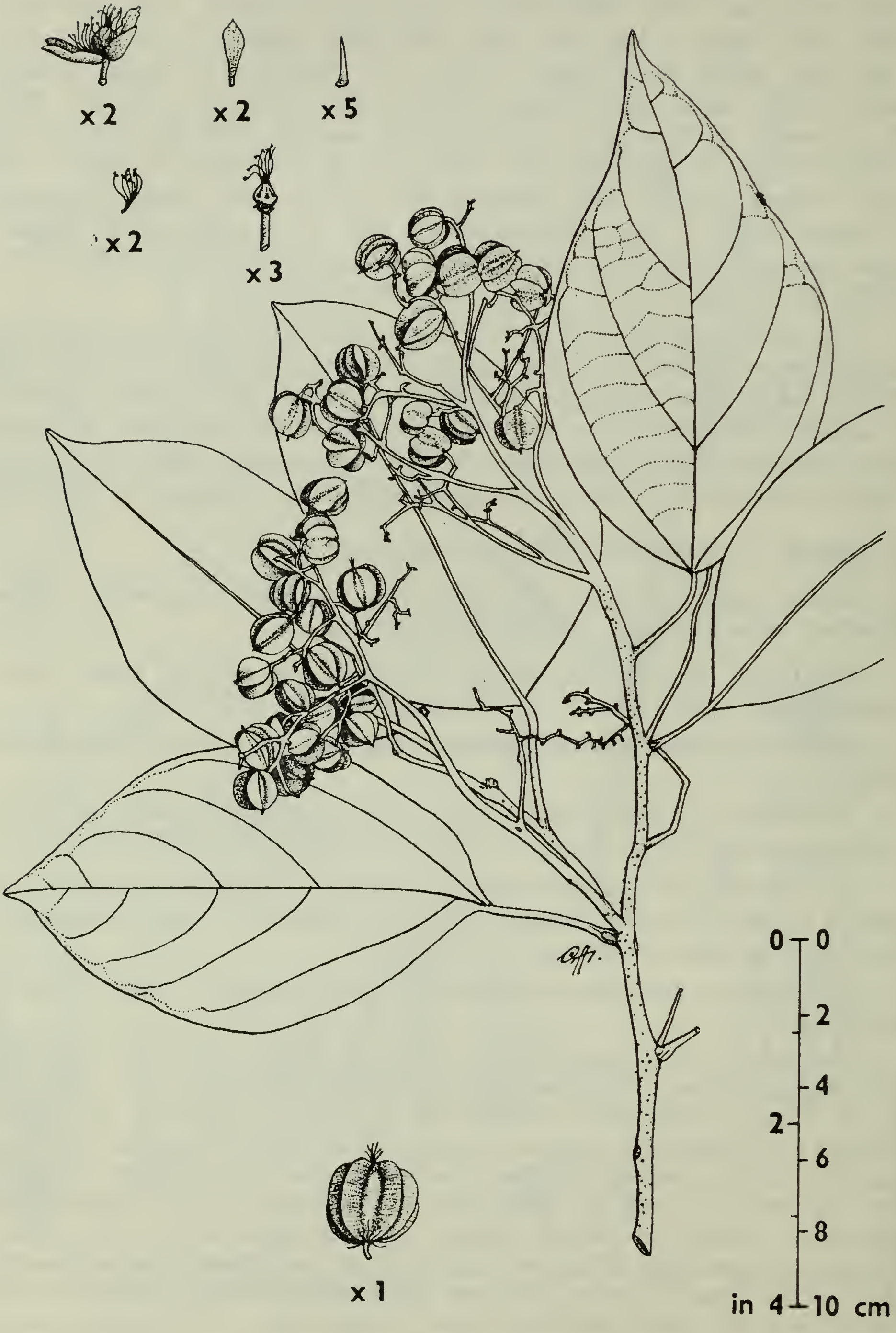

Fig. 2. *Pentace excelsa* Kochummen (FRI 10880).

XVII. Tiliaceae

K. M. KOCHUMMEN

Colona

Colona merguensis (Planch. ex Mast.) Burret Notizbl. Bot. Gard. Berlin-Dahlem 9 (1926) 807.

Columbia curtisii Ridley J.R. As. Soc. Str. Br. 57 (1911) 26 **syn. nov.**

Columbia diptera Ridley ibid. 59 (1911) 78 **syn. nov.**

Dr. P. S. Ashton in an unpublished manuscript deposited in the Forest Office, Kuching has noted this synonymy with which I concur. He observes that 'Ridley's two species are similar to *C. merguensis* though its type has narrower leaves than usual. When the achene dehisces adjacent valves from adjacent wings remain attached. *Ridley 15221,* type of *C. diptera,* possesses only these united valves, no entire achenes, hence Ridley's observation that the fruit was '2 winged'; this is the only significant difference between it and *Curtis 3692* type of *C. curtisii*'.

Pentace

Pentace excelsa Kochummen **sp. nov.** **Fig. 2**

Arbor maxima, 60 m alta, foliis coriacei, ellipticis vel ovato ellipticis, apice acuminato, basi acuto vel rotundato, supra glabra, subtus perdense stellato-lepidotis, nerviis lateralibus 4 — paribus; paniculis minute stellato-piloso-lepidotis; pedicellis conspicuis; phalangiis staminorum 5, staminodiis in basi abrupte rotundato-ovatis, parte apicale filiforme; ovario dense stellato-lepidoto, 7-8 costato, stylis 7–8 libris, lepidotis; fructibus 7–8 alatis, minutissime stellato-lepidotis, stylis libris.

TRENGGANU: Ulu Sg. Loh *FRI 10686, FRI 10853, FRI 12063* (holotype KEP! ; K, L), *FRI 12131.*

PAHANG: Ulu Sg. Keliu *FRI 10880;* main ridge G. Tapis *FRI 10148, FRI 10149.*

P. grandiflora Kochummen **sp. nov.** **Fig. 3**

Arbor 27 m magna alta, foliis chartaceis, obovatis vel obovato-ellipticis, apice acuminato, basi cuneato, supra glabra, subtus glabra, nervis lateralibus 3-paribus, petiolis gracilis; paniculis paucifloris floribus magnis petalis 11 mm longis staminibus multitudinis (c. 150) libris, ovario 5-costato; fructibus ignotis.

The few large flowers and numerous free stamens at once distinguish this species.

TRENGGANU: Bt Bauk *FRI 3951;* Ulu Dungun nr Sg. Bebir (= Ulu Sg. Loh nr K. Datok) *FRI 9667, FRI 9675, FRI 9683* (holotype KEP! ; K, L, SING), *FRI 12013;* State land Jerangau *KEP 79785.*

Schoutenia

Schoutenia furfuracea Kochummen **sp. nov.** **Fig. 4**

Arbor, ramulis juvenilibus dense-pilosis, foliis coriaceis oblongis, 16 – 26.5 × 6.5 — 10.5 cm, apice acuminato, basi inaequali rotundato vel cordato, supra glabra, costa basim versus dein piloso excepta, subtus dense-pilosis, nervis depressis, petiolo crasso 4–8 mm longo 3 mm diam; floribus ignotis; calyce in fructu campanulato, stellato-piloso, interius glabro, disco glabro, staminibus c. 40; fructibus globosis dense-pilosis stylo glabro.

PAHANG: Rompin, Ulu Sg. Anak Endau *FRI 8042* (holotypus KEP! ; A, K, L, SING).

Very distinctive in the red hairy twigs, short stout petioles and large leaves.

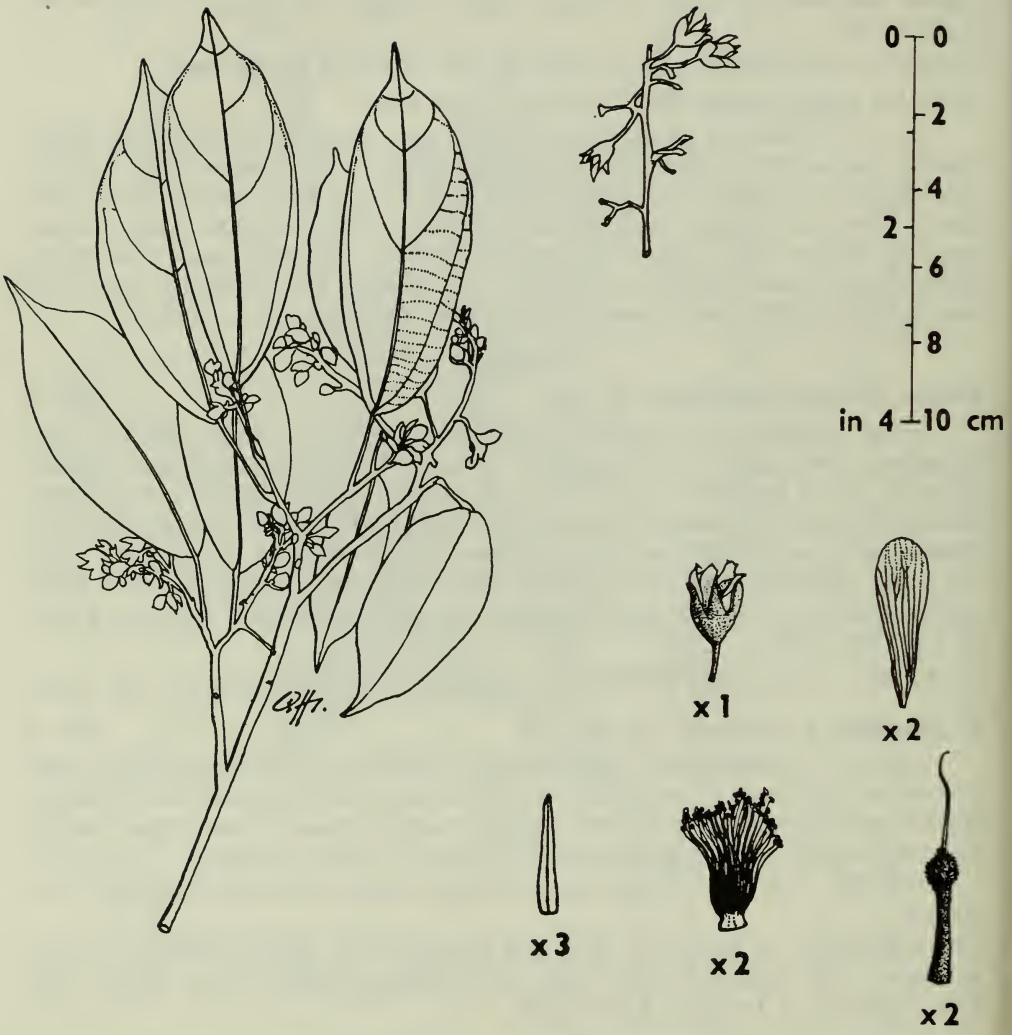

Fig. 3. *Pentace grandiflora* Kochummen (fruiting twig FRI 12013 flower FRI 9683, type).

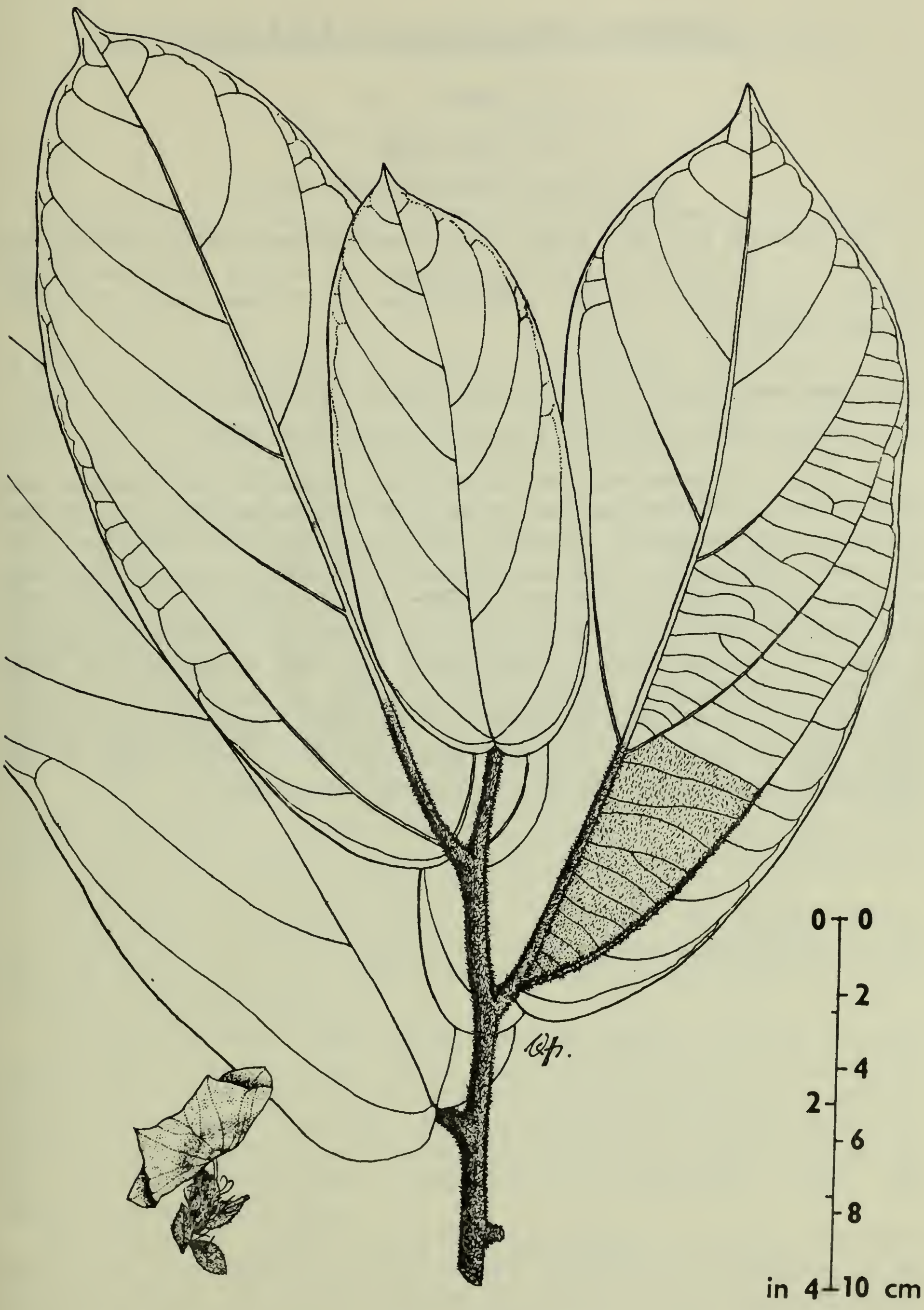

Fig. 4. *Schoutenia furfuracea* Kochummen (FRI 8042, type); *inset:* fruit with persistent bracts.

Studies in Macaranga V: M. lowii

by

T. C. Whitmore

Forest Research Institute, Kepong, Malaya

The following brief note brings the taxonomy of the Malayan species up to date for vol. 2 of the new *Tree Flora of Malaya,* now in press. Unfortunately this discovery was made too late for inclusion in part IV of these studies (Kew Bull. 25, 1971, 237–42).

Macaranga lowii King ex Hk. f., Fl. Brit. Ind. 5 (1887) 453.

M. auriculata (Merr.) Airy Shaw, Kew Bull. 19 (1965) **syn. nov.**

M. lowii is the commonest member of section *Pseudorottlera* in Malaya, and numerous new collections have been made from all over the country in the last few years. These collections completely break down the subtle distinctions Airy Shaw uses to distinguish *M. auriculata* from *M. lowii.* There is indeed a form with the leaves drying rather grey-green with rather distant secondary nerves (e.g. *FRI 4772, 5520, 6010, 6043, 10514, 10555*) and some do have sparse spreading hairs on the base of the midrib below (e.g. *FRI 38159*). There are also sheets of *M. lowii* with leaves drying reddish brown with rather closer secondary nerves (e.g. *FRI 3442, 3986, 5415, 8549, 8898*). But numerous intermediates occur with these characters in different combination (e.g. *FRI 5366, 7700, 8338, 10669, 12009*). In the circumstances I reduce the later described species to synonymy.

The Genus Johannesteijsmannia H. E Moore Jr.

by J. Dransfield
Botany School, Cambridge, U.K.

Summary

A revision of the W. Malesian genus **Johannesteijsmannia** (Palmae) is presented. Of the four species described, three represent new species.

History

In 1856/57 during his collecting trip in the Padang area of the West Coast of Sumatra, J. E. Teysmann of the Botanic Gardens, Bogor, Java, made contact with the Assistant Resident of Lima-puloe district, K. F. Stijman, who subsequently sent a variety of plants to Teysmann when he had returned to Java. Among these plants were fruits of a new palm which Stijman presumably described in an accompanying letter. Teysmann incorporated this collection in his account of his collecting trip in Sumatra (Natuurk. Tijdscht. Ned.-Indie *14* (*4*, new series) (1857) 321). In Zollinger's introduction to the description of this palm by Reichenbach f. and himself (Linnaea *28* (1856)), the finding of the palm was credited to Teysmann, who probably never saw it in the field but sent fruit and presumably leaves to Europe from Bogor; they named it *Teysmannia altifrons* Reichb. f. et Zoll. in honour of Teysmann. Miquel, however, described Apocynaceous specimens in 1857 as *Teysmannia* (versl. Med. K. Akad. Wetens. Amsterdam). The part of Linnaea *28* containing the description of *Teysmannia* Reichb. f. et Zoll. (Palmae) did not appear until 1858. In any case, Reichenbach f. and Zollinger could hardly have described the palm in 1856 before it had been collected by Stijman and sent to Bogor. By this time *Teysmannia* Miq. (Apocynaceae) had been validated and hence has priority over the palm even though it has been sunk into *Pottsia* Hook. et Arn. H.E. Moore Jr. (1961) has clarified this situation and coined the cumbersome new name *Johannesteijsmannia* H. E. Moore.

In the type description in Linnaea *28*, Reichenbach and Zollinger suggest that *Johannesteijsmannia* should be placed next to *Salacca* and *Wallichia* and not far from *Nypa*, and that it shows affinities with the "Pandanaceous genus, *Carludovica*" (Cyclanthaceae).

According to Miquel (1868), the description in Linnaea was based on young sterile shoots from the Botanic Garden, Bogor (possibly grown from the seed sent by Stijman) and inflorescences sent from Sumatra, and that the description of the fruit was erroneous. Miquel (op. cit.) gave an extensive description of the palm, based on more material from Sumatra, and showed that in fruit structure and leaf form, *Johannesteijsmannia* approached the Coryphoideae rather than *Salacca*, *Wallachia* and *Nypa*.

It has not been possible to find the type specimen of *Johannesteijsmannia altifrons*. As Reichenbach's name is used with Zollinger's as the authority for the binomial, although the article in Linnaea *28* is titled "Uber ein neues Palmengeschlecht von der Insel Sumatra, von H. Zollinger" and not "von Reichenbach and and H. Zollinger", it suggests that Reichenbach was included in the authority as a courtesy, possibly because the specimen described was in his herbarium. The palms at Vienna where Reichenbach's herbarium was housed, were destroyed by fire and Prof. Rechinger (in letter) states that the type of *Johannesteijsmannia* was evidently lost during this fire. The specimens labelled by Miquel as collected by Teysmann in Sumatra, formerly in Utrecht herbarium, now in Florence, fit the original description very well and are taken as representative of *Johannesteijsmannia altifrons* in the present study.

Palm and Jochems (1924) wrote a popular account of *Johannesteijsmannia altifrons* in Sumatra with information on the habitat, abundance, uses, and distribution in Sumatra. Ridley (1925) in his "Flora of the Malay Peninsula, 5," described *Johannesteijsmannia* and introduced into the description the new information "stem very short to 7ft tall". As a result of my researches, I can now state that the "stem short" refers to *Johannesteijsmannia altifrons,* and "to 7 ft tall" to *Jt. perakensis* from Gunong Kledang, Perak.

Beccari (1931) monographed the genus with the other known Asiatic Coryphoideae.

Johannesteijsmannia, like most palms, has been neglected by plant collectors, and available herbarium material tends to be badly collected with little or no field notes.

Johannesteijsmannia H. E. Moore Jr.

Description of the genus

Solitary, acaulescent to shortly trunked forest undergrowth palms. Stem procumbent and subterranean, in one species (*Jt. perakensis*) becoming erect at maturity, marked with leaf scars. Leaves large, usually at least 3 m in length at maturity, exceptionally 6 to 7 m in length. Petiole extending to the apex of the lamina as a midrib. Leaf sheaths short, in age rotting to form an interwoven mass of brown fibres. Petiole channelled above, convex below, armed with short lateral usually recurved thorns, and often bearing two conspicuous yellow lines along either side. Scurfy brown indumentum abundant on the abaxial surfaces of the petiole. Hastula present as a small, dry, brown, dead strip of tissue at the insertion of the lamina on the petiole. Lamina entire, plicate, diamond-shaped to broadly lanceolate, the upper margin with shallow lobes showing vestiges of induplicate splitting. Lower leaf margins continuous with the margins of the petiole and similarly armed with short recurved thorns. Inflorescence axillary with c.6 tubular, lobed spathes all but the most distal lying in the same plane of insertion (i.e. opposing the subtending leaf). Inflorescence branched, with 1 — 5(6) orders of branching and 3 — 1,000 floriferous branches, with many crowded flowers each subtended by a bracteole, flowers grouped in clusters of (1)2 — 3(4). Flowers creamy-white, sessile, scented (variously) hermaphrodite. Sepals 3, fused to form a tube. Petals 3, valvate, fused minutely at the base. Stamens 6, the filaments connate at their swollen bases to form a ring, minutely epipetalous, abruptly attenuate, short. Ovary superior, composed of three uniovulate carpels, ± free at the base but connate at the apex to form a common style. Stigma punctiform. Ovules erect, anatropous, bitegmic, crassinucellate. Fruit usually developing from one carpel only but occasionally two or more rarely three. Pericarp corky, cracking into pyramidal warts, endocarp hard, composed of lignified stone cells. Seed globose, attached at the base, embryo lateral. Endosperm homogeneous and penetrated within from the chalazal end by a convoluted mass of corky integumental and chalazal tissue.

SPECIES: 4

DISTRIBUTION: North Sumatra, Malay Peninsula, and Borneo.

Plate 1. THE FRUITS OF JOHANNESTEIJSMANNIA *Top left: Jt. altifrons; top right: Jt. perakensis; bottom left: Jt. magnifica; bottom right: Jt. lanceolata.*

Plate 2. Orang asli house thatched with daun payong Ulu Semenyih, Selangor.

Uses

The leaf of *Johannesteijsmannia* makes excellent thatching for aborigine huts and temporary shelters, either used directly, or sewn into ataps. In the Malay Peninsula it is unusual to see whole villages thatched with the leaves of *Johannesteijsmannia.* In Ulu Semenyih, Kajang, Selangor, one such aborigine village exists, where the thatch consists mostly of *Johannesteijsmannia* and some *Eugeissona* (see Plate 2). In Johore, Chinese logging huts in Mersing, Jemeluang and Kluang Forest Reserves, are very often walled and thatched with the leaves of *Johannesteijsmannia.* In Sumatra, Palm and Jochems (Palm and Jochems 1924) found the leaves of *Johannesteijsmannia,* in the form of ataps, used to the exclusion of the more usual thatching material made from *Metroxylon sagu* and *Nypa fruticans* in the area around Tandjungpura on the Batang Serangan in Atjeh, North Sumatra. According to these authors, atap of *Johannesteijsmannia* lasts from three-four years (depending on the thickness of the thatch and the pitch of the roof) whereas that of *Nypa* will last up to six years or more; however, *Johannesteijsmannia* thatch cost less than half the price of nipa-thatch.

According to an aborigine in Ulu Semenyih, Selangor, *Johannesteijsmannia* thatch in his village lasts three years. Burkill ((1935) 1966) records six years for nipa-thatch in Malaya and even longer for that of the sago palm.

A single leaf of *Johannesteijsmannia* makes a excellent umbrella (hence the Malay name "daun payong" — umbrella leaf).

The colonies of *Jahannesteijsmannia altifrons* around Wray's Camp on Gunong Tahan, Pahang, have provided leaves for wind-shelters for the numerous expeditions camping at this exposed camp-site.

The young endosperm is reputedly edible.

Native Names

MALAY PENINSULA

daun payong — umbrella leaf
pokok payong — umbrella tree
daun sal
sal
koh
pokok koh
pokok sang

SUMATRA

belawan (Miquel 1868, Beccari 1931)
sang (Palm and Jochems, 1924)
siemienjak boewah maseh (Miquel 1868)
sieboesoeng boewah masah (Miquel 1868)

BORNEO

daun ekor buaya (Malay) — crocodile's tail leaf
sumuruk (Iban)

Natural History

Flowering in the four species of *Johannesteijsmannia* occurs apparently at irregular intervals. Gregarious flowering has been observed in *Jt. altifrons* in January 1968 at S. Lalang F. R., and *Jt. magnifica* in May 1968 at S. Lalang. The flowering of the latter species followed the end of the long drought of January to March 1968 and coincided with flowering in many trees — it seems reasonable to suppose this flowering was climatically induced. In the former species it is not obvious what factor was responsible for gregarious flowering. In all species during 1967/68 it was unusual not to find one or two plants in flower in the populations at any given time.

The flowers of *Johannesteijsmannia* are variously scented, those of *Jt. altifrons* of sourmilk and sewage, those of *Jt. perakensis* sweetly, those of *Jt. magnifica* of *Tropaeolum majus,* and those of *Jt. lanceolata* of coumarin. Large numbers of Nitidulid beetle larvae and adults, Staphylinid beetles, Dipterous larvae, thrips, ants, termites and spiders can be observed among the inflorescences at anthesis, and many flowers show signs of being chewed. It is probable that pollination takes place by the unspecialized process of "mess and soil" (Faegri and van der Pijl 1966).

Nothing has been discovered, directly related to the dispersal of the fruit. Fruit occasionally show signs of having been chewed and it is possible rodents are of importance in dispersal. During germination of the seed, the cotyledonary sheath elongates to about 10 cm pushing the seedling into the ground; there is no cotyledonary ligule and the seedling most closely resembles that of *Phoenix dactylifera* (see Gatin 1906). The first photosynthetic leaf resembles that of *Licuala* spp. i.e. entire, but with a minutely dentate apex. Tomlinson (1960) suggests that burying of the seedling in the ground is an adaptation to dry conditions; this seems unlikely in *Johannesteijsmannia,* and it is not known what adaptive significance if any, this burying of the seedling in *Johannesteijsmannia* has.

The Species of Johannesteijsmannia

Before the present investigations, only one species of the genus had been recognized (*Jt. altifrons* (Reichb. f. et Zoll.) H. E. Moore). I have recognized three new species in Malaya: *Jt. perakensis, Jt. magnifica* and *Jt. lanceolata.* It is thought that these new species have remained unrecognized owing to 1) the rarity of the species, 2) the general lack of interest in palms, 3) the difficulties of collection which tend to inhibit botanists from making collections of palms, 4) the difficulties in representing adequately a palm on a normal herbarium sheet, rendering many palm specimens virtually useless for taxonomic purposes, and 5) the lack of any extended fieldwork concentrated on the genus over a whole year.

J. altifrons is widespread but local; it is common in East Johore, and locally abundant on ridge-tops in the north of Malaya, apparently quite common in parts of North Sumatra (Palm and Jochems 1924), very local in West Sarawak and unrecorded, apparently, in Kalimantan, Sabah and Brunei. *Jt. perakensis* is known from two parallel mountain systems in Perak, and is the only species known in this area. *Jt. magnifica* is known from Ulu Semenyih, Selangor, and a few hills in North-eastern Negri Sembilan, and *Jt. lanceolata* is known from Ulu Semenyih (where it grows with *Jt. magnifica* and 1.5 km away from *Jt. altifrons*). There is an old collection referable to *Jt. lanceolata* from near Temerloh in Pahang; Whitmore (pers. comm.) collecting just south of this area near Temerloh in 1969 was unable to find any daun payong, and aborigines in the area apparently did not know of its occurrence. However, it may still survive in the area to the north (see Fig. 1 distribution map).

A Key to the Species of Johannesteijsmannia

(1) Plant tree-like with a trunk up to 4 m tall, inflorescence branches divaricate .... *Jt. perakensis* J. Dransfield

(1) Plant "stemless'

Fig. 1. DISTRIBUTION MAP OF JOHANNESTEIJSMANNIA IN THE MALAY PENINSULA

(2) Leaves relatively narrow. 6 — 8 times as long as broad. Inflorescence with 3 — 6 pachycaul branches, to 1 cm in diameter, bearing spirals of papillate-petalled flowers. ....*Jt. lanceolata* J. Dransfield

(2) Leaves relatively broad. Inflorescence with 20 or more leptocaul branches not more than 2.5 mm in diameter. Petals not papillate.

(3) Leaves very broad, with dense grey-white indumentum on the lower surface of the lamina. Inflorescence with c. 1000 branches, fruits bright red brown with corky warts 2 — 3 mm high .... *Jt. magnifica* J. Dransfield

(3) Leaves glabrous below. Inflorescence with c. 20 — 100 branches, fruits dull brown with warts 7 — 9 mm high .... *Jt. altifrons* (Reichb. f. et Zoll.) H. E. Moore

Johannesteijsmannia altifrons (Reichb. f. et Zoll.) H. E. Moore Jr. Linnaea *28* 657-60 (1856), 1858, Principes 5(4) 116, 1961. Type locality: not known precisely but probably in the "Lima Puloe" province, Sumatra, West Coast. Stijman — communicated by Teysmann.

DESCRIPTION

Solitary, acaulescent, undergrowth palm. Stem subterranean procumbent to 15 cm in diameter. Leaves c. 20 — 30 erect, large, to 6 m tall. Petiole to 2.5 m x 2 cm, leaf sheaths to 40 cm rotting to form a network of brown fibres. Petiole armed with short thorns to 1 mm; petiole with lateral yellow lines prominent or not. Lamina to 3.5 x 1.8 m, diamond-shaped, with scurfy brown scales along the costa and at the short marginal lobes. Plicae to 20 or more on either side of the costa with fine anastomosing veins between the main veins of the folds. Lower leaf margin armed with short spines, as is the petiole.

Inflorescence axillary, at first erect and then pendulous from the primary axis. Spathes covered in fugaceous scurfy brown hairs, cream at first, then turning brown, five-six in number, 10 — 20 cm x 6 — 8 cm, tubular at the base, inflated above, split on one side, with acute apices. Peduncle 30 — 50 cm long, tomentose, c. 2 cm in diameter, branching to produce three orders of branches, floriferous branches 1.5 — 2.5 mm in diameter, to 100 cm long, c. 20 — 100 in number, greenish and covered in dense white tomentum; densely covered in flowers. Flowers glabrous, white, ± acute in bud, solitary or grouped in 2's or 3's, rarely 4's, borne on prominent tubercles, each subtended by a minute bracteole. Calyx short, 2 mm high, fleshy, glabrous, shallowly three-lobed. Petals fleshy, white, to 4 mm long, twice as long as broad, triangular, fused at the base into short tube c. 0.5 mm in height. Staminal ring minutely epipetalous, abruptly contracted above into six filaments. Anthers oval. Pollen grains white. Ovary glabrous with three carpels free at the base, at the apex connate into a common style. 0.8 mm in length, fruit 3.9 — 4.6 cm in diameter, usually developing from one carpel, rarely from two — three carpels, covered in 60 — 80 brown corky warts, 6.2 — 8.2 mm in height. Endocarp woody to 1 mm thick. Endosperm bony to 2.5 cm in diameter, penetrated at the base by corky integumental tissue. Embryo lateral.

Fig. 2. JOHANNESTEIJSMANNIA ALTIFRONS
A: inflorescence, *B:* flower

COLLECTIONS EXAMINED

Sumatra

1 — Teysmann s.n. Sumatra (ex U. now in Fl). 2 — Teysmann s.n. Sumatra (ex L, now in FI). 3 — No collector mentioned, (June 25/1881) Sumatra (ex. CAL. in K). 4 — Teysmann *313,* Raw, W. Kust Sumatra (BO). 5 — S.C.J. Jochems (1924) Batang Serangan, O. Kust, Sumatra (BO, K, L). 6 — A. H. Batten-Pooll *5 — 7,* (July 1939) Wassernar, Atjeh, Sumatra (SING).

Malay Peninsula

1 — Dr. Gimlette s.n. Serasa, Kelantan (SING). 2 — H. N. Ridley *3123* (1891) Tahan woods, Pahang (SING). 3 — R. E. Holttum *19118* (1928) Gunung Muntahak, Johore (SING). 4 — H. N. Ridley (1893) Tahan Woods, Pahang (FI). 5 — T. C. Whitmore, FRI *3854* (1967) Ulu Endau, Johore/Pahang (KEP). 6 — FRI *94873,* Gunong Arong Forest Reserve, Johore (KEP). 7 — Dransfield (1967) Lenggor Forest Reserve, Johore. 8 — Dransfield (1967) Kota Tinggi — Mersing Road, Johore. 9 — Dransfield *916* (1968) Sungei Lalang Forest Reserve, Selangor. 10 — Dransfield *610* (1968) Tahan Woods, Pahang. 11 — Dransfield *688* (1968) Bukit Koh, Ulu S. Kenyam, Pahang.

Borneo

1 — O. Beccari, P. B. *1942* (1866) Mattang, Sarawak (FI). 2 — O. Beccari, P. B. *3645* (1867) Mattang, Sarawak (FI). 3 — E. F. W. Brunig *47450* (1956) Bukit Tambi, Bako, Sarawak (SING). 4 — E. F. W. Brunig, S. *9544* (1957) Bako, Sarawak (SAR). 5 — Carrick and Enoch, JC. *162* (1959) Bako, Sarawak (SAR, KLU). 6 — J. W. Purseglove *5538* (1957) Bako, Sarawak (SING). 7 — Dransfield *760* (1968) Bako, Sarawak.

Country Unknown

One specimen without label in U, probably from Sumatra.

Besides the above records obtained from herbarium specimens records have been communicated by Forest Staff, Forest Department, Malaya, Dr. T. C. Whitmore, and Malay aborigines, and some records have been obtained from Beccari (1931) and Ridley (1925). All records with localities have been incorporated in the map of the distribution of the genus *Johannesteijsmannia* (see Fig. 1 distribution map).

HABITAT

Jt. altifrons like the other members of the genus is a plant of primary forest; it is never found in belukar (secondary regrowth) and it rarely survives any clear-felling of trees. It can, however, survive in selectively logged forest, but often sustains considerable damage from falling trees and scorching when exposed to direct sunlight. Within primary forest *Jt. altifrons* is a plant of ridge-tops and hill slopes on well-drained soils, often with a rich mor humus layer and occasionally podsolized. In Johore it occurs at 65 m above sea level on the gently sloping hills between fresh-water swamps. In Sarawak in Bako National Park, Kuching, *Jt. altifrons* occurs as low as 100 m above sealevel. Palm and Jochems (1924) record it at 25 m above sealevel. These records, however, are exceptionally low, the majority of populations occurring on hill slopes above 300 m. On Gunong Tahan, Pahang, *Jt. altifrons* grows at 1,000 m at the junction of Lower

Plate 3. JOHANNESTEIJSMANNIA ALTIFRONS Slender form from Bako National Park, Sarawak.

Plate 4. JOHANNESTEIJSMANNIA ALTIFRONS Northern hill-top form. Bukit Koh, Kuala Kenyam Taman Negara, Pahang.

and Upper Montane forest (sensu Richards 1952, — non Robbins 1968), growing with *Livistona tahanensis, Dipteris conjugata, Weinmannia blumei, Dacrydium elatum* and *Podocarpus neriifolius.* Another high record for *Jt. altifrons* is on Gunong Mandi Angin on the borders of Kelantan, Trengganu and Pahang where it grows at 1.200 m (Whitmore, pers. comm.). In most of its localities, *Jt. altifrons* is found in Hill Dipterocarp forest; in the low-lying Johore localities it is found in Lowland Dipterocarp forest, and in Sarawak in Kerangas forest (heath forest) on deeply podsolized soils. In all localities visited, soils are well drained. However Miquel (1861) records *Jt. altifrons* in Sumatra as growing as a swamp-palm, in maritime swamps similar to the habitat of *Nypa* — this seems highly unlikely when the Malayan and Bornean habitats are considered. Palm and Jochems (1924) record *Jt. altifrons* as occurring abundantly on the higher ground, but being absent from swamps. *Jt. altifrons* is not confined to soils derived from any one rock type, being found on granite-, rhyolite-, shale-, and sandstone-derived soils. Its main requirements appears to be one of well-drained soils.

Despite the abundance of apparently suitable habitats, *Jt. altifrons* is absent from large areas of Malaya. For example it is absent from more or less the whole of the Main Range of Malaya except for one record at Sungei Lalang, Ulu Semenyih, in Selangor. The two valley systems parallel to the Ulu Semenyih — Ulu Gombak and Ulu Langat — are well botanized and have large aborigine populations, and if *Jt. altifrons* grew there, it would have been recorded. Yet the three valleys are more or less identical in geology, vegetation, and aspect. The palm is such a conspicuous plant, and so well known to aborigines and Malaya that it is fairly safe to assume that absences represent real absences, and not lack of exploration. Similarly *Jt. altifrons* is absent from large areas of Taman Negara (the National Park), Pahang, being found only on Gunong Tahan, and on Bukit Koh near Kuala Kenyam. Bertam, *Eugeissona tristis* is similarly very local in the National Park, being known only from Bukit Jeram Panjang on the Tembeling River.

TAXONOMIC NOTES

Jt. altifrons varies considerably over its geographical range; depredations by aborigines and Malays for thatching, and forestry practices tend to obscure the pattern of variation in reducing the leaf size of the palm by leaf cutting and exposure to greater light intensities. Populations in the North of Malaya, in Pahang and Kelantan, and in Selangor on hill slopes and ridge-tops, usually have larger, more numerous leaves, and inflorescences with a larger number of branches than those of the populations of lowland Johore and Sarawak. It is sometimes possible to deduce the origin of a particular specimen if it is well collected. From the photograph in Palm and Jochems (1924) it appears that the Batang Serangan populations are most similar to those of lowland Johore and Sarawak. Plants at 1,000 m on Gunong Tahan approach in size those of lowland Johore but there is an observable gradation in size from large Hill Dipterocarp forest plants at 500 m to the small mountain forms at 1,000 m, as the mountain is ascended. Typical mature plants from Hill Dipterocarp forest at Sungei Lalang F. R., Ulu Semenyih, Selangor, had an average of 28 leaves per plant, leaves 5.5 m tall, lamina 3.5 m x 1.2 m: in contrast, typical plants from Sungei Kayu Aru, on the road between Kota Tinggi and Mersing, lowland Johore, had 20 leaves per plant, leaves 3.3 m tall, lamina 2.3 m x 1 m. Despite this variation in leaf size, floral structure appears to be constant. Owing to the scarcity of

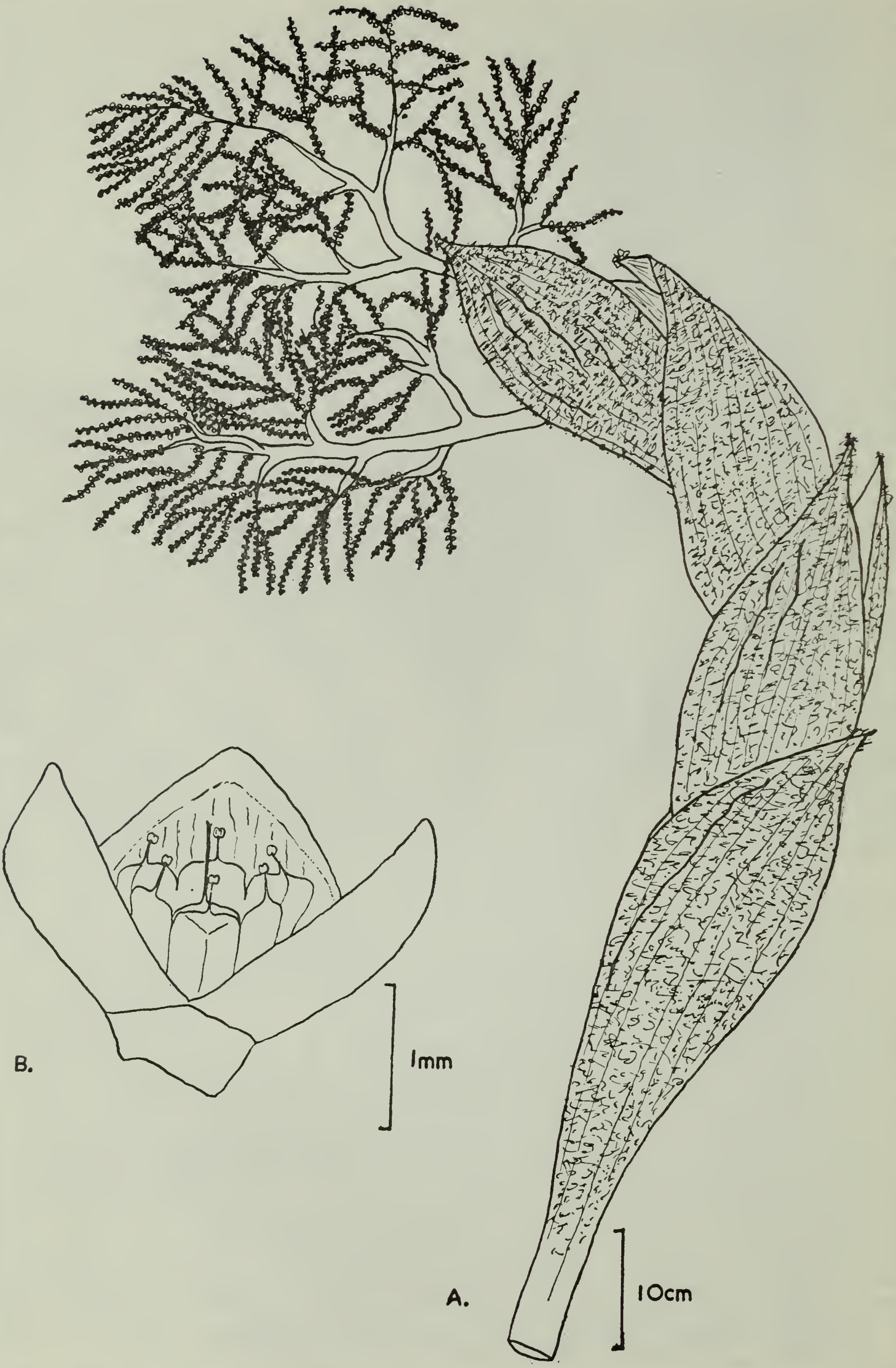

Fig. 3. JOHANNESTEIJSMANNIA PERAKENSIS
A: inflorescence, *B:* flower

flowering material it has not been possible to pursue this problem further. It is possible that some of the variation in size is environmentally induced; on Gunong Tahan the soils at 1,000 m where the palm occurs are extremely poor podsols derived from weathering quartzite, whereas lower down the soils are derived from sandstones and are not podsolized. Some of the variation, however, is probably genetically controlled; many of the populations are isolated and the chances of cross pollination with other populations are minute, so circumstances are ideal for divergence of populations. It is only possible to speculate on the significance of the variation: unwieldy plants such as *Jt. altifrons* present too many difficulties for experimental work.

Johannesteijsmannia perakensis J. Dransfield, **sp. nov.**

DIAGNOSIS

Jt. altifrons multo affinis, sed differt caule ascendenti trunci instar, inflorescentiae ramis in ordinibus quattuor divaricatis, floribus fragrantibus alabastro rotundatis, fructu maiore verrucis pluribus praedito.

DESCRIPTION

Palma solitaria, aetate caule ascendenti robusto ad 4 m alto et 15 cm diametro, annulato-cicatricoso. Folia erecta grandia ad 4 m longa. Petiolus ad 1 m longus, 2 cm latus. Lamina ad 3 m longa, ad 1.6 lata, squamis furfuraceis fuscis intra secus costam et in lobis brevibus marginalibus tecta. Plicae numerosae ad 20 utrimque, inter plicas nervulis lateralis anastomosantibus. Margo folii inferior spinis brevibus (ad 1 mm) armatus atque petiolus. Petiolus duobus striis luteis notatus. Vagina folii fibrosa marcescens reticulum fuscum formans.

Inflorescentia axillaris corona foliorum arcuata. Spathae fugaceo-furfuraceae, primo cremeae dein fuscentes, 5 — 6 numero, 20 cm longae et 8 cm latae, basi tubulosae superne inflatae, apicibus acutis, imo latere fissae. Pedunculus tomentosus ad 50 cm longus et 2 cm latus, ordinibus quattuor divaricatis ramosus. Rami floriferi 50 — 100, ad 2.5 mm diametro, ad 10 cm longi, viriduli, albotomentosi, floridi. Flores albi glabri, alabastro rotundati, solitarii vel bini vel terni aggregati, in tuberculis prominentibus insidentes, unusquisque bracteola minuta subtentus. Calyx brevis ad 1 mm altus, carnosus, glaber, paullo 3 — lobatus. Petala carnosa alba, ad 3 mm longa, late triangularis basi in tubo breve connata. Annulus staminalis minute epipetalus, in filamenta 6 aequalia superne abrupte subulata. Antherae ovales. Grana pollinis alba. Ovarium glabrum carpellis 3 basi liberis, apice in stylo communi 0.8 mm longo connatis. Fructus ad 5 cms diametro, plerumque a carpello uno evolutus, raro a 2 — 3 carpellis, c. 60 verrucis suberosis fuscis sordidis ad 9 mm altis, tectus. Endocarpium lignosum ad 1 mm crassum. Endospermium osseum ad 2.5 cm diametro, basi integumentorum contextu suberoso penetratus. Embryo lateralis.

Malay Peninsula: Perak, in monte Gunong Kledang in Hill Dipterocarp Forest. J. Dransfield 871, Holotypus, June 1968; (K) et in monte Gunong Bubu, Whitmore FRI 0673.

Very similar to *Jt. altifrons* Reichb. f. et Zoll. but differs from this in the ascending stem, forming a trunk, inflorescence with four orders of divaricate branching, sweet-smelling flowers, rounded bud, and the larger fruit with more numerous warts.

Solitary palm, in age with a robust ascending stem to 4 m high and 15 cm in diameter, marked with annular scars. Leaves large, erect to 4 m high. Petiole to 1 m long, 2 cm wide. Lamina to 3 m long, to 1.6 m wide, clothed with brown scurfy scales along the underside of the costa, and at the short marginal lobes. Plicae numerous, to 20 or more on each side of the costa, with small anastomosing lateral nerves between the plicae. Leaf margin armed with short spines (to 1 mm) as is the petiole. Petiole marked with two yellow lines. Leaf base fibrous, withering to form a brown network of fibres.

Inflorescence axillary, arching out of the crown. Spathes covered in fugaceous scurfy scales, at first cream than becoming brown, 5 — 6 in number, 20 cm long and 8 cm wide, tubular at the base, inflated above, split on one side, with acute apices. Peduncle tomentose to 50 cm long and 2 cm wide, with four orders of divaricate branches. Floriferous branches 50 — 100, to 2.5 mm in diameter, to 10 cm long, greenish, covered in white tomentum, densely covered in flowers. Flowers glabrous, white, rounded in bud, solitary or grouped in 2's or 3's, borne on prominent tubercles, each subtended by a minute bracteole. Calyx short to 1 mm high, fleshy and glabrous, shallowly three-lobed. Petals fleshy, white, to 3 mm long, broadly triangular, connate in a short tube at the base. Staminal ring minutely epipetalous, abruptly contracted above into six filaments. Anthers oval. Pollen grains white. Ovary glabrous with three carpels free at the base, at the apex, connate into a common style 0.8 mm long. Fruit to 5 cm in diameter, usually developing from one carpel, rarely from 2 —3 carpels, covered in circa 60 corky warts, dirty-brown in colour and 9 mm high. Endocarp woody to 1 mm thick. Endosperm bony to 2.5 cm in diameter, penetrated at the base by corky integumental tissue. Embryo lateral.

Malay Peninsula: Perak; on the hills of Gunong Kledang in Hill Dipterocarp forest. J. Dransfield 871, Holotype, June 1968: (K) and on Gunong Bubu, Whitmore FRI 0673.

COLLECTIONS EXAMINED

1 — H. N. Ridley (1898) Bukit Keledang, Perak (SING). 2 — C. Curtis *3350* (1898) Kledang, Kinta, Perak (SING). 3 — R. Long (1909) Kledang Hills, Perak (K). 4 — ex Penang Botanic Gardens (1909) source unknown (K). 5 — Md. Haniff and Md. Nur, Sing. F.N. *6958* (1920) Sungei Siput, Perak (K, SING). 6 — Machado s.n. & s.a. Kamuning, Perak (SING). 7 — J. Dransfield *871* (1968) Kledang Saiong Forest Reserve, Perak. (K) 8 — T. C. Whitmore, FRI *0673*, Gunong Bubu, Perak (SING, KEP).

HABITAT

In the Kledang Saiong Forest Reserve near Ipoh, Perak, *Jt. perakensis* is an abundant palm, growing gregariously on hill slopes and ridge-tops from about 175 m to 850 m. At the southern end of the range near Parit, it is equally abundant on hill slopes and ridge-tops; in the Virgin Jungle Reserve it is confined to slopes and is absent from ridge-tops. Soils are well drained and derived from granite. Much of the Forest Reserve has been selectively-logged, but *Jt. perakensis* has survived the logging in many places. On Gubong Bubu, Whitmore records the palm as locally very common on ridge-tops at 800 m.

Plate 5. Johannesteijsmannia perakensis Kledang-Saiong Forest Reserve, Perak.

Plate 6. JOHANNESTEIJSMANNIA MAGNIFICA (*left*) AND Jt. LANCEOLATA (*right*) S. Lalang Forest Reserve, Selangor. (*Photo Courtesy of HO Sai Yuen, Kepong*).

TAXONOMIC NOTES

Jt. perakensis and *Jt. altifrons* are more closely related than the other species of the genus. The separation of *Jt. perakensis* as a distinct species is justified on the basis of the characters in the diagnosis (see above) and the great isolation of the populations. The nearest populations of *Jt. altifrons* are in (1) West Kelantan separated from the Perak Hills by 100 km and the intervening Main Range rising to 2,400 m and nowhere in this region below 1,000 m, (2) Sungei Lalang in Selangor 200 km to the South, and (3) the Batang Serangan in East Sumatra 300 km to the West and separated by the Straits of Malacca. Isolation was probably even more effective during the Pleistocene at the maximum sea level, when, with sea level circa 80 m above present levels (Walker 1954), the Bubu massif and the Kledang-Saiong massif were probably isolated as islands off the main Malayan landmass.

In badly collected specimens it is usually difficult to distinguish *Jt. perakensis* from *Jt. altifrons*. Infructescences are usually represented, and these always have divaricating floriferous branches.

Johannesteijsmannia magnifica J. Dransfield, **sp. nov.**

DIAGNOSIS

Differt a speciebus ceteris foliis latissimis, lamina infra indumento lacteo tecta, inflorescentia ordinibus 5 — 6 ramosa, petalis angustis reflexis.

DESCRIPTION

Palma solitaria acaulescens, caule subterraneo procumbente ad 15 cm diametro. Folia erecta grandia latissima ad 5 m longa, lamina ad 3 m longa et 2 m lata, superne glabra, infra indumento lacteo vestita, costa marginibusque lobatis nudis. Plicae numerosae ad 20 utrinque inter plicas nervulis lateralis anastomosantibus. Margo inferior folii spinis brevibus (ad 15 mm) armatus atque petiolus. Petiolus duobus striis conspicuis notatus. Vagina folii fibrosa ad 25 cm longa marcescens reticulum fuscum formans.

Inflorescentia axillaris e cumulo foliorum mortuorum et fragmentorum plantorum aliorum in corona collectante arcuata. Spathae primo cremeae, dein fuscentes, 5 — 6, 26 cm longae et 7 cm latae, basi tubulosae superne inflatae, apicibus acutis, uno latere fissae indumento albo dense tectae. Pedunculus tomentosus ad 80 cm longus, 2 cm diametro, ordinibus 5 — 6 ramosus. Rami floriferi 500 — 1,000, ad 1.5 mm diametro ad 7 cm longi albi glabri, floridique. Flores glabri, alabastro acuti, solitarii vel bini vel terni aggregati, in tuberculi prominentibus insidentes, unusquisque bracteola minuta subtentus. Calyx brevis ad 0.5 mm altus, carnosus glaberque, paullo 3 — lobatus. Petala ad 15 mm longa, anguste-triangularia, 3 — plo longiora quam latiora, carnosa alba, reflexa, basi in tubo breve connata, intra rugosa. Annulus staminalis minute epipetalus, in filamenta 6 aequalis superne abrupte subulata. Antherae ovales. Grana pollinis alba. Ovarium glabrum carpellis 3, basi liberis, apice in stylo communi 0.4 mm longo connatis. Fructus ad 4 cm diametro, plerumque a carpello uno evolutus aliquando a 2 — 3 carpellis, c. 150 verrucis humilis suberosis fusco-rufescentibus, ad 2.5 mm altis, tectus. Endocarpium lignosum ad 1 mm crassum. Endospermium osseum ad 2.5 cm diametro, contextu integumentorum suberoso basi penetratus. Embryo lateralis.

Fig. 4. JOHANNESTEIJSMANNIA MAGNIFICA
A: inflorescence, B: flower

Malay Peninsula: *Selangor,* in valle humido, Virgin Jungle Reserve Sungei Lalang Forest Reserve, Semenyih, Kajang, in Hill Dipterocarp Forest. J. Dransfield 862, Holotypus, May 1968 (K); et *Negri Sembilan* in monte Bukit Tangga, Seremban, Napier 1903 (SING) et Dransfield (1967); et in monte Gunong Angsi, Corner.

Differing from the other species by the very broad leaves with the lamina covered with white indumentum below, the inflorescence with 5 — 6 orders of branching, and the flowers with narrow reflexed petals.

Solitary acaulescent palm with procumbent underground stem to 15 cm in diameter. Leaves erect, large and very broad, to 5 m tall, with lamina to 3 m long by 2 m broad, glabrous above, on the lower surface covered with white indumentum except along the costa and at the marginal lobes. Plicae numerous to 20 or more pairs on either side of the costa, with small anatomosing lateral nerves between the plicae. Lower leaf margin armed with short spines (to 1.5 mm) as is the petiole, Petiole with two conspicuous yellow lines. Leaf base fibrous, to 25 cm long, withering to form a brown network of fibres.

Inflorescence axillary, arching out of the pile of dead leaves and other plant debris accumulating in the crown of leaves, Spathes cream at first then becoming brown, 5 — 6 in number, 25 cm long and 7 cm wide, tubular at the base, inflated above, split down one side, with acute apices, and densely covered in white indumentum. Peduncle tomentose to 80 cm long, 2 cm in diameter, with 5 — 6 orders of branching. Floriferous branches 500 — 1,000 in number, to 1.5 mm in diameter and 7 cm long, white, glabrous, and densely covered in flowers. Flowers white and glabrous, acute in bud, solitary or grouped in 2's and 3's, borne on prominent tubercles, each subtended by a minute bract. Calyx short, to 0.5 mm high, fleshy and glabrous, shallowly three-lobed. Petals to 1.5 mm long, narrowly triangular, three times as long as broad, white and fleshy, reflexed, connate at the base into a short tube, and rugose within. Staminal ring minutely epipetalous, abruptly narrowed above into six equal filaments. Anthers oval. Pollen grains white. Ovary glabrous with three carpels, free at the base, connate at the apex into a common style 0.4 mm long. Fruit to 4 cm in diameter, usually developing from one carpel, occasionally from 2— 3 carpels, covered by c.150 low, reddish-brown corky warts, to 2.5 mm high. Endocarp woody to 1 mm thick. Endosperm bony to 2.5 cm in diameter, with corky integumental tissue penetrating at the base. Embryo lateral. Malay Peninsula: *Selangor,* in humid valley, Virgin Jungle Reserve, Sungei Lalang Forest Reserve, Semenyih, Kajang, in Hill Dipterocarp Forest. J. Dransfield 862, Holotype, May, 1968 (K); and *Negri Sembilan* on Bukit Tangga, Seremban, Mapier 1903 (SING) and J. Dransfield (1967); and on Gunong Angsi, Corner.

COLLECTIONS EXAMINED

1 — H. J. Napier (1903) Bukit Tangga, Negri Sembilan (SING). 2 — J. Dransfield (1967) Bukit Tangga, Berembun Forest Reserve, Negri Sembilan. 3 — Wong Yew Kwan *95088* (1961) Cpt. 24, Sungei Lalang Forest Reserve, Selangor (KEP). 4 — J. Dransfield (1967) Cpt. 3, Sungei Lalang Forest Reserve, Selangor. 5 — J. Dransfield *862,* (1968) Virgin Jungle Reserve, Sungei Lalang Forest Reserve, Selangor.

HABITAT

In all localities visited, *Jt. magnifica* is a plant of steep slopes and ridge-tops except in the Virgin Jungle Reserve, Sungei Lalang Forest Reserve where it also grows at the side of a small river in a very humid valley bottom, alongside *Jt. lanceolata;* in this last locality *Jt. magnifica* occurs in great abundance in the untouched forest, from the valley bottom at 150 m to the ridge-top at 500 m. At Bukit Tangga in Berembun Forest Reserve in Negri Sembilan, *Jt. magnifica* grows in much disturbed, logged forest.

TAXONOMIC NOTES

As *Jt. magnifica* and *Jt. lanceolata* grow side by side in the Virgin Jungle Reserve (see plate 6) it is possible that hybridization between the two species could take place. As any hybridization experiments would be extremely prolonged, difficult to perform, and dependent on simultaneous flowering, it has only been possible to use indirect evidence to assess the possibility of hybridization taking place. There are no intermediates observable in mature plants; in young plants the presence of white indumentum on the lower leaf surface is always correlated with laminae about 1½ times as long as broad. Narrower leaves are always glabrous except for scurfy brown scales along the midrib. Narrow leaved adults are always glabrous and always have the inflorescence and fruit characters of *Jt. lanceolata.* These facts suggest that hybridization does not occur.

Johannesteijsmannia lanceolata J. Dransfield **sp. nov.**

DIAGNOSIS

Differt a speciebus ceteris foliis angustis, inflorescentia ramis 3 — 6, crassis, petalis papillatis.

DESCRIPTION

Palma solitaria acaulescens, caule subterraneo procumbente ad 15 cm diametro. Folia erecta, plus minusve lanceolata ad 3.5 m alta. Lamina ad 2.4 m longa et 30 cm lata, squamis furfuraceis fuscis infra secus costam et nervos primarios tecta. Plicae numerosae ad 25 utroque costae latere, inter plicas nervulis lateralis anastomosantibus. Margo inferior folii spinis brevibus (ad 1 mm) armatus atque petiolus. Petiolus duobus striis luteis conspicuis notatus. Vagina folii fibrosa ad 25 cm longa marcescens, reticulum fuscum formans.

Inflorescentia axillaris inter petiolos infra cumulum foliorum mortuorum et fragmentorum plantorum aliorum infossa. Spathae primo cremeae dein fuscentes, caducae, 3 — 4 indumento fusco sparsim tectae, ad 20 cm longae et 2 cm latae, basi tubulosae, non inflatae, apicibus acutis, uno latere fissae. Pedunculus tomentosus ad 25 cm longus, 10 mm diametro, ordine uno ramosus. Rami floriferi 3 — 6, crassi ad 10 mm diametro et 16 cm longa, pubescentes, arcuati rective. Flores sessiles albi papillosique, alabastro obtusi, solitarii vel bini vel terni aggregati, unusquisque bracteola minuta subtentus, spiraliter dispositi. Calyx brevis, 0.3 mm altus, carnosus glaberque, paullo 3 — lobatus. Petala ad 1 mm longa, late-triangularis, carnosa crassissima, basi in tube breve connata, extus papillosa, intra apices aliquantum verruculosa. Annulus staminalis minute epipetalus, in filamenta 6 aequalis superne abrupte subulata. Antherae ovales. Grana pollinis alba. Ovarium glabrum carpellis 3, basi liberis, apice in stylo communi 0.3 mm longo connatis. Fructus ad 3.4 cm diametro, plerumque a carpello uno evolutantes, saepe a 2 — 3 carpellis, c. 90 verrucis humilibus suberosis fusco-rufescentibus, ad 2.5 mm altis, tectus. Endocarpium lignosum ad 1 mm crassum.

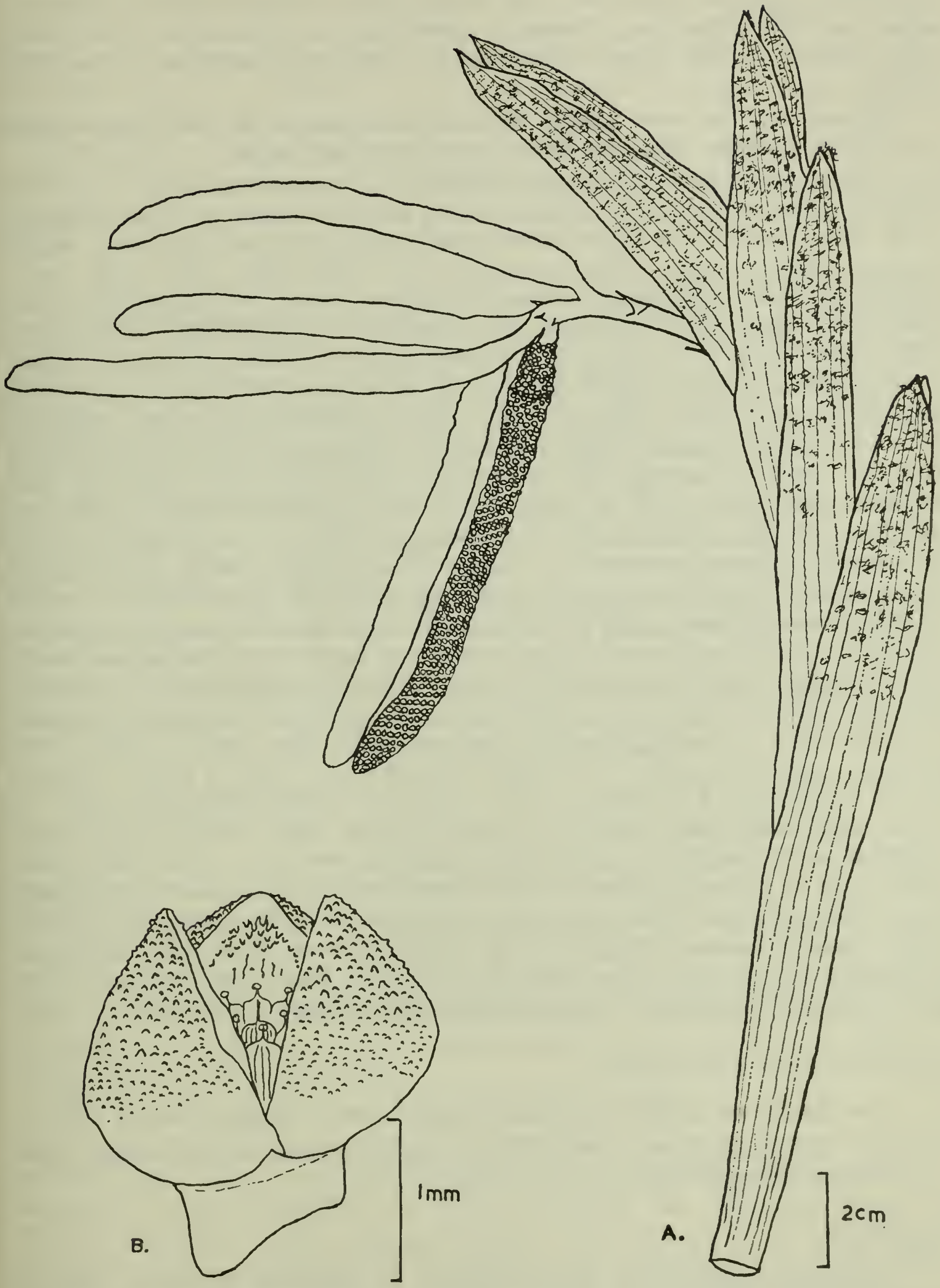

Fig. 5. JOHANNESTEIJSMANNIA LANCEOLATA
A: inflorescence, B: flower

Endospermium osseum ad 2.5 cm diametro, contextu integumentorum suberoso basi penetratus. Embryo lateralis. Malay Peninsula: *Selangor,* in valle humido prope flumen, Virgin Jungle Reserve, Sungei Lalang Forest Reserve, Semenyih, Kajang, in Hill Dipterocarp Forest. J. Dransfield 861, Holotypus, May 1968; (K) et *Pahang,* in Ulu Sungei Tekal Besar, Temerloh, Henderson March 1923 (SING).

Differs from the other species by the narrow leaves, the inflorescence with 3 — 6 thick branches and the flowers with papillate petals.

Solitary acaulescent palm, with subterranean procumbent stem to 15 cm diameter. Leaves erect, ± lanceolate, to 3.5 m tall. Lamina to 2.4 m long and 30 cm wide covered with brown scurfy scales on the underside, along the midrib and the primary nerves. Plicae numerous to 25 along each side of the costa, with small anastomosing veins between the plicae. Lower leaf margin with short spines (to 1 mm) as on the petiole. Petiole with two conspicuous yellow stripes. Leaf sheath fibrous to 25 cm long, withering to form a brown network of fibres.

Inflorescence axillary buried between the petioles under a pile of dead leaves and other plant debris. Spathes at first cream, then turning brown, caducous, 3 — 4 in number, sparsely clothed in brown indumentum, to 20 cm long and 2 cm wide, tubular at the base, not inflated, acute at the apex, split down one side. Peduncle tomentose to 25 cm long, 10 mm in diameter, with one order of branching. Floriferous branches 3 — 6 in number, thick, to 16 cm long and 10 mm in diameter, pubescent, curved or straight. Flowers sessile, white and papillate, obtuse in bud, solitary or grouped in 2's and 3's, each subtended by a minute bracteole, arranged in a spiral on the branch. Calyx short 0.3 mm high, glabrous and fleshy, shallowly three-lobed. Petals to 1 mm long, broadly triangular, fleshy, and very thick, connate into a short tube at the base, papillose without, somewhat verrucose within towards the apex. Staminal ring minutely epipetalous, abruptly contracted into six equal filaments. Anthers oval. Pollen grains white. Ovary glabrous, carpels three, free at the base, connate at the apex to form a common style 0.3 mm long. Fruit to 3.4 cm in diameter, usually developing from one carpel, often developing from two or three, covered with c.90 low corky warts, reddish-brown in colour, to 2.5 mm high. Endocarp woody to 1 mm thick. Endosperm bony to 2.5 cm in diameter, penetrated at the base by corky integumental tissue. Embryo lateral. Malay Peninsula: *Selangor* in humid valley by the river, Virgin Jungle Reserve, Sungei Lalang Forest Reserve, Semenyih, Kajang, in Hill Dipterocarp Forest. J. Dransfield 861, Holotype, May 1968: (K) and *Pahang* in Ulu Sungei Tekal Besar, Temerloh; Henderson, March 1923 (SING).

COLLECTIONS EXAMINED

1 — Henderson (1923) Ulu Sungei Tekal Besar, Temerloh, Pahang (SING).

2 — J. Dransfield 861 (1968) Virgin Jungle Reserve, Sungei Lalang Forest Reserve, Selangor (K).

HABITAT

In Sungei Lalang Virgin Jungle Reserve, *Jt. lanceolata* is known from the steep banks of a forest river in a deep humid valley; growing with *Jt. magnifica.* Despite the proximity of the river, *Jt. lanceolata* grows on well drained soils and not in the low swampy ground at the bends in the river. The population of *Jt. lanceolata* was probably once greater — further down the valley scattered individuals occur growing in logged forest near the river.

The Geography of Johannesteijsmannia

Johannesteijsmannia is confined to North Sumatra, the Malay Peninsula, and West Borneo, with one widespread species *Jt. altifrons,* and three species endemic to the Malay Peninsula. The concentration of species in the Malay Peninsula may be a reflection of the more intensive fieldwork carried out in Malaya; there are, for example, as far as in known, no post 1940 specimens of *Jt. altifrons* from Sumatra, and the possibility of new species of the genus occurring in Sumatra cannot be ruled out. *Jt. altifrons,* however, in Sarawak appears to be genuinely rare, and Forest Staff and Ibans in Brunei did not know of the existence of this very conspicuous and useful palm.

It seems most reasonable, however, to suppose that the centre of diversity of the genus coincides with present day centre of distribution — i.e. the uplands of Selangor, Negri Sembilan and Pahang, where three of the four species grow together. In late Mesozoic time this area was somewhere near the centre of the Sundaland mass (van Bemmelen 1949, Umbgrove 1949), and this area together with West Sarawak, East Sumatra, Banka and Billiton, has remained above sea level until the Pleistocene marine incursions (Umbgrove 1.c.) when it seems probable (extrapolation from Malaya) that much of Banka and Billiton and of lowland East Sumatra would have been submerged during the maximum sea level of 80 m (Walker 1954). It is the area of Sundaland now represented by Malaya and Borneo which probably remained as land through the Pleistocene, that harbours the greatest concentration of species in the palm genera *Licuala, Calamus, Daemonorops,* and *Korthalsia.* (the number of species of *Licuala* on New Guinea exceeds the number in Malaya and Borneo individually, but if Malaya/Borneo is treated as one land mass, i.e. part of Sundaland, then the total exceeds that of the land mass of New Guinea and its outlaying islands).

The limited distribution of the genus can be explained in two main ways: (1) the genus is an ancient one and survives as a relatively unsuccessful form in the area of its diversity as a relic of Coryphoid evolution, (2) the genus has relatively recently evolved and has not yet spread to areas outside its area of origin. That *Johannesteijsmannia* has many characters in common with *Licuala* but is in many ways more primitive than *Licuala* (e.g. leaf and inflorescence structure) suggests it is probably more ancient than the successful widespread genus *Licuala.* It therefore seems more likely that *Johannesteijsmannia* is an ancient genus surviving in Sundaland. Speculating further I would suggest an origin during the Mesozoic from primitive Coryphoid stock.

If a Mesozoic origin of the genus in the Malay Peninsula is assumed then the spread away from the centre could have occurred any time during the late Mesozoic and the Tertiary. Any pre-Miocene invasion of Sumatra would probably have been destroyed by marine incursions, for much of Sumatra was submerged during the Miocene (Umbgrove 1949). Only one species at the present day, *Jt. altifrons,* has spread out of the proposed centre of diversity, and is therefore to be regarded as the most successful and adaptable species. *Jt. altifrons* probably reached Sumatra during the Pliocene, and was then cut off from the Malayan populations by the appearance of the Straits of Malacca. *Jt. altifrons* could have reached Sarawak any time before Borneo was separated from the Malay Peninsula during the Pleistocene, but the very local occurrence of the species in West Sarawak suggests that the invasion of Borneo is relatively recent, (e.g. in the Pliocene corresponding with the proposed time of spread into Sumatra). *Jt. altifrons*, although it has reached Sarawak, is absent from Pulau Tioman (Pahang), Penang and the Anamba and Natuna Islands; the absence may be due to chance extinctions if the palm ever colonized these islands or else it was unable for some reason to reach the islands.

The distribution of *Jt. altifrons* within the Malay Peninsula is disjunct and it seems reasonable to suppose that *Jt. altifrons* was at one time widespread over the whole area; this may have coincided with the proposed period of active expansion which resulted in the colonization of Sumatra and Borneo. The disjunction of the range of distribution has resulted in slight vicarous evolution; the isolated populations have diverged slightly from each other. In Perak, populations on the Bubu Range and Gunong Kledang have diverged further and reached a degree of divergence where it is convenient to regard them as a distinct species, *Jt. perakensis*. The evolution and distribution of *Jt. lanceolata* and *Jt. magnifica* cannot be explained by vicariism (as Croizat 1968 would explain the speciation of *Ficus* — refuted by Corner 1969); the two species occur alongside *Jt. altifrons* in the one Forest Reserve in Selangor, apparently with the same ecological requirements. It is most reasonable to regard *Jt. lanceolata* and *Jt. magnifica* as relatively unsuccessful early products of form making within the genus which have survived near the centre of diversity without having spread. (*Jt. lanceolata* has reached central Pahang from the proposed centre of diversity).

The dispersal powers of *Jt. altifrons* appears to be very limited — seedlings are rare, — and the distribution of the whole genus suggests plants of very limited dispersal powers at the present day, surviving as relics in the centre of massing of the Asiatic coryphoid palms, as do *Liberbaileya gracilis* and *Maxburretia rupicola* (Furtado 1941).

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Soil moisture under forest, Bukit Timah Nature Reserve, Singapore

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Abstract

The results of a study of moisture of three forested hill-slope soils are presented and compared with the results of a similar study in Malaya. Soil moisture levels were found in general to be rather higher than under other forms of vegetation. Statistical analysis indicated that change of moisture content was consistent within each soil but less consistent between soils. A series of statistical experiments suggested that except for the A soil horizon, soil moisture (as determined by drying) correlated reasonably well with number of raindays and that the introduction of the factor *e* (evapotranspiration) resulted only in slightly improved correlations except for the A soil horizon where the use of *e* gave much better correlations.

The study of soil moisture in the region is one that is strangely neglected, a search of available literature failing to reveal more than two studies, both concerned with soil moisture as related to rubber. Belgrave (1930, 493–4) made observations from three levels, 2–6 in., 6–12 in. and 12–18 in., of a Serdang series soil having two types of cover, *Centrosema, Mikania,* and under bare soil. Watson, Wong and Narayanan (1963) made eighteen observations at monthly intervals from two levels, 0–6 in. and 12–18 in. of a Rengam series coarse sandy clay loam with a vegetation of two and three year old rubber and cover crops of legumes, grass, adventives and also under bare soil.

Soil Characteristics

The present study reports the results of weekly observations made from mid-February until mid-June 1970 at three points down a surveyed transect line off Jungle Fall path, Bukit Timah Nature Reserve which has a somewhat open lowland Dipterocarp-forest. The upper sampling point, 1, (172 m a.s.l.) was some 25 m from the crest of a gently-rounded interfluve and about 4 m below it with a local slope of almost 15°. The middle sampling point, 2, (141 m a.s.l.) was about 87 m downslope from the first sampling point, 1, and it had a local slope of 24°. Both soils belong to the Rengam series (Leamy & Panton 1966, 105). The lowest sampling point, 3, (126 m a.s.l.) was at the foot of the same slope, 33 m from 2, and located on a small terrace 1.5 m above the level of a small perennial stream. The soil materials were derived from colluvium and alluvium with the former predominating. This soil cannot be assigned to any described series.

The moisture-holding capacity of soil is significantly influenced by grain-size and organic material present. These data are presented for four levels in each soil, 0–10 cm (0–4 in.), 10–20 cm (4–8 in.), 30–45 cm (12–18 in.) and 60–75 cm (24–30 in.), in Table 1. Detailed analysis of grain size was made using the A.S.T.M. standard method (American Society for Testing and Materials, 1963). Only a summary of the data is presented here.

The data for loss on ignition (at 480°C) do not accurately measure total organic matter because the initial oven-dry samples still retain tightly-bound water of hydration. Total organic matter is thus slightly lower than indicated in Table 1.

Table 1. Grain Size (%) according to International System and Loss on Ignition

Sample Point	Depth (cm)	Coarse Sand (2000μ–250μ)	Fine Sand (250μ–25μ)	Silt and Clay (less than 25μ)	Textural name	Loss on Ignition % oven dry wt.
1	0–10	44.6	16.7	38.7	Coarse sandy loam	12.7
	10–20	39.3	12.9	47.8	Coarse sandy loam*	8.8
	30–45	38.2	13.3	48.5	Coarse sandy loam*	7.5
	60–75	34.1	12.2	53.7	Coarse sandy loam	7.0
2	0–10	40.3	21.9	37.8	Coarse sandy loam	10.3
	10–20	37.7	15.3	47.0	Coarse sandy loam†	5.8
	30–45	36.2	18.1	45.7	Coarse sandy loam†	4.5
	60–75	33.5	20.6	45.9	Sandy clay loam	3.7
3	0–10	60.0	5.9	34.1	Not named‡	5.2
	10–20	57.6	20.8	21.6	Coarse sandy loam	5.1
	30–45	56.7	16.1	26.3	Coarse sandy loam	4.4
	60–75	38.5	17.5	44.0	Coarse sandy loam†	7.3

* Almost sandy clay
† Almost sandy clay loam
‡ Suggested name: coarse sandy clay

Collecting Methods

Prior observation established that the maximum variability amongst samples taken from the same level at the same point on the slope was ± one per cent provided that augered samples were taken at points where there were no large roots and which were some distance away from the stems of nearby trees. Successive weekly samplings thus required only one sample from each level at each observation point. Several samples taken at point 3 were notably coarser than the majority and values for moisture are therefore less reliable.

Samples of about 300 gm were augered from each level and immediately placed in polythene bags and sealed. On arrival at the laboratory samples were well-shaken or stirred to incorporate moisture condensing on the inside of the bag and to break down lumps. Samples of about 100 gm were then spooned into dishes for drying at 105°C for 24 hours followed by weighing at 40°C. Prior experiment showed that differences arising from more protracted drying and from cooling in a desiccator to room temperature were much smaller than the differences arising from variations in the exact point sampled. It was however, necessary to weigh dried samples very rapidly taking them one by one from the oven.

Weather

The period of observation began with the dry spell which usually occurs towards the end of the north-east monsoon, and extended through a wetter inter-monsoon period to the early part of the south-west monsoon. Rainfall data were collected daily from a rainfall station some three hundred metres from the soil sampling points. Open pan evaporimeter data were obtained for Paya Lebar Airport some 14 km from Bukit Timah. Soil samples were taken shortly after the daily rainfall measurement was made. Rainfall data are presented at the top of each diagram in Figures 1–3.

Results

The results are presented in Figures 1–3. The diagrams suggest a fairly clear relationship between rainfall and soil moisture, the general trend of low values during dry spells being clear. In the two hill-slope soils points 1 and 2, soil moisture conditions were fairly stable below 30 cm with increasing variability in the upper portions of the soil. This was more marked in the 0–10 cm zone which corresponded with the A_1 soil horizon. Rather large fluctuations, sometimes even during fairly dry periods reflect large but short-lived rises of soil moisture following showers.

The mid-slope soil was slightly drier than the upper-slope soil during the main dry spell but slightly wetter during the remainder of the period. This suggests that greater slope angle and hence more rapid soil drainage becomes influential only during dry spells whereas at other times receipt of upslope water results in slightly moister conditions. Differences of soil texture would seem to be too minor to account for these differences. Furthermore the mid-slope soil contained rather less organic matter than the upper-slope soil and this should have resulted in lower moisture values for the former soil had this been an influential factor.

The slope-foot soil shows an almost complete reversal of the pattern of the other two soils. In it variation was greatest at depth, undoubtedly because of fluctuations in the position of the water-table. The upper zones of this soil were a good deal sandier than those of the hill-slope soils, organic matter was much less and rapid infiltration of rainfall and overland flow from upslope occurred.

The range of moisture is summarised in Table 2.

Discussion

Only the study by Watson, Wong and Narayanan (1963) presents data adequate for some comparisons to be drawn. Expectably the soil moisture values are considerably higher under forest than those under legumes, grass, adventives and bare soil reported in that study. The lowest values at Bukit Timah are roughly equivalent to the mean values at Serdang for the upper 20 cm of soil. The data of Watson *et al* (1964, 165) also show much greater variation of moisture in the 0–15 cm zone than in the 30–45 cm zone. They report moisture values for the 30–45 cm zone which correspond quite well with those of the present study.

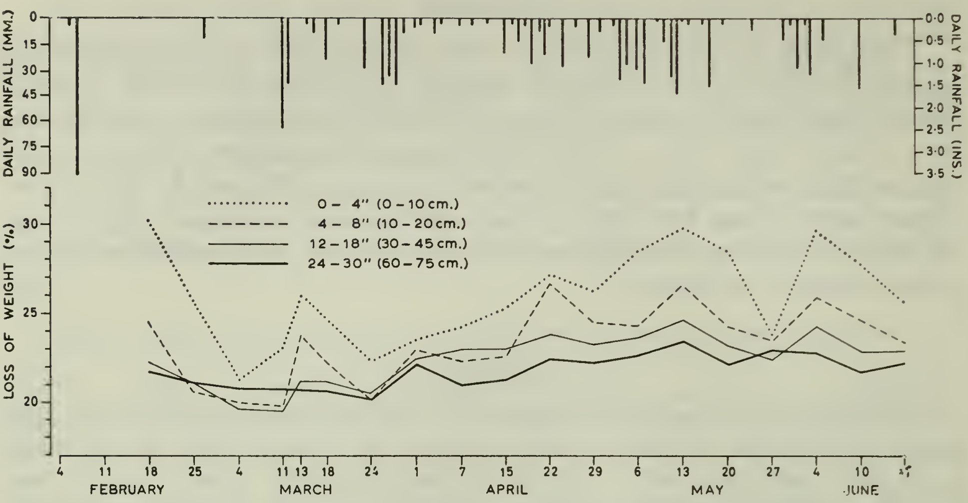

Fig. 1 Soil moisture (loss of weight on drying) for the soil near the top of the slope (1) and daily rainfall.

Table 2. Range of Soil Moisture (%)

Sample Point	Depth (cm)	Highest	Date (1970)	Lowest	Date (1970)	Range
1	0–10	30.2	18-2	21.3	4–3	8.9
	10–20	26.7	22–4	19.9	11–4	6.8
	30–45	24.7	13–5	19.5	11–3	5.2
	60–75	23.5	13–5	20.2	24–3	3.3
2	0–10	31.6	7–4 13–5	20.0	11–3	11.6
	10–20	27.8	10–6	17.9	11–3	9.9
	30–45	23.5	13–5	18.6	4–3	4.9
	60–75	26.4	22–4	20.1	11–3	6.5
3	0–10	23.4	22–4	18.5	4–3	4.9
	10–20	22.9	22–4	20.2	25–2	2.7
	30–45	25.3	22–4	10.1	13–5	6.7
	60–75	30.4	22–4	19.7	1–4	10.7

Statistical Analysis

Two sets of statistical analyses of the hill-slope soils (1 and 2) were made. The first aimed to establish the extent to which the rate of change of soil moisture between successive observations at each level within the soil were correlated. The results are summarised in Table 3 which shows that in general there is a greater degree of association between moisture change at one level within the soil and moisture change at the level below it than between moisture change at the same level of different soils. In other words rates of change within a soil were internally consistent with the notable exception of the soils at 60–75 cm where poor or no correlations with the soils at 30–45 cm were found.

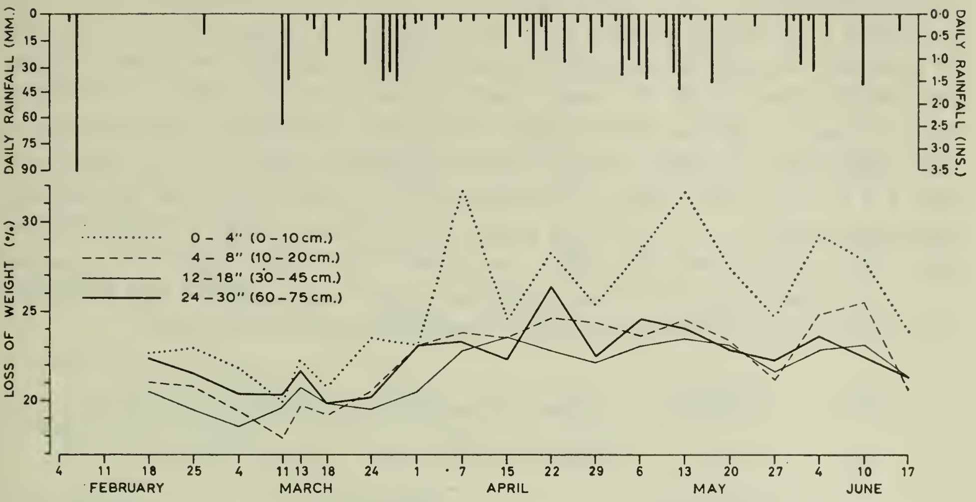

Fig. 2 Soil moisture (loss of weight on drying) for soil on the middle of the slope (2) and daily rainfall.

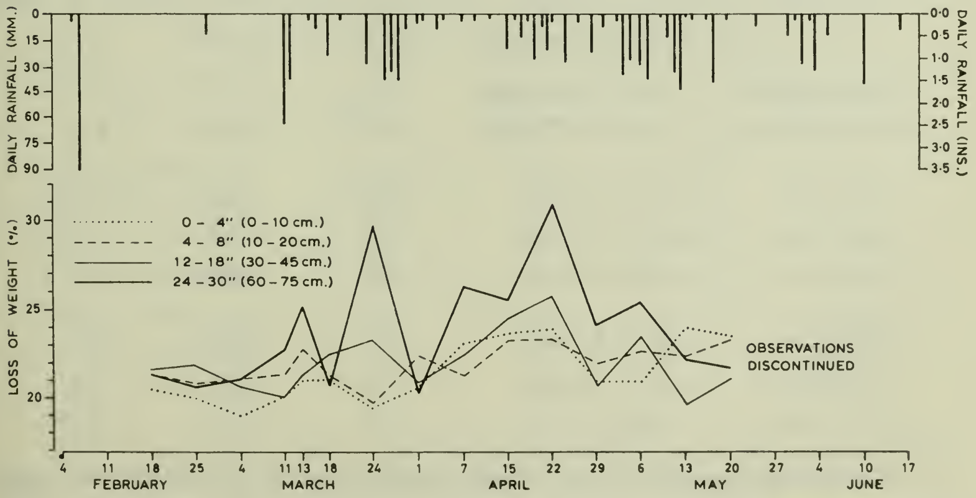

Fig. 3 Soil moisture (loss of weight on drying) for the slope-foot soil (3) and daily rainfall.

The second set of statistical analyses attempted to find a simple parameter with which soil moisture was correlated.

Since soil moisture is affected by a large number of factors including endogenous factors such as grain size and structure and exogenous factors such as rainfall and evapotranspiration, it was hardly to be expected that with only 19 successive observations statistically significant correlations between soil moisture and rainfall alone would be found. Such proved to be the case. Soil moisture was compared with the total rainfall over varying numbers of days prior to each observation. The best, but still poor correlations were first, for moisture in soils 1 & 2, (10–20 cm), with total rainfall over the fourth, third and second days before observation; $r = +0.47$, and second, for moisture in soils, 1 & 2 (60–75 cm), with total rainfall over the fifth, fourth and third days before observation; $r = +0.47$, both values for r being significant at the 5 per cent level with 24 degrees of freedom. Student's t test was used to test significance in each case.

Table 3. Correlations of Rates of Change of Soil Moisture at Various Levels in Soils 1 and 2

Variables		*Degrees of freedom*	r	*Significance (better than)*
x	y			
1 (0–10 cm)	2 (0–10 cm)	16	+0.76	1%
1 (10–20 cm)	2 (10–20 cm)	18	+0.49	5%
1 (30–45 cm)	2 (30–45 cm)	18	+0.57	1%
1 (60–75 cm)	2 (60–75 cm)	18	+0.56	1%
1 & 2 (0–10 cm)	1 & 2 (10–20 cm)	34	+0.71	0.1%
1 & 2 (10–20 cm)	1 & 2 (30–40 cm)	36	+0.70	0.1%
1 & 2 (30–40 cm)	1 & 2 (60–75 cm)	36	+0.46	1%
1 (0–10 cm)	1 (10–20 cm)	18	+0.71	0.1%
1 (10–20 cm)	1 (30–45 cm)	18	+0.76	0.1%
1 (30–45 cm)	1 (60–75 cm)	18	+0.68	1%
2 (0–10 cm)	2 (10–20 cm)	16	+0.73	1%
2 (10–20 cm)	2 (30–45 cm)	18	+0.60	1%
2 (30–45 cm)	2 (60–75 cm)	18	+0.38	None

A similar comparison of rate of soil moisture change with rainfall was even less satisfactory

A comparison between soil moisture and number of raindays ($>$ 0.1 in. or 2.5 mm per day) in the week preceding measurement gave rather better results and these are shown in Table 4 together with correlations of rate of moisture change with number of rain-days in the preceding week.

Table 4. Correlation of Soil Moisture and Rates of Soil Moisture at Various Levels with Number of Rain-days in Preceding Week

Soil *x*	*y*	*Degrees of freedom*	*r*	*Significance (better than)*
Soil m, 1 & 2, (0–10 cm)	r/days	38	+0.44	1%
Soil m, 1 & 2, (10–20 cm)	r/days	38	+0.56	0.1%
Soil m, 1 & 2, (30–45 cm)	r/days	38	+0.53	0.1%
Soil m, 1 & 2, (60–75 cm)	r/days	38	+0.55	0.1%
Rate of s.m. change, 1 & 2, (0–10 cm)	r/days	34	+0.56	0.1%
Rate of s.m. change, 1 & 2, (10–20 cm)	r/days	36	+0.49	1%
Rate of s.m. change, 1 & 2, (30–45 cm)	r/days	36	+0.47	1%
Rate of s.m. change, 1 & 2, (60–75 cm)	r/days	36	+0.47	1%

In an attempt to gain rather better correlations the factor for evapotranspiration (e) was introduced. In this, e is evaporation, multiplied by the empirical constant 0.9. The actual formula used was $R - e$, where R = daily rainfall and e the daily evapotranspiration. Values of $R - e$ were summed for varying numbers of days prior to each determination of soil moisture. The selected best results are given in Table 5.

Table 5. Selected Correlations of Rates of Change of Soil Moisture with $R - \epsilon$ over Various Days before Moisture Determination

Soil	*Days*	*Degrees of freedom*	*r*	*Significance (better than)*
1 & 2, (0–10 cm)	3, 2, 1	34	+0.57	1%
1 & 2, (0–10 cm)	4, 3, 2	34	+0.60	1%
1 & 2, (0–10 cm)	5, 4, 3	34	+0.45	5%
1 & 2, (10–20 cm)	4, 3, 2	36	+0.44	5%
1 & 2, (10–20 cm)	5, 4, 3	36	+0.31	None
1 & 2, (30–45 cm)	5, 4, 3	36	+0.37	None
1 & 2, (60–75 cm)	5, 4, 3	36	+0.42	5%

It will be seen from Table 5 that the introduction of the factor e which might have been expected to have added precision to the correlations failed to do so except in the case of the uppermost layer of soil from 0–10 cm.

In order that higher values for r might be obtained the empirical formula $Rw - e$ was used. It was felt desirable to retain the factor e since it represents a continuous process which results in loss of soil moisture. It was also desirable to weight the value R since rain falling seven days before a soil moisture determination would have much less effect upon the soil moisture level than rain falling in the day before the measurement. Rainfall was weighted with the following values, corresponding to 1, 2, 3 . . . 7 days before measurement; 1.0, 0.93, 0.85, 0.74, 0.60, 0.40, 0.10 which approximate to an exponential curve. The values for *R weighted — e* were then summed for varying periods prior to each moisture determination and separately correlated with soil moisture and rate of change of soil moisture. Selected results, giving highest values for *r*, are given in Tables 6 and 7.

Table 6. Selected Correlations of Soil Moisture with *R weighted — e*, over Various Days before Moisture Determination

Soil	*Days*	*Degrees of freedom*	*r*	*Significance (better than)*
1, (0–10 cm)	5 . . . 1	19	+0.46	5%
1, (10–20 cm)	5 . . . 1	19	+0.67	1%
1, (30–45 cm)	7 . . . 2	19	+0.66	1%
1, (60–75 cm)	7 . . . 2	19	+0.60	1%
2, (0–10 cm)	5 . . . 1	19	+0.67	1%
2, (10–20 cm)	5 . . . 1	19	+0.57	1%
2, (30–45 cm)	7 . . . 2	19	+0.57	1%
2, (60–75 cm)	7 . . . 2	19	+0.62	1%
1 & 2, (0–10 cm)	5 . . . 1	37	+0.56	1%
1 & 2, (10–20 cm)	5 . . . 1	38	+0.59	1%
1 & 2, (30–45 cm)	7 . . . 2	38	+0.59	1%
1 & 2, (60–75 cm)	7 . . . 2	38	+0.57	1%

Table 7. Selected Correlations of Rate of Soil Moisture Change with *R weighted — e* over Various Days before Moisture Determination

Soil	*Days*	*Degrees of freedom*	*r*	*Significance (better than)*
1, (0–10 cm)	5 . . . 1	18	+0.65	1%
1, (10–20 cm)	5 . . . 1	18	+0.61	1%
1, (30–45 cm)	7 . . . 2	18	+0.63	1%
1, (60–75 cm)	7 . . . 2	18	+0.40	None
2, (0–10 cm)	5 . . . 1	18	+0.67	1%
2, (10-20 cm)	5 . . . 1	19	+0.57	1%
2, (30–45 cm)	7 . . . 2	19	+0.57	1%
2, (60–75 cm)	7 . . . 2	19	+0.62	1%
1 & 2, (0–10 cm)	5 . . . 1	37	+0.56	1%
1 & 2, (10–20 cm)	5 . . . 1	38	+0.59	0.1%
1 & 2, (30–45 cm)	7 . . . 2	38	+0.59	0.1%
1 & 2, (60–75 cm)	7 . . . 2	38	+0.57	0.1%

These data suggest that while correlation with this empirical formula gives slightly higher values for r than correlations with number of rain days, especially for the upper layer of the soil, the introduction of the factor e is hardly necessary. The weighting of R would also seem to be barely worth the labour of computation involved. The conclusion is therefore, that with the exception of the upper layer of the soil where the introduction of e is desirable, the number of rain days in the period (here a week) before the measurement of soil moisture provides a simple parameter from amongst the meteorological factors affecting soil moisture. Since the method of determining soil moisture is by no means highly accurate, the coupling with it of such a 'rough-and-ready' measure as raindays seems justifiable, whereas the use of more sophisticated meteorological parameters is scarcely worth the labour involved.

Acknowledgments

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This paper is one of a projected series of studies of forest ecology in part of the Bukit Timah Nature Reserve. It is my pleasure to acknowledge fruitful discussions and the assistance of Mr. D. H. Murphy, Department of Zoology, University of Singapore who also commented upon a draft of this paper.

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Algae from Gunong Jerai (Kedah Peak), Malaysia

by

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Abstract

The author's collection of algae on Gunong Jerai is listed here with brief notes on habitat and existing records in The Malay Peninsula. Structural features of several species are also described. The total collection consists of 32 numbers, the 102 species and varieties are listed under 57 genera.

Introduction

Gunong Jerai or Kedah Peak is a mountain largely composed of sandstone, quartzite, quartz and some haematite (Robinson and Boden Kloss, 1916), and acidic intrusive igneous rocks (Alexander 1962). It rises to nearly 1219 metres (4000 feet) above mean sea level and is a prominent landmark of Kedah state. The vast flat lowlands more or less surrounding the foothills are mainly planted with rice. The sea to the west is only about 8 km (5 miles) away and in the mornings or when the moisture- and possibly salt-laden westerly winds blow, one could notice a thick mist moving across the peak towards the east. Ridley (1916), amongst other workers, has suggested that Gunong Jerai was once an island separated from the Malay Peninsula as in the case of Mt. Ophir, Johore and showed that there is much resemblance between the floras of these two mountains. The physical isolation of Gunong Jerai from the main range of the Peninsula and the absence of neighbouring mountains of any comparable altitude is phytogeographically significant, and the lack of a true Thai element in the flora (see Ridley, 1916) is noteworthy. Though the angiosperms, gymnosperms and especially ferns have been abundantly collected and well documented, no data on algae have been published.

Material and Method

This paper contains the results based on the study of 32 numbers of collections. The algae were collected by the writer at altitudes of about 823–1189 metres (2700-3900 feet) above mean sea level between May 12 and 20, 1969 (see figure 1). The two main sites of collection were (1) a stream near the Government bungalow and (2) the only concrete reservoir situated on the left side of Peak Road one-third the distance from bungalow to peak. On a clear day, temperature readings of the stream between 10.30 a.m. and 12.30 p.m. were found to vary between 21.8 and 22.2°C and pH from 8.0 to 8.3: at the reservoir the pH was 6.2 at 22.5°C. The latter were determined in the field with a Lovibond comparator.

Specimens were first examined fresh, then preserved dry or in solutions of formol acetic alcohol (Smith, 1950, p.34) or 5% formaldehyde. Of the nineteen species of diatoms collected eighteen were obtained as empty frustules from muds, bottom sediments and detrital material. The author consulted Johansen's "Botanical microtechnique" for staining methods and simple microchemical tests.

Species determination is incomplete due to inadequate reference material and absence of reproductive stages in some samples. For the nomenclature and sequence of major taxa (Divisions and Families), the system of Silva (1962) is largely adopted and to a lesser extent those of Papenfuss (1955) and Smith (1950). Genera are arranged according to systems of the following authors: Desikachary (1959, Cyanophyta), Prowse (1959, Bacillariophyta), Huber-Pestolozzi (1955, Euglenophyta), Randhawa (1959, Zygnemataceae), Scott and Prescott (1961, Desmidiaceae).

Numbers in the list refer to the author's collection. A complete set (101–133) is deposited at the Botany Division, School of Biological Sciences, University of Malaya, Kuala Lumpur; and 102, 104, 106, 107, 109–130, 132 and 133 are also at the Tropical Fish Culture Research Institute, Malacca.

List of Species of Algae

CYANOPHYTA

CHROOCOCCACEAE

Chroococcus turgidus Näg. Nos 100 & 111.

Collected from washings of *Sphagnum* and sedge growing in reservoir and of moss scraped from submerged concrete sides of reservoir.

Chroococcus ? *minutus* (Kütz.) Näg. No 109.

Collected from bottom muds, reservoir.

Gloeocapsa sanguinea (Ag.) Kütz. Nos 112, 113, 115.

Collected from surface of moist rock.

Gloeotheca ? *samoensis* Wille No 109.

Colonies of 2 to 8 ovoid cells with rounded ends, daughter colonies with individual sheaths, embedded in clear mucilage of parent envelope.

From bottom muds of reservoir.

Synechococcus ? *aeruginosus* Kütz. No 114.

Planktonic in reservoir and stream.

Dactylococcopsis acicularis Lemm. Nos 109, 110.

Collected from submerged moss-covered sides of reservoir.

OSCILLATORIACEAE

Phormidium inundatum Kütz. ex Gomont Nos 109, 116, 117.

Bright blue-green sheets; hormogonia abundant.

From surface of concrete roadside drain with water trickling over it.

NOSTOCACEAE

Anabaena sp. Nos 116, 118.

Filaments short, some up to about 500 μ long; heterocysts rectangular, about 1½ times longer than vegetative cells, intercalary, with two polar nodules; akinetes absent.

Planktonic in pool, roadside drain.

SCYTONEMATACEAE

Scytonema sp. Nos 115, 124.

In mass appears as black somewhat shiny patches on wet or dripping rock; abundant.

Tolypothrix sp. No 128.

On submerged rock or mixed in with other algae and vegetation in stream.

STIGONEMATACEAE

Hapalosiphon hibernicus W. et G.S. West Nos 124, 125.

Main axes usually uniseriate, occasionally biseriate, cells shorter or a little longer than broad, sheaths yellowish; branches uniseriate, mostly unilateral, sheaths non-lamellated, colourless, cells 2–6 times longer than broad, apex of terminal cells broadly rounded.

Collected from torrential stream amongst other algae.

Stigonema ocellatum (Dillw.) Thuret No 131.

Scraped from surface of rock in stream.

Reported from Templer Park (Hirano, 1967).

Stigonema panniforme (Ag.) Bornet et Flahault No 129.

Collected from torrential stream.

RHODOPHYTA

BATRACHOSPERMACEAE

Batrachospermum ? *moniliforme* Ralfs Nos 101–107, 108, 124. — **Plates 1, 2A-B**

Thalli macroscopic, 2–10 (–20) cm, moniliform, dark or pale blue-green or purplish brown, mucilaginous, corticated, freely branched. Nodes prominent. Internodes clear; corticating cells 2–6 times longer than broad, with short or long uniseriate filaments at the base; internodal filaments bear globose to obovate antheridial cells. Nodal filaments longer, branched; terminal cell ends in a long hair with dilated base, when fertile may bear clusters of antheridial cells at distal end. Cells of nodal branch citriform to oval, distinctly moniliform; apical cell dome shaped, obscured by upgrowing branches; branches may develop from the fourth axial cell and on the sixth, branches save as many as eight cells; young carpogonia clavate, stalked, develop at end of short but many-celled nodal branch; cystocarp rounded, more deeply pigmented, 1–3, more or less at periphery of nodal branch.

The plants collected showed considerable variation in such features as colour, size, length of internodes, degree of branching, structure of cortical and other cells, and, it is possible that two forms or may be even species are involved here. "Chantransia"-like thalli were not uncommon; these were bluish green, uniseriate, branched, the cells many times longer than broad, without terminal hairs, and vegetative. Some of these thalli resemble *Audouinella.*

Found attached to rocks or gravel in stream; few specimens found on wet soil of stream bank where seepage water overflowed, very few small plants in the reservoir. Distribution patchy, sometimes gregarious.

PYRRHOPHYTA

PHYTODINIACEAE

Dinococcus bicornis (Woloszynska) Fott Nos 123–125 — **Plates 2C, 3A-B**

Cells solitary, dorsal margin in front view convex, sometimes slightly depressed in the middle, showing at each end a short pointed spine; ventral view somewhat angular; vertical view ellipsoid; end view ovate. Stalk short, stout, colourless. Chromatophores obscured by dense accumulation of food reserve including a more or less central area of oil.

Epiphytic on *Oedogonium,* other filamentous algae, and colonial diatoms e.g. *Eunotia* in stream; frequently gregarious.

BACILLARIOPHYTA

EUNOTIACEAE

Eunotia ? *camelus* Ehrenb. Nos 122, 124.

Collected from stream muds.

Eunotia diodon Ehrenb. var. *minor* Grun. Nos 122, 124.

In stream muds and epiphytic on other algae.

Recorded in Cameron Highlands and Malacca River (Prowse, 1962a).

Eunotia lunaris (Ehrenb.) Grun. No 123.

In stream muds and epiphytic on other algae.

Recorded in Cameron Highlands (Prowse, 1962a).

Eunotia lunaris (Ehrenb.) Grun. var. *capitata* Grun. No 122.

Collected from stream muds.

Recorded in Malacca River (Prowse, 1962a).

Eunotia monodon Ehrenb. var. *tropica* Hustedt Nos 122, 123.

Among bryophytes and other vegetation in stream.

Three varieties were recorded from stream, river and fish pond elsewhere in West Malaysia (Prowse, 1962a).

Eunotia pectinalis (Kütz.) Rabenh. var *ventralis* (Ehrenb.) Hustedt No 120.

Collected from stream muds.

The species was recorded at Cameron Highlands (Prowse, 1962a). Var. *minus* (Kütz.) Rabenhorst has been recorded from Perak (Patrick, 1936).

Eunotia ? *pseudoflexuosa* Hustedt No 123.

Collected from stream muds.

Eunotia robusta Ralfs Nos 118, 120.

From roadside pool with flowing water and stream sediments.

Recorded in Malacca river (Prowse, 1962a).

Desmogonium rabenhorstianum Grun. Nos 120, 122, 123.

Epiphytic on other algae, bryophytes and in sediments of stream. Prowse (1962a) reported this species from various habitats elsewhere in Malaysia, including swamps and coastal streams, at Cameron Highlands in West Malaysia.

ACHNANTHACEAE

Achnanthes sp. Nos 118, 123.

Collected from roadside pool with flowing water; epiphytic on liverwort in reservoir.

NAVICULACEAE

Frustulia rhomboides (Ehrenb.) De Toni Nos 106, 115, 120–123, 126.

Distributed widely and abundantly in various habitats; its common occurrence suggests ecological significance and further studies are warranted.

Recorded from most states of West Malaysia, including Cameron Highlands and Fraser's Hill (Prowse, 1962a). Very abundant in algal samples collected by the writer in July 1970 at Tasek Bera, Pahang.

Navicula spp. Nos 104, 118, 120.

Many small species, especially common in bottom muds of streams and roadside pools.

Pinnularia biceps Gregory Nos 112, 113.

Collected from bottom sediments and submerged concrete sides of reservoir.

Recorded from padi-fields, Beranang (Johnson, 1970). Var *minor* (Boye Petersen) A. Cleve has been recorded in Malacca river and fish ponds (Prowse, 1962a).

Pinnularia legumen Ehrenb. No 111.

Collected from stream and reservoir sediments.

Recorded from Perak (Patrick, 1936); Taiping lakes (Prowse, 1962a) and from Templer Park (Hirano, 1967).

Pinnularia maior (Kütz.) Cleve Nos 122, 123.

Collected from stream muds and pools.

Reported from Perak (Patrick, 1936). Var. *linearis* was recorded in Templer Park (Hirano, 1967).

CYMBELLACEAE

Cymbella ? *ventricosa* Kütz. Nos 112, 113.

Collected from bottom sediments of reservoir.

Recorded at Cameron Highlands (Prowse, 1962a).

NITZSCHIACEAE

Hantzschia amphioxys (Ehrenb.) Grun. ? var. *capitata* O. Muller No 126.

Collected from stream mud.

Recorded from stream, Klang Gates (Prowse, 1962a).

SURIRELLACEAE

Surirella linearis W. Smith Nos 123, 126.

Collected from stream sediments.

Reported from Perak (Patrick, 1936); from fish ponds at Penang and Malacca river (Prowse, 1962a).

Surirella spiralis Kütz. Nos 101, 114, 120.

Collected from stream sediments. Rare.

Reported from various habitats in Malacca (Prowse, 1962a). The writer has collected the species at various times during 1968 to 1970 in the Gombak river, Selangor and in July, 1970 at Tasek Bera, Pahang.

Surirella ? *tenuissima* Hustedt Nos 123–125.

From sediments on bed-rock and liverwort in stream.

Recorded in Cameron Highlands (Prowse 1962a).

CHRYSOPHYTA

MALLOMONADACEAE

Several species of *Mallomonas* were encountered in the stream sediments, reservoir and amongst other algae and bryophytes. Cells were mostly empty and spines usually lacking. The following species appear to be present:

Mallomonas ? *elliptica* (Kisselew) Conrad Nos 110, 111.

Mallomonas producta (Zacharias) Iwanoff Nos 112, 113.

Mallomonas ? *teilingioides* Prowse Nos 112, 113.

DINOBRYACEAE

Dinobryon sertularia Ehrenb. No 111.

Mostly only empty envelopes were found; solitary or in colonies of up to six cells.

Colonies few-celled epiphytic on filamentous algae, rare in stream; mostly empty envelopes, common in sediments and waters of reservoir.

Recorded from many acid swamps and fish ponds in many states of West Malaysia (Prowse, 1962b).

RHIZOCHRYSIDACEAE

Lagynion scherffeltii Pascher Nos. 108, 109.

Epiphytic on filamentous algae in stream, sometimes gregarious, fairly common.

Lagynion ? *macrotrachelum* (Stokes) Pascher No 124.

Epiphytic on filamentous algae in stream.

XANTHOPHYTA

STIPITOCOCCACEAE

Stipitococcus crassistipitatus Prescott Nos 122, 123.

Epiphytic on filamentous algae in stream.

CHARACIOPSIDACEAE

Characiopsis sp. No 128.

Epiphytic on liverwort in stream.

TRIBONEMATACEAE

Tribonema sp. No 124.

Cells 1½–3 times as long as broad, slightly swollen in middle and narrowing at cross walls, 'H'-pieces distinct but rare, chloroplasts many. This species is related to *T. viride* Pascher.

Tychoplanktonic and in bottom muds of stream; often entangled with other filamentous algae.

Neonema sp. No 124.

Similar in habitat to that of *Tribonema;* rare.

EUGLENOPHYTA

EUGLENACEAE

Euglena ? *mutabilis* Schmitz No 120.

Collected from stream muds.

Recorded in Kedah padi fields (Sands, 1934), in carp ponds and stagnant water elsewhere in Malaysia (Prowse, 1957b, 1958) and in Templer Park (Hirano, 1967). The writer has collected it several times between 1968 and 1970 in the Gombak river, Selangor.

Var. *minuta* Fritsch has been reported from many stagnant waters in West Malaysia (Prowse, 1958).

Trachelomonas volvocinopsis Swirenko No 120.

Collected from stream muds.

Recorded from standing water and fish-ponds in various states of West Malaysia (Prowse, 1962b).

Lepocinclis ? *marsonni* Lemm. emend Conrad No 120.

Collected from stream muds. Common.

Recorded from Taiping Lakes (Prowse and Ratnasabapathy, 1970).

CHARACIACEAE

Characium sp. Nos 128, 129.

Cells solitary, fusiform, straight or slightly arcuate, poles acute and produced as long fine spines, each spine about half or more cell length; one spine terminating in a small rounded colourless attachment disc; chloroplast single, parietal, almost filling cell.

The specimens were growing attached to the leaves of aquatic liverworts in a torrential stream. This species of *Characium* closely resembles *Schroederia setigera,* which however is reported to be always planktonic (see Smith, 1950). The presence of an eyespot and the disc-like ending of the spine in some species of *Schroederia* was reported. These species may well be attached forms that have become subsequently detached by accident and incorporated into the plankton. Further work on the ecology and taxonomic status of *Schroederia* with its described species is needed.

ULOTRICHACEAE

Stichococcus ? *scopulinus* Hazen Nos 128, 131.

Filaments uniseriate, short, 1 to 4 or rarely 5 cells; cells cylindrical, sometimes up to 9 times longer than broad but usually shorter, ends rounded; chloroplast single, parietal, laminate, encircling about half the cell and usually not extending to the ends, apple-green coloured; pyrenoids lacking.

Epiphytic on leaves of aquatic bryophyte in torrential stream; tends to be gregarious.

Ulothrix sp. Nos 120, 132.

Collected from a small pool of Government bungalow; in slow-flowing stretches of stream near bungalow. Rare.

TRENTEPOHLIACEAE

Trentepohlia iolithus (L.) Wallr. Nos 114, 133.

Orange coloured, forming felted patches; filaments much-branched, unilateral at times, cells usually 2–5 times longer than broad, length up to about 90 μ, chloroplast indistinct, reticulate; haematochrome abundant; cell wall fairly thick, lamellated in older cells; sporangia borne terminally or laterally on short or many-celled branch, usually single; spherical, diameter up to 25 μ, stalk cell inflated at base and bent distally.

Epilithic, aerial.

OEDOGONIACEAE

Bulbochaete sp. Nos 111, 120.

Thallus mostly uniseriately branched, cells 3–7 times as long as broad, length of cells 25–45 μ; cell apex slightly inflated, with laterally placed seta; setae swollen at the base and very long, about 250 μ. No reproductive stages found.

Attached to other vegetation and twigs in stream and reservoir.

Oedogonium sp. Nos 112, 113, 120.

Only vegetative filaments were encountered, and probably more than one species are involved.

Attached to aquatic vegetation, twigs, etc. in reservoir and in streams.

ZYGNEMATACEAE

Mougeotia ? *elegantula* Wittr. No 120.

Collected from quieter stretches and pools of streams. Common.

Several specimens resembling *Mougeotia* and *Debarya* (No. 115–119) could not be assigned accurately as only the vegetative stages were encountered.

Zygnema sterile Transeau No 118.

Cells up to two times longer than broad; cell wall thick, lamellated; chloroplast two, more or less stellate, each with one pyrenoid.

Collected from stream, roadside pools and drains, often mixed in with other filamentous algae. Common.

Several unidentified species of *Zygnema* or *Zygnemopsis* (Nos 115, 117, 120) were collected from the stream; some of these had cells many times as long as broad; reproductive stages were absent.

Spirogyra spp. Nos 120, 127.

At last 3 species of *Spirogyra* were collected from the streams and one species from the reservoir; they had one to four chloroplasts. One of these (No. 127) was found in abundance in almost a pure stand in small cracks of stream bed-rock with static or gently flowing water, showing recently completed conjugation and young zygospores. Specific determination was not possible because the sculpture was not clear.

Sirogonium sp. No 120.

A species with four chloroplasts, each making half to three quarters of a turn; all filaments were in vegetative condition.

Collected from quieter edges of stream.

MESOTAENIACEAE

Mesotaenium caldariorum (Lagerh.) Hansgirg No 133.

Cells cylindrical, ends rounded, sides slightly to more or less parallel, length up to two times longer than broad; chloroplast single, axile, laminate, with or without a pyrenoid; mucilage surrounding cells clear, enveloping several cells.

Collected from moist rock of roadside associated with *Trentepohlia.*

Cylindrocystis brebissonii Menegh. No 115.

Amongst *Stigonema, Scytonema* and *Cosmarium* on moist rock. The writer has collected the species in April 1970 in Tasek Bera, Pahang.

Netrium digitus (Ehrenb.) Itzigs. et Rothe Nos 120, 122, 124 — **Plate 3C**

Collected from slow-flowing stretches of stream. Common.

Recorded in Taiping Lakes (Prowse and Ratnasabapathy, 1970).

DESMIDIACEAE

Actinotaenium cucurbita (Bréb.) Teil. No 118, 119.

Collected from pool with flowing water, dripping wall of small iron storage tank, roadside of hill.

Actinotaenium cucurbitinum (Biss.) Teil. No 119.

Collected from dripping wall of small iron storage tank, roadside of hill.

Actinotaenium elongatum (Racib.) Teil. No 119.

Collected from dripping wall of small iron storage tank, roadside of hill.

Actinotaenium grande (Delp.) Teil. No 112.

Collected from small impoundment to reservoir.

Actinotaenium subglobosum (Nordst.) Teil. No 119.

Collected from dripping wall of small iron storage tank, roadside of hill.

Actinotaenium truncatum (Bréb.) Teil. Nos 112, 118.

Collected from pool with flowing water, roadside of hill and small impoundment to reservoir.

Actinotaenium wollei (Grönbl.) Teil. No 119.

Collected from dripping side of small iron storage tank, roadside of hill.

Closterium cynthia de Not Nos 112, 113, 122.

Collected from bottom muds, reservoir.

Recorded in pond, Ampang (Biswas, 1929).

Closterium libellula Focke var. *intermedium* (Roy et Biss.) G. S. West Nos 111, 112 — **Plate 3D**

Collected from bottom muds of reservoir.

The species was recorded from the Taiping Lakes (Prowse and Ratnasabapathy, 1970).

Closterium libellula Focke var. *interruptum* (West et West) Donat Nos 120, 126.

Collected from stream mud.

Closterium parvulum Näg. No 120.

Collected from stream muds.

Reported from Johore (Bernard, 1909); Setapak Lake (Biswas, 1929); padi-fields, Beranang (Johnson, 1970); elsewhere in Malaysia (Prowse, 1957a).

Closterium navicula (Bréb.) Lütkem. No 115.

Scraped from moist rock, grows mixed in with *Cosmarium* spp., *Cylindrocystis* and Cyanophyceae. Recorded from Taiping Lakes (Prowse and Ratnasabapathy, 1970).

Closterium striolatum Ehrenb. Nos 109–111.

Collected from muds and vegetation in reservoir.

Recorded in Templer Park (Hirano, 1967).

Closterium tumidum Johnson Nos 104, 123.

Collected from muds overlying bottom rock of stream.

Recorded in pond, Setapak (Biswas, 1929).

Species of *Closterium* were found in practically all the samples of streams, rock pools, roadside drains and the reservoir. As an adventitious element in the plankton of both flowing and still waters they were not conspicuous. Multiplication by transverse division of cells was evident and appears to be the general method of maintaining the populations. Zygospore formation was lacking. The widespread occurrence, the ability to colonize a variety of ecological niches and fair abundance suggest ecological and economic importance.

Pleurotaenium minutum (Ralfs) Delp. var. *minus* (Racib.) Krieg. Nos 104, 119, 125.

From rock scraping and mud of stream; dripping side of small iron storage tank, roadside of hill.

Var. *excavatum* was recorded from Taiping Lakes (Prowse, and Ratnasabapathy, 1970).

Pleurotaenium trabecula (Ehrenb.) Näg. No 120, 122–124.

Collected from stream muds, mixed in with other algae and occasionally in plankton. Fairly common.

Tetmemorus laevis (Kütz.) Ralfs Nos 120, 124, 126 — **Plate 4C**

Cells up to 130 μ long and eight times the breadth, sinus open and conspicuous; semi cell slightly inflated just above base, apex deeply incised with the lobes somewhat rounded and asymmetrical; cell wall finely punctate, four punctae radially arranged at base of apical incision; chloroplast ridged with about six pyrenoids arranged longitudinally.

Collected from stream muds. Fairly common.

Recorded elsewhere in Malaysia (Prowse, 1957a).

Euastrum binale (Turp.) Ehrenb. var. *brevius* (Bernard) Hirano No 125.

A small species fairly frequently found in waters of streams.

Reported from Templer Park (Hirano, 1967).

Euastrum dubium Wolle No 113.

Collected from small impoundment to reservoir.

Euastrum sinuosum Lenorm. var. *dideltoides* Krieg. Nos 109–111 — **Plate 4A**

A larger species, up to 75 μ long.

Amongst vegetation and bottom muds, reservoir.

The species was recorded from Taiping Lakes (Prowse and Ratnasabapathy, 1970).

Euastrum gnathophorum W. et G.S. West Nos 106, 107, 120, 124.

Collected from stream muds.

Recorded from Taiping Lakes (Prowse and Ratnasabapathy, 1970).

Euastrum turgidum Wolle No 119.

Collected from dripping side of small iron storage tank, roadside of hill.

Cosmarium contractum Kirchn. Nos 120, 124.

Collected from stream.

Var. *Jacobsenii* was recorded in a pond, Ampang (Biswas, 1929).

Cosmarium decoratum W. et G.S. West No 18.

Collected from stream muds.

Cosmarium hians Borge forma No 113.

Collected from small impoundment to reservoir.

Cosmarium lunatum Turn. Nos 111, 118, 120.

Collected from pool with flowing water, hill roadside; bottom muds, stream; bottom muds, reservoir. Common.

Cosmarium quadrifarium Lund. No 118.

Collected from bottom muds, reservoir.

Cosmarium taxichondrum Lund. No 118.

Collected from pool, roadside drain with flowing waters. Rare.

Cosmarium sp. No 106 — **Plate 4B**

Several other species of *Cosmarium* specifically unidentifiable are not listed.

Staurastrum sp. No 114.

Planktonic in reservoir.

Spondylosium pulchellum Arch. No 127.

Short chains of cells epiphytic on aquatic vegetation in stream.

Hyalotheca dissiliens (J.E. Smith) Bréb. Nos 107, 120, 124, 127 — **Plate 4D**

Collected from stream, common in samples of other filamentous algae.

Recorded in pond, Setapak (Biswas, 1929); from elsewhere in Malaysia (Prowse, 1957a).

Analysis of Results

Among the algae collected, 57 genera and 102 species including varieties were identified. About 25 species were attached forms, and 72 species occurred in the bottom muds or as tychoplankton. The true planktonic element appeared to be lacking and the few encountered such as *Frustulia rhomboides* and *Hyalotheca dissiliens* were largely adventitious, stirred up from the bottom and suspended by the flowing waters. This was inferred from their abundant presence in bottom samples, apart from their features of habit and morphology. There was an abundant population and often a rich variety of species, especially desmids and diatoms, in the shallower, slow-flowing stretches of streams with aquatic phanerophytes, bryophytes and decaying vegetation and where the canopy of trees overhead was less dense. The reservoir, which is a comparatively small habitat, being only about twenty metres square, had some 25 species, though few of these also occurred in the stream.

The number of species in the Divisions of algae represented in these collections were as follows: Cyanophyta 13, Rhodophyta 1, Pyrrophyta 1, Bacillariophya 19, Chrysophyta 6, Xanthophyta 4, Euglenophyta 5, and Chlorophyta 51. The Cyanophyta, Bacillariophyta and Chlorophyta were also numerous in number of individuals and may be considered as dominant. Among the Chlorophyta, the Zygnematales formed about 80% of which the Desmidiaceae alone comprised two-thirds. Several of the species of algae are known to occur outside Malaysia, some have been recorded from elsewhere in Malaysia, and some are being recorded for the first time here. The occurrence of the temperate species *Dinococcus bicornis* Fott here extends its known range of geographical distribution.

The presence of *Dinobryon sertularia* and species of the related flagellate *Mallomonas* in the reservoir may be undesirable with respect to the quality of a water source. Population outbursts of *Dinobryon* and *Mallomonas* have been reported to impart an obnoxious odour and a fishy taste to the waters of Hoover Reservoir, Ohio and Lake Michigan thus necessitating the treatment of the water supplies (Palmer, 1964).

There are many problems concerning the freshwater algae of Gunong Jerai worthy of further investigation. Species of *Closterium, Cosmarium,* and *Frustulia rhomboides* were common and widely distributed; *Batrachospermum,* though rarer, showed an interesting sporadic occurrence with *Audouinella*-like thalli which may turn out to be the juvenile stages of the species. Studies on such aspects as their distribution, morphological variation, taxonomy, reproduction and life history should be rewarding. A comparative study of the Gunong Jerai algal flora with similar areas in other parts of Malaysia is not possible owing to the lack of published records. It may be mentioned, however, that about seven of the nineteen species of diatoms listed have been previously recorded at Cameron Highlands (see Prowse, 1962a). There is a wide and exciting field for future investigation of the Malaysian mountain algal floras.

Acknowledgements

I am indebted to Dr. Gerald Prowse, lately Director of The Tropical Fish Culture Research Institute in Malacca for advice and for checking identifications. I also wish to thank Dr. Ralph A. Lewin, Professor, Scripps Institution of Oceanography, University of California, La Jolla for critical comments on the manuscript and Dr. B. C. Stone, Reader at The School of Biological Sciences, University of Malaya, for introducing me to the background literature on Gunong Jerai.

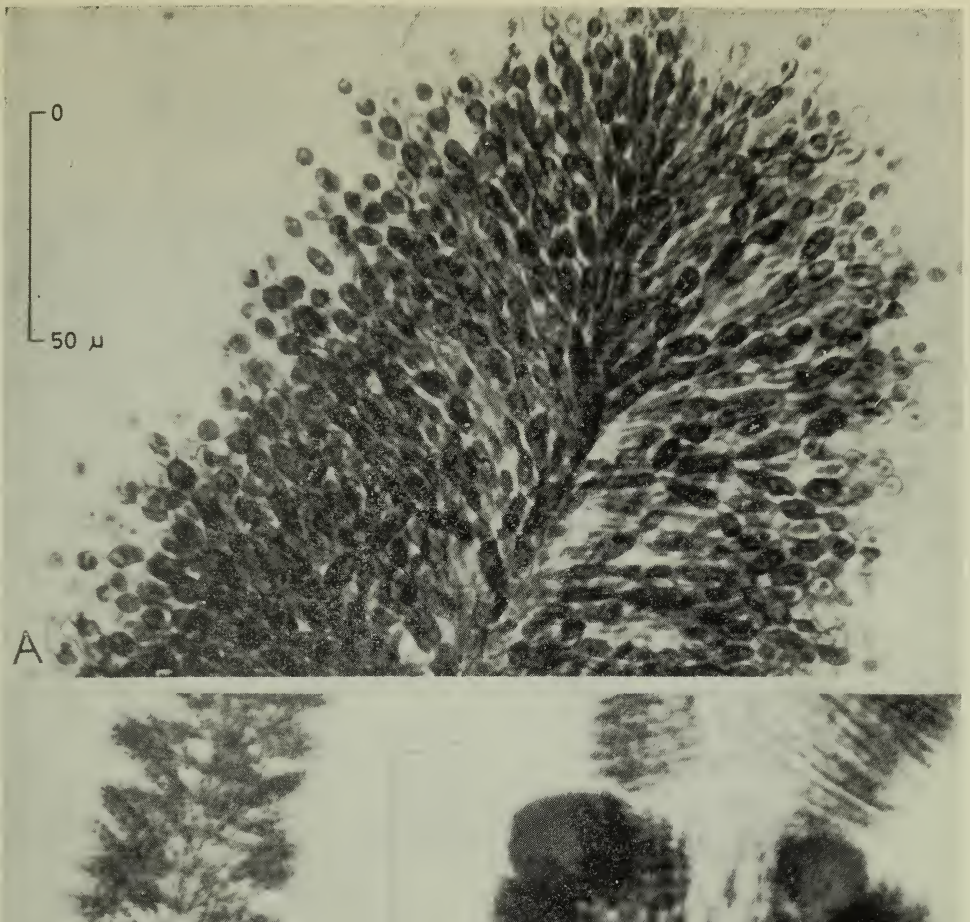

Plate 1. *Batrachospermum ? moniliforme* Ralfs

A: Apex of thallus stained with Phloxine B

B: Whorls of lateral branches of limited growth

C: Cystocarps at periphery of whorl of lateral branches

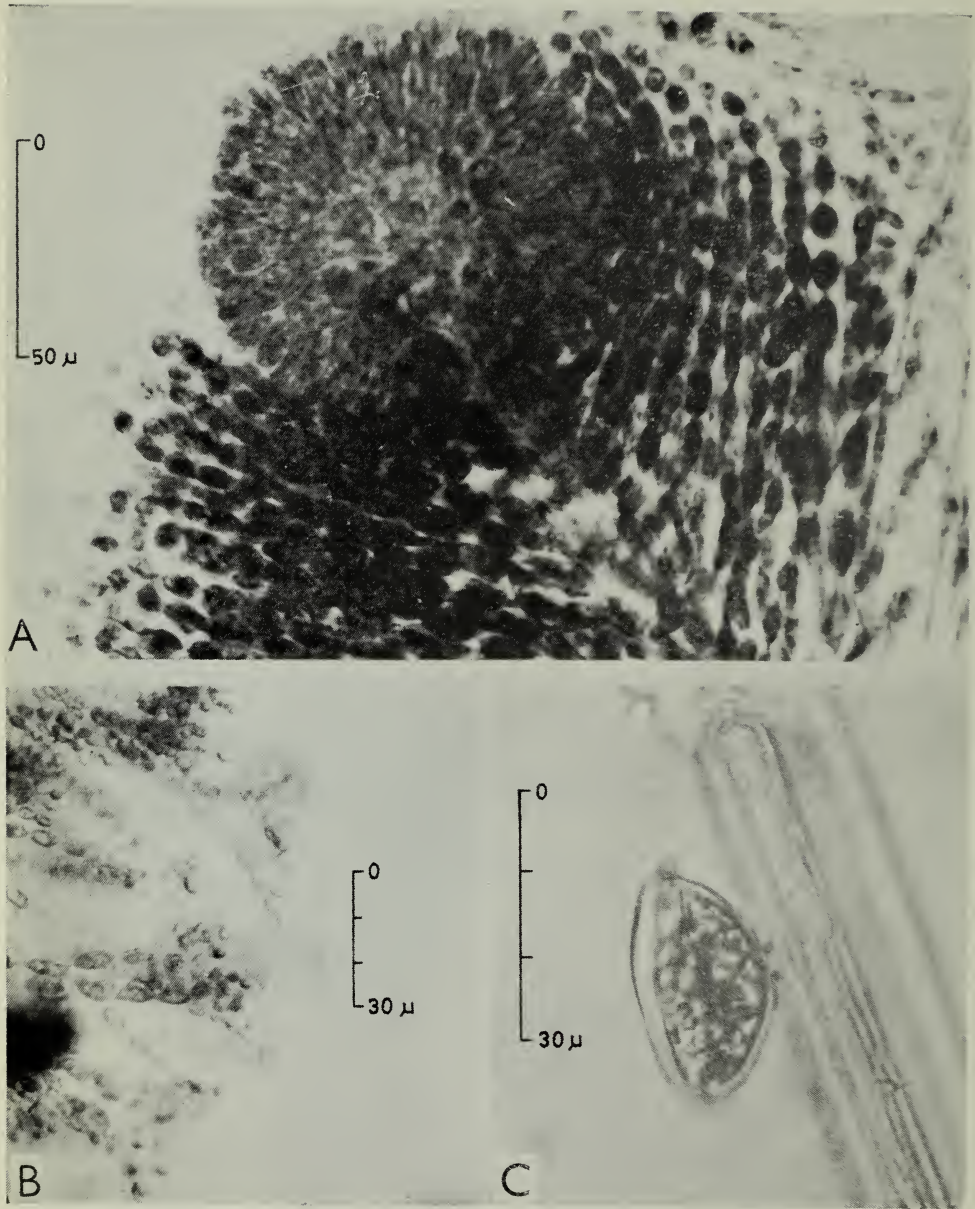

Plate 2.

A: *Batrachospermum* ? *moniliforme* Ralfs, cystocarp terminal on short lateral branch, stained with Phloxine B

B: Idem, spermatia on lateral branches of limited growth

C: *Dinococcus bicornis* Fott, epiphytic on colonial *Desmogonium,* front view

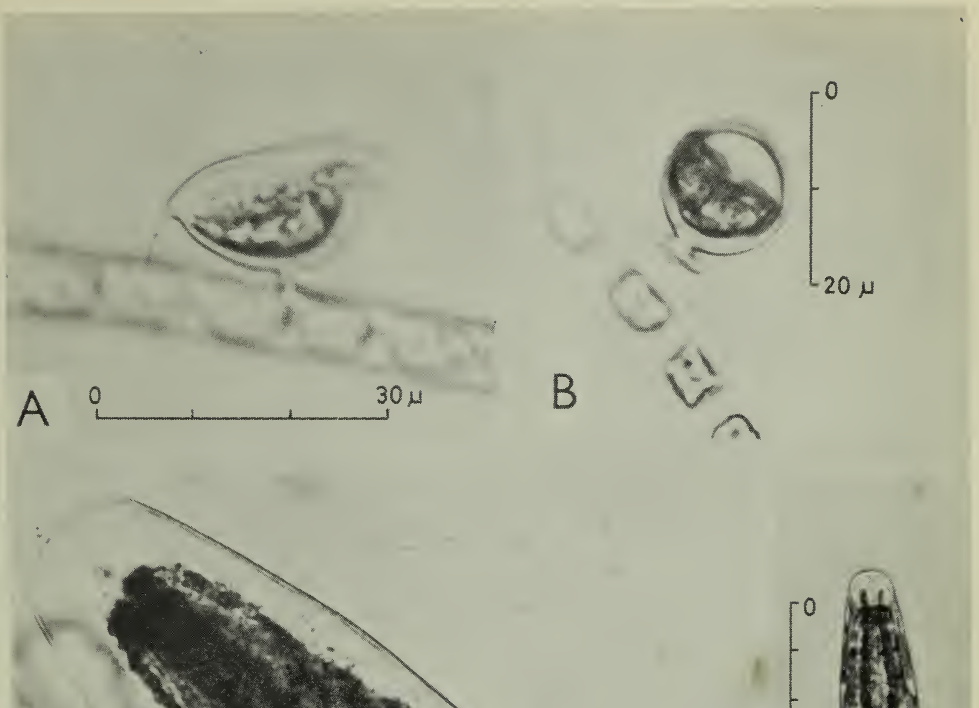

Plate 3.

A: Dinococcus bicornis Fott, epiphytic on filamentous Xanthophyceae, front view
B: *Idem*, end view
C: *Netrium digitus* (Ehrenb.) Itzigs. et Rothe
D: *Closterium libellula* Focke var. *intermedium* (Roy et Biss.) G. S. West

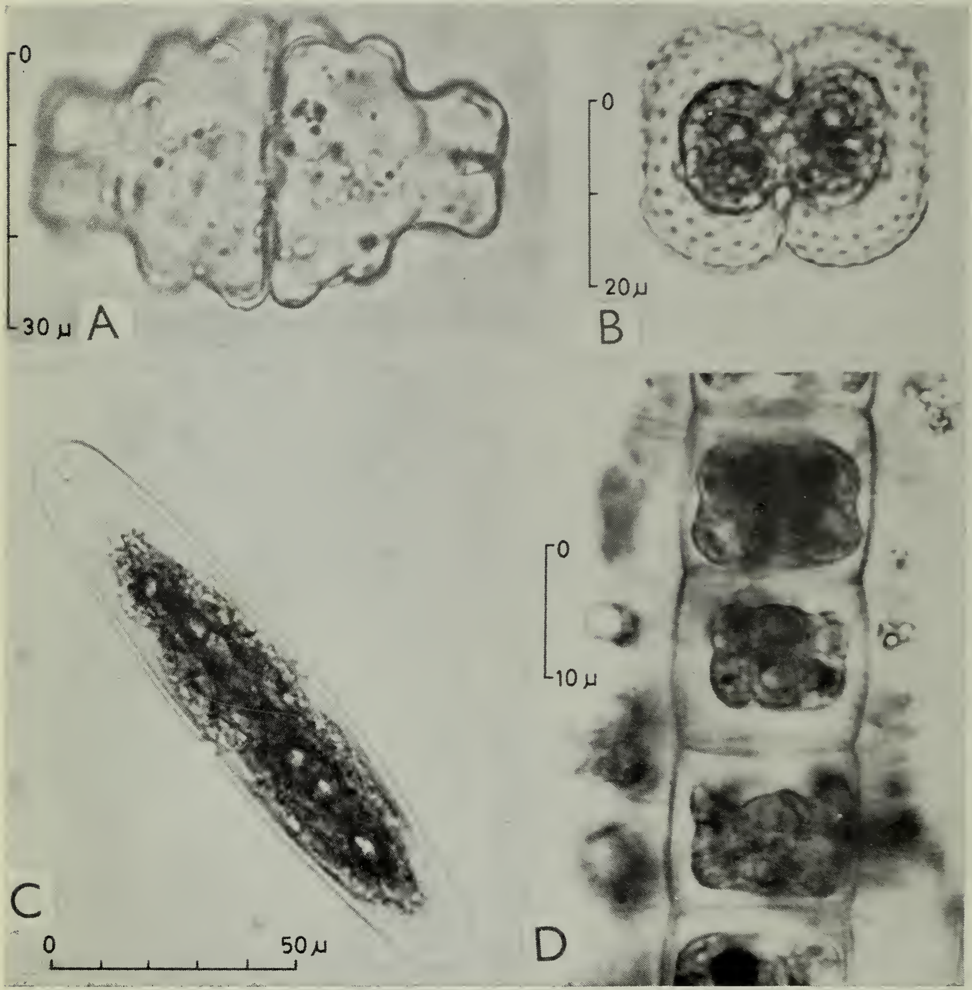

Plate 4.

A: *Euastrum sinuosum* Lenorm. var. *dideltoides* Krieg.
B: *Cosmarium* sp.
C: *Tetemorus laevis* (Kütz.) Ralfs
D: *Hyalotheca dissiliens* (Smith) Bréb. stained with methylene blue (oil immersion)

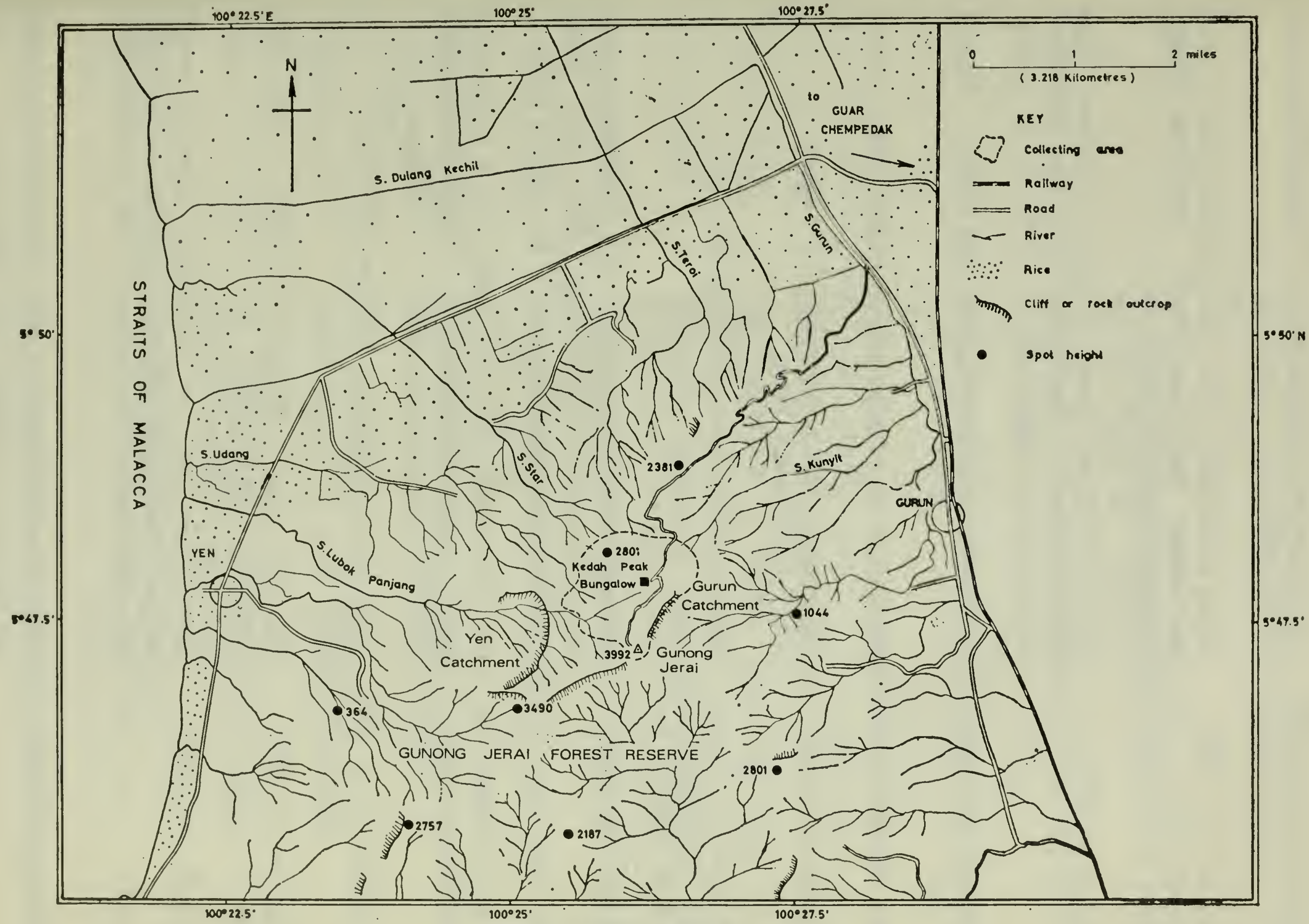

FIGURE 1 MAP OF GUNONG JERAI

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Review

E. J. H. CORNER AND K. WATANABE, *Illustrated Guide to Tropical Plants.*

Hirokawa, Tokyo, 1969. 1147 pp., 29 colour pl., c.2000 line drawings.

The title of this large and ambitious book is deceptive: It is based on a collection of line drawings of phanerogams, made by Professor Watanabe during a 3-year stay in Singapore and Malaya; the species selected are therefore largely unrepresentative of the tropics as a whole, both on taxonomic, ecological and utilitarian grounds. Besides most of the commoner cultivated plants of Malaya, many of which are exotics and indeed widely grown in the tropics, they include a somewhat arbitrary selection of native species, weeds, and many plants existing in that region only as individuals in botanic gardens, of which some are by no means common in their countries of origin. The drawings are arranged by families according to Engler's system; each is captioned by its family name. Beneath the illustration is given the scientific, Malayan (if known), Japanese, and sometimes Indian and English names; a short but useful descriptive note indicating distribution, habit, leaf arrangement and flower and fruit colour by Professor Corner; and a note on uses in Japanese. The usefulness of each plant is then summarised in a curious annotated point-grid system, which appears to have been intended as a ready-reference abbreviation but is in fact the very reverse, being difficult to follow and space-demanding; finally, the position in Hutchinson's classification is indicated. Some 700 of the more than 2,000 line drawings were originally published in two volumes by the Japanese administration of the Singapore Botanic Gardens during the second world war, entitled "Illustrations of Useful Plants of the Southern Regions: Section 1: Medicinal," and "Section II: Edible Plants." These books are now rare, but many of the same plates were used again by Professor H. B. Gilliland for his book "Common Malaysian Plants" (University of Malaya Press, 1958).

This book cannot be used for identifying plants, as the illustrations and descriptions make no attempt to be diagnostic, and no keys are given. Its purpose would appear to be a reference book for laymen in S.E. Asia, especially foreign agriculturists, foresters and businessmen who, on being shown a named plant to which certain useful properties have been ascribed, wish to check the veracity of this information. The book is a monument to Professor Watanabe's energy, but it is a pity that the illustrations, the originals of which must generally have been of high quality, have had to be reduced to a scale where the details, especially of floral morphology, have often been lost.

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REVIEW

TSENG-CHIENG HUANG. *Pollen Flora of Taiwan*

National Taiwan University, Botany Dept. Press, Taipeh. 1972;
pp. v+ 276, 177 photographic plates and index. Price U.S. $27.00 (postage and handling included).

This is one of the very few local pollen floras that have appeared in the past decades. The author was probably inspired by M. Ikuse's "Pollen Grains of Japan" published in 1956.

Part one of this book is an introduction, including an illustrated account on pollen morphology. Part two constitutes the main body of the book — the systematic treatment. It contains keys to the families (divided into 25 classes) and descriptions of 197 families of seed plants (Gymnosperms-9, Dicotyledons-157, and Monocotyledons-31). The families are arranged alphabetically within these three taxa. Each family consists of a general description of the pollens and a bracketed key to the genera (if more than 2). The descriptions of genera and species are in general very concise. Numbers of voucher herbarium specimens are also cited.

Two most valuable features of this book are probably the comprehensive and useful keys based on pollen characters for identifying families and genera, and the excellent quality of photographic plates. The latter is attributable to the facilities of fine equipment in the Palynological Laboratory at the National Taiwan University and the skilled technique in preparing slides and photographs.

This book will be very useful to plant taxonomists and palaeobotanists and I have no hesitation in strongly recommending it.

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Athrodactylis and Pandanus: A brief comment on the 'Characteres Generum Plantarum' of J. R. and G. Forster

by

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Although it is well known that, in the work "Characteres Generum Plantarum" of 1776 by Johan Reinhold and Georg Forster, these authors boldly and improperly utilized information they had acquired through their relationship with Sir Joseph Banks in working on the materials which Banks and Solander had amassed during the first of Captain Cook's voyages, in somewhat the same way that had been earlier done by the brother (Parkinson) of the expedition artist, it is interesting to discover that they did not confine their borrowings to any one source.

While working briefly in the Herbarium of St. Xavier's College in Bombay I was able to use originals of the Forsters' work, as well as a number of other ancient and precious volumes. One of these was the "Horti Indici Malabarici" of Henricum van Reede tot Draakestein (published between 1678 and 1703). Studying in particular the references to *Pandanus* I then turned to the Forsters' work, and was immediately struck by the resemblance virtually to the point of identity between the drawing of a fruit (phalange) in fig. 6 of Reede's "pars secunda" with the name "Kaida Taddi" and the illustration (fig. 75) of the Forsters' "Athrodactylis spinosa" (i.e. Pandanus). The Forsters' illustration (titled "Appendix Palmae") shows (*a*) one stamen, (*b*) one phalange, and (*c*) one seed. The last two are almost exact copies from Reede's illustration of "Kaida Taddi".

This copying, for such I am sure it was, tallies logically with the Forsters' descriptive text, where (p. 150) they give the diagnosis of "spinosa. 1. ATHRODACTYLIS." in the Linnaean manner, with the synonyms "*Bromelia Sylvestris.* Lin. Flor. Zeyl. Burm. Ind. 79.; *Keura* Forskal Arab.; *Kaida* Rheed. Hort. Malab. p. II. t. 1–8. Pandanus Rumph." This is somewhat confusing, but it seems to suggest that the Forsters considered all these names synonymous with their species "Athrodactylis spinosa," although Reede's figures show clearly (to the modern reader) about four distinct species of *Pandanus*. The Forsters' list of synonyms beneath the "species" rather than beneath the "genus" diagnosis (although, strictly speaking, there is no separate botanical diagnosis of the species; only an explanation of the generic name, followed by the "Explicatio" for Tab. LXXV.) seems to a modern reader a mixture of generic and specific synonyms. It is difficult to come to a conclusion as to whether the Forsters thought that all the synonyms they cite really referred to a single species or to a single genus. The only post-Linnaean name cited is *Keura* Forskal. This was monotypic, and thus by citing it in synonymy we would expect the epithet of the species to be taken up if we apply the current nomenclatural Code. The full name of Forskal's plant was *Keura odorifera*. This name is based on material which Forskal purchased in a small village in south-western Arabia, where the staminate inflorescences were on sale as a perfume.

To this day in both India and in adjacent regions the practice persists, and in 1968 in the villages on Madh Islet in Bombay (for example) one can still see these inflorescences for sale; children and women carry and wear them, "harvesting" them from the trees. The plants are as common in cultivation as wild, especially along the coast. Forskal's genus Keura is certainly synonymous with Pandanus Stickm. of 1754; the publication of Forskal's "Flora Aegypto-Arabica" was in 1775. The generic name *Athrodactylis* J. R. & G. Forst. is thus clearly a synonym since Forskal's publication was cited. Unfortunately the type material of *Keura* no longer exists. It is, however, very likely to be the plant which is still used in the way mentioned — as perfume — along the coasts of India and is traded for such in adjacent areas. This is clearly identical with *Pandanus odoratissimus* L. f. (the type of which is from Ceylon). At any rate, it is clear that: (1) *Athrodactylis*, as a genus, is equivalent to *Pandanus;* (2) *Athrodactylis* as a name is not nomenclaturally usable, being published with a valid name in synonymy (i.e. *Keura*); (3) the epithet "spinosa" is also illegitimate since the epithet "odorifera" of Forskal should have been taken up; (4) except for the reference to *Pandanus* Rumph. the remaining synonyms all refer to Indian or Ceylon plants; thus it is plain that *A. spinosa* is none other than *Pandanus odoratissimus* L.f. This is borne out convincingly by the fact that to illustrate *A. spinosa*, the Forsters copied Reede tot Draakestein's illustration of "Kaida Taddi" which is unquestionably *P. odoratissimus* L.f.

As a final point it is interesting to note that G. Forster in his later work on Pacific Island Plants (Prodr. 69. 1786) used the binomial *Pandanus odoratissima* (sic). This certainly means that he then considered *Pandanus* as the correct generic name, and by taking up Linnaeus filius' specific epithet also (though altering it to feminine gender) he apparently also meant that the Tahitian plants which he was discussing were to be equated with the Indian and Ceylon species. This interpretation can perhaps therefore be viewed as a confirmation of the conclusions given above.

It is interesting to note further that although much of the 'Characteres Generum Plantarum' was based on Pacific Islands plant collections, the "Appendix" with *Athrodactylis* does not specifically mention any Pacific materials. The reference to Rumphius suggests Forsters' belief that the species of India and Ceylon extended into the East Indies. But there is no mention of *Pandanus-tectorius* (sic) of Parkinson (attributed by many authors to Solander, but never published by him; Parkinson wrote it as a monomial hence it is illegitimate) which appeared in 1773 (Journ. Voy. South Seas ... H.M.S. 'Endeavour' p. 46). There is no mention of any collection by either of the Forsters, although certainly they must have seen many *Pandanus* plants while they were in Tahiti.

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Cytogenetics and Taxonomy of the Genus Globba L. (Zingiberaceae) in Malaya

IV Distribution in Relation to Polyploidy

by

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Abstract

Of the twelve species, five subspecies and eight varieties of *Globba* in Malaya, some are exclusively allotetraploid (2n = 32, AABB), some exclusively hexaploid (2n = 48, AAABBB), one decaploid (2n = 80) and some with both allotetraploid as well as hexaploid chromosome races. *Globba* species with only 2n = 32 occur in lowland forests and at moderate elevations, while those with only 2n = 48 generally in montane forests. Both are of rather restricted and localised distribution when compared to taxa with 2n = 32, 48. In the latter, the hexaploid infraspecific taxa are usually but not strictly montane in distribution. Where both the tetraploid and hexaploid taxa are montane in distribution, the hexaploids are of greater abundance. The reverse is true where tetraploid taxa occur in lowland forests and hexaploid in montane regions. *Globba* species in Malaya thrive in moist, partially shaded niches. An exception is *G. marantina* L. which colonises open habitats and has a wide distribution from India and Philippines to the Solomon Islands.

The genus *Globba L.* (Zingiberaceae) is confined in distribution to the eastern Himalayas and southern China southwards to Malaysia and the Solomon Islands (Holttum 1950, Pendleton 1949). Of the 128 species recorded (in Index Kewensis, compiled up to 1966), twelve species, five subspecies and eight varieties occur in Malaya. These include eight new taxa which are described in Lim (1972 a). Of these Malayan taxa, three species, two subspecies and five varieties are exclusively allotetraploid (2n = 32, AABB), three species and a subspecies exclusively hexaploid (2n = 48, AAABBB), one species decaploid (2n = 80) and three species and a subspecies with both allotetraploid as well as hexaploid chromosomes races. (see Table 1; Lim 1972 b). This paper presents the results of distributional studies of these Malayan taxa with special reference to their chromosome numbers.

Materials and Method

Sources of information for distribution mapping were the 363 herbarium specimens on loan from the Botanic Gardens, Singapore, and personal field collection data. Cases in which identification was doubtful and handwritten data dubious were rejected.

In the mapping of each taxon, a distinction was made between herbarium and field collections. Herbarium collections are represented by solid circles, semi-circles and squares and field collections by outlined symbols. A single dot represents one to three collections from the same station, an enlarged symbol four or more. A large number of collections need not necessarily

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represent increased density of occurrence of the taxon, as it might well represent over-collection. Absence of dots might merely mean under-collecting. With the available information, the maps (figs. 1, 2 and 3) represent what is known of *Globba* distribution in Malaya to date.

No attempt was made to distinguish between the polyploids in the herbarium specimens. Taxa with 2n = 48 were distinguished from those with 2n = 32 in the mapping of field collections.

Root tips as well as pollen mother cells were investigated for chromosome counts. Details are as described in Lim 1972 b.

Information on the sources and chromosome numbers of fresh specimens are in Table 2 on p. 124 Herbarium specimens of these are deposited in the Herbarium, Botany Division, School of Biological Science, University of Malaya, Kuala Lumpur.

Table 1. Intraspecific polyploidy in the Malayan species of *Globba*.

Species with single level of ploidy	Species with 2n = 32, 48	
(*a*) *Species with 2n = 32*	*2n = 32*	*2n = 48*
1 G. fragilis Lim	1 G. pendula Roxb.	G. pendula Roxb.
2 G. albiflora Ridl.	G. pendula var. elegans (Ridl.) Holtt.	—
G. albiflora var. aurea Holtt.		
3 G leucantha var. peninsularis Holtt.	G. pendula spp. montana (Ridl.) Lim.	—
4 G. unifolia Ridl.		
	2 G. patens Miq.	G. patens Miq.
(*b*) *Species with 2n = 48*	G. patens var. costulata Lim	—
1 G. curtisii Holtt.		
2 G. holttumii Lim		
G. holttumii ssp. aurea Lim	3 G. cernua Bak.	G. cernua Bak.
	G. cernua ssp. crocea Lim	G. cernua ssp. crocea Lim
(*c*) *Species with 2n = 80*	G. cernua ssp. porphyria Lim	—
1 G. marantina L.		
	4 —	G. variabilis Ridl.
(*d*) *Species with unknown chromosome number*	G. variabilis ssp. pusilla Lim	—
1 G. fasciata Ridl.		

Distribution

The distribution of *Globba* species with two anther appendages is recorded in figure 1 while that of *Globba* species with four anther appendages is recorded in figures 2 and 3.

Globba species with only 2n = 32 or 2n = 48 show a rather restricted distribution compared to those with 2n = 32, 48.

G. fragilis Lim (2n = 32) appears to be confined to Pulau Langkawi, Kedah (see fig. 3), *G. albiflora* Ridl. to Penang, *G. albiflora* var. *aurea* Holtt. to Gua Lambok and Sungei Betis in Kelantan, and *G. unifolia* Ridl. with its subspecific taxon to Trengganu and Kelantan. *G. unifolia* also occurs in Thailand. Trengganu might be its southern limit of distribution. *G. fasciata* Ridl. of unknown chromosome number, also has a very restricted distribution (see fig. 1).

G. curtisii Holtt. (2n = 48) has so far been found only in a restricted part of the Main Range, between Bukit Kutu, the Gap and Fraser's Hill (see fig. 3). Further investigation might show that its distribution extends to other parts of the Main Range. *G. holttumii* Lim grows in large clumps in restricted localities in the Gombak Forest Reserve, Selangor (c.2500′), Genting Simpah, Selangor (2700′), Genting Highlands, Selangor (c.4000′) and Fraser's Hill, Pahang (c.4000′). Both *G. curtisii* and *G. holttumii* are markedly montane in their distribution. *G. holttumii* ssp. *aurea* Lim, however, was collected from lowland Dryobalanops Forest, Lenggor Forest Reserve, Johore (c.300′).

Four of the twelve species of *Globba* in Malaya show 2n = 32 and 48 and these are relatively widespread in distribution.

G. pendula Roxb., "the commonest *Globba* in Malaya, occurring in all parts of the country." (Holttum, 1950) was collected from all along the west coast of Malaya from Pulau Langkawi in the North to Singapore in the South (see fig. 1). Distribution seems densest in Perak, Selangor, Negri Sembilan and Malacca. On the eastern side of the Main Range, collections are from the interior of Pahang and from Kelantan. None of the 118 herbarium collections came from Trengganu and coastal Pahang. One single collection came from Pulau Tioman, off the Pahang coast. The species has a predominantly lowland distribution. Field specimens with 2n = 48 are from Fraser's Hill, Pahang (c.4000′). Chromosome races of 2n = 32 occur alongside those with 2n = 48 by the waterfall, near the old dairy farm on Fraser's Hill. Field collections of specimens solely with 2n = 32 were made along the west coast from the foot of Gunong Jerai, Kedah to around Kuala Lumpur. The chromosome race with 2n = 48 appears to be confined to montane areas. Where *G. pendula* Roxb. occurs, plants are found in abundance. This is also true of the subspecific taxa: *G. pendula* var. *elegans* (Ridl.) Holtt. in the Fraser's Hill region of Pahang and *G. pendula* ssp. *montana* (Ridl.) Lim in Penang. Outside Malaya, the species extends to India, Sumatra, and the Banka Islands.

Common on the west coast from Penang to Malacca, in both lowland and montane forest is *G. patens* Miq. (2n = 32, 48) a species hitherto misidentified as *G. aurantiaca* Miq· see Lim (1972 a). Chromosome races with 2n = 32 seem confined to lowland forest up to c.2000′, while those with 2n = 48 are from Fraser's Hill, Pahang (c.4000′), Bujang Melaka, Perak (c.2200′), Genting Highlands, Pahang (c.4000′) and Bukit Lagong Forest Reserve, Selangor (c.200–800′). Excepting the last, *G. patens* with 2n = 48 appears mainly montane in distribution. Single herbarium collections have been made from Johore and Kelantan. A field collection of a narrow-leaved and nearly glabrous form was made from Lenggor Forest Reserve, Johore (c.200′). This appears similar to the form collected from Ulu Kahang (Holttum, S.F.N., 10927), and has 2n = 32.

At Fraser's Hill, Pahang (c.4000′), Cameron Highlands, Pahang (c.4750′), and Sungei Lallang Forest Reserve, Selangor (c.250′), *G. patens* var. *costulata* Lim was found. It resembles the specimens from Bukit Kutu in Selangor by Ridley (mentioned in Holttum, 1950, p.37). This variety (2n = 32) apparently occurs in both lowland and montane forests.

Overlapping in distribution with *G. patens* Miq. is *G. cernua* Bak, which also consists of chromosomal races with 2n = 32 and 2n = 48. *Globba cernua* Bak., however, is confined to montane forests between 2000′ and 5000′, within the region between Temangor, Perak and Gunong Angsi, Negri Sembilan. South of this, one single collection was made from Singapore. Both chromosomal races occur in abundance in Fraser's Hill, Pahang and Maxwell's Hill, Perak. More common are plants with 2n = 48 than those with 2n = 32. On Maxwell's Hill, the two chromosomal races occur together in mixed stands. In Cameron Highlands, only plants with 2n = 48 have so far been found. At Reid's Third Quartz Ridge, 12th mi, Gombak Road, Selangor all plants collected had 2n = 32 chromosomes. Fruiting specimens in the herbarium collections from Larut Hills and Maxwell's Hill in Perak, and Gunong Angsi in Negri Sembilan suggest that plants with 2n = 32 are also present.

Two new subspecific taxa, *G. cernua* ssp. *crocea* Lim (2n = 32, 48) and *G. cernua* ssp. *porphyria* Lim (2n = 32), were collected from Jenka Forest Reserve, Pahang (lowland Dipterocarp forest, c.200′) and Bujang Melaka, Perak (c.1370′) respectively. The two chromosomal races of *G. cernua* ssp. *crocea* were found side by side in Jenka Forest Reserve. Abundant occurrence along the jungle path from Kuala Tahan to Kuala Trengganu in the National Park in Pahang is reported by G. Smith in 1968 (personal communication).

G. variabilis Ridl. (2n = 48), shows a rather widespread distribution from Gunong Korbu (Perak) on the western side of the Main Range and Kuala Klah (Kelantan) on the eastern side of the Main Range to Singapore (see fig. 3). It occurs mainly in lowland forest but also in montane areas. All living specimens collected from four main localities: Fraser's Hill, Pahang (c.4000′), Ulu Gombak Forest Reserve, Selangor (c.2500′), Sungei Lallang Forest Reserve, Selangor (c·250′) and Bukit Timah Nature Reserve, Singapore (c.500′) had somatic chromosome numbers of 48.

The relatively high occurrence of fruiting materials in 9.8 per cent of the 121 herbarium sheets in the Singapore Botanic Garden collection seems to suggest the possibility of the existence of a chromosome race with 2n = 32. The possibility of these having 2n = 48, however, could not be completely ruled out.

A new subspecies, *G. variabilis* ssp. *pusilla* Lim (2n = 32) was collected from Gunong Panti (1500′), Sungei Kayu and Sungei Sedili in Johore. So far, the distribution appears limited to the southern tip of the Malay Peninsula.

An apparent exception to the general finding (that species with 2n = 32 show a rather restricted distribution compared to those with 2n = 32 and 48) is *G. leucantha* Miq. Brief cytological investigations of *G. leucantha* var. *peninsularis* Holtt. from two localities in southern Johore disclosed somatic numbers of 32. *Globba leucantha* shows a widespread but discontinuous distribution in the north and extreme south of Malaya (see fig. 1). The relative paucity of both herbarium and field collections may be related to the seasonal dormancy of the species. *Globba leucantha* var. *peninsularis* occurs in southern Johore and Singapore, reportedly "common in forest" (Holttum 1950). A few collections were from southern Trengganu, northern Pahang and Perak and two field collections were from Gunong Panti, Johore and Bukit Timah Nature Reserve, Singapore. *G. leucantha* var. *bicolor* Holtt. appears to be confined to the eastern part of the Main Range, in northern Pahang, southern Kelantan and Trengganu. *G. leucantha* var. *violacea* (Ridl.) Holtt. has been collected from Perak; and *G. leucantha* var. *flavidula* (Ridl.) Holtt. from Gunong Panti, Johore (100′). Although a direct cytological investigation of *G. leucantha* var. *bicolor* and var. *violacea* has not been conducted, the rather high incidence of fruiting materials in the two varieties seems to suggest that they have somatic numbers of 32.

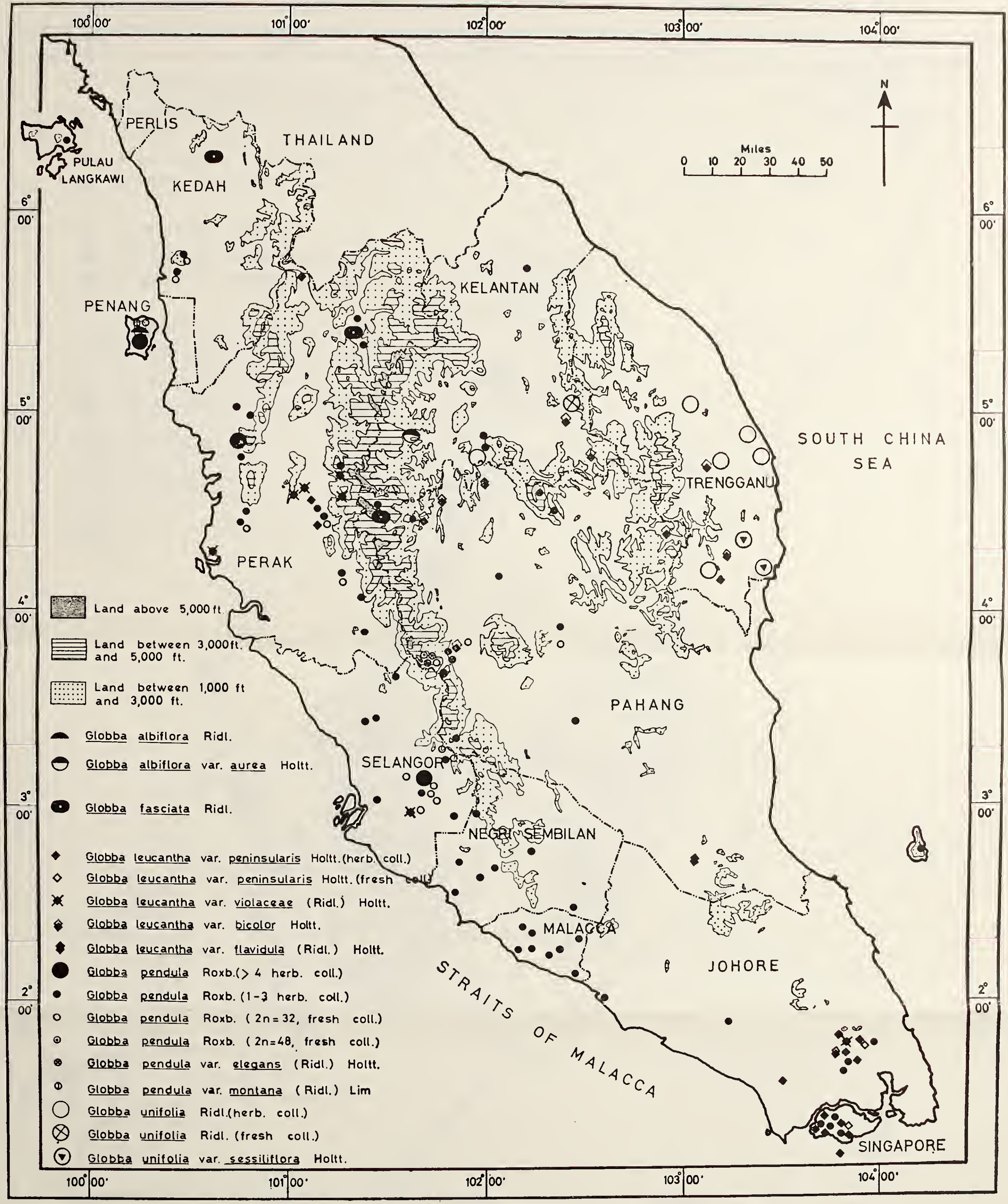

Fig. 1 Distribution map of *Globba* species with two anther appendages in Malaya.

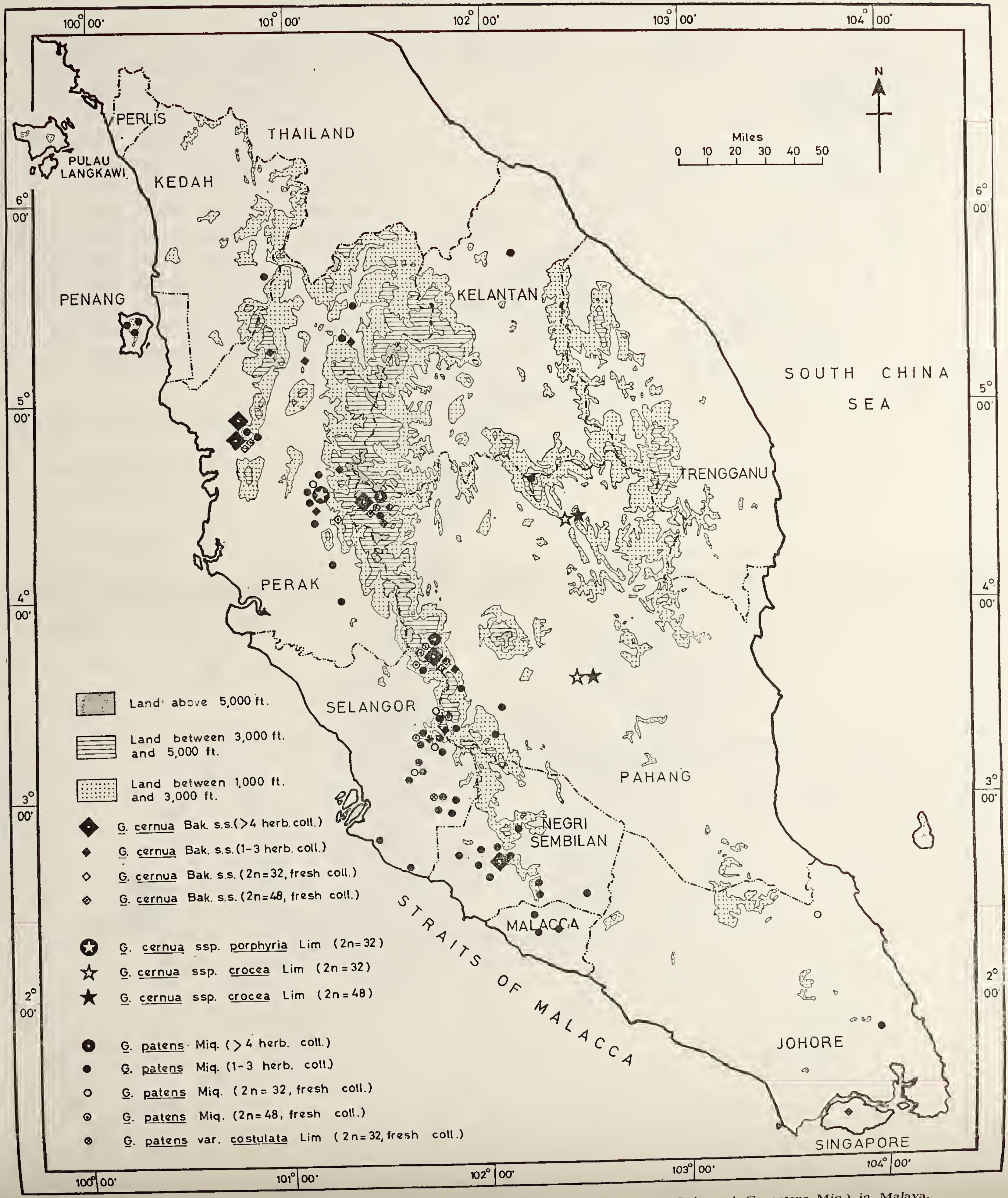

Fig. 2 Distribution map of *Globba* species with four anther appendages (*G. cernua* Bak. and *G. patens* Miq.) in Malaya.

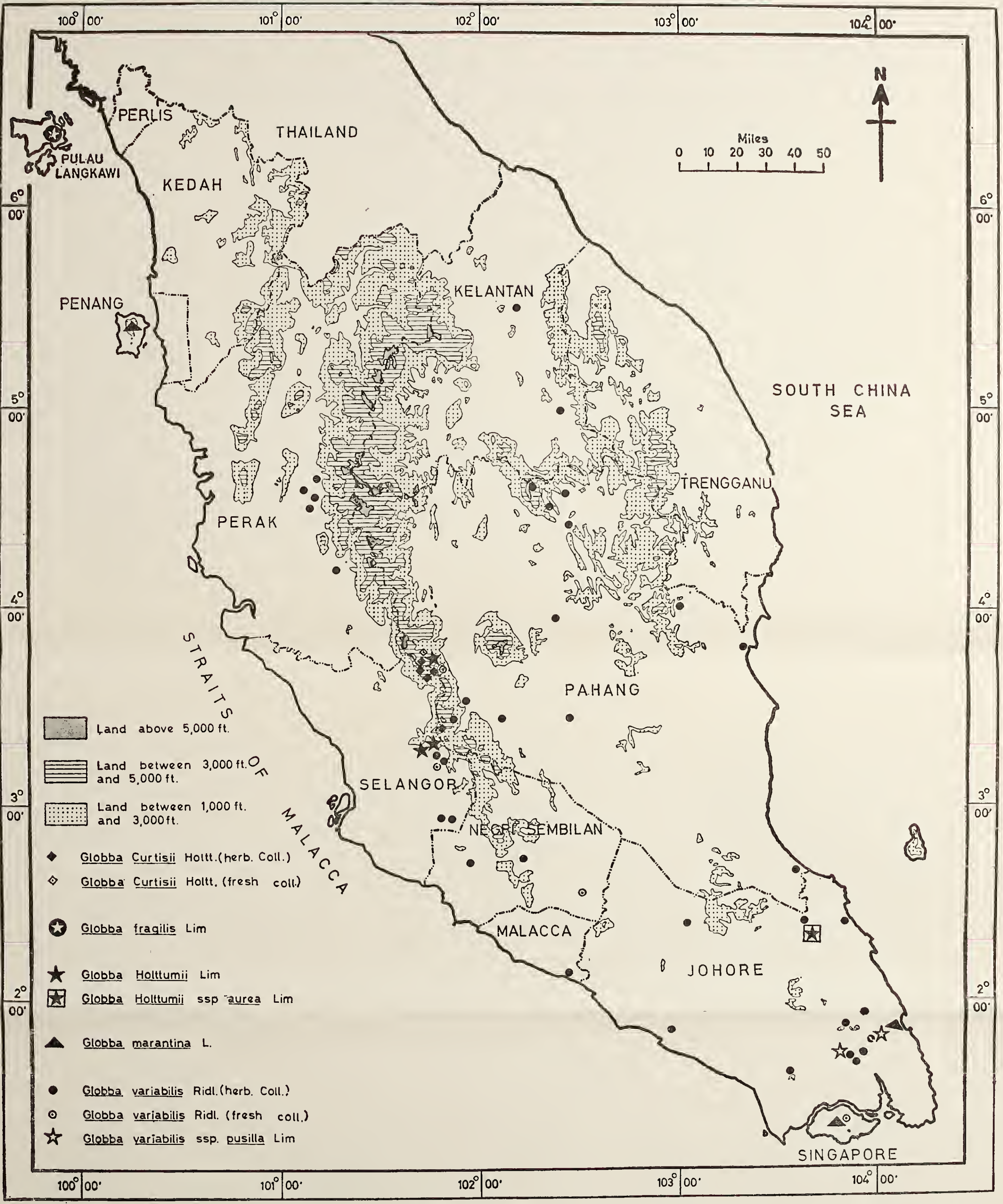

Fig. 3 Distribution map of *Globba* species with four anther appendages (*G. curtisii*, Holtt., *G. fragilis* Lim, *G. holttumii* Lim. *G. marantina* L. and *G. variabilis* Ridl.) in Malaya.

A comparison of the distribution of *Globba* species with only 2n = 32 and those with only 2n = 48 shows that, with the exception of *G. leucantha,* both are rather restricted and localised in occurrence. Species with 2n = 32 have been found on lowland forests and at moderate elevations, while species with 2n = 48 usually occur in montane forests. The exception was *G. holttumii* ssp. *aurea* (2n = 48) found so far in lowland Dryobalanops forests in north-eastern Johore.

G. marantina L. (2n = 80) was found in Ayer Itam, Penang and Jason Bay, Johore. Living materials for investigation were collected from the waterfall Botanic Garden, Penang. The paucity of collections may be attributable to its seasonal dormancy for about four months annually when it is nowhere to be seen. *G. marantina* is apparently localised in distribution in Malaya, but has a very widespread distribution in the Indo-Malaysian region — from India (*G. strobilifera* Zoll. & Mor. = *G. marantina* L., *G. bulbifera* Roxb. = *G. marantina* L., fide Index Kewensis, 1895, herbarium sheet examination of *G. bulbifera* Roxb. in comparison to living specimens of *G. marantina* L.) to Sumatra (*G. bracteata* Heyne = *G. marantina* L., fide Index Kewensis, 1895) to the Philippines, New Guinea, the Moluccas Islands and the Solomon Islands where *G. marantina* is the only species of the genus. Pendleton (1949) surmised that since the Pulau Islands, west of Solomons, were very similar to the Solomons, *G. marantina* might be there too. The ecological success of *G. marantina* may be attributed to its propagation by rhizome and bulbils, both being very resistant to adverse conditions, and its ability to colonise efficiently open habitats where competition for survival would be less keen. The other Malayan *Globba* species thrive well only in moist, partially shaded niches.

A study of intraspecific distribution in the four *Globba* species with 2n = 32, 48 shows that the subspecific taxa with 2n = 48 are generally but not strictly montane in distribution. Almost all the chromosomal races with 2n = 32 in *G. pendula* Roxb. s.s. are lowland in distribution, the one with 2n = 48 is solely montane. Those of *G. patens* Miq. s.s. show a similar distributional distinction, with the exception of the single collection of specimens with 2n = 48 from Bukit Lagong Forest Reserve, Selangor (c.200–800′). Both the chromosomal races of *G. cernua* Bak. s.s. are restricted to the highlands; but those of *G. cernua* ssp. *crocea* are found in lowland forests. In contrast, *G. variabilis* Ridl. s.s. (2n = 48) occurs both in the lowlands as well as in montane area, though predominantly in the latter. The subspecies *pusilla* has been collected from localities of moderate elevation.

The ecological spread of chromosomal races with 2n = 32 of *G. pendula* Roxb. s.s. and *G. patens* Miq. s.s. was found to be more extensive than that of chromosomal races with 2n = 48. In *G. cernua* Bak. s.s., where the two chromosomal races occur together in montane areas, plants with 2n = 48 are more abundant than plants with 2n = 32.

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Table 2. Source and Chromosome Numbers of Living Specimens of Malayan *Globba* Species.

G. marantina L.:	PENANG, Waterfall Gardens. lowland, LIM Siew-Ngo, KLU 4831, 2n = 80.
G. cernua Bak.	PAHANG, Western Hill, Fraser's Hill, 4000′, LIM Siew-Ngo, KLU 4844, 2n = 32.
	———, *idem,* KLU 4843, 2n = 48.
	———, *idem,* KLU 4832, 2n = 48.
	———, Bukit Peninjau, Fraser's Hill, 4000′, LIM Siew-Ngo, KLU 8205, 2n = 32.
	———, *idem,* M.E.D. POORE, KLU 4796, 2n = 48.
	———, Parit Falls, Cameron Highlands, 4700′, LIM Siew-Ngo, KLU 8233, 2n = 48.
	———, Robinson Falls, Cameron Highlands, 4400′, LIM Siew-Ngo, KLU 8235, 2n = 48.
	———, Gunong Jasar, Cameron Highlands, 4500′, LIM Siew-Ngo, KLU 8222, 2n = 48.
	———, idem, *, 2n = 48.
	PERAK, Maxwell's Hill, 3750′, LIM Siew-Ngo, KLU 4833, 2n = 32.
	———, *idem,* KLU 4834, 2n = 48.
	SELANGOR, Reid's 3rd quartz ridge, Gombak, 12th mi., 1800′, A. LETHBRIDGE, KLU 8228, 2n = 32.
G. cernua ssp. *crocea* Lim	PAHANG, Jenka Forest Reserve, 200′, M.E.D. POORE, KLU 4791, 2n = 32.
	———, *idem,* I. CLEAR & C. C. HO, KLU 4817, 2n = 48.
G. cernua ssp. *prophyria* Lim	PERAK, Bujang Melaka, 1370′, K. JONG, KLU 8240, 2n = 32.
G. unifolia var. *sessiliflora* Holtt.	KELANTAN, Sungei Lebir, 300′, B. C. STONE, KLU 7367, 2n = 32.
G. fragilis Lim	KEDAH, Pulau Langkawi, lowland, K. C. CHEANG, KLU 4847, 2n = 32.
G. curtisii Holtt.	PAHANG, Waterfall by old dairy farm, Fraser's Hill, 4000′, K. JONG, KLU 4793, 2n = 48.

G. holttumii Lim	———, idem, KLU 4822, 2n = 48. SELANGOR, Gombak Forest Reserve, 2500′, LIM Siew-Ngo, *, 2n = 48. ———, Genting Simpah, 2700′, K. JONG, *, 2n = 48. ———, Genting Highlands, 4000′, LIM Siew-Ngo, *, 2n = 48.
G. holttumii ssp. *aurea* Lim	JOHORE, Lenggor Forest Reserve, 300′, P. C. LEE, KLU 8206, 2n = 48.
G. × *intermedia* = *G. patens* × *cernua* Lim	PAHANG, Parit Falls, Cameron Highlands, 4700′, LIM Siew-Ngo, KLU 4840, 2n = 48. ———, Robinson Falls, Cameron Highlands, 4400′, LIM Siew-Ngo, KLU 4841, 2n = 48. ———, Gunong Jasar, Cameron Highlands, 4800′, LIM Siew-Ngo, KLU 4842, 2n = 48. ———, idem, KLU 4848, 2n = 48.
G. patens Miq.	SELANGOR, Gombak 22nd mi., 1500′, LIM Siew-Ngo, KLU 8211, 2n = 32. ———, Genting Simpah, 1800′, LIM Siew-Ngo, KLU 8219, 2n = 32. ———, *Kanching Dryobalanops* Forest Reserve, lowland, Honours students, KLU 4827, 2n = 32. ———, Ulu Langat Forest Reserve, 700′, T. WHITMORE, *, 2n = 32. ———, Gombak Forest Reserve, (12th mi.), 1500′, A. LETHBRIDGE, KLU 4849, 2n = 32. JOHORE, Lenggor Forest Reserve, 200′, P. C. Lee, *, 2n = 32. PAHANG, by Golf Course, Fraser's Hill, 4000′, K. C. CHEANG, KLU 8232, 2n = 48. ———, Genting Highlands, 4000′, B. C. STONE, KLU 6588, 2n = 48. PERAK, Bujang Melaka, 2200′, K. JONG, *, 2n = 48. SELANGOR, Bukit Lagong Forest Reserve, 200–800′, M. E. D. POORE, *, 2n = 48.
G. patents var. *costulata* Lim	PAHANG, Waterfall by old dairy farm, Fraser's Hill, 4000′, A. LETHBRIDGE, KLU 8209, 2n = 32. ———, Cameron Highlands, 4750′, W. L. CHEW, KLU 8231, 2n = 32. SELANGOR, Sungei Lallang Forest Reserve, Kajang, 250′, J. DRANSFIELD, *, 2n = 32.
G. variabilis Ridl.	SELANGOR, Gombak Forest Reserve (12th mi.), 1500′, LIM Siew-Ngo, KLU 8208, 2n = 48. ———, Sungei Lallang Forest Reserve, Kajang, 200′, J. DRANSFIELD, *, 2n = 48. PAHANG, Fraser's Hill, 4000′, LIM Siew-Ngo, *, 2n = 48. SINGAPORE, Bukit Timah Nature Reserve, 500′, LIM Siew-Ngo, *, 2n = 48.
G. variabilis ssp. *pusilla* Lim	JOHORE, Gunong Panti, 1500′, W. L. CHEW, KLU 8246, 2n = 32.

G. albiflora Ridl.	PENANG, Penang Hill, 1300′, LIM Siew-Ngo, KLU 8221, 2n = 32.
G. pendula Roxb.	SELANGOR, University Campus, Kuala Lumpur, lowland, LIM Siew-Ngo, KLU 4799, 2n = 32. ———, Kanching *Dryobalanops* Forest Reserve, lowland, Honours students, KLU 4813, 2n = 32. ———, Genting Simpah, 1800′, K. Jong, KLU 8213, 2n = 32. ———, Ayer Hitam Forest Reserve, 350′, P. C. LEE, KLU 8201, 2n = 32. PERAK, Ulu Kinta, off Ipoh, lowland, P. C. LEE, *, 2n = 32. PENANG, Waterfall Gardens, lowland, LIM Siew-Ngo, KLU 8216, 2n = 32. KEDAH, Foot of Gunong Jerai, lowland, LIM Siew-Ngo, KLU 8225, 2n = 32. ———, Jungle south of Gunong Jerai, lowland, LIM Siew-Ngo, KLU 8226, 2n = 32. PAHANG, Waterfall by old dairy farm, Fraser's Hill, 4000′, LIM Siew-Ngo, KLU 8203, 2n = 48. ———, *idem* KLU 4836, 2n = 48.
G. pendula var. *elegans* (Ridl.) Holtt.	PAHANG, *idem*, LIM Siew Ngo, KLU 4830, 2n = 32.
G. pendula ssp. *montana* (Ridl.) Lim	PENANG, Penang Hill, 1200′, LIM Siew-Ngo, KLU 8219, 2n = 32. ———, Waterfall Gardens, lowland, LIM Siew-Ngo, KLU 8216, 2n = 32. ———, Ayer Itam Dam, 1090′, LIM Siew-Ngo, KLU 8229, 2n = 32.
G. leucantha var. *peninsularis* Holtt.	JOHORE, Gunong Panti, 1500′, J. SINCLAIR, KLU 8200, 2n = 32. SINGAPORE, Bukit Timah Nature Reserve, 500′, LIM Siew-Ngo, KLU 4839, 2n = 32.

Bukit = Hill
Gunong = Mountain
Sungei = River
Pulau = Island
* = *Sine specimen exsiccatum*

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Two new Theaceous plants from Malaysia and a proposal to reduce Tutcheria to a synonym of Pyrenaria

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1. Introduction

Late 1960, I examined several specimens, incl. *Elmer 21628, 21832,* and *Wood SAN 16482* (Plate 1) from North Borneo which is now known as Sabah, a state of Malaysia. These were in the Herbarium of Singapore Botanic Gardens and identified as *Camellia lanceolata* (Bl.) Seem. A study of the fruit (a 3-loculate capsule with thin woody wall, partly dehiscent) and the seed (exalbuminous, the embryo with large thin, contorted cotyledons) reminded me of those of *Pyrenaria* and *Tutcheria.* Later, through Professor C.G.G.J. van Steenis, I learned from Mr. J. R. Sealy, that the identification of these specimens as *Camellia lanceolata* was erroneous. Dr W. Meijer, the former Forest Botanist from Sandakan, Sabah, kindly sent all the theaceous specimens belonging to this group on loan to Singapore. But I failed to find any flowering material of this plant. He also informed me that the forest in Tawau area, where the collections were made, had since been felled.

Early 1970, when checking some unidentified theaceous specimens, my attention was drawn to a specimen from the Malay Peninsula (*Corner* s.n., on Sept. 9, 1937, from Sungei Tahan, Pahang) (Plate 2). It had for many years been preliminarily identified as Euphorbiaceae, but Mr. H. K. Airy-Shaw of the Royal Botanic Gardens, Kew, wrote on an annotated sheet "cf. Theaceae", when he worked over the un-named Singapore sheets of Euphorbiaceae in February 1969 in preparation for the chapter in the new Tree Flora of Malaya. The fruit and seed structures of this plant reminded me again of those of *Pyrenaria* and *Tutcheria.* At my request, this specimen together with another old collection from the same area (*Haniff & Nur 8067*) and recognized by Ridley as a new species of *Pyrenaria,* was sent to Mr. Airy-Shaw for further confirmation. He agreed that these two specimens represent a hitherto undescribed species belonging to the *Pyrenaria-Tutcheria* complex.

Originally, I planned to collect at least the flowering material of the Malayan plant. During a recent trip (June, 1971) to Pahang in Malaya with Dr. T. C. Whitmore, we reached the lower end of Sungei Tahan. Unfortunately, our efforts to find this plant failed. I decided then that it would be better to describe these two species of *Pyrenaria* (one from Sabah, one from Malaya) without further delay. A discussion of the reason why *Tutcheria* should be merged with *Pyrenaria* with a special note on their fruit, seed and seedling characters follows the description.

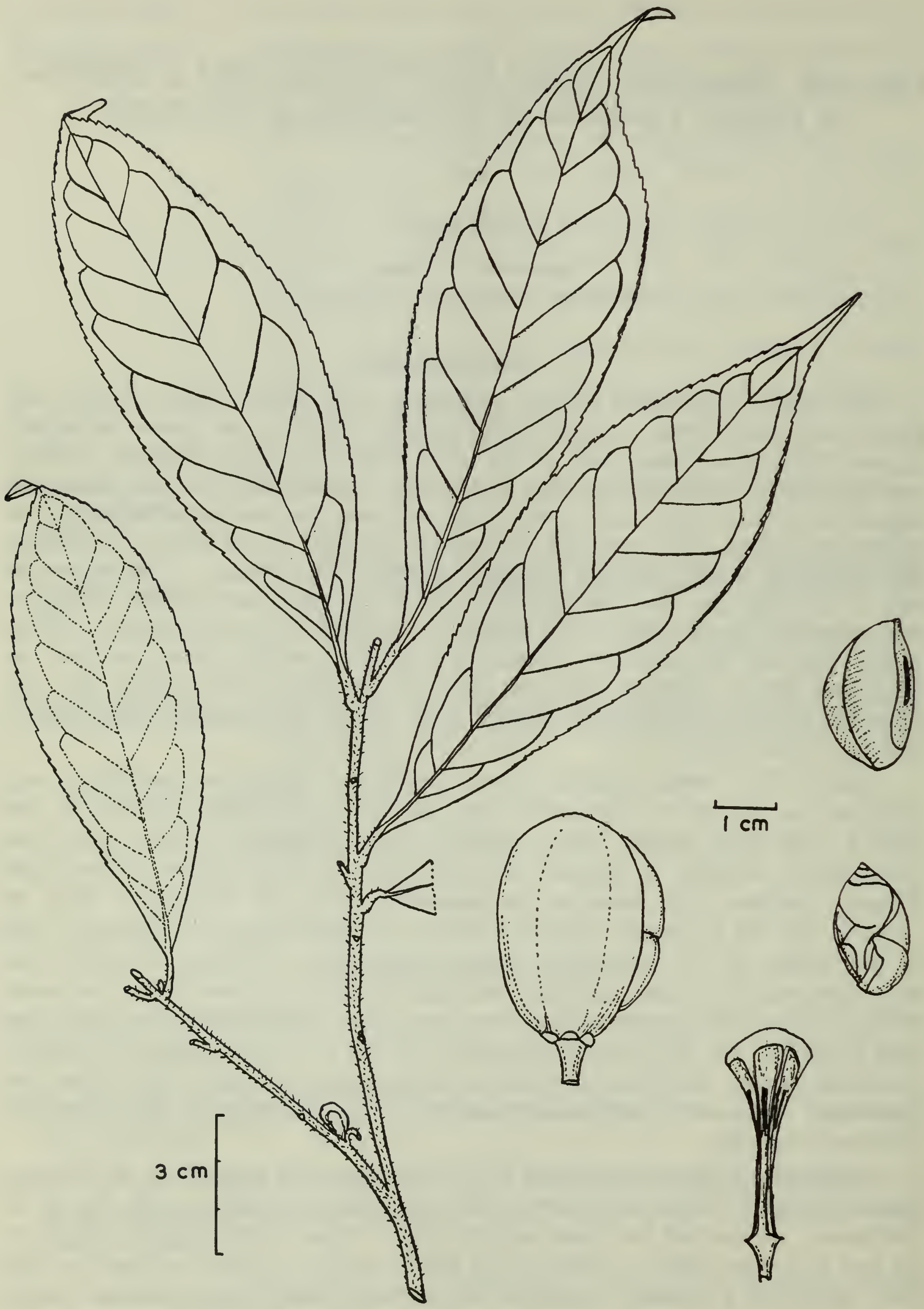

Fig. 1 *Pyrenaria tawauensis* H. Keng, *sp. nov.*

Habit sketch, fruit and seed (based on *Wood SAN 16482*, Supplemented by *Elmer 21628*)

2. Two new species of *Pyrenaria* from Malaysia

1. **Pyrenaria tawauensis** H. Keng **sp. nov.** (Plate 1, figure 1)

Arbor ad 10 m alta. Ramuli puberuli. Folia disticha, subcoriacea, anguste elliptica vel anguste ellipto-lanceolata, 10–19 cm longa, 4–4.5 cm lata, apice acuta vel caudata, basi acuta, supra glabra, subtus verrucosa vel fere glauca, margine repanda, nervis lateralibus 8–12, bene intra marginem anatomosantibus; petiolo ca. 1 cm longo. Capsula ovoidea vel subglobosa, 3–3.5 cm longa, 2.5–3.5 cm in diametro; pericarpio tenuiter lignoso. Semina atropurpurea, 1.2–2.5 cm longa.

A small or medium-sized tree, 10 m tall. Branches slender, puberulous. Leaves alternate, distichous, thin coriaceous, narrowly elliptic or narrowly elliptic-lanceolate, 10–19 cm long, 4–4.5 cm wide, acute or shortly to long-caudate at the apex and gradually or abruptly narrowed to the acute base, shining glabrous above, verrucous, puberulent or sub-glaucous beneath; lateral veins 8–12 pairs, oblique, curved and merged into the submarginal vein, slightly depressed above, elevated beneath; margin remotely serrulate or repandous; petiole about 1 cm long, slender, puberulent. Flowers not seen. Fruit broadly ovoid to depressed globose, 3–3.5 cm long, 2.5–3.5 cm across, verrucous, puberulous or glabrescent, usually 3-loculate. Pericarp thin woody (2–3 mm in thickness in mature specimen) eventually partly dehiscent along the sutures. Seeds usually 2 (rarely 3) in each locule, dorsally convex-rounded, the other surfaces variously angulate due to mutual compression, 1.2–2.5 cm long, 1.2–1.4 cm broad, dark purple, shining.

Specimens examined:

Sabah (North Borneo), Malaysia: Tawau, alt. 100 m, *G.H.S. Wood SAN 16482* (Type, Sing.) Oct. 28, 1955; *A.D.E. Elmer 21628, 21832* (Sing.), Oct. 1922 to March 1923; *C.E. Carr 26387* (Sing.) March 5, 1933.

This species is characterized by the fruit with thin, woody, partly dehiscent pericarp.

2. **Pyrenaria pahangensis** H. Keng **sp. nov.** (plate 2, figure 2)

Arbuscula c. 4 m alta. Ramuli glabrescenti. Folia pseudo-verticillata, membranacea, elliptica vel anguste oblongo-oblanceolata, 25–38 cm longa, 8–15 cm lata, apice acuta vel breviter caudata, basi cuneata, imo subcordata, supra glabra, subtus glabrata, margine serrulata vel subintegra, nervis lateralibus 7–8, bene intra marginem anastomosantibus; petiolo 0.25–0.5 cm longo. Capsula ovoidea vel subglobosa, 3–4.5 cm longa, 2.5–4 cm in diametro; pericarpio cartilagioseo. Semina badia, 1.5–2 cm longa.

A shrub or small tree, 3–4 m tall. Branches stout, glabrescent. Leaves pseudo-verticillate (i.e., 3–5 spirally congested to form a false whorl), membranaceous, elliptic to narrowly oblong-oblanceolate, 23–38 cm long, 8–15 cm wide, acute or shortly caudate at the apex and gradually narrowed to the cuneate and cubcordate base, shining, glabrous above, puberulent or glabrescent beneath; lateral veins 7–9 pairs, oblique to nearly perpendicular, curved and merged into the submarginal vein, rather faint above, distinct and slightly elevated beneath; margin remotely serrulate, nearly entire below the middle; petiole short, pulvinoid, 0.25–0.5 cm long. Flowers not seen. Fruit broadly ovoid or subglobose, 3–4.5 cm long and 2.5–4 cm across, normally 3-loculate. Pericarp very thin, cartilaginous, (1–2 mm in thickness in the mature specimen), eventually partly dehiscent along the sutures. Seeds usually 2 in each locule, dorsally convex-rounded, the other surfaces variously angulate due to mutual compression, 1.5–2 cm long, 1.2–1.8 cm broad, chestnut brown, shining.

Specimens examined:

Pahang, Malaysia: Sungei Tahan, *E.J.H. Corner* s.n. (Type, Sing.) Sept. 9, 1937 (Common shrub or treelet, in streams, off the main river); Teku, Gunong Tahan, *Mohamad Haniff & Mohamad Nur S.F.N. 8067* (Sing.) June 21, 1922 (Small tree, 10–12 ft. high).

This species is characterized by its sub-verticillate, short-petiolate leaves with a subcordate base and especially by its fruit with thin cartilaginous and partly dehiscent pericarp.

3. A proposal to reduce *Tutcheria* to a synonym of *Pyrenaria* with a special note on their fruit, seed and seedling characters

The genus *Pyrenaria* was established by C. L. Blume (in Bijdr. 1119) in 1827, based on the Javanese species, *P. serrata* Bl. It is interesting to note from the original description, ("Pomum subglobossum, depressum, carnosum, guinqueloculare, loculis 2 pyrenis. Pyrenae 1-spermae . . .") that Blume recognized the fruit as a pome, with 2 pyrenes in each of the 5 locules. From this character, the generic name *Pyrenaria* was derived. Most authors today, however, generally described the fruit as succulent, baccate or drupaceous. About twenty binomials have since been described, they were from E. India, Burma, Malay Peninsula, Borneo, Sumatra, Indo-China, Thailand and S.W. China (Yunnan). Some of them would probably be merely synonyms after critical revision; for example, out of 4 species described from Java only Blume's original species stands (cf. Backer & Bakhuizen, Fl. Java, 1: 321, 1963).

The genus *Tutcheria,* on the other hand, was established by S. T. Dunn (in Jour. Bot. 46: 324) in 1908, based on a Hongkong species, *T. championi* Nakai (formerly as *T. spectabilis* (Champ.) Dunn). Dunn clearly pointed out that the systematic position of *Tutcheria* is closely next to *Pyrenaria* which it resembles in flower and seed and from which it is distinguished by the dehiscence of its capsule and by its multiovulate locules. About ten speciecs of *Tutcheria* were described, mostly from Southern China, one from Formosa, and one from the Riukiu Islands.

In Melchior's monographic study of Theaceae in Engler's *Pflanzenfamilien* (2nd ed. 21: 126, 1925), *Pyrenaria* and *Tutcheria* were treated separately as belonging to two different subtribes. Recently, in Sealy's Rev. Gen. Camellia (p. 13, 1958) brief discussion on the classification of the subfamily Camellioideae (as Tribe Camellieae), *Pyrenaria, Tutcheria, Camellia* and *Yunnania* were treated together under a subtribe, Camelliinae.

Since *Yunnania* is rather imperfectly known, the following brief discussion on flower, fruit, seed and seedling characters is concentrated on those of *Camellia, Pyrenaria* and *Tutcheria.*

1. On flowers

In general, the flowers of *Pyrenaria* and *Tutcheria,* like those of *Camellia,* are variable to a certain extent. Whereas the subdivision of *Pyrenaria* into two sections for instance was based on the number and degree of fusion of the styles (Melchior, 1.c. 138); the classification of *Camellia* into 12 sections (Sealy 1.c. p. 28) was primarily based on a pair of characters: styles united or free, and bracteoles and sepals clearly differentiated or not. A full range of variation in flower parts of *Camellia* was also given by Sealy (1.c. pp. 16–18). No attempt has been made to subdivide *Tutcheria.*

Plate 1. Type specimen of *Pyrenaria tawauensis* H. Keng

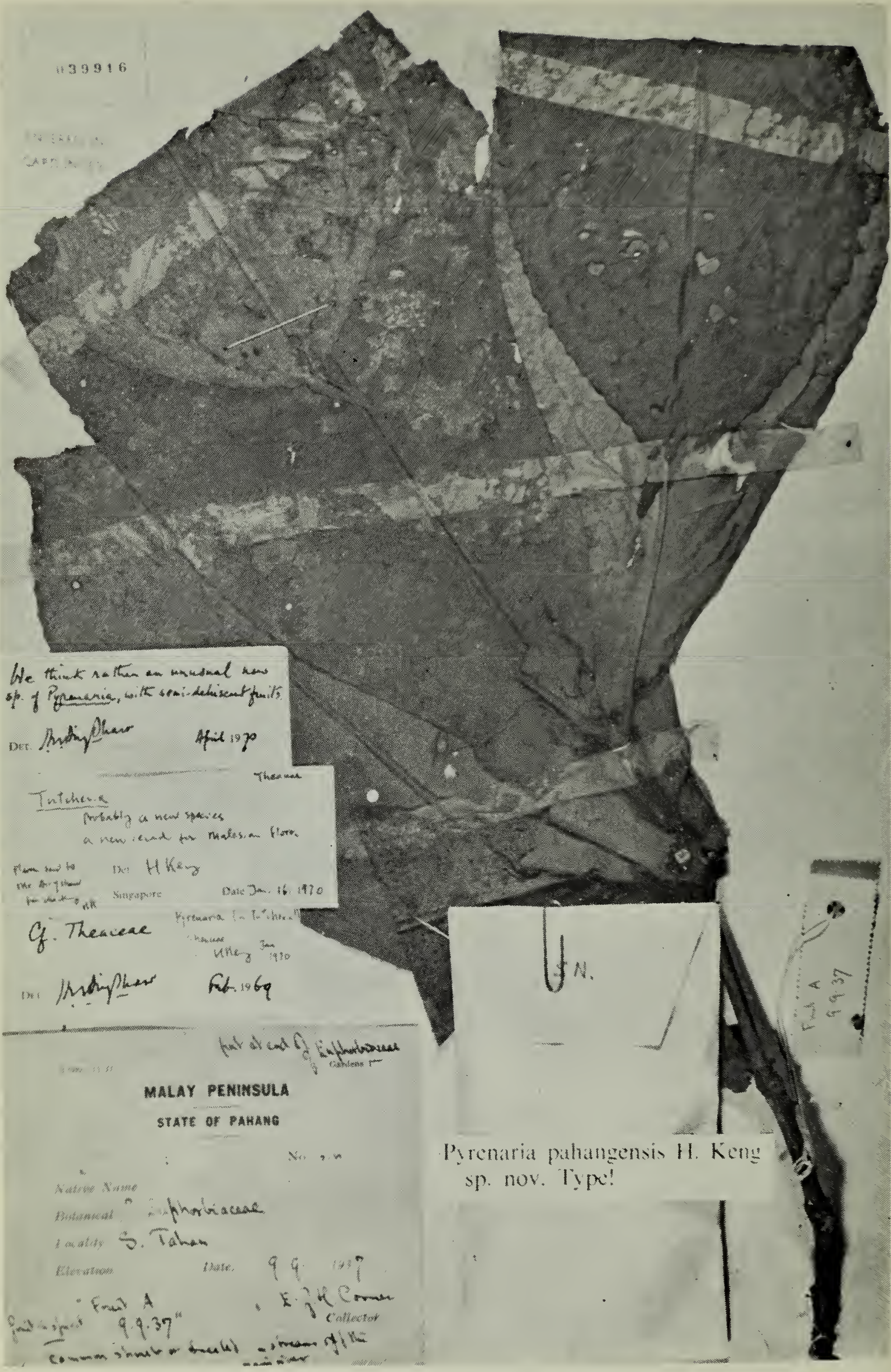

Plate 2. Type specimen of *Pyrenaria pahangensis* H. Keng

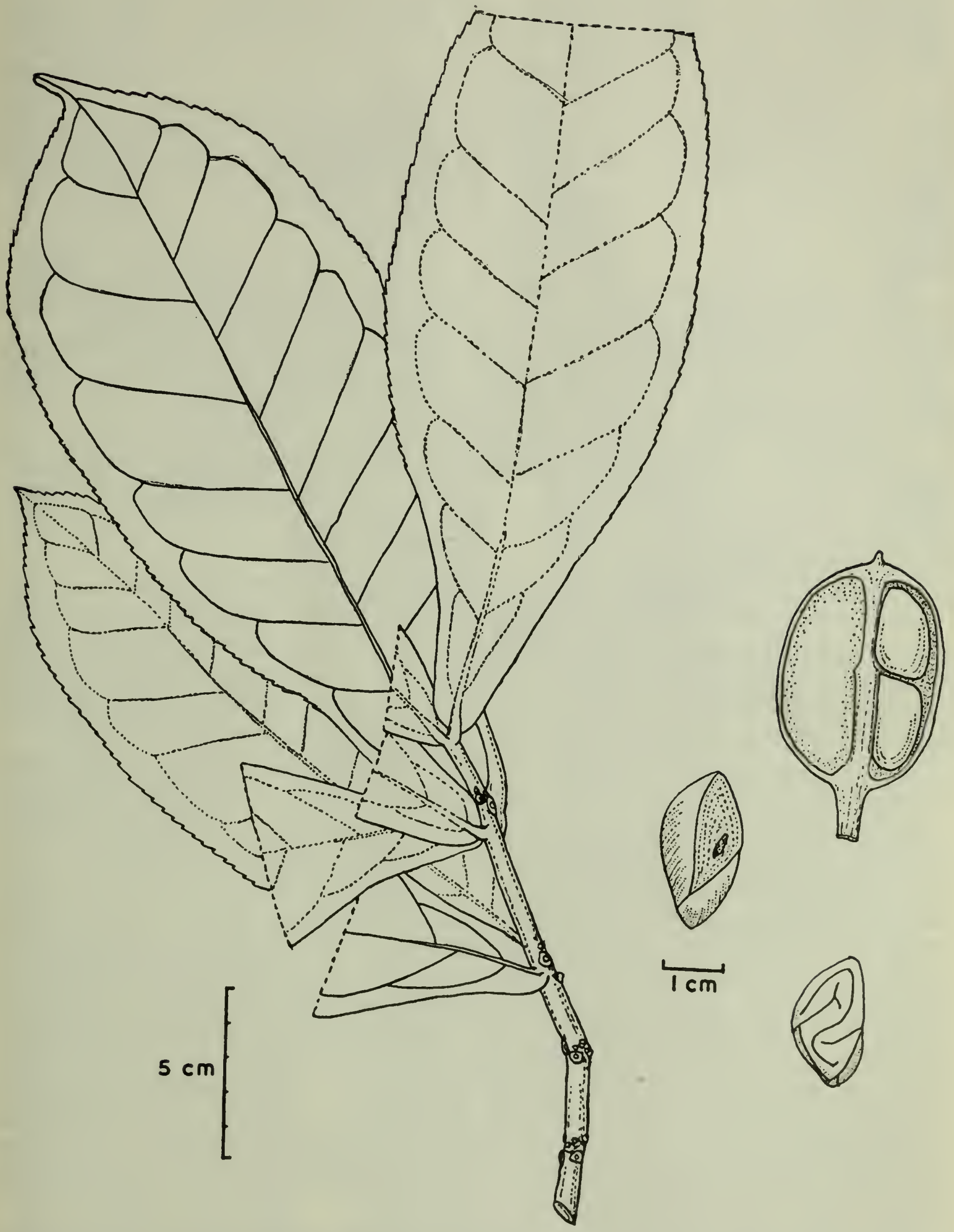

Fig 2. *Pyrenaria pahangensis* H. Keng *sp. nov.*

Habit sketch, fruit and seed (based on *Corner* s.n. [Sept. 9, 1937], supplemented by *Haniff & Nur SFN 8067*).

The number of locules in an ovary in all these three genera varies from 3–5. One particular point is the number of ovules per locule. Sealy mentioned (l.c. p. 18) that in *Camellia,* each locule contains 3–4 (very rarely 8) axile ovules attached near the apex. Dunn gave the number of ovules in each ovary in *Tutcheria* as '2–5'. Although Blume's original description states that there are two ovules per locule in *Pyrenaria,* the occurrence of three or four ovules in each locule in this genus is in fact not uncommon. Therefore, there is no real difference between *Pyrenaria* and *Tutcheria* in the number of ovules per ovary-locule as Dunn once unduly stressed.

2. *On fruit*

The fruit in *Camellia* is a woody capsule, loculicidally dehiscent from the apex downwards (Sealy, l.c. p. 18). A typical form of the fruit of *Pyrenaria* (e.g. *P. acuminata,* plate 3, c) is baccate, the pericarp fleshy or soft woody, indehiscent, 3-5-loculate. On the other hand, that of *Tutcheria,* like *Camellia,* is a woody capsule, loculicidally dehiscent into 3–6 valves, the latter often deciduous and falling from the base.

The fruit characters of *Pyrenaria* and *Tutcheria* will be further discussed below.

3. *On seeds and seedlings*

The seeds of *Camellia, Pyrenaria* and *Tutcheria* are uniformly ex-albuminous. They are generally globose, hemispheric or plano-convex in *Camellia,* and much flattened, often irregularly angulate (due to mutual pressure) in *Pyrenaria* and *Tutcheria.* The most noticeable fact is that in *Camellia,* the embryo possesses a pair of thick, hemispheric cotyledons, while in *Pyrenaria* and *Tutcheria,* it possesses a pair of very thin and large, but contorted and twisted cotyledons.

Following Martin's phylogenetic classification of seeds (Amer. Midl. Nat. 36: 513–660, esp. 519–523, 1946), *Camellia* seed belongs to the 'investing' type, and *Pyrenaria* and *Tutcheria* seed, the 'folded' type, both types are classified in his 'axile' division, and both represent the zenith of seed evolution (see his Fig. 3 on p. 523). Morphological differences of these two types are obvious, nevertheless, their selective advantages are probably even more striking. In the 'investing' type, the two thick cotyledons generally remain in the seedcoat and embedded in the ground, serving as a food storage organ for the initial growth of a seedling. In the 'folded' type, in contrast, the two thin cotyledons, during the process of germination, gradually emerge from the seedcoat, rapidly unfold and spread out, thus performing the function of photosynthesis. Previously the present writer observed the germination of species of *Camellia* and *Tutcheria* (Keng in Univ. Calif. Publ. Bot. 33: 276, Fig. 3 A & B). Photographs of seedlings of two Malayan species of *Pyrenaria* are presented in Plate 3 (*e* to *h*) of this paper. As expected, the germination processes of *Pyrenaria* and *Tutcheria* so far as it concerns the few species observed, are identical.

From the above discussion, it can be concluded that *Pyrenaria* and *Tutcheria,* as Dunn (l.c.) pointed out, are in fact, closely related. This can be further emphasized by their peculiar seed and seedling characters which are unique among the family Theaceae (cf. Keng, l.c. p. 280). It is also clear that their only substantial difference lies in their fruit character i.e. baccate, indehiscent, in the typical forms of *Pyrenaria,* and capsular in the typical form of *Tutcheria.* Is this fruit character so vital that demarcation of these two genera can be based on it alone? A negative answer could emerge from the following four examples.

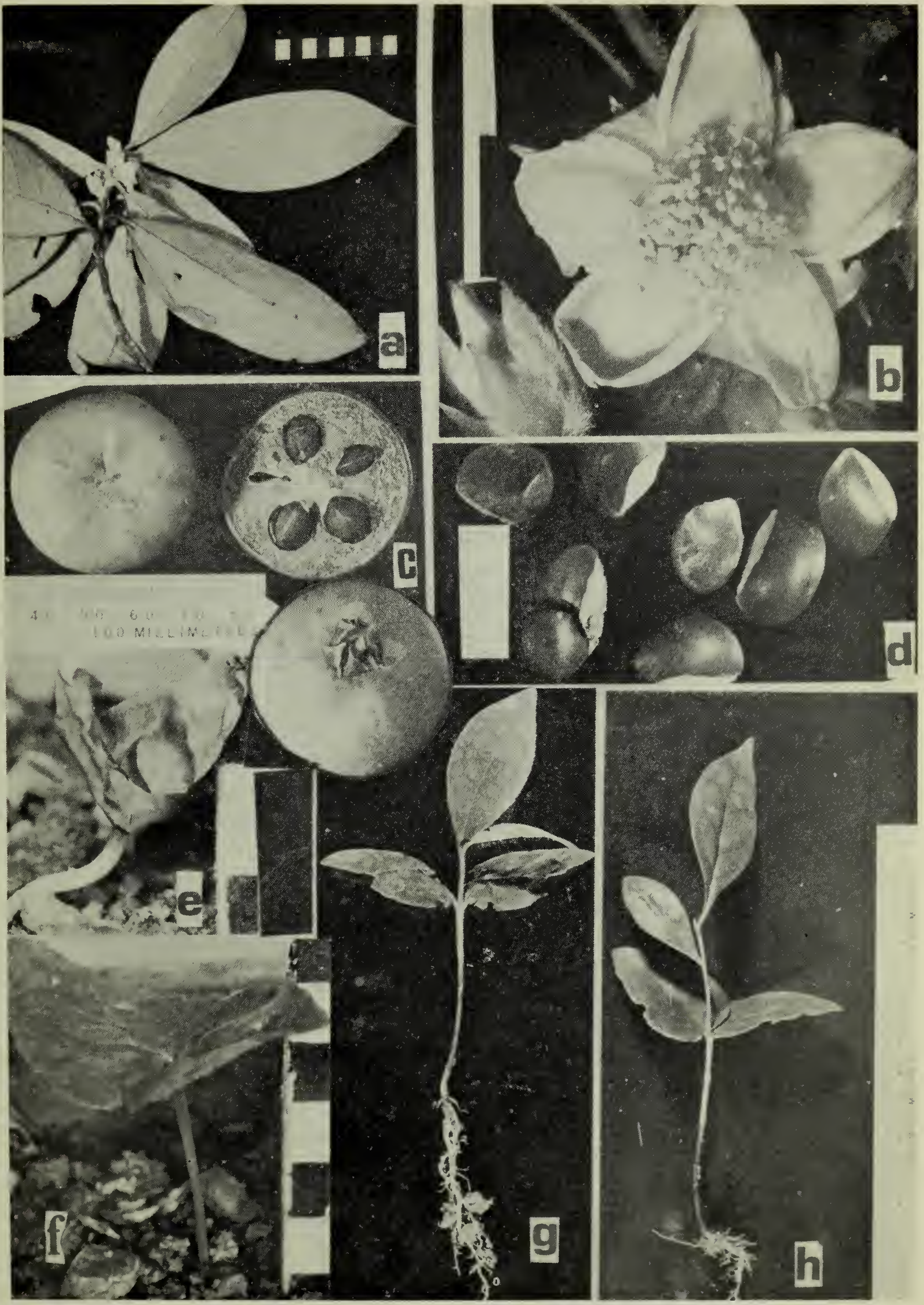

Plate 3. Two species of Pyrenaria

P. acuminata Planch.: *a*-flowering branch; *b*-flower and flower-bud; *c*-fruits; *d*-seeds; *e* & *f*-seed germination; *g*-seedling.

P. kunstleri King: *h*-seedling.

a. *Lobelia-Pratia* (Campanulaceae or Lobeliaceae).

Traditionally, these two were treated as two separate genera merely on fruit characters alone: apically 2-valved capsule in *Lobelia* Linn. and baccate in *Pratia* Gaudich. Moeliono & Tuyn (Fl. Mal. I, 6(1): 122, 1960) recently fused them into one genus.

b. *Buddleja-Nicodemia* (Loganiaceae).

Likewise, the fruit of *Buddleja* Houst. ex Linn. is a septicidal, 2-valved capsule, and *Nicodemia* Tenore, a berry. The latter was reduced into a subgenus of the former by Leenhouts (Fl. Mal. I, 6(2):336-337, 1962).

c. *Euphorbia-Elaeophorbia* (Euphorbiaceae).

The fruit is drupaceous in *Elaeophorbia* Stapf., and capsular in *Euphorbia* Linn. Recently Webster (Jour. Arnold Arb. 48:397, 1967) reverts *Elaeophorbia* to *Euphorbia*, but makes a separate section of the genus for it.

d. *Lomatophyllum-Aloe* (Liliaceae).

Fruit of *Lomatophyllum* Willd. is a large fleshy berry, whereas that of *Aloe* Linn. is a dehiscent capsule. Based on "Phenetic diagrams" from the use of a computer, Rowley (in Taxon 18:625–7, 1969) strongly queried the validity of keeping the status of *Lomatophyllum* as a genus merely on a single character basis.

Undeniably, in a number of taxa (such as Leguminosae, Umbelliferae, Ulmaceae, Juglandaceae, to mention only a few), the fruit is a paramount diagnostic character. However, in the four examples cited above, and also in case of *Pyrenaria* and *Tutcheria,* the present writer tends to believe that the fruit character, in these instances, is probably merely of ecological or physiological, rather than of phylogenetic importance.

To strengthen the argument that *Pyrenaria* and *Tutcheria* should be merged, the present writer would like to supply the description of two types of fruits from *Pyrenaria* species which appear to bridge the gap between baccate and capsulate fruits.

The first type of fruit can be found in the two new species of *Pyrenaria* described in this paper, both from the Malaysian region. Their fruit walls are thin woody or crustaceous, partly dehiscent along one or few sutures in a rather irregular way when fully matured. The second can be found in a Chinese species, *Pyrenaria camellioides* Hu from Yunnan which is characterised by the fruit with spongy pericarp partly dehiscing septicidally from above, and partly dehiscing loculicidally from below. The apex of this fruit is slightly concave, with 5 bosses (which represent the style bases) around the depression, a situation extremely similar to the Thai species, *P. garrettiana* Craib. The fruit of the latter, however, is succulent and not dehiscent.

Incidentally, *Pyrenaria garrettiana* Craib, together with two other species from Yunnan, has been segregated into a new genus, *Sinopyrenaria* Hu (in Act. Phytotax. Sin. 5:281, 1956) and *Pyrenaria camellioides* Hu, into another new genus, *Glyptocarpa* Hu (in Act. Phytotax. Sin. 10: 25, 1965). Meanwhile, a third new genus, *Parapyrenaria* H. T. Chang (in Act. Phytotax. Sin 8:287, 1963), was proposed based on *P. hainanensis* H. T. Chang, from Hainan, China. All these three are probably superfluous, if we accept a reasonably broader generic concept ot *Pyrenaria,* comparable to that of *Camellia* as recently defined by Sealy (l. c. pp. 14–32).

For the reasons given above, the present writer therefore formally proposes to merge *Tutcheria* Dunn with *Pyrenaria* Blume, and to reduce the following known species of *Tutcheria* to *Pyrenaria.*

Pyrenaria Blume, Bijdr. 1119, 1827; Miq. Fl. Ind. Bat. 1:493, 1855, et Suppl. 1:484, 1861; Hook. f. Fl. Brit. Ind. 1:289, 1872; Melch. in Engl. & Prant. Nat. Pflanzenfam. ed. 2, 21:138, 1925; Back. & Bakh. f. Fl. Java 1: 321, 1963.

Synonym: *Tutcheria* Dunn in Jour. Bot. 46: 324, 1908, 47: 197, 1909; Nakai in Jour. Jap. Bot. 16: 708, 1940; Li, Wood. Fl. Taiwan, 597, 1963; Hu & Chang in Chun, Chang & Chen, Fl. Hainan. 1:495, 1964. **Syn. nov.** A list of new combinations follows.

1. **Pyrenaria championi** (Nakai) H. Keng **comb. nov.**

Basionym: *Tutcheria championi* Nakai in Jour. Jap. Bot. 16:708, 1940.

Synonyms: *Camellia spectabilis* Champion ex Benth. in Jour. Bot. 3:310, 1851 (*non* Berlese 1843).

Tutcheria spectabilis (Champ.) Dunn in Jour. Bot. 46:324, 1908.

Distribution: Hongkong.

2. **Pyrenaria greeniae** (Chun) H. Keng **comb. nov.**

Basionym: *Tutcheria greeniae* Chun in Jour. Arnold Arb. 9:129, 1928.

Distribution S. China (Kwangtung).

3 **Pyrenaria hirta** (Hand.-Mazz.) H. Keng **comb. nov.**

Basionym: *Gordonia hirta* Hand.-Mazz. Anz. Akad. Wiss. Wien. 58:180, 1920.

Synonyms: *Tutcheria hirta* (Hand.-Mazz.) Li in Jour. Arnold Arb. 26:64, 1945.

Tutcheria villosa Wu in Engler, Jahrb. 71:192, 1940.

Distribution: S.W. China (Hupeh, Kweichow, Kwangsi).

4. **Pyrenaria microcarpa** (Dunn) H. Keng **comb. nov.**

Basionym: *Tutcheria microcarpa* Dunn in Jour. Bot. 47:197, 1909.

Distribution: S. China.

5. **Pyrenaria multisepala** (Merr. & Chun) H. Keng **comb. nov.**

Basionym: *Tutcheria multisepala* Merr. & Chun in Sunyetsenia 2:41, 1934.

Distribution: S. China (Hainan).

6. **Pyrenaria ovalifolia** (Li) H. Keng **comb. nov.**

Basionym: *Tutcheria ovalifolia* Li in Jour. Arnold Arb. 25:209, 1944.

Distribution: S. China (Hainan).

7. **Pyrenaria shinkoensis** (Hayata) H. Keng **comb. nov.**

Basionym: *Thea shinkoensis* Hayata in Jour. Coll. Sci. Tokyo 30 (1):45, 1911.

Synonyms: *Camellia shinkoensis* (Hayata) Cohen-Stuart in Meded. Proefst. Thee 40:68, 1916.

Tutcheria shinkoensis (Hayata) Nakai in Jour. Jap. Bot. 16:708, 1940.

Distribution: China (Taiwan).

8. **Pyrenaria symplocifolia** (Merr. & Metcalf) H. Keng **comb. nov.**

Basionym: *Tutcheria symplocifolia* Merr. & Metcalf in Lingnan Sci. Jour. 16:172, 1937.

Distribution: S. China (Kwangtung).

9. **Pyrenaria virgata** (Koidz.) H. Keng **comb. nov.**

Basionym: *Thea virgata* Koidz. in Bot. Mag. Tokyo 32: 252, 1918.

Synonyms: *Camellia virgata* (Koidz.) Makino & Nemoto, Fl. Jap. (ed. 2): 740, 1931.

Tutcheria virgata (Koidz.) Nakai in Jour. Jap. Bot. 16:708, 1940.

Distribution: The Riukiu Islands.

The geographic range of *Pyrenaria,* after the merging of *Tutcheria* species into it, thus covers from E. India, Burma, Thailand, Indo-China to S. China, the Riukiu Islands, Taiwan and to Malesia (Malaya, Borneo, Sumatra, Java), and conforms closely to those of *Camellia* (Sealy, l. c.), *Coptosapelta* (Steenis, in Amer. Jour. Bot. 56: 806, 1969) and a host of other genera.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to. Mr. H. K. Airy-Shaw, Dr. R. C. Bakhuizen van den Brink, Jr., Dr. P. W. Leenhouts and Professor C. G. G. J. van Steenis for useful discussions, responsibility for the views expressed in this paper, however, is solely mine. I also like to thank the directors of the Singapore Botanic Gardens and the curators of the herbarium for the facilities provided, to Dr. C. X. Furtado for going through the Latin descriptions, to Dr. T. C. Whitmore for arranging a field trip to Pahang, Malaysia, to my wife, Mrs. Ro-siu Ling Keng for preparing two habit sketches, and to Mr. D. Teow for taking the photographs which are reproduced in the plates of this paper.

Mount Maquiling Bryoflora (Luzon)

By P. TIXIER*

Résumé L'auteur analyse ses récoltes personnelles faites au Mont Maquiling en 1965. Cette liste comprend 34 espèces de Mousses et 42 espèces et variétés d'Hépatiques. Il y a 16 Mousses nouvelles pour la station et une pour la Science. Les chiffres concernant les Hépatiques s'élèvent à 35 et 5 espèces et variétés nouvelles. Les espèces et variétés nouvelles sont: **Endotrichella maquilinensis; Cololejeunea pseudoschmidtii, C. haskarliana** var. **luzonensis** et var. **thermarum, C. selaginellicola,** et **C. armata.**

Summary The author analyses in this paper his collections from *Mt. Maquiling* of 1965. This list contains 34 species of Mosses and 42 species and varieties of the Liverworts. Of the mosses 16 are new for this hill station and one for science. Liverworts number 35 as novel records and new species and varieties 5. The species and varieties described here as new are:— **Endotrichella maquilinensis; Cololejeunea pseudoschmidtii, C. haskarliana** var. **luzonensis** and var. **thermarum, C. selaginellicola,** and **C. armata.**

This paper contains the list of the author's collections on Mt. Maquiling of 10th July 1965, consisting of numbers 1358 to 1457, a complete set of which is deposited at the "Laboratoire de Cryptogamie, Muséum National d'Histoire Naturelle" in Paris. The reader is reminded that Mt. Maquiling is a dead volcano, rising up to 1100 m, on the side of Laguna de Bay — the inland lake of central Luzon — at sixty kilometers from Manila. The annual rainfall at the College of Agriculture in Los Banos at the foot of the hills reaches 1930 mm annually for 179 rainy days (figure I). The botanical aspect of this hill station is renowned by the work of the great north American botanists early in the century: Merrill, Copeland and Elmer.

I acknowledge with thanks The South East Asia Treaty Organisation which permitted me to stay in The Philippines, and Dr. D. Umali, Dean of The College of Agriculture, who kindly gave the material for my collecting trip. In addition, I express my gratitude to Professor J. V. Pancho of the Applied Botany Department. From his experience and knowledge of the mountain I profited much when he guided us in the forest of the volcano. To Dr. C. X. Furtado, Botanist in Singapore, I am grateful for his corrections of the Latin diagnosis in this paper.

I MUSCI

1. *Fissidens sylvaticus* Griff. — Corticolous, no. 1435.

Thailand, Cambodia, Vietnam, Sumatra, Java, Celebes, Borneo, Hongkong, Bataan, Luzon (M.Q.).

2. *Leucoloma molle* (C. Muell.) Mitt. — On twigs and trunks, nos. 1410, 1443, 1444, 1436.

Widely distributed from Indo Malaya to Pacific Islands, Hawaii, China, Japan, Luzon (Maquiling and Mountain Province), Mindoro, Palawan, Mindanao.

3. *Dicranodontium uncinatum* (Harv.) Jaeg. — On twigs, no. 1403.

India, Thailand, Japan, Moluccas, Luzon (Benguet and Mt. Banahao).

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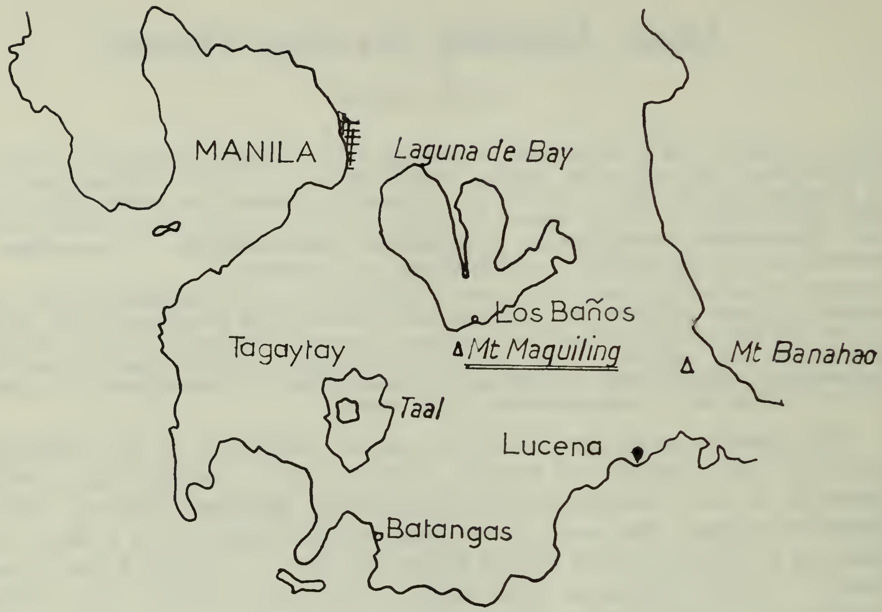
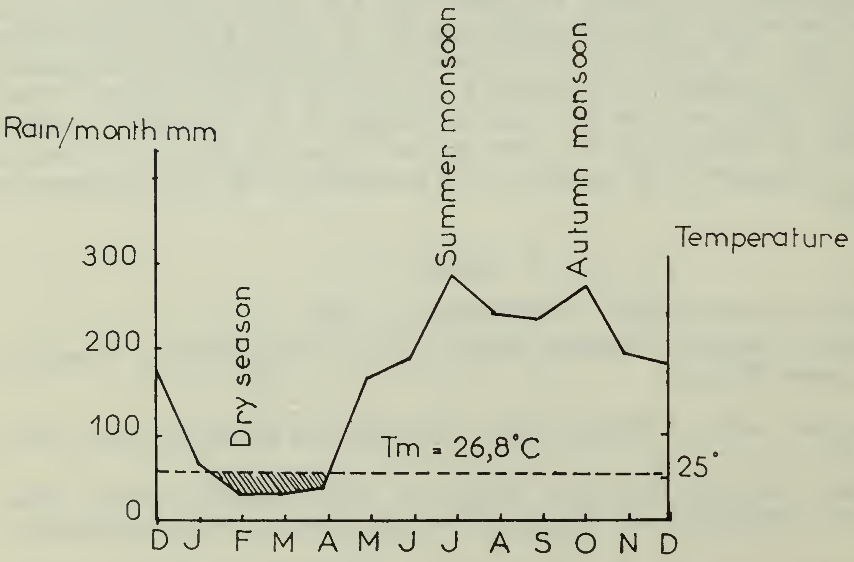


MANILA and surroundings



CLIMATOGRAM of LOS BAÑOS

Fig. I. Southern part of Luzon. Climatology of Los Banos.

4. *Leucobryum bowringii* Mitt. — Corticolous, nos. 1420, 1436.

Ceylon, Malaya, China, Japan, Formosa, Vietnam, Cambodia, Thailand, Bataan, Luzon, Sibuyan, Negros.

5. *Calymperes serratum* A. Braun — Corticolous, no. 1435.

Malaya, Eastern China, Vietnam, Cambodia, Thailand, Fiji, Samoa, New Caledonia, Luzon (MQ).

6. *Syrrhopodon tristichus* Nees ex Schwaegr. — On twigs, nos. 1416, 1420, 1424, 1425.

Ceylon, Sumatra, Java, Ambon, Borneo, Luzon, Negros.

7. *Macromitrium cuspidatum* Hampe — On trunks, nos. 1400 (c. fr.), 1410.

Sumatra, Cambodia, Java, Borneo, Luzon, Mindoro, Palawan.

8. *Macromitrium semipellucidum* Doz. & Molk. — On branches, nos. 1432 (c. fr.), 1433.

It is nearly impossible to separate *M. semipellucidum* from *M. pungens.* According to *Bryologica javanica* only one character is different i.e. the base of the leaf in *M. semipellucidum* is bordered with small cells.

Luzon, Panay, Mindanao, Vietnam, Cambodia, Sumatra, Borneo, New Guinea.

9. *Rhizogonium spiniforme* (Hedw.) Bruch — On trunks in low positions, nos. 1436, 1437.

Pantropical.

10. *Hypnodendron vitiense* Mitt. — Very common on trunks, in ridge forest, nos. 1430, 1443, 1446, 1447.

Fiji, Solomon Islands, Luzon (MQ), Negros, Mindanao.

11. *Mniodendron fusco-mucronatum* (C. Muell.) Broth. — On rocks, circa 600 m; nos. 1416, 1455.

Luzon, Negros, Biliran, Mindanao.

12. *Endotrichella maquilinensis* P. Tixier sp. nov. — On twigs, nos. 1400 (c. fr.), 1414, 1418 (c. fr.), 1424, 1425.

13. *Endotrichella compressa* (Mitt.) Broth. — On twigs, nos. 1400 (c. fr.), 1436.
Borneo, Luzon.

14. *Symphysodon subneckeroides* Broth. — On trunk, nos. 1424, 1400.

Sumatra, Java, Borneo, Panay, Luzon, Negros, Mindanao, New Caledonia.

15. *Aerobryopsis longissima* (Doz. & Molk.) Fleisch. var. *prostratula* (C. Muell.) Fleisch. — On twigs, nos. 1418, 1424, (c. fr.), 1399.

Luzon.

16. *Aerobryidium* cf. *filamentosum* (Hook.) Fleisch. — On twigs, no. 1403.

Near *A. filamentosum* by length and colour of leaves, differing only by shape of the cells. I also found this taxon in South Vietnam.

Nilghiries, Sikkim, Ceylon, Yunnan, Szechwan, Sumatra, Vietnam, Laos.

17. *Barbella* cf *clemensiae* Broth. — On trunks, nos. 1401, 1437.

Luzon.

18. *Himantocladium cyclophyllum* (C. Muell.) Fleisch. — On trunks, circa 700 m, no. 1455.

Java, Celebes, Borneo, New Caledonia, Tahiti, Luzon (MQ), Mindoro, Negros, Biliran, Mindanao, Basilan.

19. *Homaliodendron flabellatum* (Sm.) Fleisch. — On trunk, no. 1457.

India, Ceylon, Japan, Malaya to Hawaii Islands, Philippines, New Caledonia, Indochina.

20. *Pinnatella* cf. *ambigua* (Bosch. & Lac.) Fleisch. — no. 1435.

This small plant, 1 cm high, may be allied to *P. nana* (Williams) Fleisch. Bhotan, Burma, Sumatra, Java, Thailand, Luzon, Palawan, Negros, Mindanao.

21. *Eriopus microblastus* Broth

Very small specimen, epiphytic on *Clastobryum cuculligerum*. The drawing of Bartram is correct but it seems better to follow Brotherus and to separate *E. microblastus* from *E. parviretus*. The denticulation of the edge is, in the former species, denser, no. 1409.

Luzon, Negros.

22. *Chaetomitrium perarmatum* Broth. — On twigs, nos. 1408, 1411, 1414, 1415.

Mountain Province, Apayo district (Luzon).

23. *Thuidium glaucinum* (Mitt.) Bosch. & Lac. — On twigs, no. 1400.

Himalaya, Southern India, Ceylon, Thailand, Cambodia, Vietnam, Japan, Luzon (MQ), Negros.

24. *Clastobryum cuculligerum* (Lac.) P. Tixier — Whitish mat on twigs, nos. 1409, 1412 (c. fr.), 1416 (c. fr.).

Java, Thailand, Cambodia, Vietnam, Luzon (Benguet), New Guinea, New Caledonia.

25. *Trismegistia calderensis* (Sull.) Broth. — nos. 1441, 1444.

Sumatra, Malaya, Luzon (MQ).

26. *Acanthocladium piliferum* (Broth.) P. Tixier **comb. nov.**

Syn.: *Acanthocladium longipilum* Broth. Beih. Bot. Centralbl. 28, 2, (1909), 361.
Raphidostichum eberhardtii (Thér. & Varde) Broth. Nat. Pfl. 2, 11, (1925), 434.
Raphidostichum luzonense Broth. Nat. Pfl., 2, 11, (1925), 435.
Raphidostichum piliferum (Broth.) Broth. Nat. Pfl., 2, 11, (1925), 434.

On twigs and trunk, nos. 1426, 1445.

Species of variable size, distributed from Thailand to Philippines.

27. *Warburgiella cupressinoides* C. Muell. — On branches, nos. 1413, 1421.

Luzon, Panay, Mindanao, New Caledonia.

28. *Acroporium diminutum* (Brid.) Fleisch. — On twigs. nos. 1416, 1420.

Sumatra, Java, Malaya, Luzon (MQ), Mindanao, Moluccas.

29. *Acroporium hermaphroditum* (C. Muell.) Fleisch. — On trunk, no. 1455.
Thailand, Sumatra, Java, Celebes, Moluccas, New Guinea, New Caledonia, Luzon (MQ), Mindanao.

30. *Acroporium secundum* (Reinw. & Hornsch.) Fleisch. — On trunks and twigs, nos. 1402, 1425, 1426, 1440, 1446, 1454.
Java, Sumatra, Borneo, Celebes, Ceram, Luzon (MQ); Negros, Mindanao.

31. *Ectropothecium buitenzorgii* (Bel.) Jaeg. — On twigs and trunks, nos. 1413, 1438.
Widely distributed in South East Asia.

32. *Ectropothecium falciforme* (Doz. & Molk.) Jaeg. — On trunk and twigs, nos. 1413, 1426, 1442, 1444, 1448.
Luzon, Panay, Negros, Sumatra, Java, Lombok, Borneo, Celebes.

33. *Ectropothecium ichnotocladum* (C. Muell.) Jaeg. — On trunk, no. 1398.
Luzon (MQ), Bohol, Mindanao, Sumatra, Java, Borneo, Celebes, Ambon, Vietnam, New Caledonia.

34. *Isopterygium albescens* (Hook.) Jaeg. — Twigs, nos. 1415, 1419, 1436.
India and Indochina, Malesia, Japan, Pacific Islands.

II HEPATICAE

1. *Metzgeria furcata* (L.) Dum. — Epiphyllous, no. 1370.
Cosmopolitan.

2. *Chiloscyphus communis* St. — On trunk in low position, no 1436.
Assam, Vietnam, Cambodia, Sikkim, Japan, Java, Borneo, Queensland, Luzon (MQ).

3. *Schistochila aligera* Nees & Bl. — On trunk, nos. 1443, 1447.
Java, Sumatra, Moluccas, New Hebrides, Nicobar, Borneo, Ambon, Philippines, Samoa, Vietnam, Thailand.

4. *Lepidozia* cf. *subintegra* Ludg. — no. 1439.
South East Asia.

5. *Herberta* cf. *minima* Horik. — On trunk, very poor specimen, no. 1445.
Formosa.

6. *Trichocolea pluma* Mont. — no. 1446.
Cosmopolitan.

7. *Radula anceps* Lac. — Epiphyllous, no. 1378.
Java, Luzon, New Caledonia.

8. *Radula borneensis* St. — Epiphyllous on *Selaginella* sp. no. 1359.
Southern India, Borneo, Vietnam, Cambodia.

9. *Archilejeunea mariana* (G.) St. — Epiphyllous, no. 1445.
Formosa, Botel Tobago, Thailand, Sumatra, Java, Sarawak, Philippines, Celebes, New Guinea, Mariannas, New Caledonia, Solomon Islands, Tahiti.

10. *Ceratolejeunea maritima* St. — On twigs, corticolous, no. 1409.
Carribean region.

11. *Cheilolejeunea* (*Xenolejeunea*) *ceylanica* (G.) Schust. & Kachr.
Epiphyllous, no. 1405.
Tropical Asia, Ceylon, Pulau Penang, Ambon, New Guinea, Formosa, Vietnam, Cambodia.

12. *Cololejeunea floccosa* (*Taeniolejeunea*) (L. & L.) St.
Epiphyllous, no. 1395.
Japan, Ryukyu, Formosa, China, Philippines, Borneo, Java, Sumatra, Vietnam, Chittagong, Thailand, Cambodia, Laos, Tanzania.

13. *Cololejeunea gynophthalma* (Taeniolejeunea) Bx. — Epiphyllous, no. 1396.
Sumatra, Java, Vietnam, Cambodia, Malaya.

14. *Cololejeunea maquilinensis* (Taeniolejeunea) P. Tixier — Epiphyllous, no. 1394. Endemic.

15. *Cololejeunea pseudoschmidtii* (Globigerae) P. Tixier **sp. nov.**
Epiphyllous, no. 1394 (TYPE).

16. *Cololejeunea hispidissima* (St.) P. Tixier **comb. nov.** (Syn.: *Leptocolea hispidissima* St. Spec. Hep., VI, 243, 1923). Epiphyllous, no. 1394.

17. *Cololejeunea haskarliana* (G.) Bx. var. *luzonensis* **var. nov.** Epiphyllous, no. 1375.

18. *Cololejeunea haskarliana* (G.) Bx. var. *thermarum* **var. nov.** Epiphyllous, no. 1377.

19. *Cololejeunea selaginellicola* (Venustae) P. Tixier **sp. nov.**
Very common, epiphyllous, no. 1383.

20. *Cololejeunea armata* (Venustae) P. Tixier **sp. nov.** — Epiphyllous no. 1383.

21. *Cololejeunea flavicans* (Lasiolejeunea, latebrosae) (St.) Mizutani. Epiphyllous, nos. 1360, 1362.
Endemic of Luzon.

22. *Cololejeunea* aff. *nymanii* (Lasiolejeunea, latebrosae) (St.) Bx. — Epiphyllous, nos. 1364, 1397.
Sumatra, Java, Borneo, New Guinea, Thailand, Vietnam, Cambodia.

23. *Cololejeunea panchoana* (Lasiolejeunea, latebrosae) P. Tixier — Epiphyllous, no. 1358.

24. *Cololejeunea vulcania* (Lasiolejeunea, latebrosea) P. Tixier — Epiphyllous, no. 1392.

25. *Cololejeunea* aff. *yulensis* (Lasiolejeunea, latebrosae) (St.) Bx. Epiphyllous, nos. 1361, 1363, 1368, 1384, 1388.
Malaya, Sumatra, Java, Borneo, New Guinea, Cambodia, Vietnam.

26. *Colura acutifolia* S.J.A. — Epiphyllous, no. 1397.
Borneo, Sumatra, Chittagong, Thailand, Vietnam.

27. *Drepanolejeunea bakeri* Herz. — Very common on the leaves. Endemic of Philippines, known also of Mt. Polis in Mountain Province.

28. *Drepanolejeunea dactylophora* (Nees) Spruce ex Herz. — Epiphyllous, no. 1383.
Luzon, Mindanao, Malaya, Java, Ambon.

29. *Lejeunea flava* (Sw.) Nees. — Corticolous.
Tropical Asia and Oceania.

30. *Leptolejeunea foliicola* St. — Epiphyllous no. 1360.
Malaya, Sumatra, Java, Vietnam, Cambodia.

31. *Leptolejeunea schiffneri* Herz. — Epiphyllous, no. 1446.
Andaman, Malaya, Sumatra, Java, Borneo, Celebes, Moluccas, Philippines.

32. *Lopholejeunea applanata* (R.B.N.) St. — Epiphyllous, no. 1446.
Java, Ryukyu, China, Japan, Borneo, Sumatra.

33. *Lopholejeunea subfusca* (Nees) St. — Corticolous, no. 1401.
Japan, Ryukyu, India, Ceylon, Malaya, Sumatra, Java, Borneo, Philippines, New Guinea, New Caledonia, Northern and Southern America, Africa.

34. *Microlejeunea cucullata* (Nees) St. — Epiphyllous, no. 1339.
Tropical Asia and Oceania.

35. *Ptychocoleus cumingianus* (Mont.) Trev. — Corticolous, no. 1435.
Andaman, Nicobar, Sumatra, Singapore, Malaya, Java, Borneo, Philippines, Indochina, Celebes, Ambon, New Guinea, Queensland, Marquesas, Samoa, Tahiti, Caroline Islands.

36. *Pycnolejeunea bidentula* St. — Epiphyllous, s.n.
Vietnam, Formosa, Ryukyu, Java, Borneo, Philippines, New Guinea, Fiji.

37. *Pycnolejeunea eximia* S.J.A. & Tixier — Corticolous, no. 1432.
Close to *P. fitzgeraldii* St.
Vietnam, China.

38. *Stenolejeunea apiculata* (G.) Schuster — Epiphyllous, no. 1360, 1388.
Formosa, Central Vietnam, Java, Cambodia, New Caledonia.

39. *Frullania apiculata* Verd. — Epiphyllous, no. 1435.
Ceylon, Indo-Malaya to Philippines, Moluccas, New Guinea.

40. *Frullania integristipula* (Nees) Nees. — On trunk, 530 m. alt. no. 1433.
Java, Malaya, Philippines.

41. *Frullania squarrosa* (R.B.N.) Dum. — Corticolous, no. 1435.
Pantropical.

42. *Frullania ternatensis* G. — Corticolous, no. 1378, 1424.
Malaya, Ceylon, Sumatra, Java, Vietnam, Borneo, Celebes, Ternate, Bataan, Philippines.

III DESCRIPTION OF NEW SPECIES

Endotrichella maquilinensis *sp. nov.* (Fig. II).

Plantae caespitosae, caules flavi, usque ad 4 cm alti, apice divisi. Folia caulina enervia, elongata, acuminata, 4–5 mm longa, 1.2 cm lata, in parte basilari leviter plicata, apice paucidentata, auricula relative parva. Cellulae apicales pariete incrassatae, 100 μ longae, 10μ latae; marginales 80 × 10 μ; centrales 90–100 μ × 10–15 μ; alares scutulatae, quadrataeve, 20–30 μ × 10–15 μ. Folia apicalia cum propagulis, pariete aurantiacea, 1–1.6 mm longa, 20 μ lata. Fructus proprius generis; seta 0.8 mm longa; theca ovalis, elongata, 2 mm longa, 0.8 mm lata. Bracteae perichaetiales usque ad 2.5 mm.

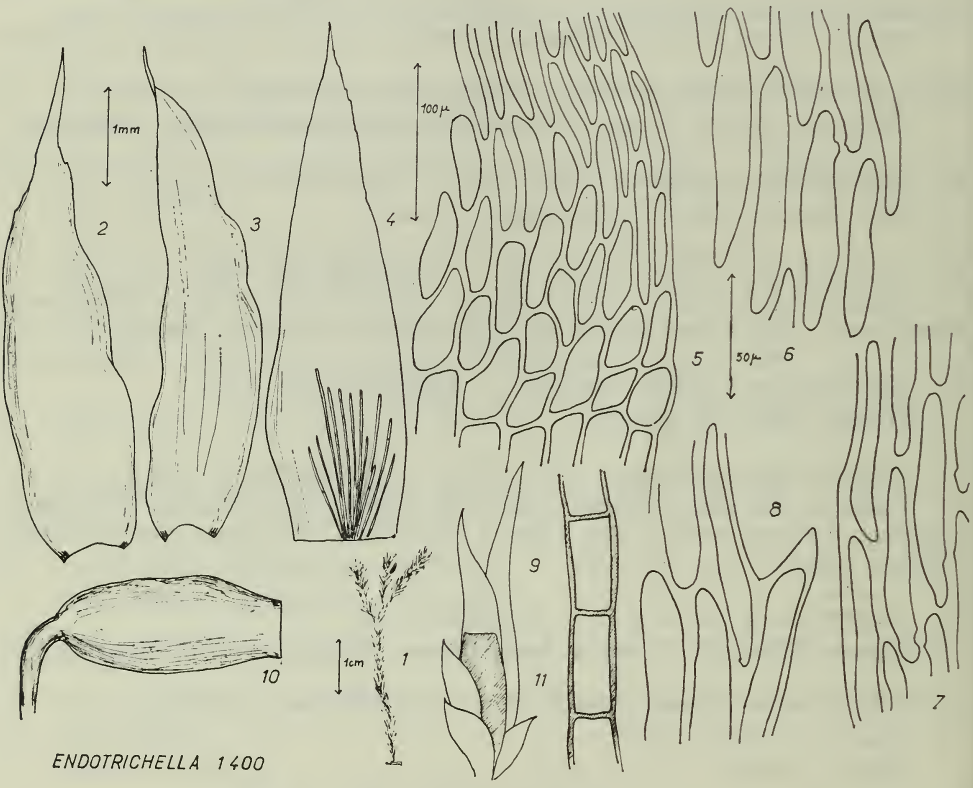


Fig. II. *Endotrichella maquilinensis* sp. nov.
1: Habit; *2–3:* Leaves; *4:* Leaf with propagules; *5:* Auricle; *6:* Leaf cells; *7:* Edge cells; *8:* Denticulate apex; *9:* Female inflorescence; *10:* Capsule.

Plant epiphytic up to 4 cm tall, branched at the top, light yellow. Stem leaves without veins, elongated, acuminate, with some folds in the basal part of the leaf. Apex with some teeth. Auricle relatively small. Cells in apex with thick walls, 100 μ long, 10 μ wide; cells of the edge 80 × 10 μ; cells of the central part 90–100 μ × 10–15 μ. Auricle cells lozenge-shaped to rectangular 20–30 μ long, 10–15 μ wide. Leaves of the top of the stem bearing propagules with orange coloured cell walls, multicellular, 1–1.6 mm long 20μ wide. Fructification characteristic of the genus, seta 0.8 mm long. Ripe capsule horizontal, 2 mm long and 0.8 mm wide, oval, elongated. Perichaetial bracts up to 2.5 mm.

Species very different from all those reported by Bartram in Mosses of Philippines and in his subsequent papers. Characterized by the elongated shape of leaves and the edge entire almost up to the apex. Resembles *E. dimorphophylla* Tx. from South Vietnam.

THE COLOLEJEUNEA COMPLEX

We now arrive at a group of 6 taxa. The first is *Cololejeunea hispidissima* (St.) Tx. conformable to the type of Stephani. Benedix, in 1953, rendered intricate the question by putting together in synonymy, under the name *Cololejeunea haskarliana* (G.) Bx., taxa which are evidently different. Mizutani, in 1961, reported that *C. venusta* Lac. was unlike *C. haskarliana* (G.) Bx. sensu lato because the Sande Lacoste's species has papillous lobule cells. In Maquiling forest the author observed the sympatry of the taxa allied to *Cololejeunea haskarliana* in the locality and sometimes on the same leaf. In Tjibodas (Java) up to 4 different taxa on one leaf were collected. The author intends to return to this problem.

The following three taxa are allied to *Cololejeunea haskarliana: Cololejeunea pseudoschmidtii* is related to the Section Globigerae of Benedix, *Cololejeunea selaginellicola* and *Cololejeunea armata* to Section Venustae of Mizutani.

Cololejeunea pseudoschmidtii *sp. nov.* (Fig. III).

Planta dioica, parva, pallide virens, sicca, ad substratum appressa. Caules usque 0.5 cm longi, 0.10 mm crassi, cum foliis 1.4 mm lati. Folia inter se 0.2 mm distantia. Lobus obovalis, 0.9 mm longus, 0.5 mm latus. Cellulae basalis intermedio leviter incrassatae 20–40 μ longae, 15–20 μ latae haud papillosae; marginales quadratae hexagonales, 10–20 μ longae, 10–15 μ latae, cum papillis humilibus. Lobulus elongatus, inflatus, 0.25 mm longus, 0.15 mm latus, papillosus ad carenam.

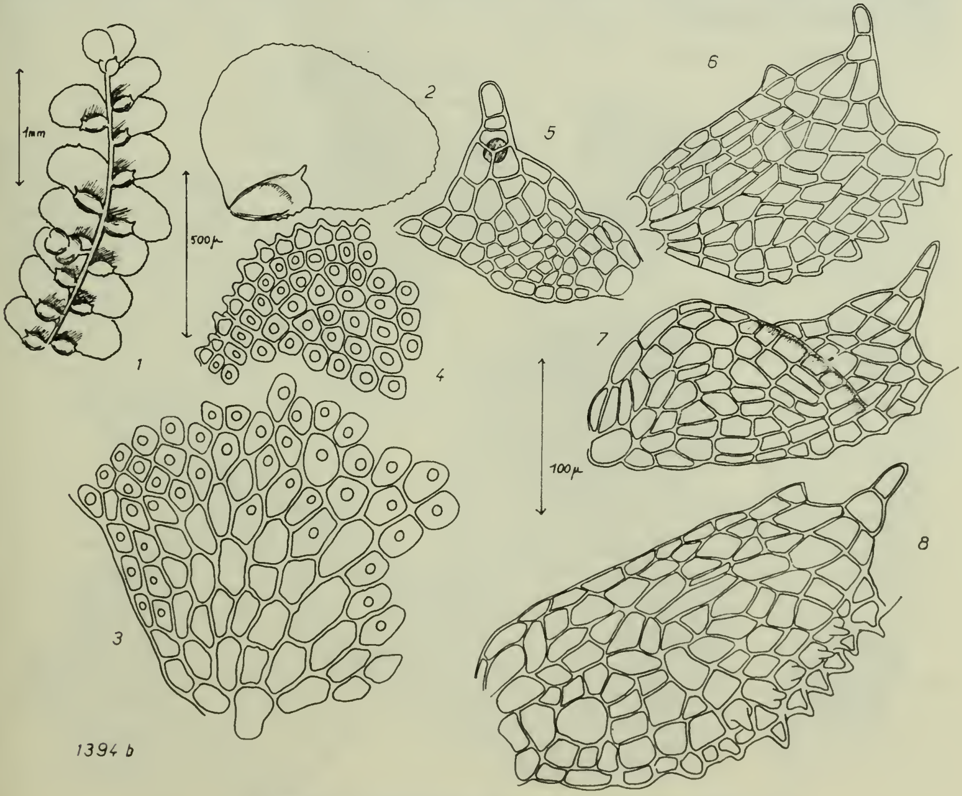


Fig. III. *Cololejeunea pseudoschmidtii* sp. nov.

1: Stem; *2:* Leaf; *3:* Basal part of the lobe; *4:* Edge of the lobe; *5:* Young lobule; *6–8:* Mature lobule.

Dens apicalis parvus, triangulari-unicellulatus. Dens medianus cum cellules in 3 series dispositis, una serie, duabus alteris unicellulatus. Papilla hyaline sphaerica, sub dente media 20 μ in diametro. Stylus haud visus. Androecia lateralia, 0.3 mm alta, bracteis 2-jugis.

Plant dioic, small, light green, applied to the substrate. Stem 0.5 cm long, 0.10 mm thick, with leaves 1.4 mm wide. Rhizoids hyaline. Leaves spaced on stem at 0.2 mm. Lobe oboval, 0.9 mm long, 0.5 mm wide. Basal cells with light intermediate thickenings 20–40 μ long, 15–20 μ wide, apapillose. Edge cells rectangular to hexagonal, 10–20 μ long, 15–20 μ wide with a low papilla thickened at the top similar to those of *C. schmidtii*. Lobule elongated, inflated on mature leaves, 0.25 mm long, 0.15 mm wide, sometimes papillose near the keel. Apical tooth weak, reduced to a triangular cell. Median tooth with 3 tiers of cells, one with 3 cells, the others with one cell only. Papilla hyaline, spheric, below the median tooth, 20 μ in diameter. Male inflorescence lateral with 2 tiers of fertile bracts, 0.3 mm high.

Cololejeunea hispidissima (St.) P. Tixier *comb. nov.* (Fig. IV).

Small plant, light green, applied on substrate. Stem to 0.5 cm or more, 0.07 mm thick, with leaves 1.2 mm wide. Rhizoids hyaline. Leaves spaced at 0.25 mm. Lobe oval, trapeziform, 0.5 mm long, 0.4 mm wide. Basal cells making a short *pseudo-vitta,* cells 20–70 μ long, 10–35 μ wide with a slight papilla. Cells of the edge more or less isodiametric, with thin walls, 10–20 μ × 10–16 μ with cylinder-shaped papillae.

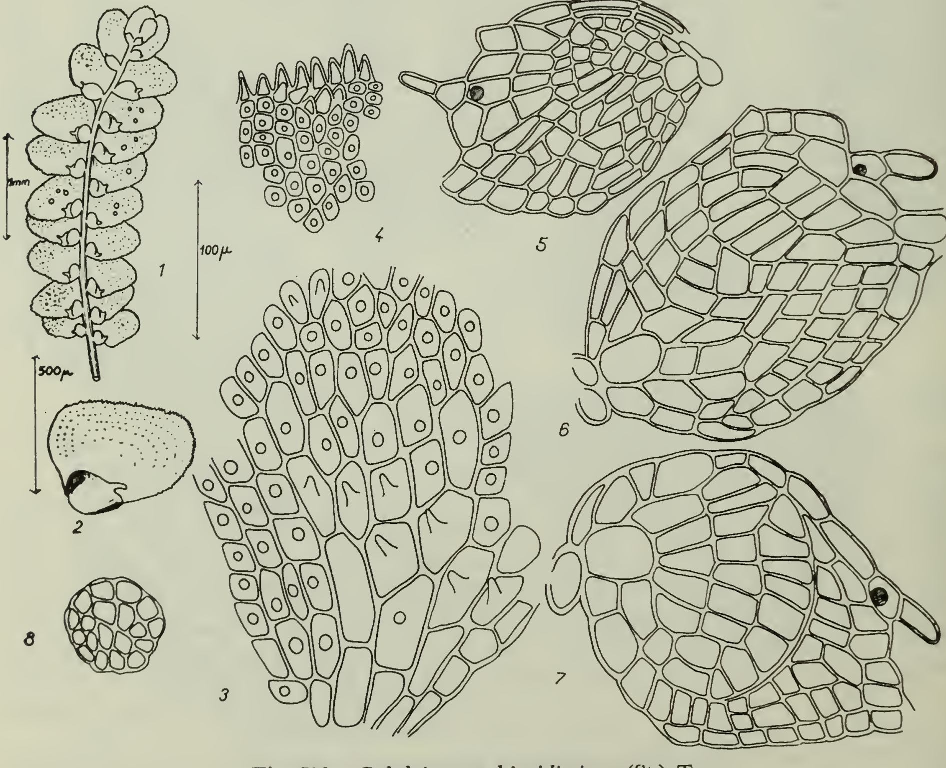


Fig. IV. *Cololejeunea hispidissima* (St.) Tx.
1: Stem; *2:* Leaf; *3:* Basal part of the lobe; *4:* Edge of the lobe; *5:* Young lobule; *6 & 7:* Mature lobule; *8:* Propagule.

Lobule inflated, rounded, 0.25 mm long, 0.25 mm wide, keel without papillae. Apical tooth present on the young leaf, missing on the mature ones. Median tooth with 2 cells, young erect, repelled on the inferior edge.

Hyaline papillae spheric, 10 μ in diameter, under the first cell of median tooth. Fugaceous stylus 16 μ high and 10 μ wide. Propagules discoidal with 20 cells and 65 μ in diameter. Fructification unknown.

Cololejeunea haskarliana (G.) Bx. var. **luzonensis** *var. nov.* (Fig. V).

Planta dioica, parva, pallida, ad substratum appressa. Caules 0.5 cm longi, 0.07 mm crassi, cum foliis 1.1 mm lati. Rhizoidea hyalina. Folio inter se 0.2 mm distantia. Lobus subtriangularis, 0.5 mm longus, 0.4 mm latus. Cellulae basales in pseudo-vitta 30–40 μ longae, 30–15 μ latae, cum papilla crassa usque ad 25 μ altae, marginales parvae, 10–15 μ in diametro, papillosae. Lobulus ovalis 0.2 mm longus, 0.15 mm latus, carina papillosa. Dens apicalis unicellularis, dens medinus cellula arcuata, latere externo lobuli locata. Una cellula e dente medio usque ad marginem posticum. Papilla hyalina subsphaerica, 10 μ in diametro. Stylus bicellularis, 40 μ altus, 10 μ latus. Propaguli disciformes, in statu 12 cellulares, 50 μ in diam. Capitula feminea 0.4 mm alta. Bracteae florales cum lobo 0.4 mm longo, 0.15 mm lato, et lobulo 0.3 mm longo, 0.10 mm lato. Perianthia 0.3 mm alta, 0.2 mm lata.

Dioic plant, small, light green, applied on substrate. Stem 0.5 cm long, 0.07 mm thick, with leaves of 1.1 mm wide. Rhizoids hyaline. Leaves spaced on stem at 0.2 mm. Lobe subtriangular, 0.5 mm long, 0.4 mm wide. Basal cells making a *pseudo vitta,* cells 30–40 μ long and 30–15 μ wide with a strong papilla

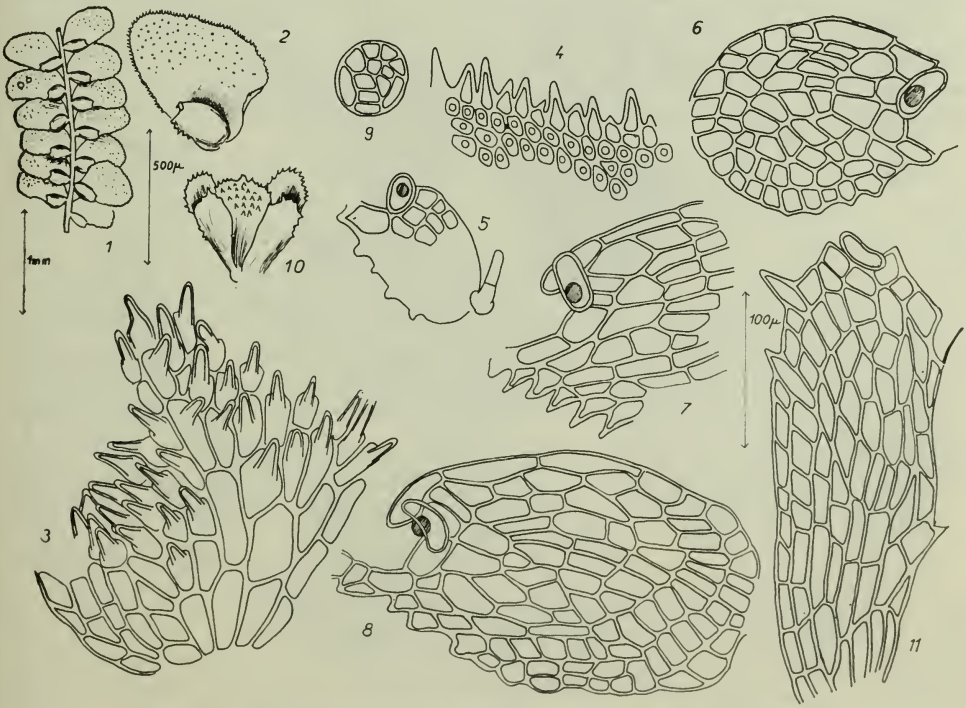


Fig. V. *Cololejeunea haskarliana* Bx var. *luzonensis* var. nov.

1: Stem; *2:* Leaf; *3:* Basal part of the lobe; *4:* Edge of the lobe; *5:* Young lobule; *6–8:* Lobule; *9:* Propagule; *10:* Perianth; *11:* Lobule of the perianthal bract.

up to 25 μ tall. Cells of the edge, small, more or less isodiametric, 10–15 μ in diameter, papillose on the edge of leaf. Lobule oval, 0.2 mm long, 0.15 mm wide papillose on the keel. Apical tooth unicellular, median tooth of one, arc shaped cell lying on the external face of lobule. One cell between the median tooth and the keel. Papillae spheric, hyaline, 10 μ in diameter, stylus bicellular, 40 μ high, 10 μ wide.

Young (?) propagules, 50 μ in diameter and with 12 cells. Female inflorescence 0.4 mm high. Perianthal bracts with a lobe 0.4 mm long, 0.15 mm wide and the lobule 0.3 mm long and 0.10 mm wide. Perianth shorter than perianthal bracts, piriform, 0.3 mm high, 0.2 mm wide.

Cololejeunea haskarliana (G.) Bx. var. **thermarum** *var. nov.* (Fig. VI).

Planta dioica, parva, pallide virens, ad substratum appressa. Caules usque 0.5 cm longi, 0.07 mm crassi, cum foliis 1 mm lati. Rhizoidea hyalina. Folia inter se 0.2 mm distantia. Lobus subtriangularis, 0.4 mm longus, 0.4 mm latus. Cellulae basales in pseudo-vitta, 30–60 μ longae, 15–30 μ latae cum papilla humili (10 μ alta): marginales parvae, 10–20 μ × 10–15 μ metientes. Papillae per tutam marginem. Dens apicalis unicellularis, triangularis, pariete hyalinis. Dens medinus unicellularis, rotundatus cum dente medinus decussatus: 1 cellula unter dentem medianum et marginem posticum. Papilla hyalina subsphaerica, 25 μ in diametro. Stylus unicellularis, 30 μ altus, 10 μ latus. Capitula feminea 0.5 mm alta. Bracteae florales cum lobo 0.5 mm longo, 0.25 mm lato, et lobulo 0.3 mm longo, 0.15 mm lato. Perianthia piriformia, inflata, 4 plicata, 0.5 mm alta, 0.3 mm lata.

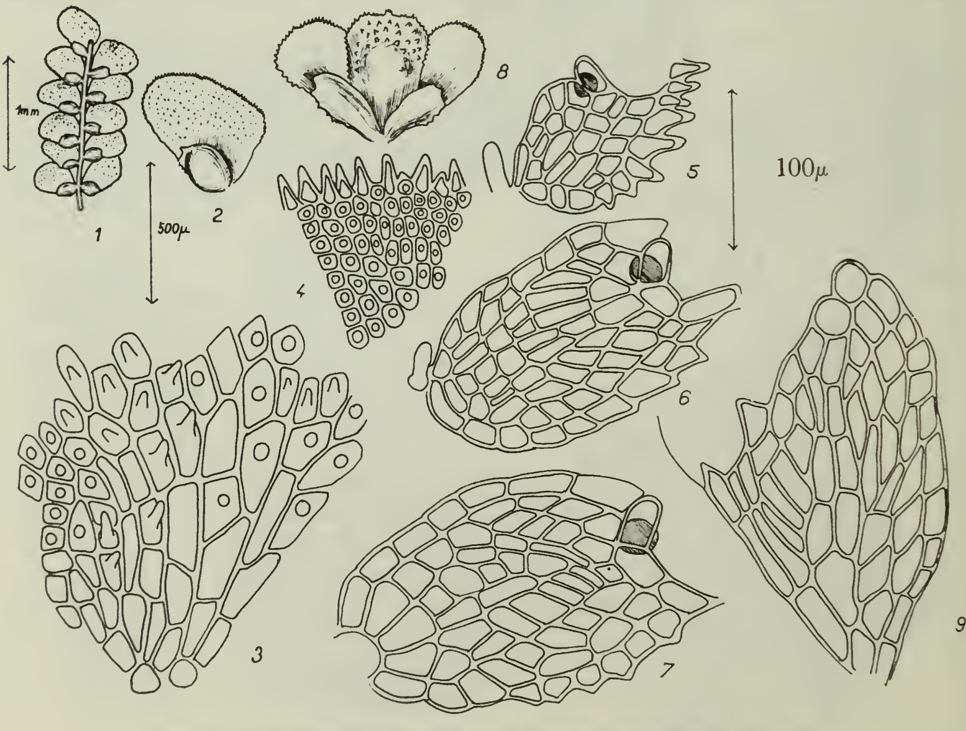


Fig. VI. *Cololejeunea haskarliana* Bx var. *thermarum* var. nov.

1: Stem; *2:* Leaf; *3:* Basal part of the lobe; *4:* Edge of the lobe; *5:* Young lobule; *6 & 7:* Lobule; *8:* Perianth; *9:* Lobule of the perianthal bract.

Small dioic plant, light green, applied on substrate. Stem to 0.5 mm long, 0.07 mm thick, with leaves 1 mm wide. Rhizoids hyaline. Leaves spaced on stem at 0.2 mm. Lobe subtriangular, 0.4 mm long and 0.4 mm wide. Basal cells making a *pseudo-vitta*, cells 30–60 μ long and 15–30 μ wide with a low papilla 10 μ high. Edge cells small, more or less isodiametric, 10–20 μ long, 10–15 μ wide. Edge papillose on almost all the periphery. Oval lobule, keel lightly papillose, 0.2 mm long, 0.15 mm wide. Apical tooth triangular with hyaline walls. Median tooth unicellular, crossed with apical tooth. One cell between the median tooth and the edge. Papillae hyaline, spheric, 25 μ in diameter. Stylus unicellular, 30 μ high, 10 μ wide. Female inflorescence 0.5 mm long, perianthal bracts with a lobe 0.5 mm long, 0.25 mm wide and a lobule 0.3 mm long, 0.15 mm wide. Perianth piriform, inflated, with 4 folds, 0.5 mm high, 0.3 mm wide.

Near to the preceding species, differing by the ornamentation of leaf cells, the disposition of the lobule teeth, the shape of the papillae and the perianthal bracts.

Cololejeunea selaginellicola *sp. nov.* (Fig. VII).

Planta dioica, parva, pallide virens, ad substratum appressa. Caules usque ad 0.6 cm longi, 0.10 mm crassi, cum foliis 1 mm lati. Rhizoidea hyalina. Folia 0.2 mm inter se distantia. Lobus ovalis, 0.6 mm longus, 0.25 mm latus. Cellulae basales 30–60 μ longae, 15–20 μ latae, papillosae; marginales, pariete incrassatae rotundatae 10–15 μ in diametro, cum papillis altis conicis. Lobulus magnus 0.25 mm longus, 0.15 mm latus, papillosus usque ad $\frac{1}{3}$ latitudinis. Margo superior lobuli cum uniseriatis cellulis hyalinais dens apicalis magnus, unicellularis, triangularis, parietibus hyalinis. Dens medianus unicellularis, sphaericus, 2 cellulis usque ad marginem posticum. Papilla hyalina parva sphaerica 7–10 μ in diametro. Stylus tricellularis, 40 μ longus, 10 μ latus. Capitula feminea 0.8 mm alta. Bracteae cum lobo 0.6 mm alto, 0.25 mm lato, et lobulo 0.45 mm longo, 0.08 mm lato, apice acuminato. Perianthia piriformia, 4 plicata, rostro notato, 0.8 mm alta, 0.5 mm lata.

Dioic, small species, light green, applied on substrate. Stem to 0.5 cm long and more, 0.10 mm thick, with leaves 1 mm wide. Rhizoids hyaline. Leaves spaced on stem at 0.2 mm. Lobe oval, 0.6 mm long, 0.25 mm wide. Basal cells 30–60 μ long, 15–20 μ wide, papillose. Lobule large, 0.25 mm long, 0.15 mm wide with an angle between the keel and the edge of the leaf. Lobule papillose, up to $\frac{1}{3}$ its width. Superior edge of lobule with a row of hyaline cells finishing with an apical, unicellular tooth, triangular, large, thin-walled. Median tooth reduced to a spheric cell; 2 cells between the median tooth and the edge. Papillae hyaline, small, spheric, 7–10 μ in diameter. Stylus tricellular, 40 μ long 10 μ wide.

Female inflorescence 0.8 mm high. Perianthal bracts with a lobe 0.6 mm long, 0.25 mm wide and a lobule 0.45 mm long, 0.08 mm wide with an acute top. Perianth piriform with 4 folds and a strong beak, 0.8 mm high, 0.5 mm wide.

Cololejeunea armata *sp. nov.* (Fig. VIII).

Planta dioica, parva, pallide virens, ad substratum appressa. Caules 0.5 cm, 0.06 mm crassi, cum foliis 0.6 mm lati. Folia 0.15 mm inter se distantia. Lobus ovalis, magis aut minus arcuatus, 0.4 mm longus, 0.25 mm latus. Cellulae basales, pariete pauciter incrassatae, 20–30 μ longae, 10–17 μ latae, papillosae; marginales rotundatae 10 μ in diametro. Lobulus rotundatus 0.15 mm longus, 0.10 mm latus, papillosus praeter ad basin. Margo superior lobuli cum cellulis hyalinis uniseriatim dispositis usque ad dentem apicalem ipsam hyalinam. Dens medianus, bicellularis

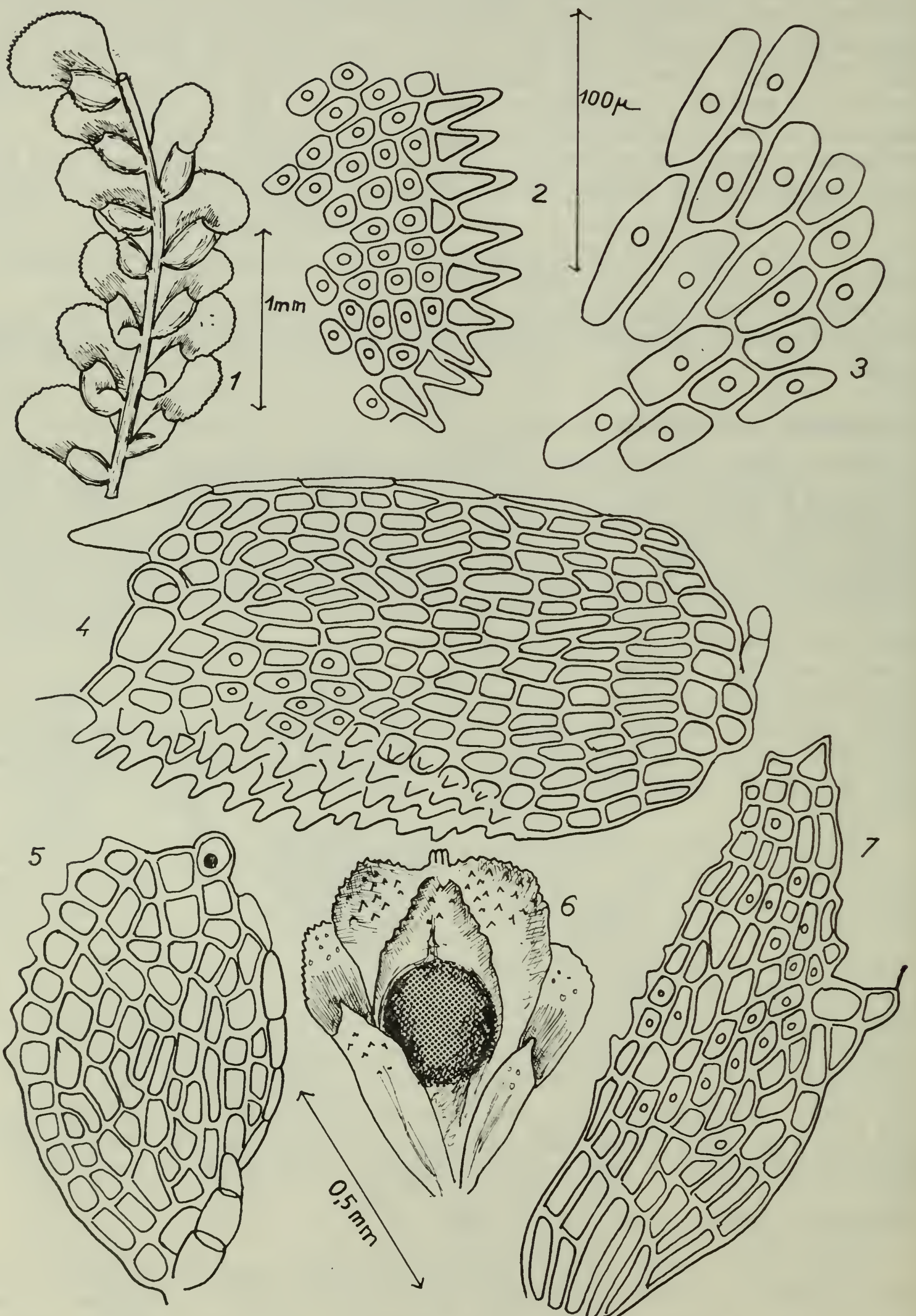


Fig. VII. *Cololejeunea selaginellicola* sp. nov.

1: Stem; *2:* Edge of the lobe; *3:* Basal cells of the lobe; *4:* Lobule; *5:* Young lobule; *6:* Perianth; *7:* Lobule of perianthal bract.

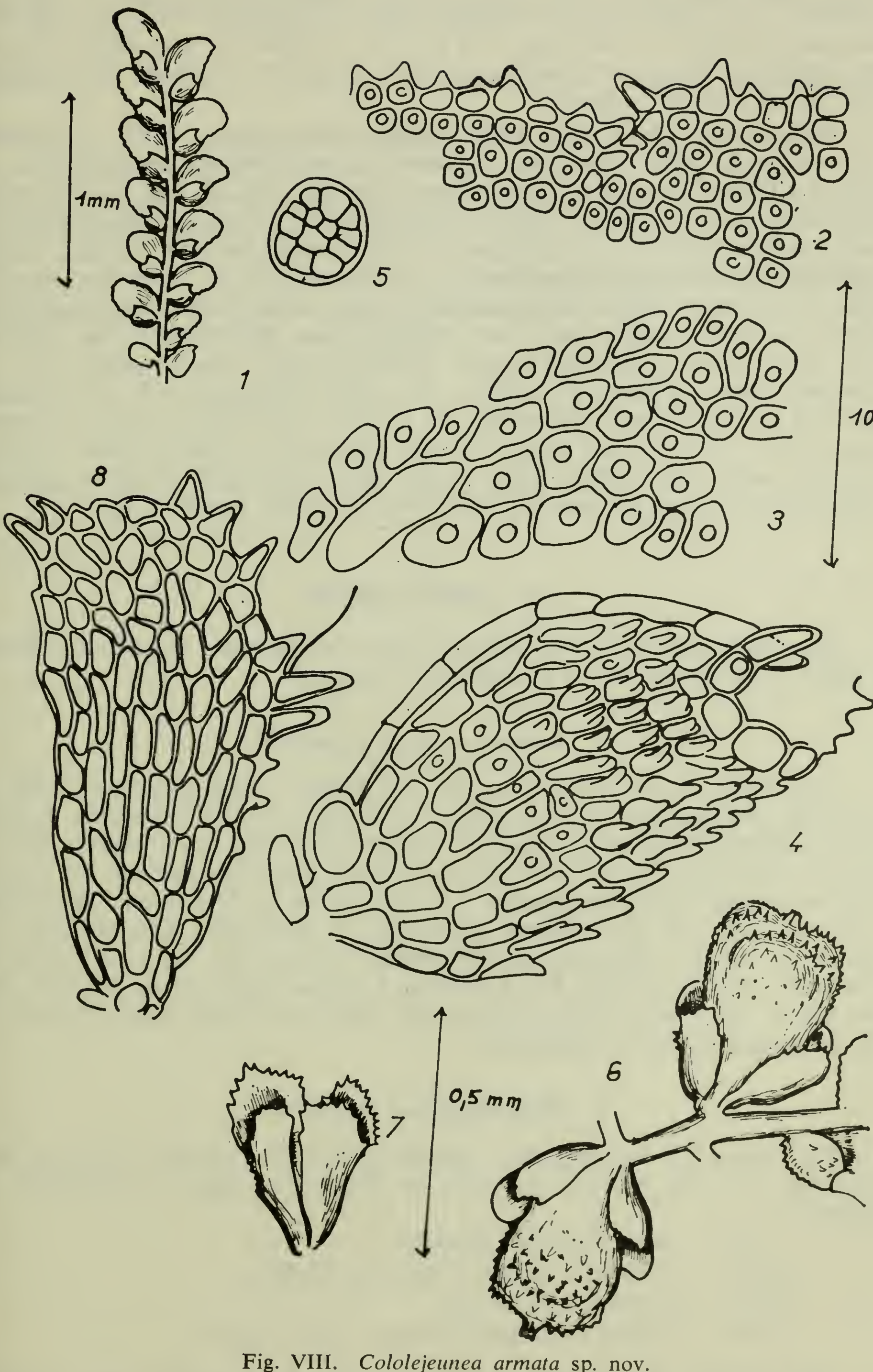


Fig. VIII. *Cololejeunea armata* sp. nov.

1: Stem; *2:* Edge of the lobe; *3:* Basal cells of the lobe; *4:* Lobule; *5:* Propagules; *6:* Perianth; *7:* Perianthal bract; *8:* Lobule of the perianthal bract.

decussatus cum dente apicali. Papilla hyalina, parva, sphaerica, 10 μ in diametro. Stylus cylindratus, 30 μ altus, 10 μ latus. Propaguli disciformes, in statu 12 cellulares, 40 μ diam. Capitula feminea magis aut minus lateralis, 0.4 mm alta. Bracteae cum lobo, 0.4 mm longo, 0.18 mm lato, et lobulo 0.3 mm longo, 0.10 mm lato, margine crenulato. Perianthia piriformia, rotundata, 4 plicata, 0.4 mm alta, 0.25 mm lata, rostro notato.

Dioic, small plant, light green, applied on substrate. Stem to 0.5 cm, 0.06 mm thick, width with leaves 0.6 mm. Rhizoids hyaline. Leaves spaced on stem at 0.15 mm. Lobe oval, more or less arc shaped, 0.4 mm long and 0.25 wide. Basal cells with thick walls, 20–30 μ long and 10–17 μ wide; papillose edge with isodiametric cells about 10 μ in diameter, with a papilla low and cylindric. Lobule rounded, 0.15 mm long, 0.10 mm wide, papillose except in the basal part. Superior edge with a row of hyaline cells finishing in apical tooth cell, hyaline, thickwalled. Median tooth of 2 cells, crossed with the apical one. The apical border of lobule from apical tooth to keel arc shaped. Papillae hyaline, small, spheric 10 μ in diameter. Stylus cylindric, 30 μ high, 10 μ wide. Propagules, 40 μ in diameter and with 12 cells. Female inflorescence on the lateral side, 0.4 mm high. Perianthal bracts with a lobe 0.4 mm long, 0.18 mm wide and a lobule 0.3 mm long and 0.10 mm wide, the superior edge of the lobule crenulated. Piriform perianth, rounded with 4 folds 0.4 mm high, 0.25 mm wide with apparent beak.

IV CONCLUSIONS

This study devoted to few species shows the necessity of serious reflexion because of the complexity of *Cololejeunea* bryoflorula.

1. Interest of these collections

The object of this work is to find out whether these gatherings bring an interesting contribution to the knowledge for Bryology for Mt. Maquiling. According to Bartram (1939) sixty species of Mosses were found at the station. My list contains 34 species, 16 of which are new for Mt. Maquiling and one for science. This contribution shows an increase of known mosses by 20 per cent. There arose a few inquiries on the different gatherings of liverworts. The Herzog's list concerning Baker's collections had 28 species. My own has 42, 34 of which are new and 5 new for science. For liverworts a 50 per cent increase is found. The two figures based on a one-day collection show that further collecting trips to Mt. Maquiling would be worthwhile.

2. Biogeographical connections

For mosses of my list, the community floristic coefficients between Mt. Maquiling and the different countries of South East Asia is established as follows:—

40	Java, Sumatra, Thailand
30–40	Vietnam, Borneo, Cambodia, Celebes
30–20	Ceylon, Japan, China
20–10	Himalaya, Malaya, Hawaii, New Caledonia.

The main axis of affinities goes from Japan to Sunda Straits. Some relations with Hawaii and New Caledonia still remain puzzling.

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Philippine Species of Nepenthes

by

SHIGEO KURATA* and MASAMI TOYOSHIMA*

This paper lists the results of two expeditions to the Philippines in search for **Nepenthes.** It records seven species and describes one of them and three hybrids as new taxa. All but one were collected during the three-week expedition made by both authors to the islands of Mindanao and Luzon in August 1965. *N. burkei* was collected by the senior author (S. Kurata) when he participated in the second expedition from December 1967 to February 1968 to Mindoro Island. Some Bornean species were also found but are excluded in this paper. The authors are grateful to Dr. C. X. Furtado for correcting the latin diagnosis.

The new taxa are **N. globamphora, N. mirabilis** x **alata, N. petiolata** x **alata** and **N. truncata** x **petiolata.**

1. *Nepenthes alata* Blanco, Fl. Filip., ed. 1, p. 805 (1837).

LUZON: Mountain Prov., Baguio, 1470 m. alt., Aug. 28, 1965, *S. Kurata 1136-a 1136-b;* en route to La Trinidad, 1500 m. alt., Aug. 28, 1965, *S. Kurata 1135.* MINDANO: Surigao del Sur, eastern slope of Mt. Legaspi, 270 m. alt., Aug. 19, 1965, *S. Kurata 1101-a, 1101-b, 1104.*

Distribution. Philippines, Malaya, Sumatra, Borneo.

Between the Luzon plants and those from Mindanao there are some differences. The former are hairy on the pitchers and tendrils. The purple blotches or stripes are usually distributed on its pitcher wall. On the other hand, the pitcher of the latter is strikingly narrow but dilate in the lower part, and the hair is absent from its wall. The colour of the pitcher is mostly yellowish green and at times becoming brownish green near the mouth.

2. *Nepenthes burkei* Masters. Gard. Chron. Ser. 3, VI p. 492 (1889).

MINDORO: Occidental Mindoro, Mt. Kidayap, summit, 1550 m. alt., Feb. 12, 1968, *S. Kurata 2033, 2034, 2035.*

Distribution. Philippines (Mindoro and Panay).

3. *Nepenthes* (*Montanae*) *globamphora* Kurata et Toyoshima, **sp. nov.** (Fig. 1, pl. 1). — *Nepenthes globamphora* (nomen nudum), Kurata et Toyoshima, Journ. Insectivorous Plants Soc. 36: p. 15-22, 1966.

Planta tenuis, breviter scandens, luteo-viridis. Caulis 30-80 cm altus, 4-5 mm crassus, cylindricus. Folia 8-12 cm longa, 1-1.8 cm lata, lanceolata, coriacea, sessilia, basi $\frac{2}{3}$ amplexicaulia, utrinque glabra; nervi longitudinales utrinque 3; nervi transversales obscure, oblique ascendentes; cirrhus 15-20 cm longus, cylindricus, glaber, luteo-viridis saepe etiam lucido-purpureus. Ascidia 4-9 cm longa, 3-5 cm lata, subdimorphia, inferiora ellipsoidea vel globosa, superiora ampulliformia, omnia luteo-vel, rubro-viridia, diffuse purpureo-maculata, coriacea, glabra, intus omnino glandulosa, bialata, alis margine dentatis, dentibus 3-ciliatis; os orbiculare obliquum; peristomium 5-8 mm latum, sub-cylindricum, aequale, luteo-viride, margine exteriore revolutum, interiore denticulatum; operculum 2-3.5 cm latum,

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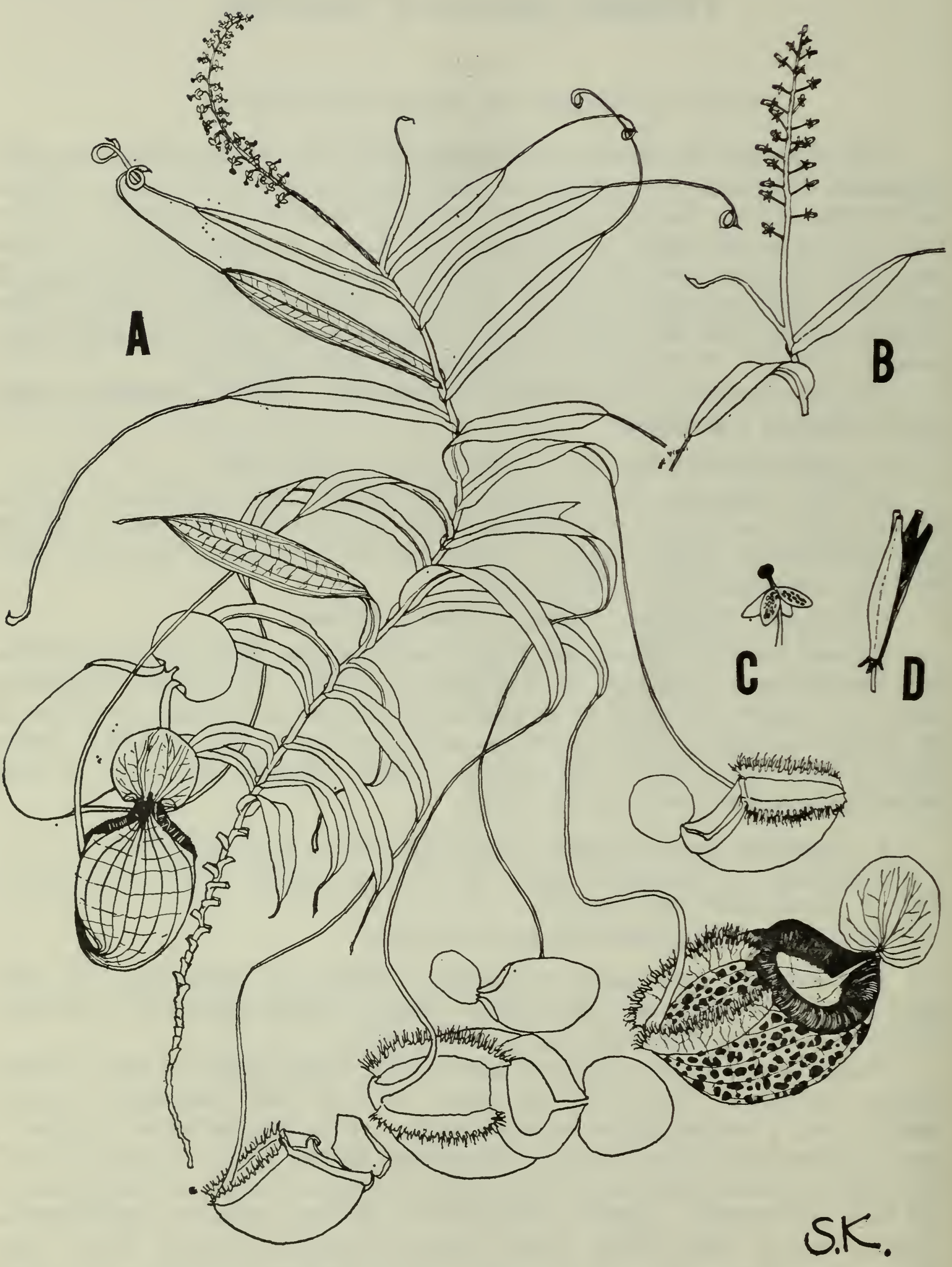

Fig. 1. *Nepenthes globamphora* Kurata et Toyoshima: *A*. male plant with flowers and pitchers (x 0.3); *B*. upper portion of female plant with flowers (x 0.3); *C*. male flower (x 2); *D*. capsules (x 1).

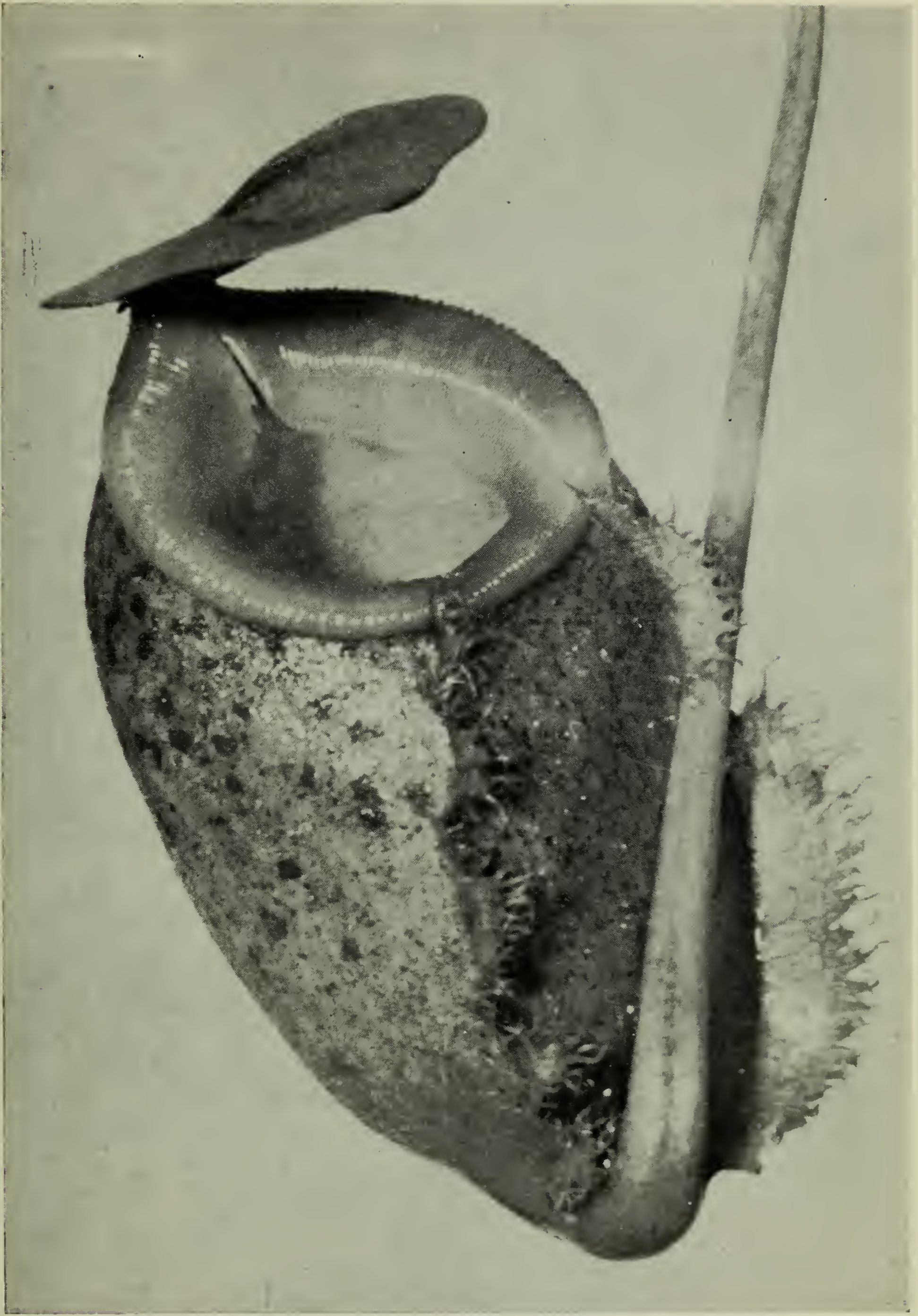

Plate 1. *Nepenthes globamphora:* a pitcher on the lower stem (x 2.5).

cordato-orbicularum; calar ca. 1 mm longum, filiforme. Inflorescentia 10-15 cm longa, racemosa, pedunculus 6-9 cm longus, ferruginio-tomentosus, pedicelli 3-4 mm longi, uniflori; sepala 4, ovata, 2-2.5 mm longa, 1-1.2 mm lata, extus minute tomentosa; columna staminae sepalis brevior, glaber, antherae 8, uniseriatae; capsula 17-20 mm longa, 4 mm lata, fusiformis, brunneo-nitida, glabra, valvae lanceolatae.

MINDANAO: Surigao del Sur, eastern slope of Mt. Legaspi, 270 m alt., Aug. 22, 1965, *S. Kurata and M. Toyoshima 1128* holotype in Herb. NDC (Nippon Dental College) *1129, 1130, 1132.*

This new species is easily distinguishable from all others by the peculiar pitcher which has an unusual roundness (hence the epithet "globamphora"), and by the trifid ciliae fringing the pair of wide wings — a very unique occurrence in the genus. The lid has no appendix on its lower surface where nectar glands are sparingly distributed. The glands are very small and deep. The remarkable feature of this species is that the inner surface of the pitcher is wholly glandular. When dry the specimen is red-brown, and the lower surface of leaves and flowers are more reddish. The lid has a ceramic luster on its lower surface. This plant is comparatively common on the eastern slope of Mt. Legaspi, but its distribution seems limited to a narrow area.

4. *Nepenthes merrilliana* Macf., Contrib. Bot. Lab. Univ. Pennsylv., III, p. 207, t. I (1911).

MINDANAO: Surigao del Sur, Camp David (a lumberer's camp, 10 miles upper stream of the mouth of Carrascal river). 150 m alt., Aug. 20, 1965, *S. Kurata 1117, 1118, 1119, 1120-a, 1120-b, 1124, 1125, 1126;* eastern slope of Mt. Legaspi, 270 m alt., Aug. 19, 1965, *S. Kurata 1116, 1121, 1122, 1123, 1127.*

Distribution: Philippines (Mindanao), Sulawesi.

5. *Nepenthes mirabilis* Druce, Rept. Exch. Cl. Br. Isl., 1916, p. 637 (1917).

MINDANAO: Surigao del Sur, on a river side near the Carrascal Bay, 20 m alt., Aug. 19, 1965, *S. Kurata 1107.*

Distribution: Southern China, Indochina, Malaya, Philippines (Mindanao), Borneo, Java, Sumatra, Sulawesi, New Guinea, Parau, Australia (York Pen.).

6. *Nepenthes mirabilis* x *alata,* **hybr. nov.**

Hybrida naturalis inter *N. mirabilis* et *N. alata.* Folia lanceolata, herbacea, glabra, petiolata. Ascidia 10-15 cm longa, 3-4 cm lata, monomorphia, cylindrica, bialata, alis fimbriatis, luteo-viridia, herbacea, glabra; os orbiculare obliquum; peristomium 2-3 mm latum, subcylindricum, aequale; operculum 3-5 cm latum, orbicularum, facie inferiore prope basin appendiculatum; calcar ca. 1 cm longum, bifidum. Inflorescentia ignota.

MINDANAO: Surigao del Sur, on a river side near the Carrascal Bay, 20 m alt., Aug. 9, 1965, *S. Kurata 1111-a* (type in Herb. NDC), *1111-b.*

This specimen has thin, herbaceous, petiolate leaves and cylindrical pitchers with orbicular lids. The pitcher is intermediate between its parental species; the strong folds on the boundary between the waxy zone and the glandular zone are derived from *N. mirabilis* whilst the appendix on the lower surface of the lid agrees with *N. alata.*

7. *Nepenthes petiolata* Danser, Bull. Jard. Bot. Buitzg. ser. III, Vol. IX, p. 353 (1928).

MINDANAO: Surigao del Sur, eastern slope of Mt. Legaspi, 270 m alt., Aug. 19, 1965, *S. Kurata 1108.*

Distribution. Philippines (Mindanao).

8. *Nepenthes petiolata* x *alata,* **hybr. nov.**

Hybrida naturalis inter *N. petiolata* et *N. alata.* Folia elliptico-lanceolata, coriacea, glabra, petiolata. Ascidia 10-15 cm longa, 3-4 cm lata, monomorphia, cylindrica, bialata alis fimbriatis, luteo-viridia, diffuse purpureo-maculata, coriacea, minute tomentosa; os orbiculare obliquum; peristomium ca. 2 mm latum, subcylindricum, aequale; operculum 3 cm latum, ovatum, facie inferiore prope basin appendiculatum; calcar ca. 1 cm longum, filiforme. Inflorescentia ignota.

MINDANAO: Surigao del Sur, eastern slope of Mt. Legaspi, 270 m alt., Aug. 19, 1965, *S. Kurata 1113-a* (type in Herb. NDC), *1113-b.*

This specimen has elliptical leaves with petioles and cylindrical pitchers with ovate lids. The colour of the pitcher is yellow-green with purple blotches and/or stripes and is densely covered with short hairs which seem to be the same of that of *N. petiolata.* On the other hand, the small glands and the appendix on the lower surface of the lid seem to be derived from *N. alata.* A lustrous belt on the boundary between the waxy zone and the glandular zone on the inner surface of the pitcher is also from *N. alata.* Both species *N. petiolata* and *N. alata* are found growing in the same area.

9. *Nepenthes truncata* Macf., Contrib. Bot. Lab. Univ. Pennsylv., III, p. 209, t. II (1911).

MINDANAO: Surigao del Sur, Camp David, 150-300 m alt., Aug. 20, 1965, *S. Kurata 1105, 1106, 1115.*

Distribution. Philippines (Mindanao).

10. *Nepenthes truncata* x *petiolata,* **hybr. nov.**

Hybrida naturalis inter *N. truncata* et *N. petiolata.* Folia oblonga, apice truncata, coriacea, supra glabra, subtus villosa, petiolata. Ascidia 10-15 cm longa, 3-4 cm lata, monomorphia, inferne ventricosa, superne cylindrica, bialata, alis fimbriatis, luteo-viridia, diffuse purpureo-maculata, coriacea, tomentosa; os orbiculare obliquum; peristomium 5-8 mm latum, subcylindricum, margine exteriore expansum, margine interiore denticulatum; operculum 4-5 cm latum, cordato-ovatum, facie inferiore prope basin appendiculatum; calcar ca. 1 cm longum, bifidum. Inflorescentia ignota.

MINDANAO: Surigao del Sur, eastern slope of Mt. Legaspi, 270 m. alt., Aug. 22, 1965, *S. Kurata 1109-a* (type in Herb. NDC), *1109-b.*

This specimen has wide coriaceous leaves with petioles, and the lamina is cordate at the apex. The petiole and lamina are densely covered with brownish coarse hairs beneath. The pitcher has a wide and expanded peristome. The lid has on its lower surface an appendix and two kinds of nectar glands: one small and deep, surrounded with a wide rim, the other large and shallow, surrounded with a narrow rim. The above characters show that this specimen is a natural hybrid between *N. truncata* and *N. petiolata.* At the place where this plant was collected, both parental species and the other i.e. *N. alata* were growing together.

Studies in the basidium
Spore-spacing and the Boletus spore

by

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A geometrical analysis of the 4-spored homobasidium is made on the assumption that spore-spacing is determined by sterigmatic spacing on the basidium-apex. Given, then, the values of spore-width and the interval between adjacent spores of the tetrad, other details of the basidium-unit can be worked out except the lengths of the spores, sterigmata and basidium. The relations between the parts are summarised as equations; their values in ratios of spore-width are tabulated in an appendix. Observations on *Mycena illuminans* with subglobose spores are given as a check on the theory.

The smooth *Boletus*-spore is shown to be the unornamented endospore of a subglobose spore with endosporic ornamentation that has suffered compression and reduced spacing through the adaxial displacement of the sterigmata. The spores of *Strobilomyces* and *Phylloboletellus* appear as the more primitive.

The use of this theory is shown by analysis of the cruciform spores of *Marasmius nigricans*.

During the tumultuous years 1942–1945, when Dr Kwan Koriba maintained the scientific status of the Singapore Botanic Gardens, I was permitted to work with him in the upstairs laboratory of the office. We studied trees, their seasons and their reproduction, and I was allowed a more personal investigation, which had long intrigued me, into the construction of the basidiomycete hymenium. Some of this work has been published (Corner 1947, 1948). It has shown that the lengths and widths of basidia, spores and cystidia are bound by specific constants which have generic trends. The dimensions of these parts are usually given independently in taxonomic descriptions, but they are related in consequence of the characteristic of the hypha that produces them. The relations can be displayed as sporographs, basidiographs and so on, as explained in those papers, but their interconnection lies in the dependence of spore-width on that of the basidium. This is the matter that I now take up, and it becomes the problem of spore-spacing on the basidium.

With many detailed observations for such genera as *Amanita, Lepiota, Hygrophorus, Marasmius, Russula, Entoloma, Agaricus* and *Coprinus,* I had intended an extensive survey but the long hours necessary for such a work have never recurred. I take it up for the special case of *Boletus* because in the course of my account of the rich *Boletus*-flora of Malaysia (Corner 1972) the problem has loomed continually and is fundamental to the classification of the species by means of their distinctive spores. My thesis is the geometrical analysis of the position of the spores on the basidium. It is not an explanation of their arrangement by physical means but a guide to understanding how the spore grows to its full size and shape and, indeed, how it may develop its superficial structure. I have set forth this analysis in the simplest terms, step by step, so that it may be followed by mycologists who, like myself, may have lost touch with advanced mathematics.

Most basidiomycetes have four spores on the basidium. There have been several accounts of the development of individual spores (Corner 1948, 1968; Malençon 1958; Perreau-Bertrand 1967). I propose to consider the tetrad as a unit. The four spores are regularly spaced. Their arrangement can be affected by adjacent basidia. The spacing is affected by the contour of the hymenium. Spore-shape results from the way in which spore-volume is contained in this spacing. A prime factor is the width of the basidium. Yet the tetrad of one basidium does not contact that of another; the spores of a tetrad are not in contact; they are separated from the basidium by sterigmata; maturing basidia are separated from each other by immature. To secure this spacing there must be action at a distance. The force appears to be electrostatic repulsion at free surfaces; the whole mechanism collapses when wetted. To prove this, I had intended to grow basidia in an induced electric field, but this has not materialised. I hope, however, that this article will open a new line of enquiry from which some real understanding of the precision of the hymenium will come and better appreciation of the basidiocarp which houses it. The toadstool is essentially an umbrella opened geotropically.

Method

The sporing basidium is a delicate turgid structure that readily shrinks in contact with a fixative. As my object was to make fine measurements of spore-size and the intervals between spores on the basidium, it was necessary to examine undistorted living basidia under high enough magnification to make reasonably large camera lucida drawings. I first used dry mounts of thin strips of hymenium for surface-view and moderately thick sections for side-view, and observed them with an oil-immersion lens. Condensation on the coverslip, however, in the high humidity of Singapore brought failure and I had to resort to aqueous mounts. Thus I learnt that sooner or later, after ten minutes with some species or an hour or two with others, the apex of the wetted basidium collapsed and the sterigmata inclined, even jumped, inwards; to be effective the basidium had to be superficially dry. By dint of perseverance I managed to obtain for subsequent analysis many accurate camera lucida drawings of a great variety of agarics, boleti, polypores, stereums and clavarias. The present article merely summarises these results because names are not available for most of the fungi, and the labour is great; about a thousand measurements are needed for accuracy in any one species.

The two aspects of the basidium, end-view and side-view, need to be combined. From this a geometry of the basidium emerges to relate the shape of the basidium-apex via the sterigmata with the spore-spacing and, thus, with spore-shape. As the spores are borne at the same level above the basidium (though there are exceptions), one can obtain in end-view an optical section of the tetrad. Focussing down, one can see the basidium-outline in its optical section at maximum width and, on then focussing slightly upwards, even the tips of the sterigmata. However, it is easier to see these tips on discharged basidia before they have collapsed. The four spores, as seen in end-view, occupy the corners of a square and one can imagine them to be confined by two spore-circles, an outer circumscribing circle S' (Figure 3) and an inner inscribing circle S''', to which may be added a third spore-circle S'' passing through the centres of the spores. Then there is the real basidium-circle as the outline of the basidium, which I call w, and for the sterigmata one can imagine a sterigmatic circle M passing through the tips of the sterigmata. The circles are concentred on the long axis of the basidium. S' exceeds the basidium circle which can often be seen to lie within S''; the M circle lies slightly outside or abaxial from S'''. These real and imaginary circles, derived from end-view of the basidium-unit, can be projected on to the basidium apex, as in Figure 3.

Since a basidium cannot be examined both in end-view and side-view, an average must be taken from a set of measures for each. In end-view basidia are often seen to be compressed and ellipsoid in optical section. Such can be avoided but they cannot be recognised in side-view, for which the average is necessary. The figures in the following pages are based on such averages from sets of twenty to one hundred drawings.

Following the system adopted in my previous papers, I continue with this notation: —

n is the spore-number per basidium.

D is spore-length.

d is spore-width; *d rad,* when measured in side-view, and *d tan,* when measured tangentially or at right angles to *d rad.*

E is the ratio D/d.

l is the length of the basidium.

w is the maximum width of the basidium.

M is the diameter of the sterigmatic circle.

m is the diameter of the sterigmatic patch circle.

S' is the diameter of the outer spore-circle.

S″ is the diameter of the middle spore-circle.

S''' is the diameter of the inner spore-circle.

(S'), (S''), (S''') and (m) refer to the inner spore or endospore when needed to be distinguished.

σ is the ratio of spore-interval to d.

θ is the spore-angle.

δ is the angle subtended by the half-spore on the spore-circle.

α: is the angle subtended by the sterigmatic patch at the centre of the curved apex of the basidium.

Evidence of spore-spacing

The following considerations supply the evidence that the spores of a tetrad are regularly spaced.

Elongate spores. A tetrad of elongate spores in end-view appears as four circles equidistant round the basidium-apex (Figure 1; Buller 1924, fig. 84-86, 91; Corner 1964 p. 234). The long axes of the spores are parallel with that of the basidium; the spores face this axis and are not inclined. This is the main evidence for supposing the imaginary circles S' and S''' and the lateral spacing factor ‘ σ ’.

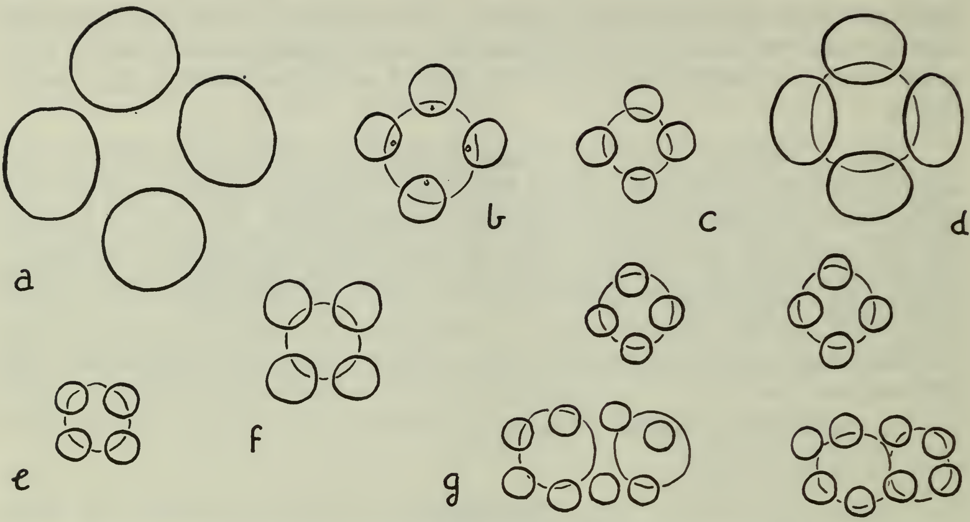

Figure 1. Spore-tetrads in end-view, x 800 (*a.* x 500); *a, Oudemansiella*; *b, f, Amanita; c, Pluteus; d, Panaeolus; e, Psathyra; g, Boletus ravenelii,* with two normal basidia and two pairs of approximated basidia having their eight spores set in an ellipse.

Interfering tetrads. Usually a basidium develops its tetrad freely at some distance from other sporing basidia. New basidia are intercalated and take the place of those that have discharged their spores and become ineffective. Occasionally two basidia mature so close together that their tetrads are distorted and, as seen in end-view, their eight spores are combined into one imaginary ellipse (Figure 1). This re-arrangement shows that sporing basidia act as spacing units and influence their neighbours. Where two S' circles approach or would intersect the adjacent spores of each tetrad are repulsed outwards. The unit has a boundary at S'.

The adaxial patch. In many verrucose or echinulate spores, for which *Russula* and *Thelephora* are good examples (Malençon 1958; Corner 1968), the warts or spines develop all over the spore except in a small area on the adaxial side of the spore just above the apiculus. I call this smooth area the adaxial patch. It is the part of the spore impinging on the inner spore-circle S''' and it shows that this imaginary circle is a boundary defining a central 'dead space' over the basidium-apex where spore-growth is forbidden. It is the sharpest boundary in the tetrad.

Tangentially compressed spores. The tetrads of *Panaeolus* (Figure 1) and some species of *Coprinus* (Buller 1922, fig. 104; 1931, fig. 29-32), show radial or adaxial compression of the spores; *d rad* is less than *d tan*. In contrast with globose spores that are strictly confined by the one spacing given by S' and S''', they bulge laterally; a lateral spacing has to be considered as well as a radial. More spectacular are the trigonous and cruciform spores in various agarics (Figure 12). Evidently there may be variation in the lateral spacing and in the intensity of inhibition from S' (as shown by abaxially echinulate spores), while that of S''' is rigid. Here, however, the exception comes with the *Boletus*-spore.

Reversed spores. Tetrads of homobasidiomycetes do not bear reversed spores; that is, spores do not develop with the apiculus turned abaxially. This may happen with diads in normally tetrasporous species (Corner 1950, fig. 271). In such cases the two spores are evidently so far apart that the sterigmatic spacing by the sterigmatic disc is ineffective; nevertheless, S' and S''' operate from the basidium-apex to maintain the spore-shape, even if σ is also ineffective.

6-8-spored basidia. When n is 3, the spores in end-view fit the angles of an equilateral triangle; when n is 4, they fit a square; when n is 5, they fit a regular pentagon. But, when n is 6 or 8, they do not fit a regular hexagon or octagon; they are disposed in an ellipse, as with interfering tetrads. This ellipse, however, seems not to be plane but to have decurved ends. Four spores occupy the central part of the ellipse and one or two spores at each end lie at a slightly lower level through the obliqueness of their sterigmata. The same effect may be seen in the tetrads of *Russula* and *Lactarius.* I have not succeeded in examining such hexads and octads in any detail. The obvious material is to be found in *Cantharellus, Craterellus* and *Pterygellus* (Corner 1966), but the basidia of these fungi are too long for suitable study in end-view. The regular disposition of the spores proves, nevertheless, that spacing factors operate through the ring of 6-8 sterigmata placed peripherally at the basidium-apex with its superimposed dead space.

Towards the geometry of the basidium

Certain features of the basidium-unit need more explanation.

Positioning of the spores. They are positioned by the sterigmata. These outgrowths, at first normal to the curved apex of the basidium, become parallel with the basidium-axis and develop at their attenuate tips the sterigmatic discs. From these the spores, inhibited by S''', develop abaxially to the limit of S' and then elongate within these limits, parallel to the basidium-axis, if they are to become larger. The transverse sterigmatic discs appear to be the initial spacers and the apiculus of the mature spore is the adaxial feeler which indicates, but seldom coincides with, S'''. Careful measurement of the spore- and sterigmatic circles have shown me that, as a general rule, $M = S'' - 0.7d$; for a single spore, that is, the tip of the sterigma is situated external to S''' by a distance of $0.15d$.

If spore-spacing is determined by sterigmatic spacing, the cause of this cannot be discovered by simple observation because it must lie within the basidium. It must be connected with the hyaline cap which forms at the apex of the basidium shortly before the sterigmata emerge (Corner 1948). The substance of this cap forms, evidently, the walls of the sterigmata and those of the spore-rudiments; presumably it becomes electrically charged at the surface. It must be partitioned into four blocks which underlie the sterigmatic patches, or bases of the sterigmata (Corner 1948). I have pursued the geometrical consequences of the projection of this patch on the plane of the spore-circles and its hypothetical function in spore-spacing (p. 169).

Spore-angle. The direction in which the spore grows from the transverse sterigmatic disc was studied by Buller. He concluded that this angle was at 45° to the long axis of the basidium. I have measured the angle on camera lucida drawings and, though it is impossible to be precise with such minute structures, I agree with Buller's conclusion. It is supported by the following argument.

With reference to Figure 3, $\angle MTC$ is the spore-angle θ. If this is 45°, then

$$\mathrm{MC} = \mathrm{TC} \sin \theta = \frac{d}{2} \sin 45^\circ = 0.35d$$

or, for the whole basidium-unit,

$$M = S'' - 2\mathrm{MC} = S'' - 0.70d$$

This is the value of M found by direct measurement of S''', S' and M. The longitudinal plane of S''' lies adaxially to that of M by this small fraction $0.15d$.

The ratio d/w. The positioning of the sterigmata and that of the spores about the longitudinal axis of the basidium so that the basidium circle (in end-view of the tetrad) lies within S'' imply that there is a close relation between spore-width d and basidium-width w. These are two easy measures and their relation is an important feature of the basidium-unit. For the smooth ellipsoid spores of many homobasidiomycetes from *Amanita* to *Clavaria,* I find that in general $d = 0.6$ to $0.65w$. Large globose spores may increase the ratio to $0.8w$ and narrow spores may decrease it to $0.5w$. These differences may occur within a genus; the latitude in positioning of S' may be the explanation, but specific differences in spore-width generally imply differences in the valve of w. Thus, a basidium 8μ wide will bear spores 5μ wide; one 10μ wide will bear spores 6.3μ wide. Despite records to the contrary, I have not seen a tetrasporous homobasidiomycete in which d equals or exceeds w. The exception among the disporous is *Clavulina* with $d = 1.18w$ (Corner 1948).

No species has basidia of constant width. There is always some variation. Hence I have used as values of w and d either the mean of their variation or, when there have been sufficient measurements, their averages.

Lateral spacing in the tetrad. As a measure of this feature, I take the ratio σ of the spore-interval to spore-width, as seen on the spore-circle. In Figure 3

$$\sigma = \frac{\mathrm{KL}}{2\mathrm{CK}} = \frac{\mathrm{KL}}{d}$$

Measurements of the tetrads of various basidiomycetes with isodiametric spores (*d rad* equals *d tan*) show that in general $\sigma = 0.5$.

The spacing can also be expressed by the angle δ (Figure 3), as explained on p. 169.

The basidium-apex. The projection of the spore-circles and other items of the basidium-unit on to the basidium-apex in median longitudinal section implies knowledge of the curvature of the apex, but this is a difficult matter and I can give only an approximation. The clavate basidium, fully grown but without sterigmata, has a hemispherical apex. When the hyaline cap forms, the apex protrudes slightly and in the long basidia of agarics with polymorphic basidia (such as *Coprinus*) this projection is lengthened and becomes almost cylindric with hemispheric apex. The question is whether it is ellipsoid or paraboloid. To test this, I measured the diameter of the basidia with hyaline caps, yet without sterigmata, at certain levels. These were the level of maximum width w and those at $\frac{1}{4}$, $\frac{1}{2}$ and $\frac{3}{4}$ of the vertical distance between the apex of the basidium and the plane of w. I compared these results with those that can be calculated for similar chords of a sphere (or ellipse) and a parabola, as shown in Table 1.

Table 1. Diameter of the basidium-apex, as ratios of w, at successive levels from the apex.

Levels	w	$0.25w$	$0.5w$	$0.75w$
ellipse	1	0.661	0.866	0.968
observed	1	0.687	0.854	0.954
parabola	1	0.438	0.750	0.938

The apex is clearly ellipsoid but, as rounding off of a clavate apex with slight protrusion, it is probably ellipsoid with a small dome of spherical curvature. This is the dome between the sterigmatic bases that struts them and collapses when wetted.

Globose spores. Longitudinal alignment cannot be discerned directly from such spores but, from their positioning on the sterigmata, they clearly obey the dead space defined by S'''. Presumably they have lateral spacing and external limits, defined at least by the total effect of the basidium-unit.

Spore-length. A globose spore fills the space between the limits of S' and S'''. If more protoplasm enters the spore, it elongates within these limits. For a given spore-volume, the closer these limits the longer the spore will be. But spores vary in the way that they grow into and fill this space. Some are globose from the first and then lengthen; others expand gradually as they lengthen and become pip-shaped, obovoid or clavate. None of these factors, however, has prime significance in spore-spacing, though the limits of S' and S''' explain why ellipsoid spores vary much in length though little in width, and conform to a sporograph-locus.

Sterigmatic length. Since the sterigmata become parallel, their length has no immediate effect on spore-spacing. They may lengthen abnormally, however, and remove one or two spores of the tetrad from the spacing effect of the whole, and this may be usual in Tremellaceae, but it is exceptional in homobasidiomycetes and leads to the abortion of the spore. Many exceptional states occur in Gasteromycetes with their variously disorganised basidium-mechanism.

I have been unable to detect any relation between the length of the sterigmata and other features of the basidium-unit. The length seems to depend on the hydrostatic pressure in the basidium and to be related with spore-number. Thus in species with $n = 3$ or 2 or 1, as variations on $n = 4$, the sterigmata are progressively longer. Sterigmatic length can, therefore, be neglected in basidium-geometry.

Basidium-length. With any one kind of basidium as defined by its equation (Corner 1947) w depends on l, but l does not otherwise determine spore-spacing. In all species l varies, but the resulting differences in w are so slight that the shorter basidia bear spores of practically the same shape and size as the longer. Thus, in tetramorphic species of *Coprinus*, there are not four sizes and shapes of spores. Nevertheless, as always, there are exceptions. At least two species of *Hygrophorus* have normally basidia of two sizes, very different in length, and they bear spores of very different size (Corner 1936). For the purpose of spore-spacing, basidium-length can also be ignored.

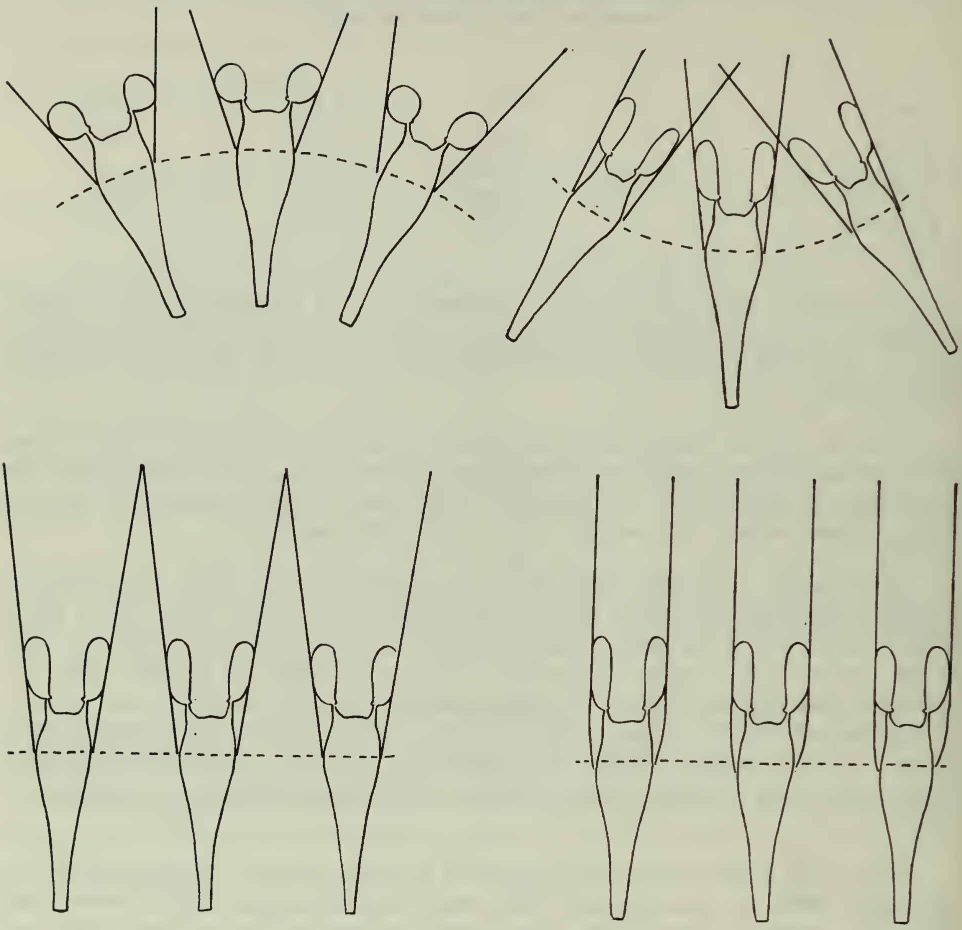

Figure 2. Diagrams of basidium-units, treated as cones, divergent in the convex hymenium (upper left), convergent in the concave hymenium (upper right), and divergent or paraboloid in the plane hymenium (lower figures).

The basidium-unit. The whole basidium with its spores can be regarded as an inverted cone expanding from the base (inverted apex) to the value of *S′*. Within the cone the unit develops; outside the cone it restrains other basidia. The effect is well seen in clavarioid basidia. Their sterigmata often diverge slightly and their long spores may also diverge and appear in optical section on the spore-circle as short ellipses. I suppose that this divergence is connected with the convex curvature of the hymenium, developed on the outside of the cylindric or clavate fruit-body, and that this curvature makes the basidia slightly divergent (Figure 2). In the agaric hymenium the basidium-unit becomes paraboloid with sterigmata and spores parallel to the long axis of the basidium. But the poroid hymenium is concave, lining tubes; the basidia are convergent and their cone-effects interfere; the outer spore-circles of adjacent units conflict and the whole unit is distally compressed. This is the problem in *Boletus*, many species of which have long and narrow spores with convex adaxial face, known as the boletoid spore. Superficially this spore may resemble a *Clavaria*-spore; actually it is developed in a more complicated manner because the sterigmatic circle is displaced inwards.

The hydnoid hymenium resembles the clavarioid. Its basidia are often small and their divergence may explain the prevalence of globose or subglobose spores. The stereoid hymenium with plane extension resembles that of the agaric but the basidium-units are not strictly aligned because of the thickening hymenium; new basidia may project beyond the influence of the mature and have slightly divergent sterigmata.

Asymmetric basidia. Very occasionally a basidium that has grown aslant develops a typical spore-circle asymmetrically on the exterior side of the apex. Whether or not this is the effect of light, gravity or some other external stimulus on the hyaline cap, the configuration proves that the sterigmatic arrangement is a structural unit.

Measurements. I have relied on my own measurements from living material. The basidium-unit is an inflated, semi-rigid structure prone to collapse, and it is not certain that measurements from dried material or that fixed in alcohol-formalin agree exactly with those from the living. It is tempting to use the published data in descriptions, but I have avoided these not only because they often refer to preserved specimens but because it is clear that immature basidia are often measured and such will give misleading results.

The geometry of the basidium

The geometry, as I have analysed it, is set out in Figure 3. The upper part shows the spore-tetrad, as seen in optical section from the end-view of the basidium, together with the spore-circles S', S'', S''', the basidium-circle w, the sterigmatic circle M, the square joining the spore-centres C, and the tangents from the long axis of the basidium A to the spores. Then there are shown four small circles m on the spore-radii; they are the orthogonal projections of the sterigmatic patches on to this transverse plane. The lower part of the figure shows the longitudinal geometry of the basidium-apex which is drawn as a hemisphere on the base ww of maximum width of the basidium. The right half of the basidium-apex shows the sterigmatic patch (arc Hw) and the angle Haw which it subtends; I call this angle $\propto$. The various circles of the upper figure are projected on to the base-line ww. The lower right-hand spore represents a globose spore in side-view as it would fit on to the sterigma which, for clarity, has been omitted. If the upper figure is rotated through 90°, it represents the spore-circles above the basidium.

Many relations of the parts can be derived from this figure. I give merely the more useful that can be reduced to the minimum data d and σ , when $n = 4$. It must be noted that the symbols S', S'', S''', M, w, d and m refer to diameters and not radii.

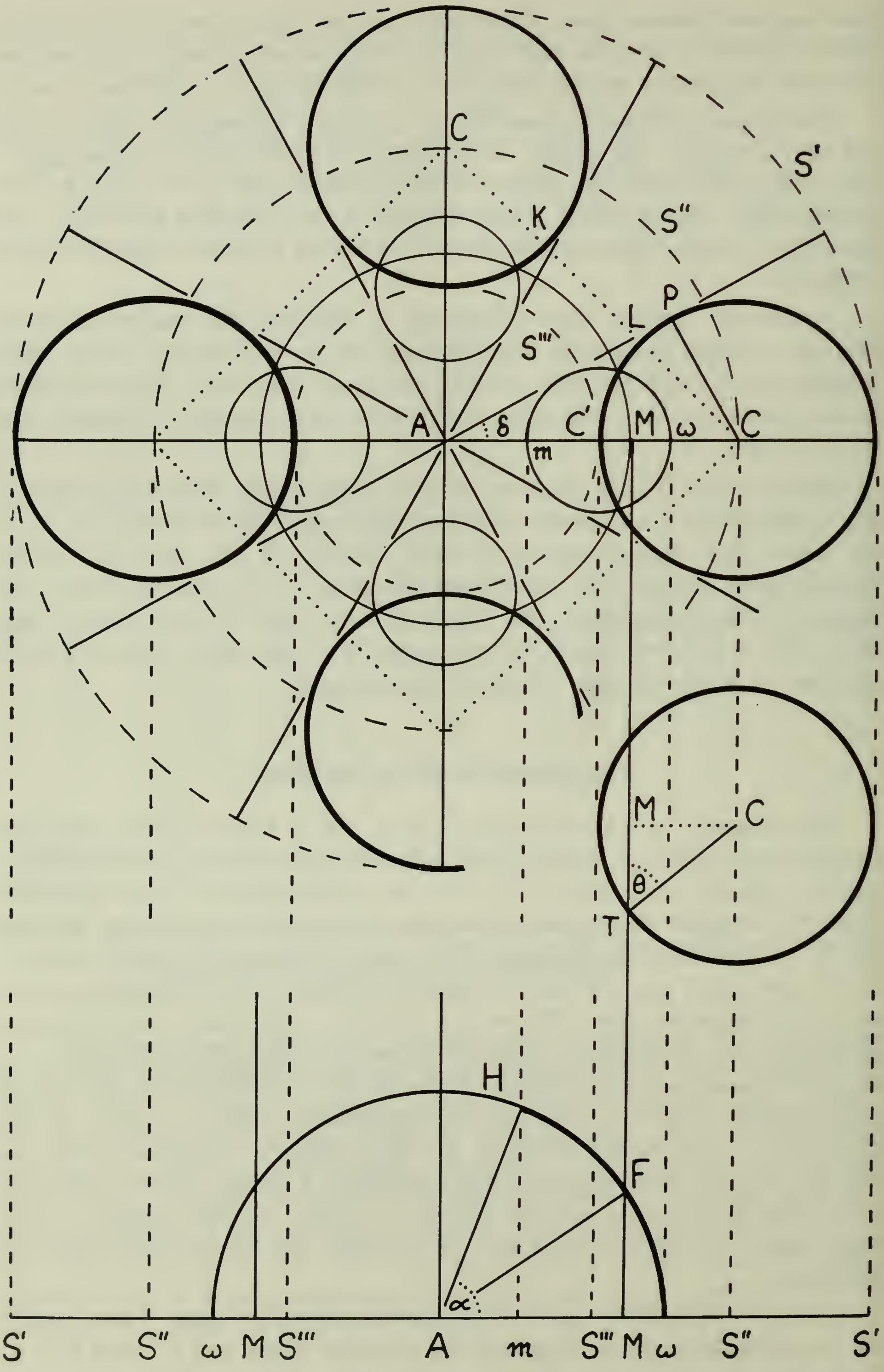

Figure 3. The geometry of the spore-circles in relation to that of the basidium-apex in median longitudinal section; constructed for σ = 0.5, w = 1.65 *d*. For explanation, see text.

$$\text{CC (side of the square)} = d\,(1+\sigma) \quad \dots\dots\dots (1)$$

because CC = CK + KL + LC, and by definition KL = $d\sigma$, therefore

$$\text{CC} = \frac{d}{2} + d\sigma + \frac{d}{2} = d + d\sigma = d\,(1+\sigma)$$

$$S'' = \sqrt{2}d\,(1+\sigma) \quad \dots\dots\dots (2)$$

because S'' = 2AC and, as S'' (diameter) is hypotenuse to the rt. ∠ triangle with sides CC, then

$$(2\text{AC})^2 = 2(\text{CC})^2$$

$$\text{AC} = \sqrt{2}\text{CC} = \sqrt{2}d\,(1+\sigma), \text{ as from (1)}$$

Obviously $S' = S'' + d$ and $S''' = S'' - d$ ……… (3)

$M = S'' - 0.7d$ (see p. 164) ……… (4)

Now it is convenient to turn these relations into functions of δ . In Figure 3, P is the point where the tangent from A meets the spore.

$$\sin\delta = \frac{\text{PC}}{\text{AC}} = \frac{d}{2} \times \frac{2}{S''} = \frac{d}{S''} = \frac{1}{\sqrt{2}\,(1+\sigma)} \quad \dots\dots\dots (5)$$

$$\text{or } \operatorname{cosec}\delta = \sqrt{2}\,(1+\sigma)$$

$$S'' = \frac{d}{\sin\delta} = d\,\operatorname{cosec}\delta \quad \dots\dots\dots (6)$$

$$S' = S'' + d = \frac{d}{\sin\delta} + d = \frac{d\,(1+\sin\delta)}{\sin\delta} = d\,(+\operatorname{cosec}\delta) \quad \dots\dots\dots (7)$$

$$\text{or } S' = d\,[\sqrt{2}\,(1+\sigma) + 1]$$

$$S''' = S'' - d = \frac{d}{\sin\delta} - d = \frac{d\,(1-\sin\delta)}{\sin\delta} = d\,(\operatorname{cosec}\delta - 1) \quad \dots\dots\dots (8)$$

$$\text{or } S''' = d\,[\quad 2\,(1+\sigma) - 1]$$

$$M = d\,(\operatorname{cosec}\delta - 0.7) \quad \dots\dots\dots (9)$$

$$\text{or } M = d\,[\sqrt{2}\,(1+\sigma) - 0.7]$$

$$\sigma = \frac{\operatorname{cosec}\delta}{\sqrt{2}} - 1 \quad \dots\dots\dots (10)$$

Sterigmatic patch hypothesis. I assume that the spacing of the sterigmatic patches provides that of the spores by transmission through the sterigmata. The symmetrical partition of the hyaline cap in the basidium-apex into four areas, set as far as apart as possible on the level of w, may be the physical basis. The geometrical consequence must be traced by the projection of the sterigmatic patch on to the transverse plane of the spore-circles. In Figure 3 any circle with centre on AC′C and inscribing AP will provide the spore-spacing, but the sterigmatic patch implies certain conditions. Its projection must lie within the basidium-circle; it must place the sterigmatic tips on the sterigmatic circle; and it must be related with w (that is the perpendicular ww in Figure 3). For convenience I use $m^{\bullet}$ for the diameter of the projected circle of the sterigmatic patch and denote the circle accordingly.

The most likely position for the centre of m is C′ where AC cuts the S''' circle (in the upper part of Figure 3). This m circle contacts the basidium-circle, as can be seen from the following argument with reference to Figure 4.

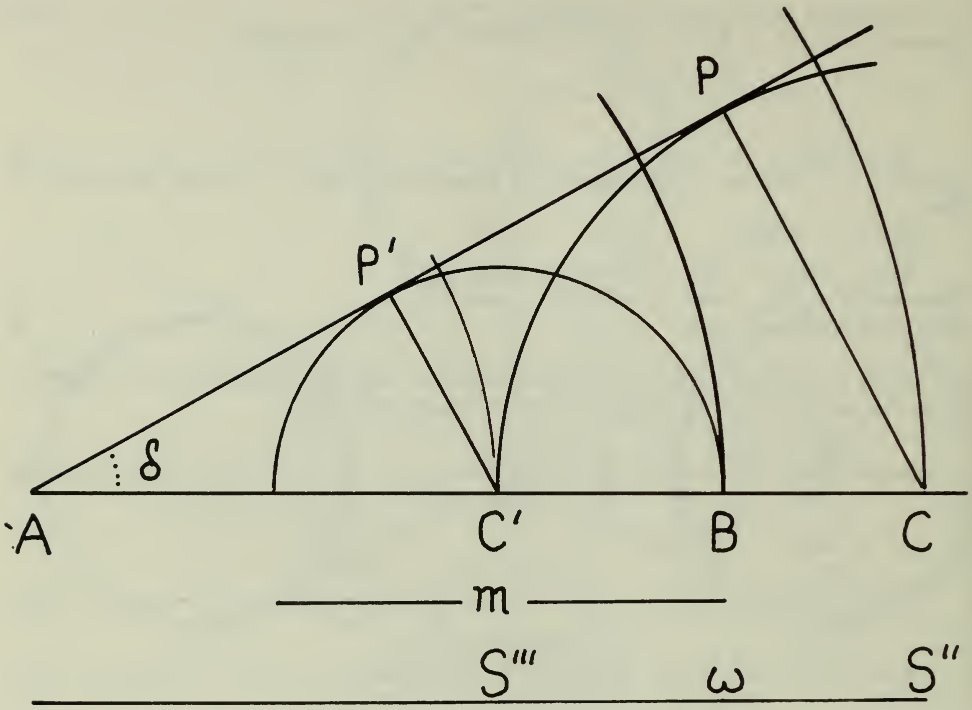

Figure 4. Construction to prove that the *m* circle with centre C on the S‴ circle contacts the basidium circle *w*.

For a circle with centre on AC and with AP as tangent, then C′ P′ = C′ B, as radii of this circle.

C′P′ = AC′ sin δ, or in this case

$$= \frac{S''' \sin \delta}{2} = \frac{d\,(1 - \sin \delta) \sin \delta}{2 \sin \delta} = \frac{d\,(1 - \sin \delta)}{2} \text{ from (8)}$$

C′B = AB − AC′, or in this case

$$= \tfrac{1}{2}\,(W - S''')$$

$$\text{Now } S''' = \frac{d\,(1 - \sin \delta)}{\sin \delta} \text{ from (8)}$$

$m = S''' \sin \delta$ ex hypothesi

$w = S''' + m = S''' + S''' \sin \delta = S'''\,(1 + \sin \delta)$

Therefore,

$$C'B = \frac{d\,(1 - \sin \delta)\,(1 + \sin \delta)}{2 \sin \delta} - \frac{d\,(1 - \sin \delta)}{2 \sin \delta}$$

$$\frac{2 \sin \delta \; C'B}{d} = 1 - \sin^2 \delta - 1 + \sin \delta = \sin \delta - \sin^2 \delta$$

$$\text{Therefore } C'B = \frac{d\,(1 - \sin \delta)}{2} = C'P'$$

The following equations may therefore be added

$$m = S''' \sin \delta = d\ (1 - \sin \delta) \qquad \text{(11)}$$

$$w = S''' + m = S'''(1 + \sin \delta) = \frac{S'\ S'''}{S''} \qquad \text{(12)}$$

This curious relation between w and the spore-circles follows from that between w and d as determined by σ and δ. Thus

$$w = S''' + m \text{ and } S''' = S'' - d$$

$$m = S''' \sin \delta = (S'' - d) \times \frac{d}{S''} = \frac{S''\ d - d^2}{S''}$$

$$\text{Therefore } w = (S'' - d) + \frac{S''\ d - d^2}{S''}$$

$$= \frac{(S'')^2 - S''\ d + S''\ d - d^2}{S''} = \frac{(S'')^2 - d^2}{S''} = \frac{(S'' + d)\ (S'' - d)}{S''}$$

$$= \frac{S'\ S'''}{S''} \text{ from (3)}$$

$$w = S'''\ (1 + \sin \delta) = d \cos \delta \cot \delta \qquad \text{(13)}$$

$$\text{because } S'''\ (1 + \sin \delta) = \frac{d\,(1 - \sin \delta)}{\sin \delta} \times (1 + \sin \delta) = \frac{d\,(1 - \sin^2 \delta)}{\sin \delta}$$

$$= \frac{d \cos^2 \delta}{\sin \delta} = d \cot \delta \cos \delta$$

The longitudinal relations may now be considered.

Let the sterigmatic patch circle m be projected on to the basidium-apex, as in the lower part of Figure 3. It occupies arc Hw and subtends ∠ HAw or α Bisect α and the bisecting radius AF will meet the arc Hw where it is intersected by the projection of the sterigmatic circle M. That is, if the centre of the longitudinal sterigmatic arc on the basidium is projected parallel with the long axis of the basidium up to the level at which the spores are developed, it becomes the sterigmatic tip, whence the spores grow abaxially with the spacing initiated on the basidium-apex. This is one of the most remarkable agreements between the geometry of the basidium and the observation of the spore-circles, the sterigmatic circle and the spore-angle. At first there seems to be no reason for the position of the sterigmatic tips, other than structural convenience; now it is seen to be an integral part of the basidium-unit. The tips are eccentric in the sterigmatic patch circle. It would be interesting to compare this construction with the basidium of Gasteromycetes with sessile or subsessile spores.

By means of the angle α, other relationships in the basidium can be found which have value in checking reconstruction from specific data.

$$M = w \cos\frac{\propto}{2} \tag{14}$$

$$\cos\propto = \frac{1 - \sin\delta}{1 + \sin\delta} \tag{15}$$

$$\text{because } \cos\propto = \frac{\text{Am}}{\text{AH}} = \frac{2\text{Am}}{w} = \frac{2\text{Am}}{S'''(1 + \sin\delta)} \qquad \text{from (12)}$$

$$\text{Am} = \frac{S'''}{2} - \frac{m}{2} = \frac{S'''}{2} - \frac{S'''\sin\delta}{2} = \frac{S'''(1 - \sin\delta)}{2} \qquad \text{from (11)}$$

Therefore

$$\cos\propto = \frac{S'''\ (1 - \sin\delta)}{2} \times \frac{2}{S'''\ (1 + \ \text{in}\,\delta)} = \frac{1 - \sin\delta}{1 + \sin\delta}$$

$$\text{Alternatively, } \cos\propto = \frac{S''' - m}{S''' + m} \tag{16}$$

$$\sin\delta = \frac{1 - \cos\propto}{1 + \cos\propto} \quad \text{from (15)} \tag{17}$$

$$\sin\theta = \frac{S'' - m}{d} \tag{18}$$

$$\text{because } \sin\theta = \frac{\text{MC}}{\text{TC}} = \frac{S'' - M}{2} \times \frac{2}{d} = \frac{S'' - m}{d}$$

$$d = \frac{S'' - M}{\sin\theta} \qquad \text{from (18)} \tag{19}$$

$$M = w\sqrt{\frac{1 + \cos\propto}{2}}, \qquad \text{from (14)} \tag{20}$$

$$= w\sqrt{\frac{1}{1 + \sin\delta}} \qquad \text{from (15)}$$

$$S''' = \frac{d\,(1 - \sin\delta)}{\sin\delta} \tag{21}$$

$$\text{because } S''' = S'' - d = \frac{d}{\sin\delta} - d = \frac{d\,(1 - \sin\delta)}{\sin\delta}$$

$$M = d \cot\delta \cos\delta \sqrt{\frac{1}{1 + \sin\delta}} \qquad \text{from (20) and (13)} \tag{22}$$

This, at last, gives M a value in terms of spore-spacing.

$$\sin\theta = \operatorname{cosec}\delta - \cot\delta \cos\delta \sqrt{\frac{1}{1 + \sin\delta}} \tag{23}$$

This, at last, gives θ in terms of spore-spacing. The proof is detailed, thus

$$\sin\theta = \frac{S'' - M}{S'' \sin\delta} \qquad \text{from (18), because} \quad \sin\delta = \frac{d}{S''}$$

$$\text{whence} \quad \sin\delta = \frac{S'' - M}{S'' \sin\theta}$$

$$\text{Now for} \quad \frac{S'' - M}{S''} = 1 - \frac{M}{S''} \quad \text{write k}$$

Then $\sin\theta = \text{k cosec}\,\delta$ and $\sin\delta = \text{k cosec}\,\theta$, and from (22)

$$\text{k} = 1 - \frac{M}{S''} = 1 - \frac{d\cos^2\delta}{\sin\delta}\sqrt{\frac{1}{1+\sin\delta}} \times \frac{\sin\delta}{d} = 1 - \cos^2\delta\sqrt{\frac{1}{1+\sin\delta}}$$

Therefore

$$\sin\sigma = \text{cosec}\,\delta\left(1 - \cos^2\delta\sqrt{\frac{1}{1+\sin\delta}}\right)$$

$$= \text{cosec}\,\delta - \cot\delta\cos\delta\sqrt{\frac{1}{1+\sin\delta}}$$

These equations are summarised in Appendix 1. The values of the various factors are given in Appendix 2. With the three data d, σ and $n = 4$, all other parts of the basidium-unit can be calculated except the lengths of the spores, sterigmata and basidium.

If the values of the factors, as given in Appendix 2, are plotted against those of σ as graphs (which is the easiest method of obtaining intermediate values), it will be found that they form very gradual curves. This stability of form is the character of the homobasidium, which is one of the more constant structures in botany.

The curve $\sin\theta = \text{f}\,\sigma$ has its greatest curvature where $\sigma = 0.73 = \sin\theta$ The curves $\sin\theta = \text{f}\,\sigma$ and $\sin\delta = \text{f}\,\sigma$ intersect at $\sigma = 0.807$ when $\sin\theta = \sin 2\delta = 0.72$.

When $\sigma = 0.5146$, there is the special case in which the diameter of the basidium equals the circumference of the sterigmatic patch circle; that is, $w = \pi m$. Thus

$$m = S''' \sin\delta \text{ and } w = S''' + m = S'''(1+\sin\delta)$$

$$\text{Therefore} \ \frac{w}{m} = \frac{1+\sin\delta}{\sin\delta} = \sqrt{2}(1+\sigma) + 1 \qquad \text{from (5)}$$

$$= 2.414 + \sqrt{2}\,\sigma$$

If this expression is to give the value of π, then

$$\sqrt{2}\sigma = \pi - 2.414 = 0.7276, \text{ and } \sigma = 0.5146.$$

Also, at this value of σ, the length of the arc subtended by $\propto$ equals $1.004d$, which is practically the value of d. In other words, at the commonly observed value of σ, the longitudinal arc of the sterigmatic patch equals the spore-width, and the diameter of the basidium, if rolled up into a circle, equals the circumference of the sterigmatic patch circle. Here, again, it would seem that the volume of the hyaline cap of the basidium must be the basic cause.

Mycena illuminans P. Henn., as a test

This small luminous agaric, not uncommon in Singapore (Corner 1954), has fairly large, almost globose spores and the sporing basidia are fairly resistant to immersion in water. I used it, therefore, as a test of the theory. However, the basidium is large and the gill-tissue opaque, with the result that I could not obtain the basidium-circle along with the spore-circles; focussing down to the basidium-outline crushed the spore-circles. Therefore I have used average measures. The spore is very slightly wider tangentially than radially and I have kept these measures apart as *d tan* and *d rad*. Then, the basidia project to various levels; they are not clearly dimorphic, but those that project most have slightly wider spore-spacing. I have given the average for M as observed; insufficiency of basidia may account for the discrepancy with the calculated value of M.

The measures were taken from camera lucida drawings, averaged, and then used to construct an ideal basidium for the species at a magnification of 10,000. Angles on such a figure could be measured with sufficient accuracy. The figure so closely resembles that in Figure 3 that I limit myself to the comparison between the calculated values and those observed, whether in the original drawings or in the geometric reconstruction. These are given in Tables 2 and 3.

I do not consider any of the slight discrepancies in Table 3 to conflict with the general theory. I would emphasize how the variability of the basidium-unit, constructed from interweaving hyphae, is combined in the hymenium into an average regime. Thus, some basidia were so compressed as to be oblong ellipses in end-view, with diamond-shaped sterigmatic 'square', yet the average of the two diagonals of this diamond was that of the square. Spores vary in size and spacing, yet the averages obtain.

The Boletus-spore

The spores of most boleti are elongate with the smooth and slightly thickened wall brown, ochraceous or pink. The adaxial face bulges slightly, but the abaxial is remarkably straight. Other species, placed in *Strobilomyces, Boletellus, Heimiella* and *Porphyrellus,* have a verrucose, echinulate, reticulate or striate ornamentation which is also coloured. These spores have recently been studied in great detail by Perreau-Bertrand (1967), who distinguishes five layers in the wall of the ornamented spore. For my present purpose I simplify this complexity into the two layers of customary application, namely the outer colourless and apparently structureless exospore (which is the ectospore and perispore of Perreau-Bertrand) and the coloured endospore with its ornamentation, which I regard as an extension of the endospore into the exospore; the ornaments make the exospore of Perreau-Bertrand. The point is that, as Perreau-Bertrand discovered, these spores have a hyaline outer layer, 0.5–1.5μ thick, within which the coloured layer forms as the endospore. Often this outer layer becomes mucilaginous and is scarcely noticeable in aqueous mounts. The question arises whether the coloured and apparently external wall of the smooth boletoid spore represents the outer hyaline or the inner coloured layer of the wall of the ornamented spore. Perreau-Bertrand found that some smooth boletoid spores had a hyaline mucilage-sheath to suggest that the coloured wall was endospore. I confirm this observation from many Malayan species and add positive proof that the coloured layer is endospore (see the following observation iii). Evidently the smooth boletoid spore is an endospore; that it is peculiar is shown by the following points.

(i). For most boletoid spores $d = 0.36\ w$ to $0.58\ w$, instead of the usual $0.6\ w$ to $0.65\ w$. The spore, therefore, is compressed.

(ii). In the case of the ornamented spores of *Strobilomyces* and other genera, $d = 0.59\ w$ to $0.71\ w$ but, if the inner spore is taken, then $d = 0.48\ w$ to $0.60\ w$ as with the smooth boletoid spore. This means that there are two spacing factors, σ' for the outer spore of diameter d' and σ for the inner spore of diameter d. However, some species of *Boletellus* have spores that are merely finely striate and such spores are equivalent only to the endospore of *Boletellus;* and this genus, incidentally, becomes practically inseparable from *Boletus.*

(iii). In some pink-spored species, such as *B. albo-ater* Schw. and *B. nanus* Mass., the spore grows to a size that exceeds the final spore by c. 1μ in length and breadth. This larger spore is hyaline and, very soon, there forms within it a coloured, thickening layer which becomes the outside of the mature spore, while the outer hyaline layer turns mucilaginous and loses its firm limiting membrane, In these cases the larger transient spore has $d = 0.46\ w$ to $0.60\ w$ and the mature spore has $d = 0.37\ w$ to $0.50\ w$. This proves that the endospore makes the coloured wall of the boletoid spore and, as corroboration, some of these spores, are extremely finely striate and could be referred to *Boletellus*, except for the spore-colour. I think that this phenomenon of spore-shrinking is widespread among smooth-spored boleti and that the limits of *Boletellus*, as of most segregates from *Boletus*, are unsatisfactory.

(iv). The ornamented spores of *Strobilomyces* and *Porphyrellus* sect. *Graciles* have a small adaxial patch without ornamentation; it is absent from the spores of *Boletellus* and *Heimiella.* The adaxial patch forms where the spore-wall contacts or approximates with S''' and, therefore, in these two genera exospore and endospore must coincide more or less in this area. Radial spacing must be the same for both exospore and endospore, in which respect these spores are less specialised than those of other boleti.

(v). The elongate spores are strictly parallel with the long axis of the basidium and, as already noted, the abaxial side is straight. This is evidence of the compression of the spore-circles which is to be expected from the tubular hymenium.

In order to discover what may be happening in the development of the *Boletus*-spore, I studied in detail several species with a diversity of spores. Table 4 summarises the results. Figures 5-11 show the simplified geometry of the basidia. The reconstruction of such figures I find to be the only satisfactory way to appreciate the intricacy of the basidium-unit. The species which I studied have the following particulars.

Strobilomyces velutipes Cke. et Mass., with purple brown, verrucose, ellipsoid to subglobose spore; adaxial patch present.

Porphyrellus sect. *Graciles*, an undescribed species with imperfect observations; spores purple brown, verrucose but with smooth apex and base, and with a narrow adaxial patch.

TABLE 2

MYCENA ILLUMINANS

Values of the basidium-unit in μ from observation

—	D	d tan	d rad	σ tan	S'	S'''	M	w	l	θ
Average	9.58	9.00	8.86	3.86	26.88	9.16	10.94	14.07	30.5	50° 85′
Range	8.5–10.3	8.0–10.1	8.0–9.6	2.4–6.6	24.0–30.9	5.3–12.5	8.5–13.5	11.9–16.8	23–39	48.3°–56.5°
Number observed ..	20	118	103	118	52	52	64	85	30	10
Ratio to										
d tan	1.06	1	0.98	0.430	—	—	1.22	1.56	—	—
d rad	1.08	1.02	1	0.438	3.03	1.03	1.24	1.59	—	—
w	—	0.63	0.63	—	1.91	0.65	0.78	1	2.17	—

TABLE 3

MYCENA ILLUMINANS

Comparison of observed and calculated values of the basidium-unit in μ

	TANGENTIAL SPACING			RADIAL SPACING			OBSERVED
	σ equations	w equations	observed	σ equations	w equations	observed	mean values
d	..	9.08	9.00	..	9.00	8.86	9.05 and 8.82
σ	..	..	0.430	..	..	0.438	..
S'	27.2	27.44	..	..	27.29	26.88	27.45
S'''	9.2	9.35	..	..	9.3	9.16	8.9
M	11.25	11.35	10.94	11.19	11.36	10.94	11.0
w	13.75	..	13.87	13.67	..	13.87	14.35
m	4.55	4.59	..	4.50	4.57	4.67	..
δ	29° 38′	29° 38′	..	29° 27′	29° 27′	..	29° 30′ to 30°
$\propto$	70° 13′	70° 12′	69° 14′	70° 5′	70° 4′	69° 14′	..
θ	50° 33′	..	..	50° 26′	..	50° 85′	52° 38′

Boletus emodensis. B. and *B. longicollis*. Ces. with olive brown, striate-costate, ellipsoid spores as in *Boletellus*.

B. retisporus Pat. et Baker with olive brown, reticulate and ellipsoid spore (*Heimiella*).

B. albo-ater Schw., *B. nanus* Mass. and an undescribed species (Boletus 18b of my notes), with pink, smooth boletoid spores but with evanescent exospore and very faintly striate endospore.

B. aureomycelinus Pat. et Baker, *B. phaeocephalus* Pat. et Baker, *B. ravenelii* B. et C. and *B. umbilicatus* Mass. with olive brown smooth ellipsoid to boletoid spores. [It is to be noted that *B. phaeocephalus* is the species which I called *B. funerarius* Mass. in my earlier paper (Corner 1947); there is a mixture of type-painting and type-specimen for *B. funerarius*, the former being *B. phaeocephalus*].

Phylloporus cingulatus Corner with smooth, brown ellipsoid spores.

The first point to note from Table 4 is that, except for *Strobilomyces*, the observed values of w exceed those calculated from the spore-circles. The circles are smaller than would be expected. The sterigmata have been approximated by an adaxial shift, upwards along the basidium-axis, and therefore the spore-circles have been narrowed and the spores compressed. The compression is most marked in *B. emodensis* (Figure 11) and *B. phaeocephalus* (Figure 5) in which S'' lies within w.

The point is illustrated by the position of the sterigmatic patch. In all species, if a sterigmatic patch circle is drawn on S''' with radius $S''' w$, it greatly exceeds the arc of the sterigma on the basidium-apex. I have shown two sterigmatic patch circles in the figures, m for σ' spacing and (m) for σ spacing. The (m) circle is the determinant that fits the sterigmatic arc, while the m circle is the unstable, excessive factor. However, the centres of m and (m) vary from S''' to M itself. Thus *B. emodensis* (Figure 11) shows the greatest compression with the centre of (m) on S''' and radius $S''' M$.

The second point is that in the species with a distinct, if evanescent, exospore the value of d (inner spore) gives a better approximation to that of M than does d (outer spore). Reference to the figures or to the table in Appendix 2 will show that the values of M and w to be expected from d are excessive; this means that σ' spacing is too large and gives place to σ spacing. For some physical reason the exospore is more or less unstable and the spore, constructed on σ spacing, is an endospore. It is not clear, however, that there is any geometrical reason for the development of ornamentation; presumably it is a physical reaction of the membrane to the instability of σ'. Comparison with other species in the groups with ornamented spores may reveal some common peculiarity.

In all the species with smooth spores the plane of S'' approaches that of w in evidence of the compression of the spore-circles. However, as noted, *B. emodensis* with striate-costate spore agrees in this respect with the apparently smooth-spored *B. phaeocephalus* and, hence, this relation cannot be connected with ornamentation. Yet *B. phaeocephalus* is one of the species in which the endospore can be seen to be exceedingly finely striate.

TABLE 4

Spore-measurement in Boletus

——	Observed values (μ)						Theoretical values* (μ)		
	d	σ	S''	S'''	M	w	M	w	
S. velutipes	8.00		16.72	8.74	11.8	14.0	10.88	13.20	for d'
	6.80		16.60	9.90			11.76	13.95	for d
ratio to d'	1	0.50	2.09	1.09	1.48	1.75	1.36	1.65	
ratio to d	1	0.76		1.45	1.75	2.06			
(number)	(120)	(104)	(26)	(26)	(61)	(91)			
B. emodensis	7.28		13.91	6.63	9.54	14.46	10.3	10.1	for d'
	6.08		13.91	7.83			9.38	11.26	for d
ratio to d'	1	0.38		0.91	1.31	1.99	1.42	1.39	
ratio to d	1	0.65		1.23	1.57	2.38			
(number)	(152)	(102)	(34)	(34)	(44)	(79)			
B. longicollis	10.33		17.44	7.11	11.55	14.5	8.97	11.31	for d'
	8.70		16.77	8.07			9.95	12.26	for d
ratio to d'	1	0.20		0.69	1.12	1.40	0.87	1.10	
ratio to d	1	0.36		0.93	1.33	1.67			
(number)	(80)	?	(24)	(24)	(24)	(100)			
B. retisporus	9.18		17.61	8.42	10.58	15.51	10.39	12.81	for d'
	7.58		17.61	10.02			11.99	14.33	for d
ratio to d'	1	0.36		0.92	1.15	1.69	1.13	1.40	
ratio to d	1	0.65		1.32	1.40	2.05			
(number)	(164)	(152)	(38)	(38)	(51)	(94)			
Boletus 18b	5.25		11.00	5.75	9.06	10.00	6.98	8.47	for d'
	3.90		11.02	7.12			8.28	9.62	for d
ratio to d'	1	0.48		1.10	1.73	1.91	1.33	1.61	
ratio to d	1	1.01		1.83	2.32	2.56			
(number)	(364)	?	(86)	(86)	(40)	(86)			
B. albo-ater	4.77		10.91	6.14	8.58	10.34	7.34	8.82	for d'
	3.97		10.91	6.94			8.11	9.47	for d
ratio to d'	1	0.618		1.29	1.80	2.17	1.54	1.85	
ratio to d	1	0.945		1.77	2.16	2.60			
(number)	(142)	(112)	(62)	(62)	(41)	(51)			
B. nanus	5.38		10.96	5.58	8.35	10.98	6.81	8.32	for d'
	4.03		10.96	6.93			8.10	9.48	for d
ratio to d'	1	0.441		1.04	1.55	2.04	1.26	1.54	
ratio to d	1	0.924		1.72	2.07	2.73			
(number)	(250)	(180)	(46)	(46)	(42)	(92)			
B. phaeocephalus	4.55		11.65	7.10	8.68	12.20	8.37	9.87	
ratio to d	1	0.810		1.56	1.91	2.68	1.84	2.17	
(number)	(102)	(160)	(50)	(50)	(82)	(66)			
B. umbilicatus	5.37		13.06	7.69	8.86	12.33	9.12	10.85	
ratio to d	1	0.720		1.43	1.65	2.30	1.70	2.02	
(number)	(56)	(10)	(9)	(9)	(6)	(38)			

Table 4 — *continued.*

Spore-measurement in Boletus.

	Observed values (μ)						Theoretical values* (μ)	
	d	σ	S''	S'''	M	w	M	w
B. ravenelli	4.21		10.22	6.01	6.81	9.96	7.14	8.49
ratio to d	1	0.720		1.43	1.62	2.37	1.70	2.02
(number)	(132)	(92)	(40)	(40)	(22)	(69)		
B. aureomycelinus	4.89		10.89	6.00	7.90	10.47	7.22	8.69
ratio to d	1	0.575		1.24	1.62	2.14	1.48	1.78
(number)	(126)	(56)	(28)	(28)	(36)	(64)		
P. cingulatus	5.20		11.98	6.80	8.96	11.63	8.14	9.95
ratio to d	1	0.615		1.31	1.72	2.24	1.57	1.91
(number)	(188)	(80)	(40)	(40)	(17)	(73)		

* calculated from $M = S'''\sqrt{\frac{S'}{S''}}$ and $w = \frac{S'\,S'''}{S''}$

d' outer spore, d inner spore.

(number) refers to the number of observations.

Various errors in observation and construction can be imagined to explain the differences in positioning of the sterigmatic patch circles, but without understanding of the physical forces involved I do not think that they help the solution. I mention one possibility because it is a step in the adaxial displacement of the sterigmata. In Figure 5 I have drawn w' w' as the false base of the basidium-apex; it is the base that makes the basidium-apex hemispheric instead of ellipsoid and, as will be seen, it has the effect of shifting the sterigmata upwards and adaxially to compress the spore-circles. The sterigmatic patch, nevertheless, seems to fit not the arc of $\angle$HA′ w′ but the upper half of this arc. It appears that the compression of the cone-effect of the basidium-unit in the concave hymenium acts on the sterigmatic patches before emergence of the sterigmata. This is a part of the more general problem of the hymenium-level where some force causes basidia to stop elongating and to mature; thus cystidia are basidia that have exceeded this level, often before it has become established in the developing hymenium, and remain sterile. The hymenium-level is another apparently electrostatic effect of the fruit-body.

B. phaeocephalus (Figure 5). At first sight this appears to be a normal reconstruction but the S'' circle lies within the w circle, a spacing circle on S''' with radius S''' w greatly exceeds the sterigmatic patch, and the observed spacing, whereas a spacing circle on M with radius Mw almost fits the tangent to the spore; and the sterigmatic arc is much shorter than Hw. I detected no exospore but comparison with Figure 6 shows that the spore of *B. phaeocephalus* is an endospore developed from an adaxially displaced sterigmatic patch. This construction probably represents the normal state for the smooth boletoid spore.

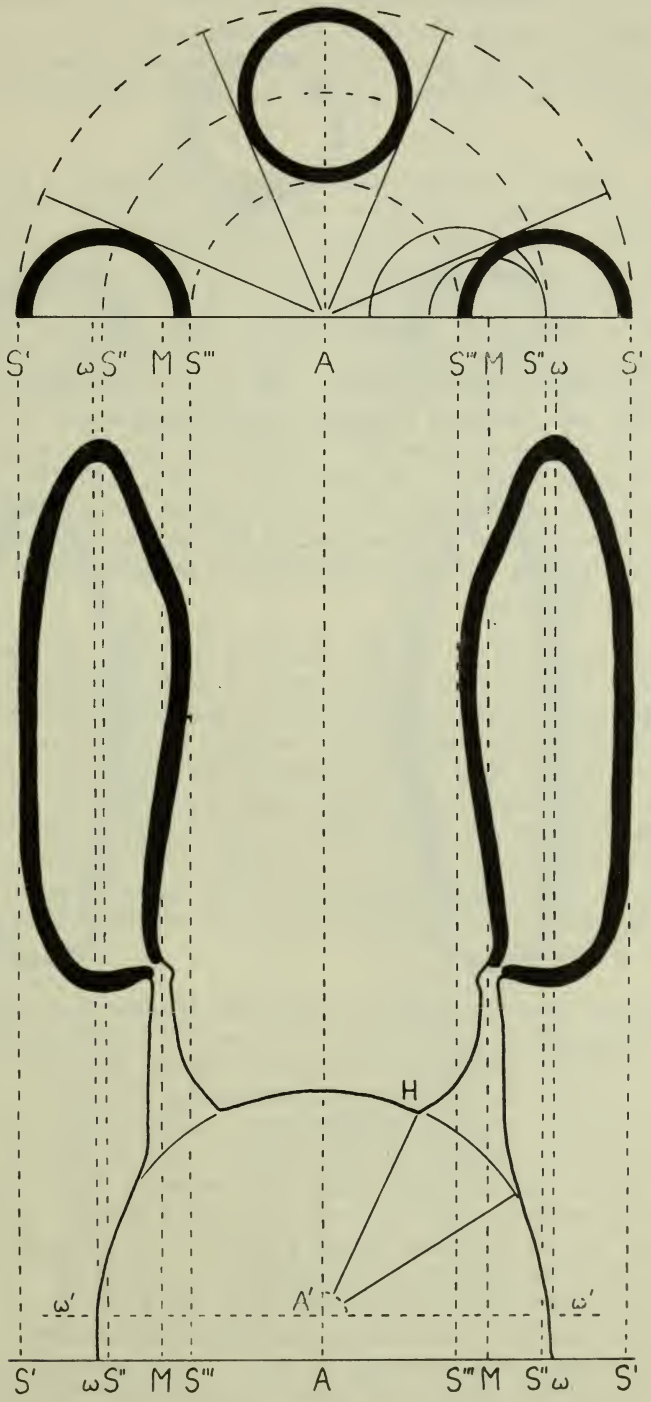

Figure 5. *Boletus phaeocephalus*, with w′w′ as the false base of the basidium-apex; x 5000.

B. albo-ater (Figure 6). This reconstruction shows the excessive σ' spacing which leads to the disappearance of the exospore and its substitution by the endospore with (*m*) spacing. The centre of the (*m*) circle is not on S''' but midway between S''' and M (on the inner limit of the endospore). Construction of $\propto'$ on the false base gives the sterigmatic arc with the radius of the half angle contacting the M ordinate.

B. nanus (Figure 7). In this reconstruction I have drawn a normal spore on the right with its evanescent exospore and durable endospore. The centre of the (*m*) circle almost coincides with M; that of the *m* circle is slightly abaxial from S''', but for both the radius is now to S'' which coincides with w; a spacing circle with centre on S''' and radius $S'''\ w$ is clearly of no consequence. On the left I have drawn an imaginary ellipsoid spore (with endospore and exospore) and an imaginary globose spore; the volume of the latter (6.8 x 7.1μ) and that of the ellipsoid endospore (8.0 x 4.6μ) are equal to the volume of the normal endospore. They are positioned according to the spacing factor σ' for the normal exospore and its theoretical value of w (as from the table in Appendix 2). These spores are eccentric because S'' is 14.47μ for σ' and 12.59 for σ. The reconstruction shows how a globose spore of normal spacing relations with the basidium, such as might have occurred in the ancestor of *Boletus*, may have been transformed into the smooth boletoid spore by compression of the spore-circles commensurate with the concave hymenium.

B. retisporus (Figure 8). In this reconstruction (S‴), for the inner spore, almost coincides with M; they are 0.3μ apart. It appears that sterigmatic spacing is more compressed than spore-spacing; thus M is displaced adaxially towards S''' and the wider gap which results between exospore and endospore may allow the development of the reticulate ornamentation all over the spore without a smooth adaxial patch. In this case the (*m*) circle contacts the w' ordinate of the false base. It is likely that *B. longicollis* agrees with *B. retisporus* though the measures of S''' and M (in Table 4) do not show it. The basidia of *B. longicollis* collapse very easily in aqueous mounts and my measures of the spore-circles are probably too small. (*B. longicollis* has also been described as *B. altissimus* Mass. and *B. singaporensis* Pat. et Baker).

Strobilomyces velutipes (Figure 9). The reconstruction is complicated by the necessity to distinguish the spore-circles S', S'' and S''' for the exospore from (S'), (S'') and (S''') for the endospore. Two reconstructions are shown. That on the right fits the smooth boletoid spore and that on the left is the true spore. The spore on the right has exospore and endospore concentric, but this would allow ornamentation to be developed all over the spore, as with *B. retisporus*. The normal spore has a smooth adaxial patch, where the membrane of the exospore can be seen to touch the endospore, and the warts are graded in height from the shortest on the adaxial face to the tallest on the abaxial. The endospore has, therefore, to be constructed eccentrically to the exospore. The *m* circle for the normal spore gives too large a spacing but the (*m*) circle with centre on S''' and radius $S'''\ w$ gives the correct spacing for the endospore. This arrangement means compression of S' to (S') without compression of M, and S''' remains unaffected. The spore is produced on a wide basidium with much less compression than with the smooth boletoid spore and is, accordingly, broadly ellipsoid and even subglobose. The whole basidium-unit is the least modified and, presumably, the most primitive among boleti.

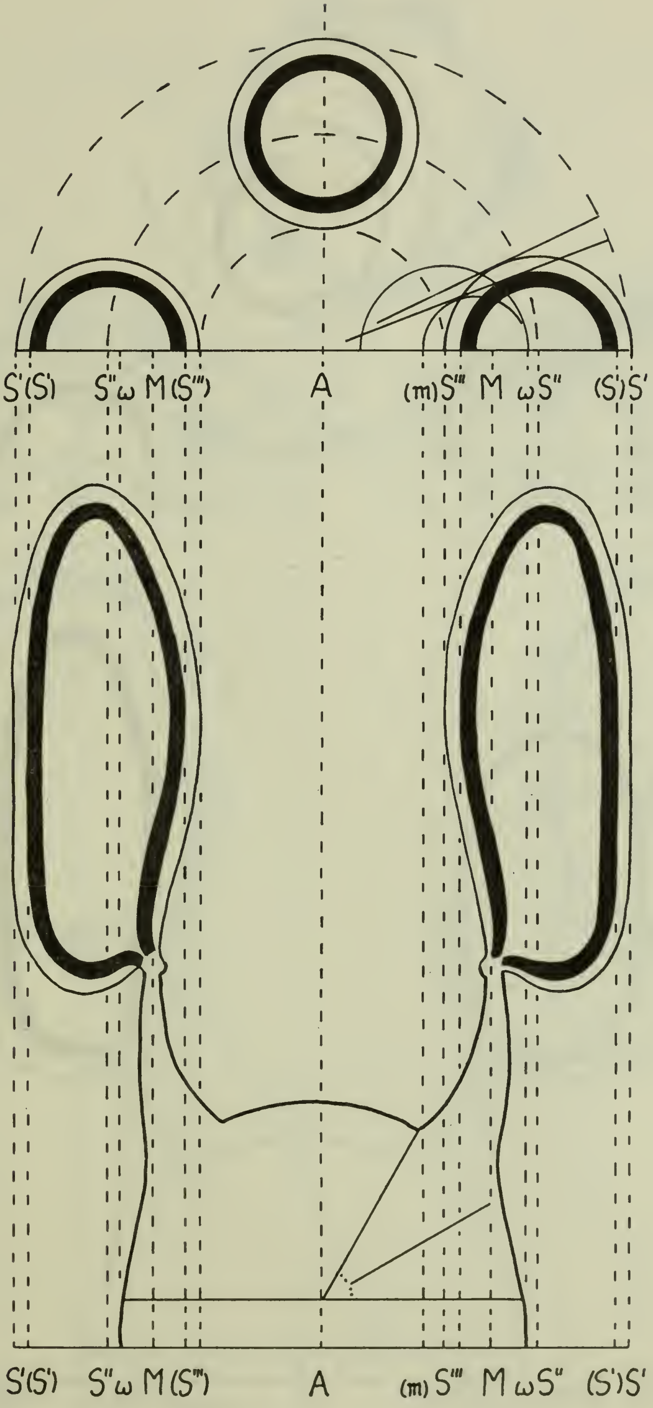

Figure 6. *Boletus albo-ater*, with exospore and endospore; x 5000.

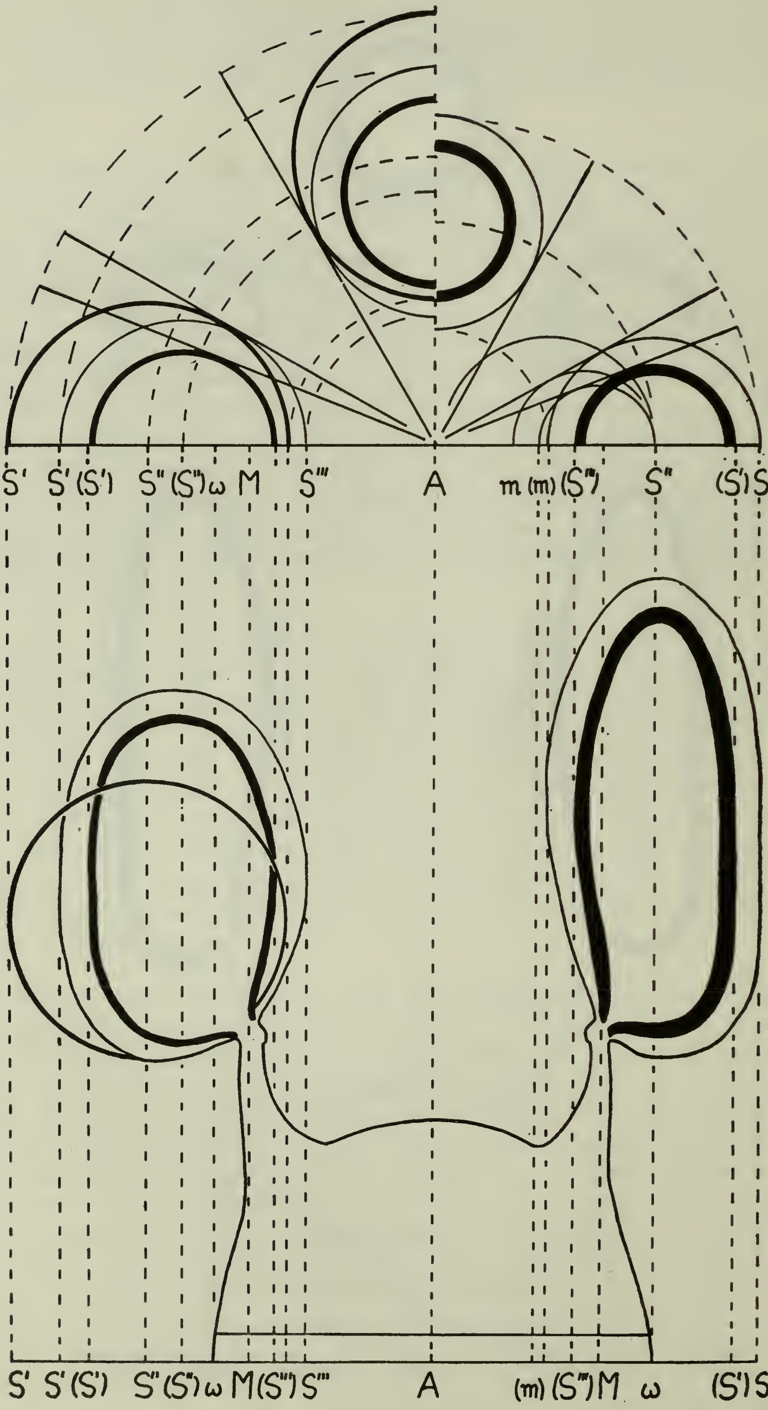

Figure 7. *Boletus nanus* with a normal spore on the right and, on the left, imaginary ellipsoid and globose spores of the same volume as the normal endospore but altered in shape according to the spacing (see text); x 5000.

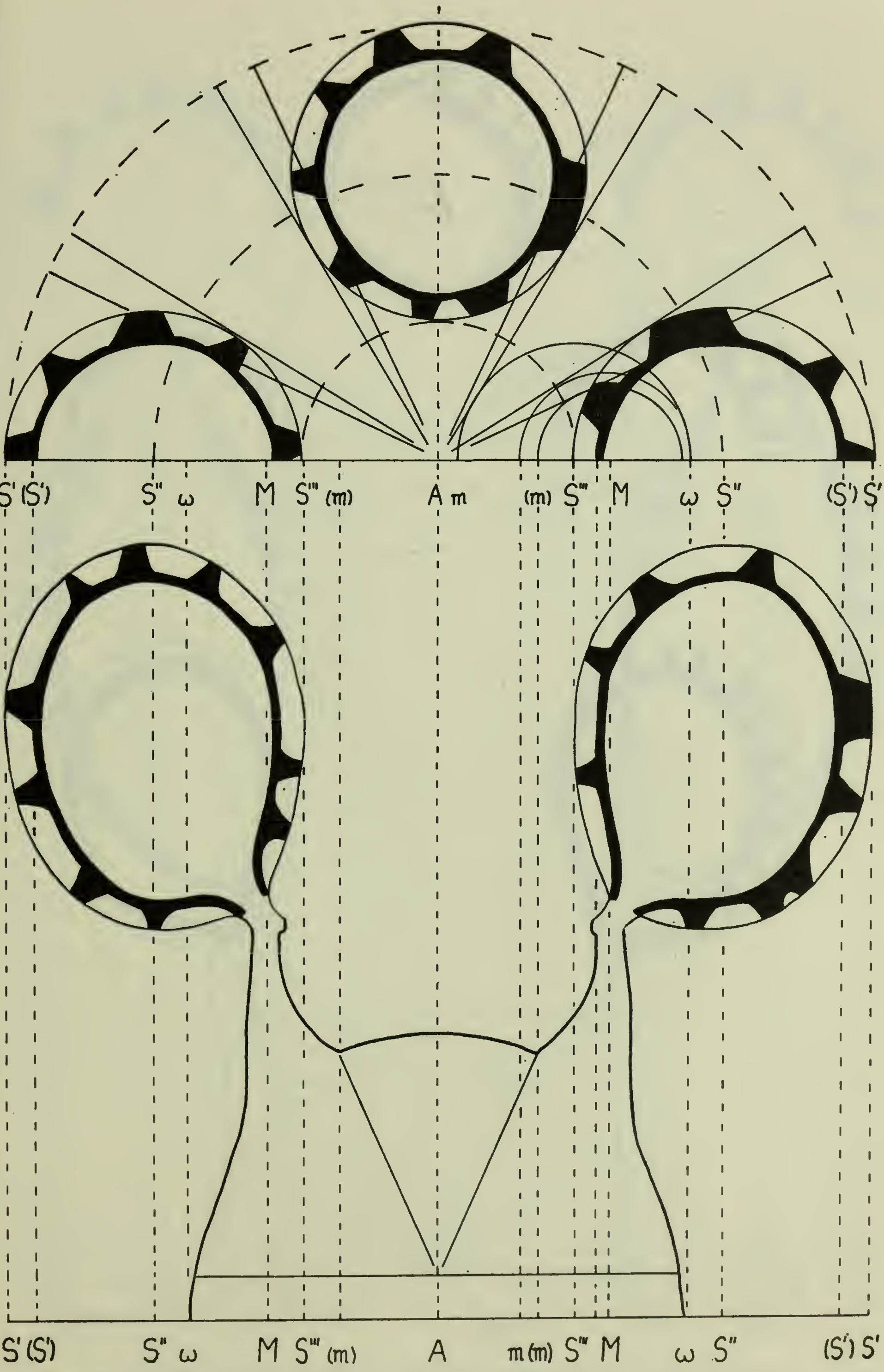

Figure 8. *Boletus* (*Heimiella*) *retisporus*; x 4500.

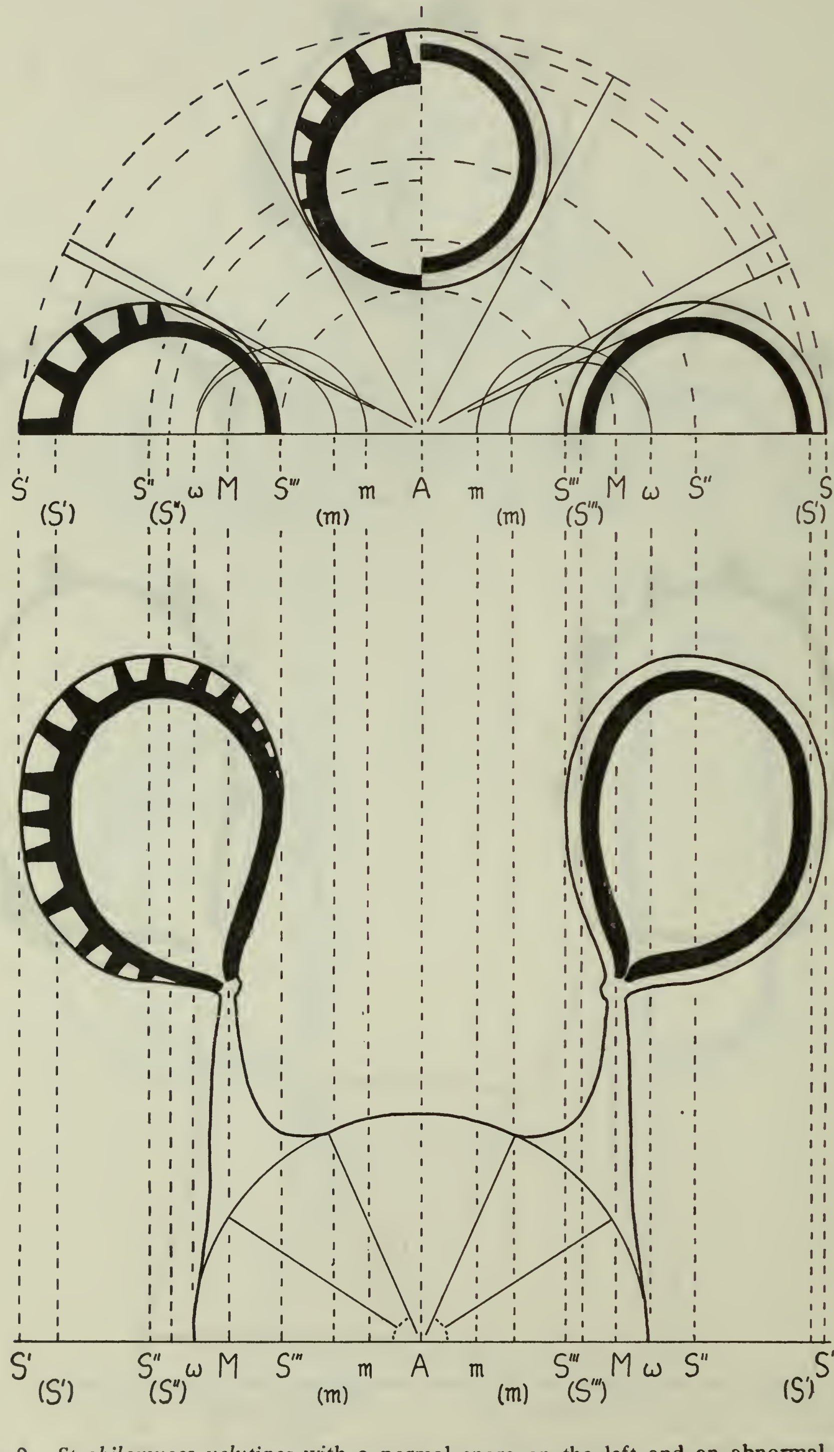

Figure 9. *Strobilomyces velutipes* with a normal spore on the left and an abnormal spore, constructed as a smooth spore, on the right; x 4800.

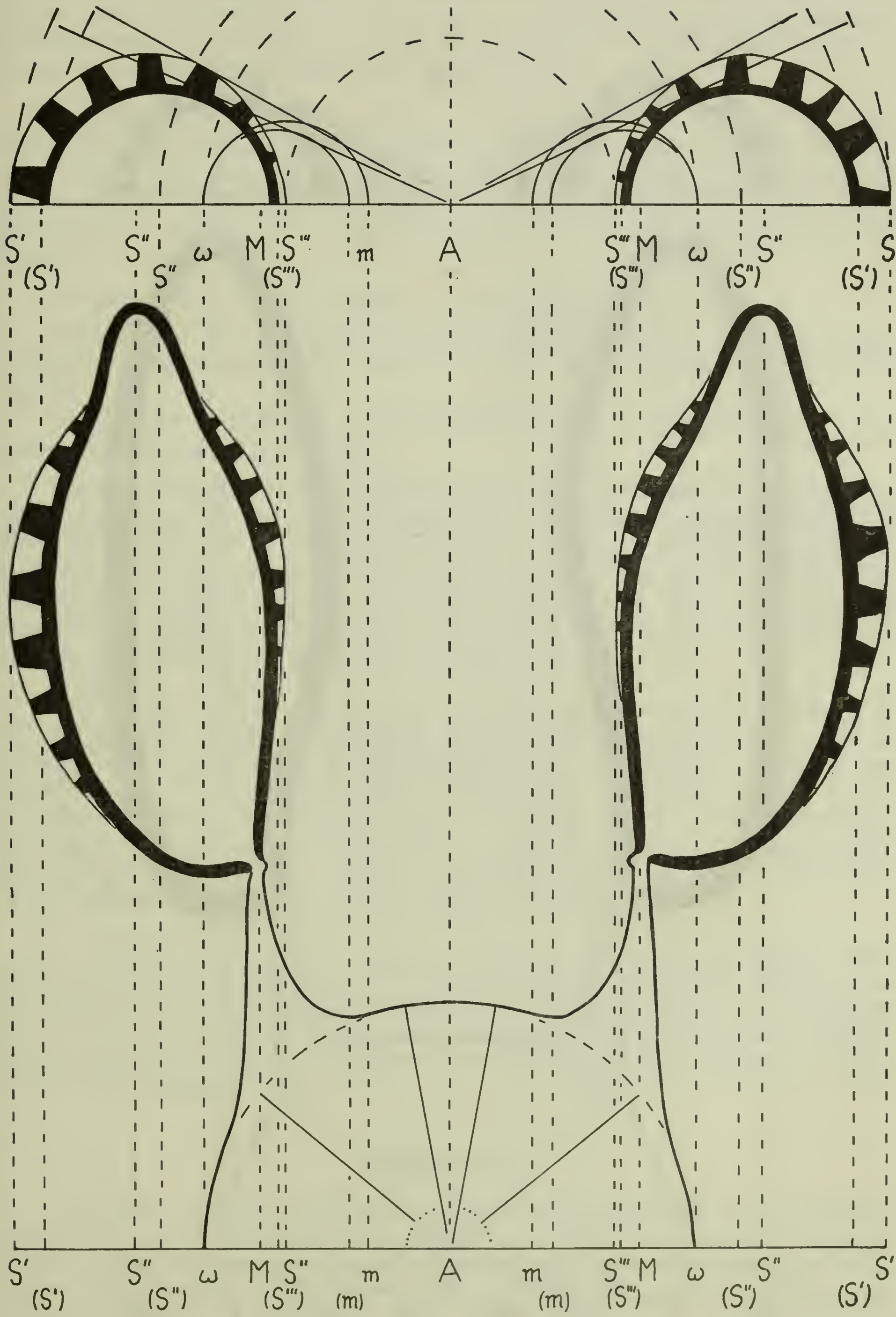

Figure 10. *Porphyrellus* sect. *Graciles* (unidentified species); x 4600.

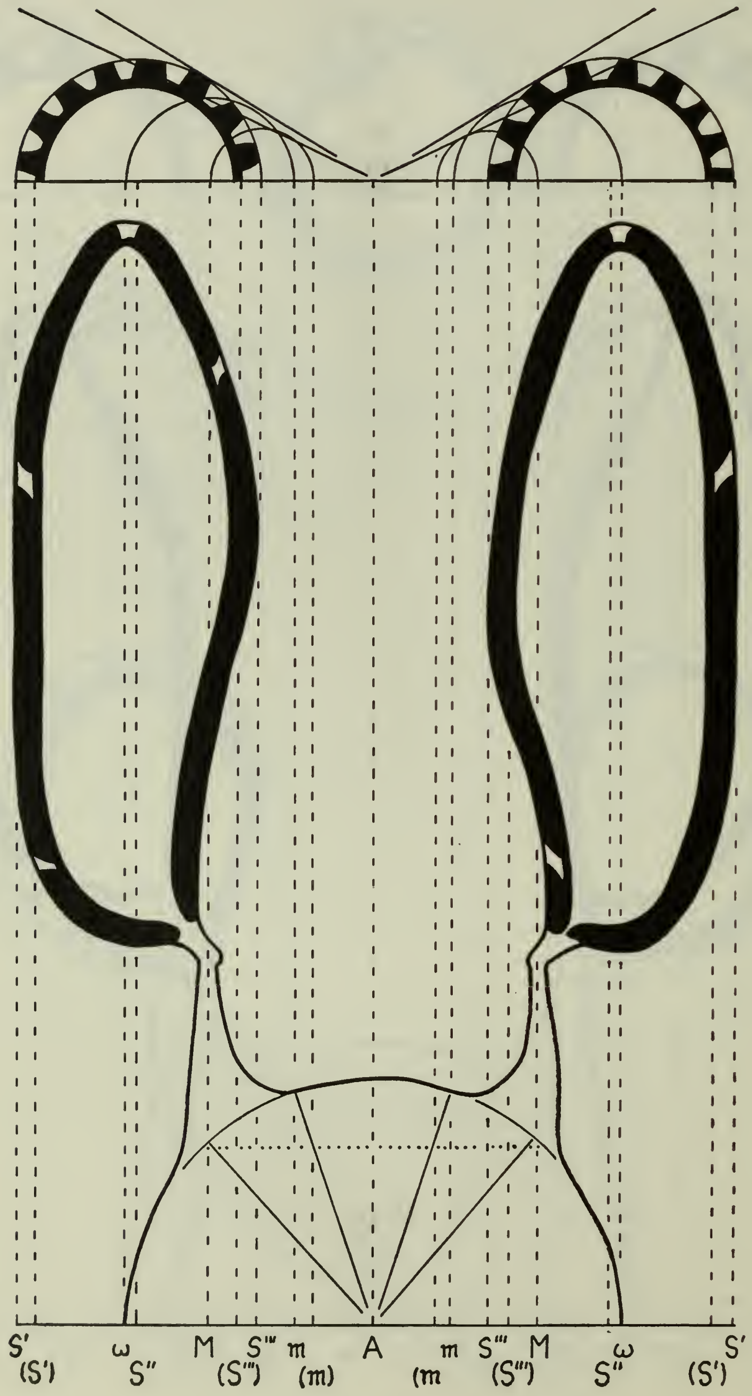

Figure 11. *Boletus emodensis;* x 5000.

Having no detailed analysis of the curvature of the basidium-apex in this species, the reconstruction has been made on a hemispheric apex. It is probably a reconstruction on the false base with the effect that the radius which bisects $\propto$ meets the sterigmatic arc where intersected by the M ordinate.

Porphyrellus sect. *Graciles* (Figure 10). Having no fresh material to study in this interesting case allied with *Strobilomyces,* I used alcohol-formalin material of an undescribed Malayan species. This did not give reliable measures for the spore-circles. I reconstructed the basidium-unit from measures of d and w and the ratio $w = 1.655d$ for d' tan, which gives $\sigma' = 0.5$. The measures were as follows: —

exospore 17.36 × 8.41μ (radial), × 9.16μ (tangential);

endospore 17.36 × 7.26μ, with truncate conical warts 0.7– 1.2μ high (mean 0.95μ) on the sides and abaxial face, 0.1–0.3μ on the adaxial side; (average of 30 spores);

basidium 32 × 15.16μ, with the sterigmatic circle 11.8μ wide (average of 50 basidia and 40 sterigmatic circles).

The reconstruction on a hemispheric apex for the basidium is similar to that of *Strobilomyces* but the spore is compressed and elongate through the adaxial shift of M towards S'''. The point is shown by the value of S' which is 27μ in the reconstruction though, theoretically, it should be 28.6μ. The adaxial shift of M is the principal change leading to the smooth boletoid spore. Thus, this section of *Porphyrellus* appears to be half-way between the state of the basidium-unit in *Strobilomyces* and that in *Boletus* with smooth spore.

B. emodensis (Figure 11). The high compression of these spores is shown by the upward and adaxial displacement of the sterigmata on the wide basidia. Though I have constructed the basidium-apex as a hemisphere, the false base would need to be lifted even higher, as shown by the dotted line, to fit the sterigmatic patches; the dotted line gives $w = 10.1\mu$, which is the usual width of basidia in smooth spored boleti. Then, as further evidence of compression in this figure, the real value of w slightly exceeds that of S''; the m circle has centre M and radius Mw; the (m) circle has centre S''' and radius $S''' M$.

B. longicollis belongs in this same alliance of *Boletellus* with striate-costate spores. So, apparently, does *B. obscurecoccineus* Hoehn. with faintly striate spores equivalent to the endospore of *B. emodensis.* It would seem that in this alliance the series can be traced from the broadly ellipsoid spore to the smooth boletoid. Unfortunately other species in Malaya have $n = 2$ or 3, and comparable results could not be obtained.

Phylloporus

This genus is close to *Boletus* in its wide sense and differs in the lamellate hymenium. Among fifteen Malayan species for which I have accurate measures (Corner 1970), thirteen have $d = 0.42w$ to $0.56w$, but in *P. borneensis* $d = 0.58w$ and in *P. coccineus* $d = 0.71w$. Evidently there is the tendency to the compression of the spore-circles in this genus without the development of the fully tubular hymenium. I worked out the details for *P. cingulatus* (Table 4); they showed the boletoid features of close agreement between the values of S'' and w and of the location of the M ordinate through the m circle on the false base.

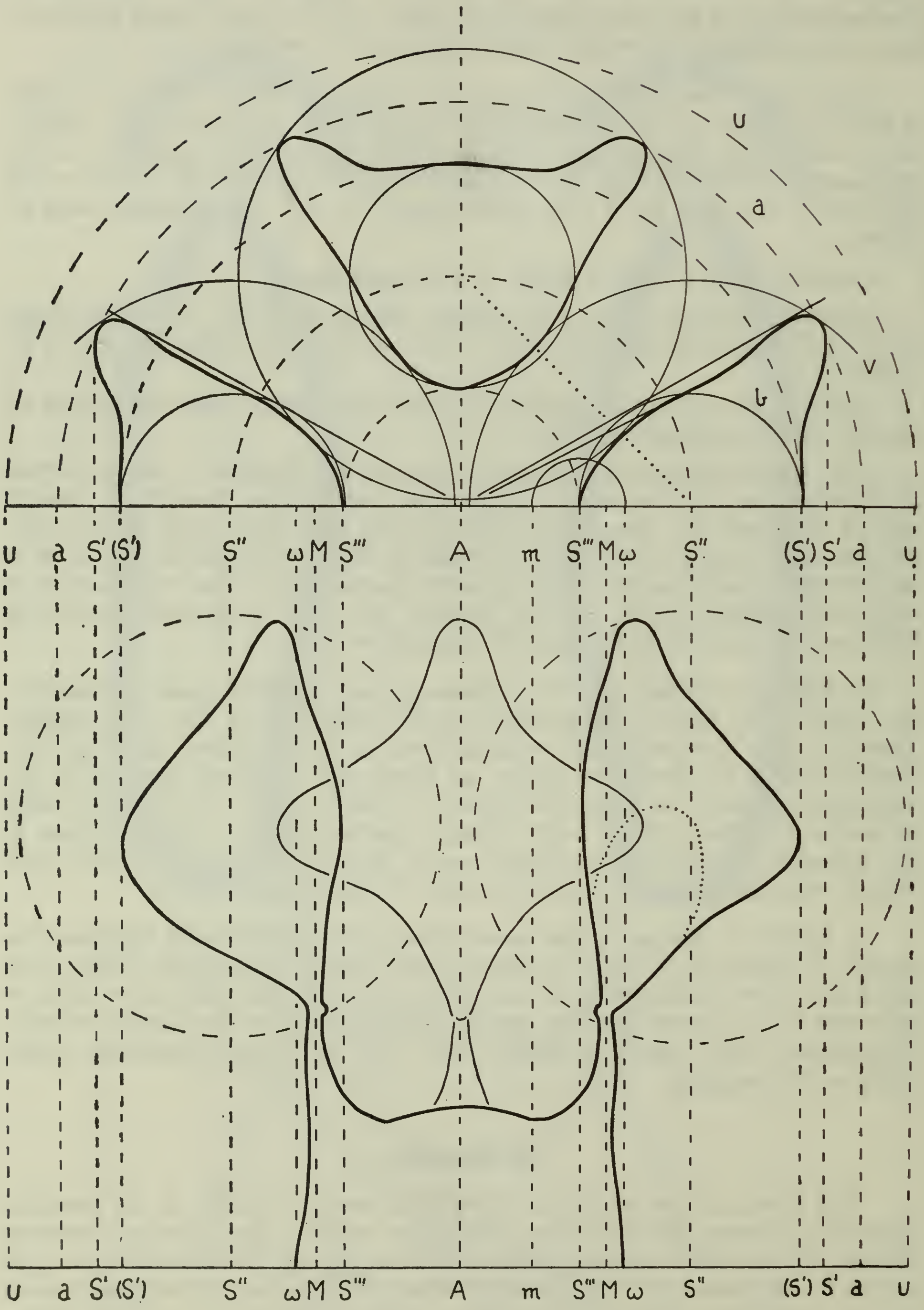

Figure 12. *Marasmius nigripes;* x 5000

If, as I consider, the poroid *Boletus* has been derived from a lamellate agaric of *Paxillus-Phylloporus* affinity, then it seems that the characteristic of the *Boletus*-spore was developed in this ancestor, but both *Paxillus* and *Phylloporus* have smooth spores. This conflicts with the idea, put forward in previous pages, that the primitive *Boletus* had an ornamented endospore. Therefore the monotypic South American *Phylloboletellus* Singer stands out because it has the phylloporoid hymenium and the striate-costate spore of *Boletellus* (Singer 1964). According to Singer's measurements, in *Phylloboletellus chloephorus* $d = 0.78w$ and this implies both σ' and σ spacing. Certainly it suggests a primitive boletoid fungus, though apparently without adaxial patch. This is supplied by *Gloeocantharellus* with ornamented spores and apparently no exospore. For three of its five species $d = 0.59$ to $0.65w$ (Corner 1969). There appears to be a single spacing factor with external ornamentation, as in *Russula* and without any of the elaboration of the boletoid spore.

Marasmius nigripes Schw.

The remarkable spores of this fungus illustrate the use of geometrical analysis (Figure 12). In adaxial and abaxial view the spores are cruciform; in side-view they are trigonous and in end-view crescentic. They develop from the spore-rudiment into a shortly clavate form ($6 \times 3\mu$), typical of many species of *Marasmius;* this form is shown in dotted outline in the figure. Then shoulders develop to extend laterally and abaxially while the apex lengthens into the third arm and the spore-body swells to full size. There are no radial arms against the boundaries of S' and S'''. Figure 12 is based on averages from ten basidia in side-view and ten in end-view; the basidium apex is drawn as semicircular.

On this reconstruction I then drew (i) the radial tangents to the spore-body and spore-arm; (ii) the sterigmatic patch circle (centre S''', radius $S'''\ w$); (iii) a spore-body circle b inscribed on S'' between S''' and S', and found to my surprise that it fitted the tangent to the spore-arm; (iv) a spore-arm circle v (centre S'', radius S'' to the apex of the arm), and found to my surprise that it contacted adjacent spore-bodies and almost reached the long axis of the basidium; (v) an outer spore-circle a (centre A, circumscribing the spore-arms); (vi) an outermost circle u circumscribing the v circles, as the outermost limit of the basidium-unit.

This figure leads to the following conclusions: —

(i) the m circle may be the prime spacing circle for the spores; that it does not contact the tangent in the drawing may be due to the difficulty in locating the exact tangent in this region where the curvature of the spore is changing.

(ii) the m circle gives $\sigma = 0.42$ or $w = 1.51d$, which corresponds with $w = 1.52d$ for average measures of spores ($9\text{-}12 \times 8\text{-}11\mu$) and basidia ($25\text{-}32 \times 8\text{-}10\mu$).

(iii) the b circle, contacting the spore-arm tangent, gives $\sigma = 0.44$ or $w = 1.55d$.

(iv) the actual spore-body (with radius measured along the dotted line joining adjacent spore-centres in Figure 12) gives $\sigma = 0.61$ or $w = 1.84d$.

(v) the spore starts with theoretical spacing of σ for the mature basidium; it then reduces this to σ', grows radially to the allowance of σ', but this extension occurs only about the mid-length of the spore; the spore-body is itself compressed tangentially to a value between σ' and σ.

(vi) in final form, as shown by the *v* circles, the spore comes to fulfil by some physical means the whole spore-sector.

The compression of the spore-body, mentioned in (v), may bear on the nature of the long, narrowly clavate spores of many species of *Marasmius,* as another instance of spore-compression, similar to that of *Boletus.* I have seen a fine mucilage sheath round many *Marasmius* spores. On germination of the spore of *M. nigripes,* it is only the spore-body that swells.

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Appendix 1

Summary of the relations between the spores and the basidium ($n = 4$) d = spore-width; m = diameter of the sterigmatic patch circle; w = basidium-width; M = diameter of the sterigmatic circle; S', S'', S''' = diameters of the outer, middle and inner spore-circles respectively.

$\propto$ = the sterigmatic patch angle; δ = half the spore-subtending angle; θ = the spore angle; σ = the spore-spacing factor.

Text reference

Side of square inscribed in $S'' = d\,(1 + \sigma)$ .... (1)

$$S'' = d\sqrt{2}\,(1 + \sigma) = d \operatorname{cosec} \delta = \frac{d}{\sin \delta}$$ .... (2), (6)

$$S' = S'' + d = d\sqrt{2}\,(1 + \sigma) + d = \frac{d\,(1 + \sin \delta)}{\sin \delta} = d\,(1 + \operatorname{cosec} \delta) = S''' \sec \propto$$ .... (7)

$$S''' = S'' - d = d\sqrt{2}\,(1 + \sigma) - d = \frac{d\,(1 - \sin \delta)}{\sin \delta} = d\,(\operatorname{cosec} \delta - 1)$$ .... (8)

$$S' + S''' = 2S'' \text{ and } S' - S''' = 2d$$

$$\frac{S'}{S''} = 1 + \sin \delta \qquad \frac{S'''}{S''} = 1 - \sin \delta \qquad \frac{S'''}{S'} = \cos \propto \qquad \frac{S'\,S'''}{S''} = w$$

$$M = \frac{w \cos \propto}{2} = w\sqrt{\frac{1}{1 + \sin \delta}} = w\sqrt{\frac{S''}{S'}} = S'''\sqrt{\frac{S'}{S''}}$$ .... (14)

$$M = d \cot \delta \cos \delta \sqrt{\frac{1}{1 + \sin \delta}}$$ .... (22)

$$M = S'' - 0.7\,d = d\,(\operatorname{cosec} \delta - 0.7) = d\,[\sqrt{2}\,(1 + \sigma) - 0.7]$$ .... (9)

$$\sigma = \frac{S''}{d\sqrt{2}} - 1 = \frac{\operatorname{cosec} \delta}{\sqrt{2}} - 1$$ .... (10)

$$\sigma = \frac{1 + \cos \propto}{\sqrt{2}\,(1 - \cos \propto)} - 1$$ .... (15)

$$m = S''' \sin \delta = d\,(1 - \sin \delta)$$ .... (11)

$$w = S''' + m = S'''\,(1 + \sin \delta) = \frac{S'\,S'''}{S''} = d \cos \delta \cot \delta$$ .... (12) (13)

$$\sin \delta = \frac{d}{S''} = \frac{1}{\sqrt{2}\,(+ \sigma)} = \frac{S'' - M}{S'' \sin \theta} = \frac{1 - \cos \propto}{1 + \cos \propto}$$ .... (17)

$$\cos \propto = \frac{S''' - m}{S''' + m} = \frac{1 - \sin \delta}{1 + \sin \delta} = \frac{S'''}{S'}$$ .... (15)

$$\cos \frac{\propto}{2} = \sqrt{\frac{1 + \cos \propto}{2}} = \sqrt{\frac{1}{1 + \sin \delta}} = \sqrt{\frac{S''}{S'}}$$

$$\sin \theta = \frac{S'' - M}{d} = \frac{S'' - M}{S'' \sin \delta} = \operatorname{cosec} \delta - \cot \delta \cos \delta \sqrt{\frac{1}{1 + \sin \delta}}$$ .... (18), (23)

$$d = \frac{S'' - M}{\sin \theta}$$

APPENDIX 2

Variations in the parts of the basidium-unit with variations in σ

σ	S'	S''	S'''	M	m	w	2δ	θ	α	$\sin\delta$	$\sin\theta$	$\cos\alpha$
0	2.414d	1.414d	0.414d	0.5413d	0.2929d	0.7069d	90°	60° 47′	80° 7′	.7071	.8728	.1715
.1	2.555d	1.555d	0.555d	0.7106d	0.3569d	0.9119d	80° 3′	57° 33′	77° 27′	.6431	.8439	.2172
.2	2.697d	1.697d	0.697d	0.878d	0.4109d	1.1079d	72° 10′	54° 48′	75° 1′	.5891	.8172	.2584
.3	2.838d	1.838d	0.838d	1.042d	0.4559d	1.2939d	65° 56′	52° 52′	72° 50′	.5441	.7972	.2952
.4	2.980d	1.980d	0.980d	1.203d	0.4949d	1.4749d	60° 41′	51° 3′	70° 48′	.5051	.7776	.3289
.5	3.121d	2.121d	1.121d	1.360d	0.5286d	1.6496d	56° 14′	49° 33′	68° 57′	.4714	.7610	.3591
.6	3.262d	2.262d	1.262d	1.516d	0.5579d	1.8199d	52° 28′	48° 15′	67° 14′	.4421	.7460	.3869
.7	3.404d	2.404d	1.404d	1.671d	0.5840d	1.9880d	49° 10′	47° 13′	65° 39′	.4160	.7338	.4124
.8	3.545d	2.545d	1.545d	1.824d	0.6071d	2.1521d	46° 16′	46° 8′	64° 10′	.3929	.7210	.4358
.9	3.687d	2.687d	1.687d	1.976d	0.6270d	2.3149d	43° 42′	45° 17′	62° 46′	.3721	.7106	.4576
1.0	3.828d	2.828d	1.828d	2.126d	0.6464d	2.4744d	41° 24′	44° 30′	61° 29′	.3536	.7010	.4775
1.5	4.535d	3.535d	2.535d	2.872d	0.7171d	3.2521d	32° 52′	41° 32′	56° 1′	.2829	.6630	.5590
2.0	5.242d	4.242d	3.242d	3.603d	0.7643d	4.0063d	27° 16′	39° 43′	51° 48′	.2357	.6390	.6184
2.5	5.950d	4.950d	3.950d	4.330d	0.7980d	4.7480d	23° 18′	38° 19′	48° 24′	.2020	.6200	.6639
3.0	6.656d	5.656d	4.656d	5.051d	0.8232d	5.4792d	20° 22′	37° 14′	45° 36′	.1768	.6050	.6997

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Frequency and Habitat of Tree Species in the Rain Forest of Ulu Kelantan

by

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Abstract

In 1967 a survey was made as part of the Forest Resource Reconnaissance Survey of Ulu Kelantan district. 26, 628 trees were enumerated ⪸ 4ft girth on sample strips 1 chain wide, in primary rain forest mostly below 2800ft elevation. For this analysis the survey area of 1672 acres has been divided into 4 classes on geology and altitude, comprising sedimentary and granitic rocks and below or above 750ft. The occurrence of different tree species, genera and families in these 4 classes is listed in a series of Tables. No such extensive analysis has previously been made. There are many groups which are markedly more common in one or other of the 4 habitat classes and several groups have a distribution in Ulu Kelantan which counters subjective preconceptions. It is suggested that at any altitude species' distribution is likely to be more closely correlated with relief and soil than with geology.

INTRODUCTION

Our knowledge of the habitat preferences of Rain forest trees in southeast Asia is very largely based on the subjective impressions of forest botanists not backed up by measurements of tree frequency in particular habitats or precise records of the nature of the habitats themselves.

An enumeration of all trees over and including 4 ft girth on a small sample of the Lowland Rain forest of Ulu Kelantan district, northeast Malaya has been the stimulus to evaluate the relative frequency of the various tree families, genera and species occuring there, and to analyse their distribution between the two major kinds of rock in the district, and at low or higher elevations. This is of course, background information of fundamental importance when attempting to summarise our knowledge of particular species for such publications as the new Tree Flora of Malaya (Malayan Forest Records 26, Whitmore 1972, 1973 *a*).

Species with horticultural and some with known pharmacological potential enumerated in this survey have already been discussed in Whitmore (1971).

It is well known in Malaya, as a matter of observation, that different species have different altitude preferences, and there is a growing awareness that the rock type on which a forest occurs, to some extent at least, appears to determine its species composition, in a manner tentatively analysed below where we attempt to investigate a little further these suspected discriminants to species distribution.

THE FOREST SURVEY

The forest survey was conducted between June and November 1967 by Forest Resource Reconnaissance Survey teams under the able direction of Mr. N. Cerra, working from Kepong as an American Peace Corps volunteer, as part of an operation which has now covered the lowland forest of the whole country.

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The forest was divided into a series of 'phototypes' from the study of aerial photographs. Teams then went into Ulu Kelantan and systematically sampled these types throughout the district, at a low intensity. The sample lines were 1 chain wide and up to several miles long, but divided into 10 chain lengths, so individual plots of 10 sq. ch. (1 acre) are the basic unit. The lines were cut across the 'grain' of the country so as to sample ridge tops, hillsides and valleys; altitude was recorded; the precise position of each line was recorded on a set of 1 inch maps. Access was mainly by river, and from any one camp a series of lines was surveyed; the inset of Fig 1 shows the location of each cluster of survey lines. The total sample area was 1,672 acres; 26,628 trees were enumerated and named according to the preferred vernacular list in Kochummen & Wyatt-Smith (1964). The upper limit of most lines was below 2,800 ft, a few went up as high as 3,800 ft. Thus the whole survey is restricted to the Lowland Tropical Rain forest formation (Symington 1943, Burnham & Whitmore 1969).

Because this was a reconnaissance survey no attempt was made to take a rigorously, objectively selected sample. It was adequate to cover different phototypes throughout the whole district. It follows that it is unwise to multiply up from the results of this sample to find tree numbers over the whole of Ulu Kelantan. The results are, however, likely to be indicative for this part of Malaya. No pretence is made that the present analysis indicates frequency and habitat everywhere in Malaya; indeed, as pointed out below, there are, in Ulu Kelantan, several marked departures from what are suspected to be the preferences of species and groups elsewhere in Malaya.

The forest data were divided into stands for each of which a table was prepared stating, *inter alia,* the number of stems of each vernacular-named group occurring and the total basal area of all the trees enumerated. The stand tables have been the basis for the present analysis. Each stand is either one whole survey line or part of one. Each one contains homogeneous forest of one of the forest types recognised by the Forest Resource Reconnaissance Survey.

For the present analysis the stands were divided into two groups, those below 750 ft elevation and those above, to separate lowland dipterocarp forest from hill and upper dipterocarp forest in the sense of Symington (1943).* Regrettably, nearly all the stands transgress the 750 ft contour, and have had to be included on the side where they mostly lie. This can only blur the altitudinal preferences of species and groups and weaken the clarity of the analyses presented below.

ULU KELANTAN

Ulu Kelantan district was in 1967 mostly still under primary rain forest. The major areas of settled agriculture are shown in the inset to Fig 1. Logging had then not long begun, though by early 1972 much of the district had been let out on logging concessions. The total area of this administrative district is 4,817 sq. mi. and about 80 per cent was then still forested. Within the forested part of Ulu Kelantan there is little flat land except in the Lebir/Aring basin in the east; mostly the rivers run through narrow, steep-sided valleys. The main mountains lie to the west and east (Fig 1) and this is also, roughly, the distribution of granite, of Triassic age, which forms the Main and east coast ranges

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* Symington drew the boundary at 1,000 ft. I have divided at 750 ft on the advice of Mr. P. F. Burgess who considers the latter a more realistic elevation especially, as here, in hilly country.

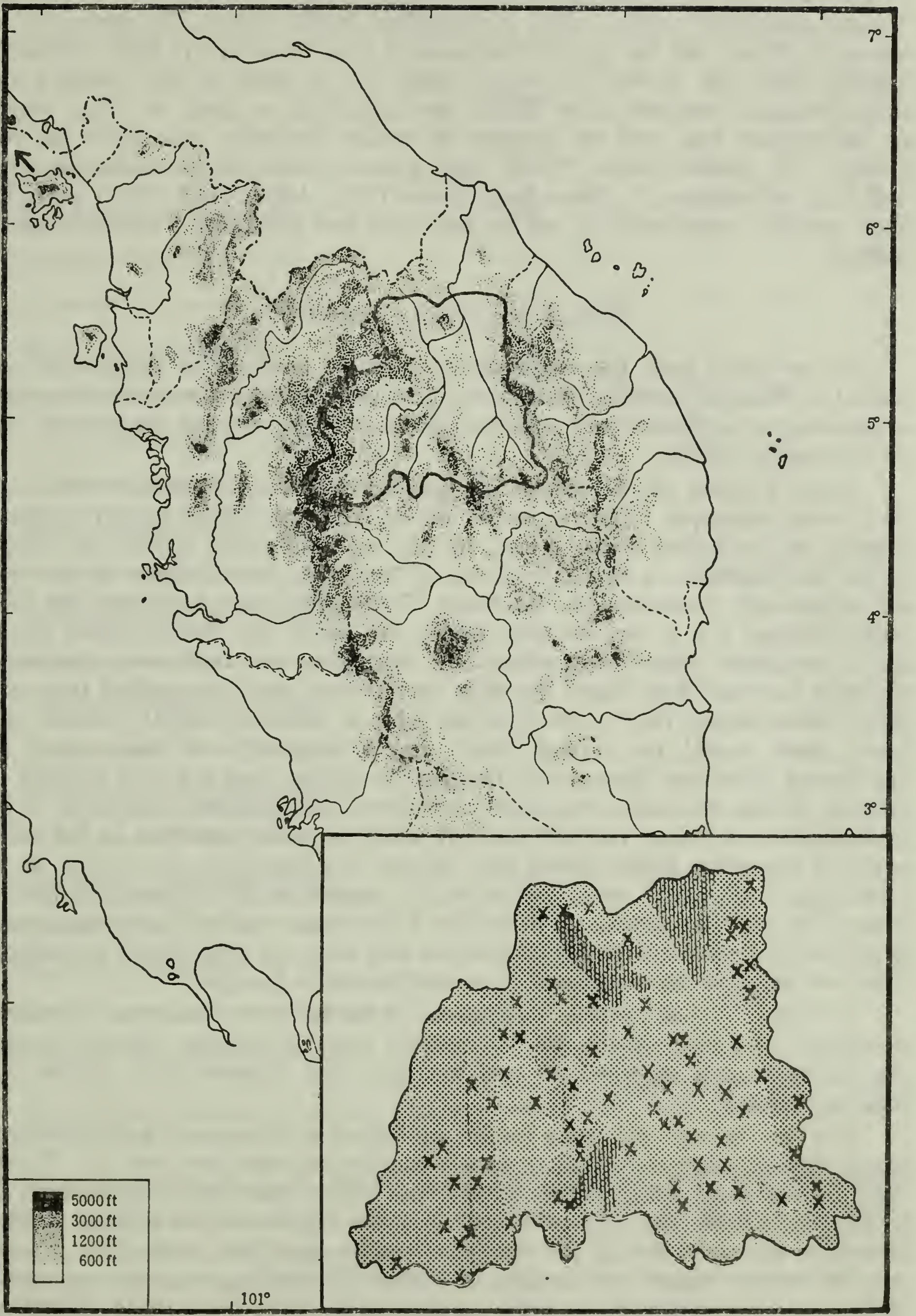

Fig. 1. Ulu Kelantan District, location and relief. Taman Negara also shown, S. and E. of Ulu Kelantan and partly over-lapping. Inset, location of sample sites, rock types (granite dark, sedimentary rocks pale) and approximate main area of cultivation (hatched). Geology from Alexander 1963. Cultivation limits from Wyatt-Smith (1964).

of the Peninsula respectively. The centre of the district is mainly of Permian and Triassic sedimentary rocks, which are described further below. The geology is not known in detail, but the granite/sedimentary rock boundary is fairly accurately known; only eight of the 222 survey stands lay so close to the boundary that their geology is doubtful. The stands were classified as lying on either granite or sedimentary rock and the analysis of species frequency was made for four groups, low granite (below 750 ft), high granite (over 750 ft), low sedimentary and high sedimentary; in these four classes 113.8, 448.8, 716.4, 393.0 acres had been sampled respectively; it can be seen that low granite was distinctly under-sampled.

SPECIES AND FAMILY FREQUENCY

So few have been the extensive, quantitative analyses of composition and habitat in Malayan Lowland Rain forest that, when quoting the relative frequency of species, one is thrown back on observations scattered through the pioneer work of Foxworthy (1927).

Table 1 shows the 21 species in order of decreasing frequency which have 10 or more stems per 100 acres in this survey. The first column gives the average density, the next four columns give, for the ten commonest species, the density in the four habitats. A major weakness in this table is that many species were not individually recognised in the forest. Dipterocarpaceae dominates the table, partly because it is a very common family but partly also because every species has a vernacular name. Burseraceae and Sapotaceae are both very common in Malayan Lowland Rain forest but their species were not distinguished from each other. Nevertheless, the top third of the table is probably roughly correct, only lower down would one expect other species, especially of Burseraceae and Sapotaceae. Note that the order of the first six species does not vary between the habitats, though the order does vary lower down. The important exception to this generalisation is *Shorea curtisii** (seraya) which is almost confined to hill ridges where it sometimes forms almost pure stands; this species is so common in hill forest that it still easily comes top of the list, despite its low frequency in lowland forest. The next two species (*S. parvifolia, S. leprosula*) are both light red merantis which are fast growers and light demanders and come up gregariously in clearings. They are amongst the commonest trees everywhere in Malaya.

In Table 2 the 42 families encountered in the survey are arranged in order of decreasing frequency. Again, the first column gives the average density (in stems per hundred acres rounded off) and the next four columns relate to the four separate habitats.

One sees at once why these forests are known as *dipterocarp* rain forests, the family Dipterocarpaceae is four times as abundant, amongst the trees $\geqslant$ 4 ft girth, than Leguminosae, which comes second, and this is true of all four habitats. As in the species table the order of frequency of the families differs between habitats low down the table, though the first four families are in the same order in every one. Of the two biggest tree families in Malaya Euphorbiaceae comes surprisingly high in the list compared to other surveys which have been made (Whitmore, 1973 *b*); Rubiaceae, which is actually slightly larger than Euphorbiaceae in Malaya in number of species, comes much lower, this is because very few of them reach 4 ft girth. Leguminosae always come high in a survey of this nature, but

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* Species names throughout follows the new *Tree Flora of Malaya* (Whitmore 1972 and 1973*a*) or, for families not yet revised, Kochummen & Wyatt-Smith (1964).

Table 1. The commonest of the species identified in the forest, those with on average more than ten stems per hundred acres

		average	*granite*		*sedimentary*	
			low	*high*	*low*	*high*
1.	Shorea curtisii (Dipterocarp.)	125	21	126	20	345
2.	Shorea parviflora (Dipterocarp.)	108	91	93	127	95
3.	Shorea leprosula (Dipterocarp.)	80	57	88	77	82
4.	Koompassia malaccensis (Legum.)	51	36	39	66	45
5.	Shorea ovalis (Dipterocarp.)	40	26	33	51	34
6.	Dipterocarpus cornutus (Dipterocarp.)	35	40	13	56	24
7.	Elateriospermum tapos (Euphorbi.)	33	16	45	20	49
8.	Dryobalanops oblongifolia (Dipterocarp.)	31	17	3	66	6
9.	Shorea multiflora (Dipterocarp.)	23	16	11	30	25
	Intsia palembanica (Legum.)	23	18	26	23	22
11.	Shorea platyclados (Dipterocarp.)	21	—	—	—	—
12.	Koompassia excelsa (Legum.)	18	—	—	—	—
	Cynometra malaccensis (Legum.)	18	—	—	—	—
14.	Dipterocarpus crinitus (Dipterocarp.)	15	—	—	—	—
15.	Shorea bracteolata (Dipterocarp.)	14	—	—	—	—
16.	Shorea guiso (Dipterocarp.)	13	—	—	—	—
17.	Parashorea lucida (Dipterocarp.)	12	—	—	—	—
18.	Pometia pinnata (Sapind.)	11	—	—	—	—
19.	Mesua ferrea (Guttif.)	10	—	—	—	—
	Endospermum malaccense (Euphorbi.)	10	—	—	—	—
	Ochanostachys amentacea (Olac.)	10	—	—	—	—

Family name abbreviated in brackets; stems per hundred acres rounded off to nearest whole number.

Myrtaceae and Lauraceae are usually lower and Burseraceae higher. The complete absence of Flacourtiaceae, with several big trees with well known vernacular names, is curious. Alangiaceae, Proteaceae, Symplocaceae and Theaceae would also all have been expected in Ulu Kelantan. It is a well known weakness of Forest Dept. survey teams in Malaya to assign an unknown tree to either medang or kelat, and it is likely that trees of these missing families, and one must assume Flacourtiaceae too, have been mistakenly included in Lauraceae or Myrtaceae and thus contribute to the unexpectedly high figures for these two families.

Basal Area and Tree Numbers per Acre

Sedimentary rock has a higher basal area of trees ⩾ 4 ft girth per acre than granite, due to the much lower basal area per acre on granite over 750 ft than elsewhere (Table 3). In Ulu Kelantan (as shown below, Table 9) the important hill forest timber species *Shorea curtisii* is relatively rare on granite; doubtless this contributes to the low basal area.

It can be seen from Table 3 that stems per acre are more numerous above 750 ft than below. These figures reflect a bias in the sample. In the hills big trees tend to be commonest on ridges and sparse on hill sides and in valleys and it can clearly be seen on Table 4 that survey lines above 750 ft have tended to follow ridges rather than to cut across the lie of the country, which becomes increasingly difficult with increasing elevation. The slightly larger number of stems per acre on low sedimentary rocks than on low granite, and other slight differences in Table 3 may not be statistically significant. An analysis of variance would be required to demonstrate that they are not due merely to chance variation in the data, and this has not been attempted because of the difficulties involved in extracting the figures from the survey summaries.

HABITAT PREFERENCES OF SPECIES AND GROUPS

Limitations to the Analysis

The main analysis with which we are here concerned is that which attempts to elucidate how far individual species are confined to particular habitats, in this case defined on altitude and underlying rock.

Two main weaknesses of the analysis have already been pointed out; firstly, that the forest data have been arranged in stands many of which cut across the boundary at 750 ft between lowland and hill forest; secondly, that the forest staff do not recognise many individual species outside Dipterocarpaceae but do recognise genera (e.g. petai: *Parkia;* sepetir: *Sindora,* etc.) generic groups (e.g. mempening: *Lithocarpus, Quercus*) or whole families (e.g. nyatoh: Sapotaceae). The result of this second weakness is, as of the first, an obfuscation of revealed habitat preferences. Individual species (or indeed groups within them) must be expected to show the greatest specificity for habitat, and to lump species together can only lead to blurring.

A third and serious source of weakness is that the rocks have only been divided into the two great categories granite and sedimentary. There are considerable variations in the granites of Malaya, often over very short distances, in texture and composition. No attempt has ever been made to map these. The sedimentary rocks are even more varied and include, in Ulu Kelantan, the pre-Carboniferous Teku schists in the north, which are the only large area of schist in the country, plus large areas of predominantly argillaceous Permian sediments and of predominantly arenaceous Triassic sediments. The various sedimentary rocks are usually interbedded and have in places been metamorphosed, especially along the boundaries with the granite. In places they are variously calcareous. No record was made of the rock type of the survey lines, indeed it is unlikely to have been homogeneous along their length, and the published geological records are not sufficiently detailed for high precision. It is for these reasons that the analysis is restricted to granite versus sedimentary rocks, as the boundary between these two major types is believed to be well and accurately known.

Table 2. Frequency of Families

		average	*granite*		*sedimentary*	
			low	*high*	*low*	*high*
1.	Dipterocarpaceae	634	439	602	587	815
2.	Leguminosae	161	139	153	182	140
3.	Myrtaceae	122	73	122	124	133
4.	Lauraceae	76	57	94	72	68
5.	Anacardiaceae	73	25	69	64	109
6.	Burseraceae	72	48	90	67	66
7.	Euphorbiaceae	55	50	67	39	71
8.	Olacaceae	41	47	35	46	36
9.	Fagaceae	39	40	60	30	31
10.	Sterculiaceae	37.8	41	69	37	37
11.	Guttiferae	37.7	21	33	38	47
12.	Moraceae	33	34	43	29	30
13.	Sapotaceae	32	27	40	33	22
14.	Sapindaceae	24	24	24	27	20
15.	Annonaceae	20	16	29	14	21
16.	Dilleniaceae	14	11	14	17	8.9
	Myristicaceae	14	23	16	14	9
18.	Polygalaceae	12.2	7	8	16	12
19.	Tiliaceae	10	13	8	12	10
20.	Apocynaceae	8.0	6.1	9.8	7.3	7.9
21.	Lecythidaceae	7.6	11	6.3	8.8	5.9
22.	Bombacaceae	7.1	12	12	5.3	3.1
23.	Thymelaeaceae	5.0	1.8	6.0	6.2	2.8
24.	Rutaceae	4.1	5.3	1.8	6.8	1.5
25.	Celastraceae	3.7	0.9	1.3	5.2	4.6
26.	Combretaceae	3.0	0.9	1.3	4.2	1.8
27.	Ebenaceae	2.8	1.8	2.9	2.0	4.3
28.	Rhizophoraceae	2.0	1.8	1.3	2.5	2.3
29.	Hypericaceae	1.9	—	2.7	1.9	1.5
30.	Meliaceae	1.7	3.6	2.9	1.6	—
31.	Loganiaceae	1.6	1.8	0.2	1.8	0.8
32.	Rubiaceae	1.5	1.8	2.6	0.6	1.8
33.	Simaroubaceae	1.3	—	11	1.4	1.8
34.	Juglandaceae	0.6	—	2.2	—	—
35.	Malvaceae	0.5	4.9	0.5	0.1	—
36.	Ulmaceae	0.2	—	0.5	0.1	—
37.	Melastomataceae	0.2	—	0.4	0.1	—
38.	Oxalidaceae	0.9	0.9	0.2	1.3	0.8
39.	Coniferae	.04	—	—	—	1.8
40.	Magnoliaceae	.02	—	—	3.9	—
41.	Theaceae	.0006	—	—	0.1	—
	Linaceae	.0006	—	—	0.1	—

In Tables 2 and 5–14 the figures given are for stems per 100 acres.

Table 3. Basal area and tree numbers per acre

	granite		*sedimentary*	
	low	*high*	*low*	*high*
Basal area (sq ft)	55.8	47.9	52.9	56.7
average each rock	49.5		54.3	
overall average	52.7			
Stems per acre	12.0	17.3	14.9	17.3
average each rock	14.6		15.8	
overall average	15.9			

Table 4. Representation (as percentage of total acreage) of different topographic sites

		granite					*sedimentary*				
Both rocks Overall Mean	*altitude in ft*	*Mean*	0–500	500–1,500	1,500–2,500	2,500–4,000	*Mean*	0–500	500–1,500	1,500–2,500	2,500–4,000
11	valley . .	**11**	16	12	8	7	**11**	14	9	4	—
67	hillside . .	**72**	80	72	67	70	**65**	70	62	58	—
22	ridge crest . .	**18**	4	16	25	23	**24**	16	29	38	—
	area sampled (acres) . .	—	41.8	251.8	91.8	48.3	—	244.7	396.7	12	0

based on an unpublished analysis by P.F. Burgess of 1087.1 out of the total 1,672 acres.

A fourth potential source of weakness is that valleys, hillsides and ridge crests might have been sampled in different proportions in the four classes, and if species have topographic preferences a bias would emerge in the results. Examination of an unpublished analysis by Mr P. F. Burgess of 1087.1 acres (out of the total 1,672 acres), see Table 4, shows that, fortunately, the proportion of the topographic classes does not vary largely either with rock type or altitude for the two altitude groups 0-750 ft and over 750 ft considered here. But, because there are differences of the order of 10 percent, comments on the present analysis are restricted to major differences in species' density. It has been noted already that the area of low granite sampled was disproportionately low, and this is borne in mind in the comments which follow.

All these limitations must be borne in mind in the analysis which follows, which is presented as a series of tables showing stems per 100 acres. Individual species are shown as far as they were recognised (the Dipterocarpaceae dominating the lists), then genera (either straight from the survey data or by adding together species' frequencies), then families. It is interesting to see how far genera and families do show habitat preferences, and whether these support the preconceptions forest botanists have about such things, though in general these big groups cannot be expected to show much uniformity in habitat.

It must also be remembered that only trees $\geqslant$ 4 ft. girth were sampled. The effect of this may be illustrated by considerating two genera of the Sapindaceae. *Xerospermum* (gigi buntal) is actually far commoner in the forest than *Nephelium lappaceum* (rambutan hutan), but quite the reverse is shown in the result of this survey, because its trees rarely attain 4 ft girth and so only a few exceptionally large individuals have been counted, whereas rambutan hutan grows to a larger tree and so a larger fraction of the total population of the species has been included.

In general little is known about species or group preferences for sedimentary or igneous rocks in Malaya as this is the first analysis made of a large body of data. Comments on the tables are therefore restricted to particular points which confirm or conflict with our existing subjective impressions.

In fact, rock type itself probably exerts a less direct controlling influence on the distribution and frequency of plant species than the nature of the relief and of the soil (which is partly dependent on relief) which themselves are not directly related to rock type as expressed in this analysis.

In the hot, wet climate of Malaya all soils are very strongly leached and consequently poor in plant nutrients; physical soil properties are probably usually more important to plant life than chemical ones, notably the depth to which the rock has weathered and the particle sizes formed by weathering. Granites tend to weather very deeply and to form well-structured soils, such as are seen along road cuttings in the Main Range, though quartz-rich areas may yield very shallow and coarse soils. Sedimentary rocks tend to weather less deeply, especially where metamorphosed; shale-derived soils are much more finely textured than sandstone-derived soils. Further, the relief of granite country tends to be less rugged than of sedimentary where precipitately sided knife-edge crests often replace broad, rounded ridges. The task of collecting detailed data on topography and soils, such as would be needed for a fully analysis, would be formidable in rain forest country, and has never been attempted over more than a few acres. On small areas the problem of correlating plant distribution with habitat is confounded, in these excessively species-rich forests, by the probability that there is not enough space in a small area of any particular habitat for all the species to grow which are ecologically suited.

The Analysis

The first important conclusion results from a glance at Tables 5–12. It can be seen at once that nearly all species, except some of the rarer ones, occur in all four habitats, but that the *frequency* of occurrence varies in nearly all cases. This shows how misleading qualitative impressions of species' distribution can be, and how important it is that ecological analyses of the rain forest are not based solely on presence or absence.

Groups showing a marked preference for granite.

(i) *Below 750 ft*, Table 5:

Hibiscus floccosus (kangsar) and *Pterygota horsfieldii* (kasah) are valley species not known previously to prefer granite.

The genus *Hopea* is usually considered commonest at high elevations; the preference here for lowland forest is unexpected.

Table 5. Groups showing a marked preference for granite and below 750 ft elevation

			granite		*sedimentary*	
			low	*high*	*low*	*high*
(*a*)	species					
	Dipterocarp.	Shorea assamica	11	0.2	3.3	—
		S. kunstleri	18	8.7	—	—
	Euphorbi.	Endospermum malaccense	22	12	8.7	7.6
	Malv.	Hibiscus floccosus	4.9	0.5	0.1	—
	Mor.	Artocarpus rigidus	13	8.0	7.1	5.6
		A. scortechinii (elasticus)	7.9	5.6	2.4	1.5
	Sterculi.	Pterygota horsfieldii	5.3	2.9	0.4	0.3
(*b*)	genera					
	Dipterocarp.	Hopea	33	27	22	18
	Legum.	Parkia	19	11	7.3	6.1
(*c*)	families					
	Myristicaceae		23	16.1	14.4	9.4

All the species of the forest survey are included in the tables 5–12 except for a few obviously mistaken identifications.

(ii) *Above 750 ft,* Table 6:

Shorea platyclados (meranti bukit) is the highest growing Malayan *Shorea* and a very important timber tree of upper dipterocarp forest from 2,500–4,000 ft; it is locally gregarious; its almost complete absence from sedimentary rocks in Ulu Kelantan is certainly not true of Malaya generally. Inspection of Table 4 shows that none of the subsample Burgess has analysed is on sedimentary rocks over 2,500 ft, and the result for meranti bukit is therefore almost certainly an artefact due to sampling bias.

Table 6. Groups showing a marked preference for granite and above 750 ft elevation

			granite		*sedimentary*	
			low	*high*	*low*	*high*
(*a*)	species					
	Dipterocarp.	Shorea platyclados	—	73	0.4	4.3
	Rubi.	Anthocephalus chinensis	1.8	2.2	0.3	1.8
(*b*)	genera					
	Anacardi.	Campnosperma	2.6	6.9	2.0	1.3
	Jugland.	Engelhardtia	—	2.2	—	—
	Sterculi.	Heritiera	12	25	11	10
(*c*)	families					
	Annonaceae		16	29	14	21

Anthocephalus chinensis (*cadamba*) (kelempayan) is a species of valleys and alluvial soils in Borneo; we have noticed it common on hill slopes, e.g. at Genting Sempah, and this preference for hill forest is borne out by this survey.

Engelhardtia (dungun paya) is well known as a genus of hill and mountain forest in Malaya.

(iii) *Just granite,* Table 7:

None of the preferences revealed here was previously suspected.

Table 7. Groups showing a marked preference just for granite

			granite		*sedimentary*	
			low	*high*	*low*	*high*
(*a*)	species					
	Bombac.	Bombax valetonii	5.3	6.9	0.4	0.8
	Dipterocarp.	Dipterocarpus appendiculatus	4.4	0.2	—	—
	Sterculi.	Pterocymbium javanicum	8.8	7.3	2.0	1.0
(*b*)	genera — nil					
(*c*)	families					
	Bombacaceae		12	12	5.3	3.1
	Fagaceae		40	60	30	31
	Meliaceae		3.6	2.9	1.6	—
	Sterculiaceae		41	69	37	37

Groups showing a marked preference for sedimentary rocks.

(i) *Below 750 ft,* Table 8:

Dryobalanops oblongifolia (keledan) is a riverine species. The other *Dryobalanops* in Malaya *D. aromatica* (kapur) is known strongly to prefer sedimentary rocks; both are found mainly east of the Main Range.

Mesua ferrea (penaga) is a species of poor soils and dry sites, this is consonant with its marked preference for sedimentary rocks.

Table 8. Groups showing a marked preference for sedimentaries and below 750 ft elevation

			granite		*sedimentary*	
			low	*high*	*low*	*high*
(*a*)	species					
	Dipterocarp.	Dryobalanops oblongifolia	17	2.7	66	5.6
		Shorea bracteolata	19	2.9	21	13
		S. multiflora	16	11	30	25
		S. parvifolia	91	93	127	95
		S. singkawang	—	—	3.9	0.8
	Guttif.	Mesua ferrea	4.4	3.3	14	12
	Magnoli.	Aromadendron elegans	—	—	3.9	—
(*b*)	genera					
	Combret.	Terminalia	—	—	3.9	—
	Dipterocarp.	Dipterocarpus	68	48	94	69
(*c*)	families — nil					

(ii) *Above 750 ft,* Table 9:

Shorea curtisii (seraya) is the most important timber tree of hill dipterocarp forest; its distribution seems to be correlated with sites liable to periodic drought, which tend to be mainly shallow, sedimentary-derived soils and hill ridges, as is amply confirmed by the present survey (P. F. Burgess, unpublished observations).

Swintonia, Vatica and *Calophyllum* are well known to be commoner in the hills. Their preference for sedimentary rocks was not known, though all are known as genera of 'poor' soils or sites.

The preference of the genus *Shorea* and of the family Dipterocarpaceae for this habitat completely obscures the markedly differing preferences of the many individual species enumerated and reflects the abundance of *S. curtisii.*

Table 9. Groups showing a marked preference for sedimentaries and above 750 ft elevation

			granite		*sedimentary*	
			low	*high*	*low*	*high*
(*a*)	species					
	Dipterocarp.	Shorea curtisii	21	126	20	345
		S. guiso	7.9	11	11	16
(*b*)	genera					
	Anacardi.	*Rengas**	11	21	22	35
		Swintonia	9.7	27	28	63
	Dipterocarp.	Shorea	298	468	372	653
		Vatica	1.8	6.0	7.7	14
	Guttif.	Calophyllum	17	29	23	34
(*c*)	families					
	Anacardiaceae		25	69	64	109
	Dipterocarpaceae		439	602	587	815
	Coniferae		—	—	—	1.8

* Gluta, Melanochyla, Melannorhoea, Semecarpus

(iii) *Just sedimentary rocks,* Table 10:

Koompassia malaccensis (kempas) is one of the commonest trees everywhere in Malaya. Its preference for sedimentary rocks was not suspected and may not be typical of the whole country.

Myrtaceae is a family which, throughout Malesia, becomes prominent in 'poor' sites, its preference in Ulu Kelantan for hills and for sedimentaries is not unexpected.

Table 10. Groups showing a marked preference just for sedimentaries

			granite		*sedimentary*	
			low	*high*	*low*	*high*
(*a*)	species					
	Dipterocarp.	Dipterocarpus crinitus	4.4	5.8	20	21
		Shorea dasyphylla	1.8	1.6	2.1	2.3
		S. faguetiana	0.9	0.2	1.5	2.3
		S. macroptera	—	0.9	2.9	3.3
		S. ovalis	26	33	51	34
		S. ovata	—	—	1.3	1.8
		S. sumatrana	—	—	0.8	0.3
	Legum.	Koompassia malaccensis	36	39	66	45
	Mor.	Antiaris toxicaria	—	—	0.1	0.8
		Artocarpus integer	—	—	0.4	0.3
	Olac.	Ctenolophon parvifolius	1.8	2.0	5.7	4.3
(*b*)	genera					
	Celastr.	Lophopetalum	0.9	1.3	5.2	4.6
	Legum.	Koompassia	54	56	84	63
	Polygal.	Xanthophyllum	7.0	7.6	16	12
	Rhizophor.	Pellacalyx	1.8	0.9	2.5	2.0
(*c*)	families					
	Myrtaceae		73	122	124	133

Groups showing a marked preference for forest below 750 ft, Table 11:

Dipterocarpus oblongifolius (keruing neram) is a riverbank species.

Pometia pinnata var *pinnata* (kasai) is, in Malaya, a valley species.

Barringtonia (putat), as a genus, is commonest in valleys and along rivers.

Euodia (pepauh) is nowhere common in Malaya. It has been considered a genus preferring the hills, an impression contradicted by this survey.

Pentace (melunak) likewise has been considered mainly a hill genus.

Table 11. Groups showing a marked preference for elevation below 750 ft irrespective of rock

			granite		*sedimentary*	
			low	*high*	*low*	*high*
(*a*)	species					
	Dipterocarp.	Dipterocaropus oblongifolius	0.9	—	0.4	—
		Dipt. cornutus + kunstleri	48	21	60	29
		Shorea balanocarpoides	7.9	1.1	5.2	3.3
	Olac.	Ochanostachys amentacea	20	4.4	15	5.6
	Sapind.	Pometia pinnata v. pinnata	18	9.1	12	9.7
(*b*)	genera					
	Lecythid.	Barringtonia	11	6.3	8.8	5.9
	Logani.	Fagraea	1.8	0.2	1.8	0.8
	Oxalid.	Sarcotheca	0.9	0.2	1.3	0.8
	Rut.	Euodia	5.3	1.8	6.8	1.5
	Tili.	Pentace	13	7.6	12	9.8
(*c*)	families					
	Olacaceae		46	35	46	36

Groups showing a marked preference for forest above 750 ft, Table 12:

Elateriospermum tapos, (perah), *Cratoxylum formosum* (derum) and *Tristania* (pelawan) are well known to prefer hills.

Lauraceae characterise the Lower Montane or oak-laurel forest of Malaya so their increase with elevation is also as expected.

Table 12. Groups showing a marked preference for elevations above 750 ft irrespective of rock

			granite		*sedimentary*	
			low	*high*	*low*	*high*
(*a*)	species					
	Dipterocarp.	Dipterocarpus grandiflorus	7	11	6.8	13
		D. sublamellatus + verrucosus	—	0.7	0.1	4.3
		Parashorea lucida	—	13	4.6	7.6
		S. leprosula	57	88	77	82
	Euphorbi.	Elateriospermum tapos	16	45	20	49
	Hyperic.	Cratoxylum formosum	—	2.7	0.1	1.5
	Mor.	Artocarpus lanceifolius	12	25	15	17
	Rhizophor.	Carallia brachiata	—	0.4	—	0.3
	Simaroub.	Irvingia malayana	—	1.1	1.4	1.8
(*b*)	genera					
	Dipterocarp.	Anisoptera	21	37	20	48
	Eben.	Diospyros	1.8	2.9	2.0	4.3
	Myrt.	Tristania	—	1.1	0.8	1.8
	Sterculi.	Scaphium	13	30	20	24
(*c*)	families					
	Lauraceae		57	94	72	68

Ubiquitous Groups, Table 13:

This class includes several very common and easily recognised big tree species (*Shorea pauciflora,* nemesu; *Dyera costulata,* jelutong; *Cynometra malaccensis,* kekatong; *Intsia palembanica,* merbau; *Koompasia excelsa,* tualang; *Scorodocarpus borneensis,* kulim) which no doubt have helped to create the impression, sometimes held, that Malayan timber trees can grow almost anywhere in the mesic Rain forest climax forests, though this impression is also undoubtedly strengthened by the fact, revealed by this survey and commented on above, that habitat affects frequency but seldom prevents occurrence.

No significance is attached to the long list of ubiquitous genera and families for reasons already discussed.

Table 13. Ubiquitous groups

		granite		*sedimentary*	
		low	*high*	*low*	*high*
a) species					
Apocyn.	Dyera costulata	6.1	8.7	6.7	6.9
Dipterocarp.	Dipterocarpus baudii	3.5	7.8	6.0	2.0
	Shorea pauciflora	19	10	11	23
Euphorbi.	Baccaurea griffithii	3.5	2.0	2.4	2.3
	Sapium baccatum	4.4	2.0	2.7	5.9
Legum.	Cynometra malaccensis	18	19	18	18
	Intsia palembanica	18	26	23	22
	Koompassia excelsa	18	17	18	18
Olac.	Scorodocarpus borneensis	22	25	19	21
	Strombosia javanica	2.6	1.3	3.2	2.5
	S. rotundifolia	—	2.5	3.2	2.5
Sapind.	Nephelium lappaceum	2.6	7.6	5.9	5.1
	Pometia pinnata v. alnifolia	2.6	6.0	9.1	5.6
(*b*) genera					
Bombac.	Durio	4.4	4.5	4.0	2.0
Dilleni.	Dillenia	11	14	17	8.9
Fag.	Castanopsis	14	9.6	11	12
Legum.	Dialium	22	26	26	23
	Sindora	7.0	9.8	7.1	5.9
Sterculi.	Pterospermum	1.8	3.3	3.3	1.3
(*c*) families					
Apocynaceae		6.1	9.8	7.3	7.9
Burseraceae		43	90	67	66
Euphorbiaceae		50	67	39	71
Leguminosae		139	153	182	140
Guttiferae		21	33	38	47
Moraceae		34	43	29	30
Rhizophoraceae		1.8	1.3	2.5	2.3
Rubiaceae		1.8	2.6	0.6	1.8
Sapindaceae		24	24	27	20
Thymelaeaceae		1.8	6.0	6.2	2.8

Table 14. Groups which tend to avoid granite below 750 ft

		granite		*sedimentary*	
		low	*high*	*low*	*high*
Legum.	Pithecellobium splendens	0.9	4.5	3.8	2.0
Anacardi.	Mangifera	1.8	7.8	7.1	6.1
	Pentaspadon	1.8	6.0	4.9	3.1
Burser.	Santiria	11	29	23	25
Hyperic.	Cratoxylum	—	2.7	1.9	1.5
Mor.	Ficus	—	2.7	2.1	3.6
Myrt.	Eugenia	73	121	123	131
Thymelaea.	Aquilaria	0.9	4.7	5.3	2.0

Table 14 shows groups which avoid low granite but are otherwise ubiquitous. The area of this habitat sampled is much lower than of the other three habitats, and therein lies the simplest explanation of this category.

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I am grateful to Enche Salleh b. Mohd. Nor for allowing me to have a set of the stand tables prepared from Mr. Cerra's forest survey; to Mr. P.F. Burgess for encouraging me to undertake the analysis, for commenting on a draft and for allowing me to make use of his unpublished analysis of part of the same data; also for considerable assistance with the computation to Enche2 Loh Hoy Shing, T. Suppiah, P. Selveraj, Chan Yee Chong and Zainuddin b. Sohadi.

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APPENDIX

Species and groups with fewer than one stem per 100 acres.

No significance is attached to the different frequency of these between the four habitats.

Anacardiaceae
- Bouea

Annonaceae
- Xylopia ferruginea
- Cananga odorata

Apocynaceae
- Alstonia

Bombacaceae
- Coelostegia
- Neesia

Coniferae
- Agathis dammara
- Podocarpus imbricatus

Dipterocarpaceae
- Dipterocarpus apterus
- D. chartaceus
- D. gracilis
- Shorea atrinervosa
- S. glauca
- S. laevis
- S. maxwel'iana
- S. scrobiculata
- S. multiflora
- S. resina-nigra

Euphorbiaceae
- Macaranga gigantea
- Mallotus leucodermis/muticus

Guttiferae
- Garcinia

Hypericaceae
- Cratoxylum arborescens

Leguminosae
- Adenanthera
- Ormosia

Linanceae
- Ixonanthes icosandra

Melastomataceae
- Memecylon

Meliaceae
- Amoora
- Lansium domesticum
- Sandoricum koetjape

Moraceae
- Artocarpus kemando
- Streblus elongatus

Rubiaceae
- Adina
- Randia scortechinii

Sapindaceae
- Xerospermum

Theaceae
- Gordonia concentricicatrix

Thymelaeaceae
- Gonystylus

Ulmaceae
- Gironniera

A New Bamboo from Mt. Kinabalu

by

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In 1956 I described five species of a new genus *Racemobambos,* slender bamboos from mountain forest, three of them from Mt. Kinabalu (Gard. Bull. Sing. 15: 267–273). When visiting that mountain in November 1972 I found a fourth species in flower, on the ridge below Kambarangoh, a route followed by many persons who have climbed the mountain during the past forty years. I did not find young culms from which culm-sheaths could be described, and hope someone else will be able to remedy this deficiency. The strongly tessellate lower surface of the leaves (at least when dry) and their quite large size, are distinctive, and should be sufficient to identify a plant which is not flowering. A comparison of living plants with *R. hirsuta* is desirable.

Racemobambos tessellata Holttum, **sp. nov.**

Vaginae basium culmorum non visae. Culmus florifer c. 8 mm diametro, glaber; rami ad quodque nodum c. 8, inaequales, usque 80 cm longi, longiores ramosi; ramuli ultimi basi foliiferi apicem versus floriferi; folia usque 16 cm longa, 1.9 cm lata, subtus valde tessellata, basi auriculis parvis setas tenues flexuosas usque 10 mm longas ferentibus praedita, in apicem setiformi 5 mm longum terminata; ramuli floriferi usque 8 cm longi, leviter hirsuti basin versus tantum; spiculae usque 3.5 cm longae; glumae vacuae 2, inferior 6–7 mm longa, 5-venosa, superior 8–9 mm longa, omnino glabrae; rachillae internodia 5 mm longa, apicem versus adpresse sericea; lemmata 9–10 mm longa, marginibus omino minute ciliata, cetera glabra, apice non setiformia; paleae 9–10 mm longae, carinis ciliatis; lodiculae c. 3 mm longae, ciliatae; antherae 5 mm longae.

TYPE: Mt Kinabalu, Sabah, below Kambarangoh, in ridge forest at 6500 ft, Holttum 46, Nov. 1972. (SING; dupl. K.).

In its foliage this species is near *R. hirsuta,* which is only known from the original Clemens collection on Penibukan ridge; but *R. hirsuta* is densely appressed-hairy throughout the branches of the inflorescence and on the dorsal surface of lemmas, and its leaves are not tessellate on the lower surface. The leaves of *R. tessellata* have very distinct cross-veins connecting the smaller longitudinal veins with which they make a tessellate pattern. *R. tessellata* has a'so a much more amply branched inflorescence than *R. hirsuta* and its lemmas lack the short setiform tip found in *R. hirsuta.*

Notes on the Vegetation of the Cardamom Mountains, Cambodia

by

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Summary

The following pages present some floristic and phytogeographic observations made in the course of ethnobotanical work. They must be considered merely as preliminary notes to a future more detailed study of a massif of which only the periphery has been previously visited by naturalists. It is therefore felt that, notwithstanding their incompleteness, these notes will represent a useful contribution to our botanical knowledge of the western Cambodian mountains, as little in the literature, and none of it in English, presently exists.

Introduction

In 1965-1966, thanks to a grant from the National Institute for Scientific Research in Paris, I made my first ethnobotanical expedition to Cambodia. The investigations were then principally carried out in the area around Leach in Pursat province, and concentrated on the plants used by the lowland Cambodian peasants. I therefore had occasion, through the study of their uses, to become acquainted with tropical plants, and a flora, at first totally unknown to me, and particularly with the species of the Dry Dipterocarp forests, the monsoon forests rich in Leguminosae and Lythraceae, the swamp forests, and also those of certain secondary types.* Some forays into the Cardamoms at this time convinced me of the intrinsic interest, as much to anthropology as to botany, that this, the most extensive montane area in Cambodia, presented. Further, during my second mission which began in February, 1969, I decided on this region, as little known to botanists as to ethnologists, as my study area. The forests to the south of the range alone have been recently studied (1), apart from some notes that are available on the vegetation of the Tamyong river basin in Pursat province (2). The following pages can hardly claim to contain an exhaustive study of this flora; they are merely observations that have been made within the framework of an ethnobotanical investigation: on-the-spot records that have for the most part been made along the lanes and tracks figured in map 2. It need hardly be added that the lists of species are very incomplete, but as far as possible the dominant or characteristic species have been noted; some. even of these, are yet to be identified.

The herbarium specimens collected are retained in the Natural History Museum in Paris. Those already identified are incorporated in the herbarium of the Phanerogam Laboratory; the remainder, which will be examined on my return to France, can meanwhile also be consulted in this laboratory. It is for this reason that I cite collection numbers for all unidentified species.

---

* I also made very limited number of collecting trips in lowland mixed rain forest.

1. P. Dy Phon, 1969. La végétation du sud-ouest du Cambodge. Thesis, Toulouse University, 261 pp. (unpublished). (This has subsequently been published in Ann. Fac. Sc. Phnom Penh 1970, no. 3, pp. 1–135 & 1971 no. 4, pp. 1–77 — *ed.*)

2. M. Schmid, 1969. Considérations sur la végétation du centre-ouest Cambodgien. Ann. Fac. Sc. Phnom Penh, 2: 81 - 100.

The field-work was carried out without any outside scientific assistance except for some botanical excursions made on the southern flanks of the massif with Dr. P. S. Ashton. I am most grateful to him for this opportunity to exchange our botanical experience, and for his encouragement; I am also indebted to him for the English translation of this manuscript.

The Vegetation Types

No extensive rainfall figures are available for the Cardamom massif itself, merely limited observations from the Thmar Beng region near the centre and some valuable summaries from Khemarak Phouminville on the coast. The annual rainfall for the former (extrapolated from incomplete data) is approximately 4 m., and 5 m. for the latter; neither do detailed soil studies exist. Further, for non-scientific reasons it has not been possible to explore the montane vegetation above 1000 m. altitude.

The vegetation is here delineated according to the physiography; the main types to be considered are:

Forests of humid valley bottoms, notably riverain forests.

Forests of the slopes.

Forests of ridges.

Some notes are also provided for:

Moist submontane grasslands.

Monsoon forests (forêts claires) and savanna forests (forêts sèches).

1. Riverain forests

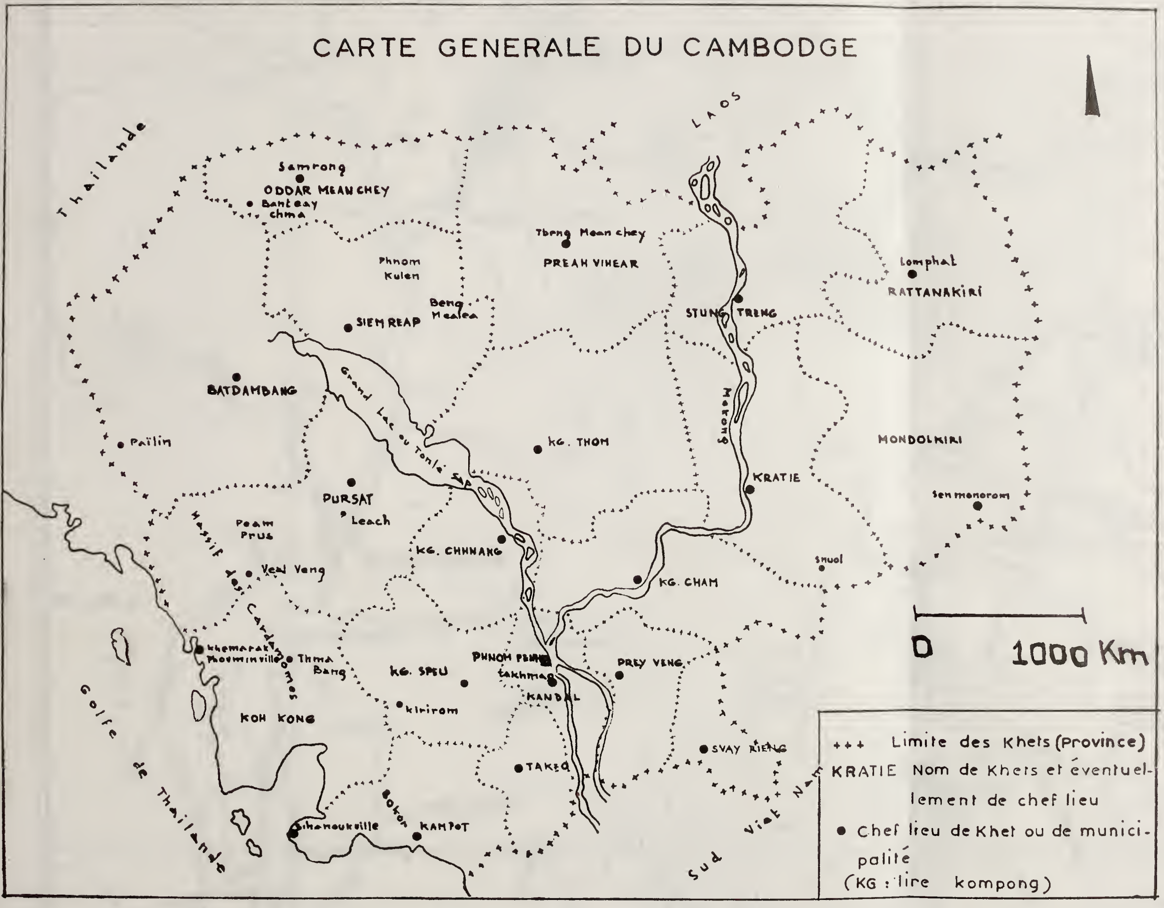
These form a narrow fringe along the margins of the rivers. Where the valley is narrow and enclosed, the species of the hillslopes descend to the waterside; these will be described later. When the valley is broad, the forest which borders the river contains several characteristic species, one of which, *Altingia* (*siamensis*) is nearly always present. The structure is that of a true closed evergreen forest, with emergent species such as:

Altingia (*siamensis*)
Anisoptera sp. or *Hopea odorata* Roxb.
Tristania (*burmanica*)

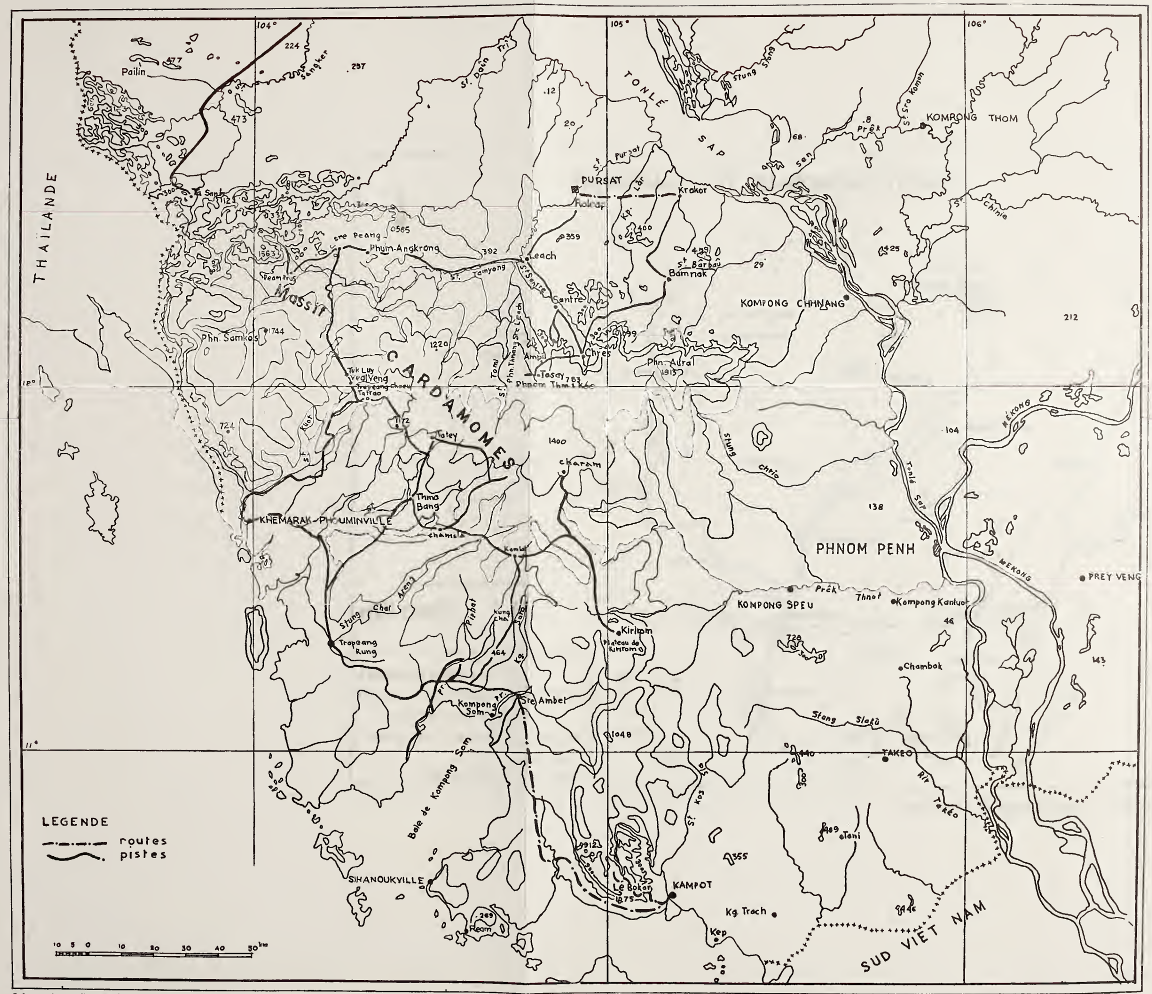
Hopea is strictly riparian and disappears when one penetrates into the forest. The following species are prominent in the middle and understorey:

Syzygium zeylanicum (L.) DC
Pandanus (*tectorius*)
Fagraea racemosa Jack ex Wall.
Ficus sp.
Cinnamomum sp.
Xanthophyllum glaucum Wall. ex Hassk.

With the exception of *Hopea* and *X. glaucum* the other species cited here are nearly always present and form the characteristic floristic component.



Map 1 : General Map of Cambodia.



Map 2 : Location of places near Pursat and in the Cardamom Mountains.

2. Evergreen forests of ridges and plateaux

(*a*) Forest with Fagaceae, Lauraceae, Myrtaceae, Meliaceae. This occurs also on some slopes free of rocks. It is possible to recognize several strata:

An upper and a lower canopy stratum; these when taken together are dense. Trees of the former are often variable both in height and diameter, yet form a more or less complete cover except in certain types where the understorey is very dense. The lower canopy stratum only sometimes forms a complete cover. Taken together, the espacement between individual trees is typically 3-5 m. The boles are cylindrical and straight, without prominent buttresses though often somewhat flared at the base; in some areas between a quarter and a third of the lower canopy trees are leaning. The crowns of the upper canopy stratum are generally light, with diffuse foliage; those of the lower tend to be lanceolate, and the stratum taken as a whole is more dense. For the most part the first branches appear in the upper two-thirds to three-quarters of total height of the trees; they generally arise from the same point at the bole apex, with the exception of certain monopodial species in the lower canopy, notably *Garcinia vilersiana* Pierre and *Sageraea elliptica* (A. DC.) Hook. f.

The understorey stratum includes many Rubiaceae and spiny palmlets as well as tree ferns. Along the roadsides a Melastomataceous shrub *Medinilla coerulescens* Guill. is very abundant.

The herb and shrub stratum consists essentially of zingibers, some ferns, and a semi-woody gregarious *Strobilanthes* which can reach 2½ m. and which often by itself consistitutes the shrub layer. In open glades a Cyperaceae (1537) is usually noted.

Epiphytes are abundant both in the upper and lower canopy strata: orchids of many kinds, the smallest growing in among the moss; many ferns, in particular *Asplenium, Platycerium* and *Drynaria;* mosses and hepatics are conspicuously abundant.

Herbaceous and semi-woody climbers are frequent, twisted round the tree trunks; large woody climbers, reaching into the upper-most branches, are less abundant.

Appearance of the understorey: When the forest is completely closed, as is generally the case, the understorey though lush is easy to pass through in spite of the presence of spiny palms. When light penetrates the canopy to any extent, the more the understorey (both woody and herbaceous) is illuminated the more it burgeons; the plants become entangled and progress becomes exceedingly difficult.

This evergreen forest with Lauraceae, Fagaceae and Myrtaceae is the most widespread in the massif. It is rich in species, of which the most frequent are:

MAIN CANOPY:

Cinnamomum aff. *javanicum*
Cinnamomum sp. (1443)
Syzygium sp. (1553)
Syzygium aff. *cochinchinensis*
Quercus chrysocalyx Hick. & A. Camus
Castanopsis pierrei Hance
Dysoxylum cauliflorum Hiern.
Dysoxylum aff. *hoaensis*
Dysoxylum procerum Hiern.
Schima crenata Korth.
Podocarpus imbricatus Bl.
Parkia streptocarpa Hance
Baccaurea oxycarpa Gagnep.
Aquilaria krassna Pierre ex Lecomte
Garcinia hanburyi Hook. f.

UNDERSTOREY:

Areca triandra Roxb. or *Pinanga duperreana* Pierre ex Becc. (The two species never occur together.)

Daemonorops aff. *pierreanus*

Cyathea podophylla (Hook.) Copel.

Cyathea latebrosa (Wall.) Copel.

Some Rubiaceae

Medinilla coerulescens Guill.

Some spiny *Smilax* spp.

HERB AND SHRUB STRATUM:

Amomum kravanh Pierre ex Gagnep. (the Cambodian Cardamom plant, confined to rich soils).

Amomum spp. (Among which is No. 1507)

Alpinia spp. (Among which is No. 1709)

Strobilanthes sp.

Many vascular cryptogams, especially *Selaginella siamensis* Hiern. and *Pteridium esculentum* (Forst.) Cookayne

CLIMBERS AND EPIPHYTES:

Albizzia sp.
Apocynaceae (1528)
Dischidia aff. *imbricata* (Bl.) Steud.
Dischidia nummularia R. Br.
Certain Annonaceae
Cassytha filiformis L.
Araceae (*Pothos* spp. ?)
Gleichenia aff. *norrisii*
Asplenium nidus L.
Platycerium coronarium Desv.
Drynaria spp.
Many orchids, notably *Eria, Bulbophyllum, Dendrobium* and *Appendicula* spp.

MOSSES AND HEPATICS*:

Acroporium sp.
Bazzania sp.
Chaetomitrium sp.
Cheilolejeunea ceylanica (St.) Schust. & Kahr.
Cheilolejeunea verdonii (Hoff.) Schust. & Kahr.
Cololejeunea sp.
Dicranoloma braunii (C.M.) Par.
Drepanolejeunea thwaitesiana
Ectropothecium buitenzorgii (Bel.) Jaeg.
Fissidens aff. *nobilis* Griff.
Homaliodendron crassinervium Ther.
Leptolejeunea subacuta St.
Leucobryum bowringii Mitt.
Leucoloma molle (C.M.) Par.
Plagiochila sp.
Radula acuminata St.
Raphidolejeunea subacuta St.
Trachypus bicolor Reinw. & Hornsch.
Trichocolea pluma Mont.
Thuidium meyenianum (Hamp.) Jaeg.

---

* Identified by Mr. Pierre Tixier.

Besides these species there are others which can become locally abundant within this forest type:

TREES:

A very large Apocynaceae, reaching 50 m. tall (1533)
Anisoptera sp.
Dipterocarpus turbinatus Gaertn. f.
Dipterocarpus costatus Gaertn. f.
Vatica odorata (Griff.) Sym.
Ficus sp. (1562)
Heritiera javanica (Bl.) Kost.
Sapium baccatum Roxb.
Adenanthera pavonina L.
(?) *Aglaia* sp.
Maba sp.
(?) Lauraceae: No. 1548
Leguminosae or Sapindaceae (1534)
Irvingia malayana Oliv. ex Benn.
Castanopsis cambodiana A. Cheval.
Lithocarpus cerifera Hick. & A. Camus
Calophyllum sp. and other Guttiferae
Melia azedarach L.
Baccaurea sapida Muell.-Arg.

SHRUBS AND HERBS:

Sageraea elliptica (A.DC.) Hook. f.
Evodia triphylla DC.
An arborescent *Pandanus*

Certain species reach 1000 m. altitude (and perhaps higher), such as many Myrtaceae, some Lauraceae and Guttiferae, *Schima crenata, Podocarpus imbricatus* and *Sapium baccatum.*

On the other hand there are others confined to middle altitudes, including:

All Meliaceae
Parkia streptocarpa
Dipterocarpus costatus
Ficus sp.
Apocynaceae No. 1533

Most palms (excepting *Pinanga duperreana*) do not exceed 600-800 m.

By contrast: *Irvingia malayana, Heritiera javanica, Quercus chrysocalyx, Baccaurea oxycarpa, Melia azedarach* disappear near 400-600 m.

Yet others only appear at certain restricted altitudes: the genus *Cyathea,* at c. 500 m., *Pinanga duperreana,* at c. 600 m., Fagaceae, No. 1549, at c. 800 m.

On red soil derived from basalt, Meliaceae, the larger Lauraceae notably *Cinnamomum* aff. *javanicum, Tetrameles nudiflora, Sapium baccatum* and *Syzygium* sp. (1553) are particularly well represented.

(*b*) Forest with *Hopea pierrei* Hance, *Quercus chrysocalyx* Hick. et A. Camus, *Anthocephalus* sp. (1739).

One finds this type in the western part of the mountain range. One dominant species, *Hopea pierrei,* exceptionally successful, prevails at all levels, as saplings, poles and mature trees. It grows also to the north, around the plateau of Veal Veng in the same forest type. The height of its crown hardly exceeds 20 m. In both areas the soil is a red lateritic clay. Two species of medium height (c. 30 m.) are associated with *Hopea pierrei: Anthocephalus* sp. (1739) and *Quercus chrysocalyx.* A *Tristania* (1736) which is sometimes associated seems to prefer in particular the moister habitats. Finally, another Fagaceae appears in this type, which it has not so far been possible to collect.

Apart from these distinctions, one meets in this forest type nearly all the trees of evergreen forest type (*a*), and the understorey is equally similar.

Locally, several dipterocarps appear: besides *Hopea pierrei, Anisoptera* sp. and *Dipterocarpus costatus* can occur. In the forests to the north, *Vatica odorata* is abundant adjacent to *Hopea pierrei* and *Anthocephalus* sp.

In rocky places these species are mixed with a bamboo (*Bambusa* sp., 1710).

3. Forests on slopes, with bamboo

It can happen that, on the slopes of certain phnoms*, the vegetation may not be different from that which covers the summits; this occurs particularly where the soil remains of more or less uniform depth. Generally, however, the slopes present the appearance of a mosaic of sandstone blocks, the prevailing substrate of the Cardamom mountains, and of more or less humiferous clay screes — resulting from the decomposition of certain types of sandstone.

On occasion walls of exposed rock strata are exposed, as if the water, in seeping down the slopes had exposed a buried relief; on others they occur in irregular screes. Sometimes also, landslips have carried the sandstone down from the hilltops towards the lower slopes, where it accumulates; the persisting scars on the slopes, and the blocks that mark their course, remain as testimony. Be that as it may, whether the rock rests in situ or has fallen from the ridges, there is hardly any room for the establishment of vegetation.

Here bamboos (*Bambusa* sp., 1710, 1696) are dominant. Sometimes there are few trees, or even none. On the ground an *Alpinia* and a small species of fern can grow among the bamboos, but are local. Above 500 m. one meets some cyatheas here and there. Two large and aggressive invading ferns, *Gleichenia* aff. *norrisii* and *Dicranopteris* sp. can grow among the bamboos and even completely replace them. It appears that this comes about when the soil is particularly impoverished. Certain spiny plants, such as *Rubus* spp. (especially bordering tracks) and certain climbers can render such thicket impenetrable.

Between these communities with bamboos and the majestic evergreen forests occurring on ridges and here and there on slopes, there can occur a transitional type where some species of the evergreen forests mix with the bamboos. *Quercus chrysocalyx* is the most frequent but all the other species can occur from time to time; their density is generally low and their height hardly exceeds 20 m. The spiny palms, and in particular the rattans, are numerous.

These bamboo forests climb to 1000 m., possibly higher seeing that we know so little about the vegetation that grows above that altitude.

4. The vegetation of the wet grasslands

The tracks that cross the range from time to time open out into plateaux covered with herbaceous vegetation. Trees are very scattered or for much of the time absent. On the ground grasses and *Drosera* (*indica*) occur in abundance; an unidentified herb (1664) is generally associated with them. Locally, *Leptocarpus disjunctus* Mast. is dominant, at which time it is associated with *Centrolepis cambodiana*. Further plants encountered here sometimes are a Euphorbiaceae (1769) and another small undetermined herb (1764).

This vegetation has been observed to occur over sandy soil and on surfaces where the iron pan, close to the surface, outcrops here and there.

Where swampy terrain occurs it is hemmed by giant grasses such as *Saccharum arundinaceum* Retz., by *Phragmites* sp. or by Cyperaceae.

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* Phnom: a mountain, hill or mound.

5. Dry deciduous forest, Erythrophloeum cambodianum Gagnep., Irvingia malayana, Lagerstroemia sp.

On the slopes of certain phnoms to the north of the range grows a semi-deciduous forest, characteristised by the abundance of leguminous trees.

TREES: the following are dominant:

Erythrophloeum cambodianum Gagnep.
Irvingia malayana
Lagerstroemia sp.
Bombax ceiba L.
(?) *Nephelium* sp.

and are accompanied by:

Dalbergia nigrescens Kurz
Xylia kerrii Craib & Hutch.
Sindora cochinchinensis Baill.
Pterocarpus sp.
Ficus sp.
Aquilaria krassna Pierre ex Lecomte
Garcinia ferrea Pierre
Terminalia nigrovenulosa Pierre

Near the summits *Tetrameles nudiflora* R.Br. is noticed.

SHRUBS:

Cratoxylon sp.
Memecylon sp.
Some Rubiaceae
A few climbers and spiny plants

The ground is covered by numerous ferns and zingibers, including *Amomum kravanh* Pierre ex Gagnep.

Many of the species quoted grow in dry habitats and one comes across them often in the deciduous formations of the plains of Tonlé Sap and Mekong. In the mountains they are to be found up to 500 m. altitude on rocky outcrops with shallow soils.

6. The savanna forests

(*a*) The pine forests:

> *Pinus merkusii* Jungh. et de Vriese. These are as a rule submontane, but they do exist also in the lowlands. On the Cardamoms themselves they follow certain cuestas and plateaux.
>
> In the regions visited *Tristania burmanica* is the best represented woody species though *Dipterocarpus obtusifolius* Teysm. and *Melastoma* sp. also occur; *Imperata cylindrica* P. Beauv. and *Selaginella* sp. dominate the field layer. In all, the number of species appears to be low.

(*b*) The savanna forests with dipterocarps:

Unique to South-East Asia, these, frequently called Dry Dipterocarp forests, are widespread in Cambodia; they occur to several hundred metres altitude and are generally found on sandy soils. The best represented species in them are:

Shorea obtusa Wall. ex Bl., which can form almost pure stands.
Dipterocarpus tuberculatus Roxb.
Dipterocarpus obtusifolius Teysm.
Pentacme siamensis Kurz
Dipterocarpus intricatus Dyer, which seems to indicate somewhat better soil conditions.

The Dipterocarpaceae can alone constitute the single tree stratum, or equally can be accompanied by:

Careya sphaerica Roxb.
Aporosa sphaerosperma Gagnep.
Terminalia alata Heyne ex Roth
Mitragyna brunonis (Wall. ex G.Don) Craib
Diospyros erhetioides Wall.
Melanorrhoea laccifera Pierre
Sindora cochinchinensis Baill.
Xylia kerrii Craib & Hutch
Parinari anamensis Hance
Buchanania reticulata Hance
Dillenia ovata Wall. ex Hook. f. & Thoms.
Dillenia pentagyna Roxb.
Zizyphus cenoplia Mill.
Randia tomentosa Bl.
Feroniella lucida (Teijsm. & Binn. ex Scheff.) Swingle
A bush with distinct red bark (1349)

In the understorey *Corypha lecomtei* Becc. is particularly abundant; it occurs also in analogous vegetation types to the north of Kompong Thom away on the other side of the Great Lake. The most abundant and ubiquitous herb is *Arundinaria falcata* Nees, though it can sometimes be replaced by *Imperata cylindrica* P. Beauv., notably after persistent burning.

It should be recalled that the savanna forests, including the pine forests, are for the most part burned annually to facilitate the hunting of game which frequent them. Some foresters (3) believe that these types are mostly man-induced and that the climatic climax-type is an unfired savanna forest with dipterocarps; such a savanna forest, which still occurs here and there on the plains, includes many Leguminosae:

Xylia kerrii Craib & Hutch.
Sindora cochinchinensis Baill.
Peltophorum aff. *pterocarpa*
Afzelia xylocarpa Craib
Dalbergia nigrescens Kurz
Dialium cochinchinensis Pierre
Dalbergia aff. *cochinchinensis*
Dalbergia aff. *lanceolaria*

as well as:

Lagerstroemia spp.
Combretum quadrangulare Kurz
Terminalia sp.
Terminalia nigrovenulosa Pierre
Bombax ceiba L.
Shorea talura Roxb.
The shrub (1349) already mentioned.

Sometimes also, *Dipterocarpus intricatus* Dyer occurs.

A bamboo (1696), encountered also in evergreen forest, grows at times in the understorey.

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(3) P. Maurand, 1968. Politique forestière â envisager au Vietnam, dans l'après-guerre. Bull. Soc. Ét. Indochin., Saigon, 43, 4: 267–309.

The *Xylopia malayana* fruit: significance of its dehiscence

by

HSUAN KENG* & E. A. HEASLETT**

Xylopia malayana Hook. f. & Thoms. of the family Annonaceae, is a small tree, 10–20 m tall, with smooth, pale greyish bark, distributed in Malaysia, Singapore, and Sumatra (Sinclair 1955). In Singapore it can be found scattered in lowland forest around MacRitchie Reservoir and in the Bukit Timah Nature Reserve.

The mature carpels of this tree are oblong obovoid, 3–3.8 cm long, 1.5–18 cm across, slightly ridged on the dorsal side and shortly stipitate at the base. They are greyish green to yellowish green in colour, sometimes with a pinkish tinge when fully matured. The surface of the carpels is densely covered with short, velutinous hairs. The mature carpels, usually 2, 3 to many (12 or so) in a bundle (Figure 1a), form an aggregate fruit, or botanically a follicetum.

The mode of dehiscence of these mature carpels is interesting. A dehiscent line at first appears at the median of the dorsal suture, and from there it extends towards both apical and basal ends (Figure 1b). After the carpel has completely

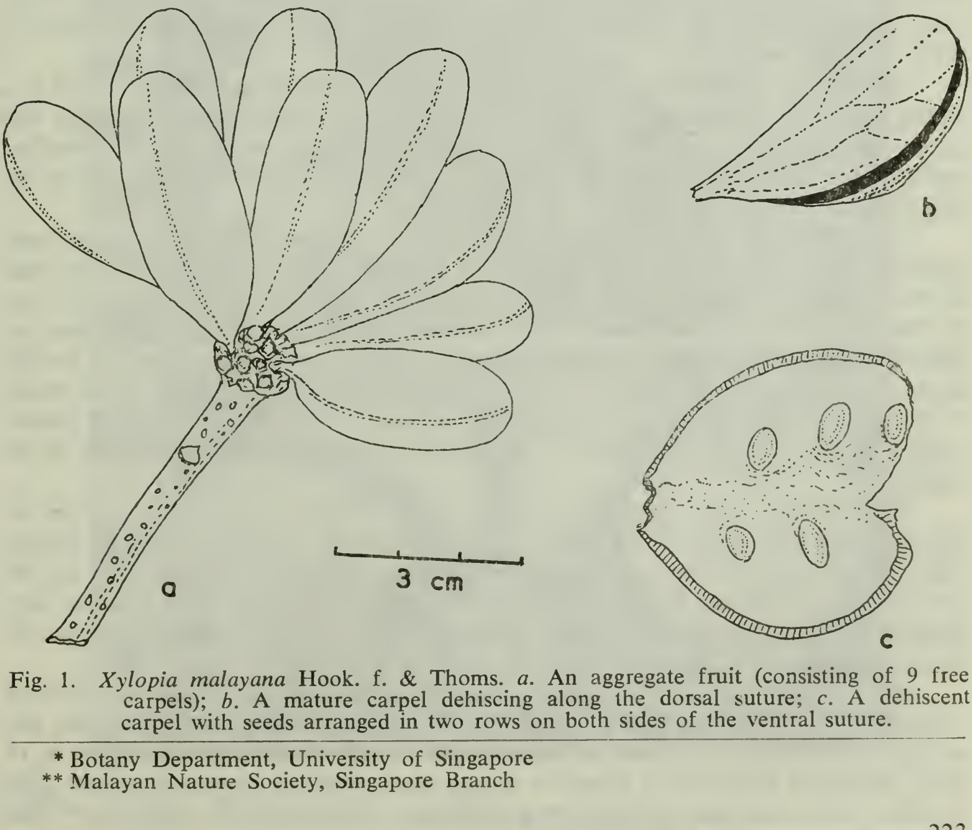

Fig. 1. *Xylopia malayana* Hook. f. & Thoms. *a*. An aggregate fruit (consisting of 9 free carpels); *b*. A mature carpel dehiscing along the dorsal suture; *c*. A dehiscent carpel with seeds arranged in two rows on both sides of the ventral suture.

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dehisced along its dorsal suture, it exposes the soft, somewhat juicy, pink to scarlet-red pulp in which two rows of seeds were embedded, showing 2 to 4 seeds on each row, alternatively arranged along the ventral suture (Figure 1c). In the freshly exposed fruit, the seeds are coated with a thin layer of creamy white, waxy substance. After the seeds are exposed in the air for a day or two, the colour of the seed coat gradually changes from creamy white to pale chestnut and then to dark chestnut brown. The fruit wall or pericarp is soft leathery in texture. The two wing-like valves of the dehiscent carpels gradually curve acutely backwards, often severely damaging the adjacent tissues near the apex and base of the fruit. Therefore, in an advanced stage of dehiscence, carpels are often found to be further split along the ventral suture to a greater or lesser extent.

The trees which we examined in Singapore and in Southern Johore, Malaysia were fruiting during October and November, 1972. A considerable amount of fruit, partly or fully dehiscent, was found on the ground under the trees, and some of it had been damaged by an unknown animal. Since the open carpels possess a faint, fragrant smell, and display a mass of bright pink to scarlet pulp with several white to brown seeds, it seems probable that the seeds of *Xylopia malayana* are dispersed by birds. (cf. Pijl 1969).

Hutchinson (1959, 1: 134) gives a general description of the fruit of Annonaceae as follows "carpels usually stipitate in fruit, free, rarely united into 1– or many-locular mass, dry or fleshy, rarely dehiscent". Sinclair (1955, p. 168) observed that in the Malayan Annonaceae, "the carpels are indehiscent, except in the case of *Anaxagorea,* where the carpels are follicles. In some species of *Xylopia* and *Alphonsea,* there is a kind of semi-dehiscence but the carpels do not open by well-defined sutures".

Further it is interesting to note as Sinclair pointed out (p. 347) that there is a strong resemblance between *Anaxagorea* and *Xylopia* in their carpels, stamens and geographical distribution. Both genera, together with several others are classified under the tribe Xylopieae by Sinclair, but reduced to the *Xylopia* Group of the tribe Unoneae by Fries (1959).

It is generally accepted that the follicular fruit probably represents the basic pattern of fruit among angiosperms (Eames 1961, Takhtajan 1969). Most members of the modern Magnoliaceae have follicular fruits. The fruit of the ancestral form of the Annonaceae is very likely of a similar nature. Therefore the presence of follicular carpels in *Anaxagorea* (which contains only one or two nearly basally attached ovules and seeds in each carpel) and *Xylopia* (which has a special mode of dehiscent as described above) probably indicate that each of these two genera retains in part the characteristics of the fruit of the putative ancestral form of the family.

It should also be pointed out that the main dehiscent line of the carpels in *Xylopia,* like that of many members of the Magnoliaceae, is along the dorsal suture. This is in contrast to the definition of a follicle as given in most glossaries and to the follicular fruits as found in *Anaxagorea* and in various other families (e.g. Illiciaceae, Dilleniaceae, etc.) in which the dehiscent line is invariably along the ventral suture.

Monographers of the Annonaceae generally agree that the flower structures of *Anaxagorea, Xylopia,* and allied genera which constitute the tribe Xylopieae, are all characterized by the valvate sepals and petals, and are thus considered to be of fairly advanced nature. The retention of the more primitive characters of the fruit in these genera may be explained by postulating a discrepancy in evolutionary rate between the flowers and the fruits.

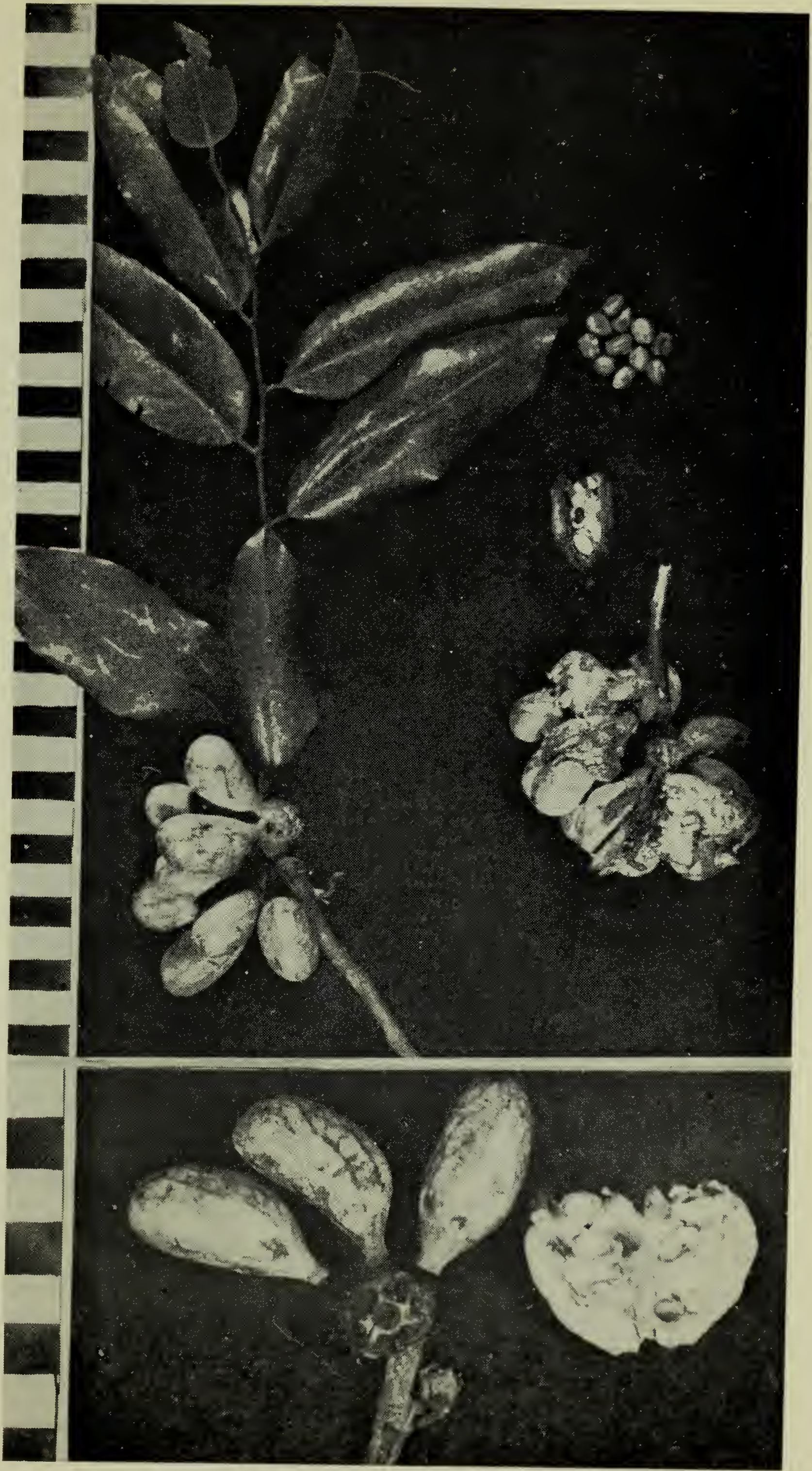

Plate 1. *Xylopia malayana* Hook. f. & Thoms.
Above: a fruiting branch with dehiscent carpels and seeds;
Below: an aggregate fruit and a dehiscent carpel.
(scale: 1 cm divisions)

Photo by Mr. D. Teow

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Nepenthes from Borneo, Singapore and Sumatra

by

Shigeo Kurata*

This paper comprises the result of an expedition to Indonesian Islands in search of *Nepenthes.* It records thirteen species and describes two of them as new taxa. All but one were collected during this research trip made by the author and G. Mikil (participant from Malaysia) to Borneo, Singapore, Java and Sumatra in March 1972.

The new taxa are *N. campanulata* and *N. rhombicaulis.* The author is grateful to Drs. C. X. Furtado and K. L. Chang for their kind assistance.

1. *Nepenthes alata* Blanco, Fl. Filip., ed. I, p. 805 (1837).

SUMATRA: West Sumatra, Bukittinggi, en route to Lake Manindjau, 1100 m alt., *Kurata & Mikil 4101, 4102, 4103.*

Distribution. Philippines, Malaya, Sumatra and Borneo.

The plants grow on the sand-stone cliff of a river. The two wings on the pitcher wall are not ciliated at the margins. The leaf is sessile and the stem is remarkably trigonous with the wider wings. By these characters the Sumatran plants vary from those of the Philippines.

2. *Nepenthes ampullaria* Jack, Comp. Bot. Mag., I, p. 271 (1835).

SINGAPORE: MacRitchie Reservoir, 50 m alt., *Kurata & Mikil 4030, 4031, 4032.* SUMATRA: North Sumatra, near the headwater of Asahan river, 800m. alt., *Kurata & Mikil 4309, 4310, 4311, 4312, 4313.*

Distribution. Malaya, Singapore, Borneo, Sumatra and New Guinea.

3. *Nepenthes bongso* Korth., Verh., Nat. Gesch. Bot. p. 19, t. 14 (1839).

SUMATRA: West Sumatra, Mt. Talang, 1540–1950 m alt., *Kurata & Mikil 4245, 4246, 4247, 4248, 4249, 4250, 4251, 4252.*

Distribution. Sumatra.

4. *Nepenthes campanulata* Kurata, **sp. nov.** (Pls. 1 & 2) — *Nepenthes campanulata* (nomen nudum) Kurata, The Heredity, Vol. 26, No. 10, p. 44 & 50 (1972).

Planta tenuis, breviter scandens. *Caulis* 20–35 cm altus, 3–4 mm crassus, cylindricus, glaber. *Folia* sessilia, 5–7 cm longa, 1.2–2 cm lata, spathulato-lanceolata, basi $\frac{3}{4}$–$\frac{4}{5}$ amplexicaulia, apice rotundata et leviter peltata, coriacea, utrinque glabra; nervi longitudinales utrinque 2–3, nervi transversales obscure, oblique ascendentes; cirrhus tenuis, 2.5–4 cm longus, cylindricus, glaber. *Ascidia* monomorphia, campanulata, 4.5–7 cm longa, parte inferiore cylindrica vel leviter ventricosa, 1–1.5 cm lata,

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parte superiore infundibuliformia, 3.5–5.5 cm lata, luteo-viridia, diffuse purpureo-maculata, herbacea, glabra, intus parte $\frac{1}{4}$ inferiore glandulosa, costis 2 prominentibus; os circulare, fere horizontale; peristomium fere 0, breviter denticulatum; operculum elliptico-oblongum, 1.2–1.5 cm longum, facie inferiore planum; calcar ca. 1 mm longum, filiforme. *Inflorescentia* ignota.

Stem slender, shortly climbing, 20–35 cm high, the part with adult leaves 3–4 mm thick, cylindrical, glabrous. *Leaves* scattered, coriaceous, sessile, spathulate-lanceolate, 5–7 cm long, 1.2–2 cm broad, the base $\frac{3}{4}$–$\frac{4}{5}$ amplexicaul, rounded and slightly peltate at the apex; longitudinal nerves 2–3 on both sides, pinnate nerves obliquely ascending; both surfaces glabrous; tendril slender, 2.5–4 cm long, cylindrical, glabrous. *Pitchers* herbaceous, campanulate, 4.5–7 cm high, 1–1.5 cm broad at the lower cylindrical or slightly ventricose part, 3.5–5.5 cm broad in the upper infundibuliform part, with 2 prominent ribs; mouth circular, almost horizontal; peristome almost none, the minute teeth fringing the mouth; inner surface of the pitcher glandular in the lower $\frac{1}{4}$ part; the pitcher yellow-green with purple-spots, glabrous; lid elliptic-oblong, 1.2–1.5 cm long, under surface plain; spur filiform, about 1 mm long. *Inflorescence* unknown.

Typus: *A. Kostermans 13764* (SING.); foot of Mt. Ilas Bungaan, East Borneo, 300 m. alt., Sept. 9, 1957.

This new species is closely related to *N. inermis* Danser of Sumatra by its slender habit and campanulate pitcher without conspicuous peristome. However present species differs clearly from the latter by the lamina with peltate portion near the apex, elliptic-oblong lid of a remarkably small size (its length always measures less than $\frac{1}{4}$ of the mouth-diameter) and existence of glandless but waxy zone which occupies greater part of the inner surface of the pitcher. The digestive glands on the inner surface of the pitcher are all round (not overarched) and are only distributed in the bottom part with a sparse density of 100–250 glands per square cm. Also, colour of dried specimen distinctly differs from that of *N. inermis*. Danser described the dried specimens of *N. inermis* as blackish in all parts (examined by the author), but those of present species are reddish brown all over. See addendum on p. 232.

Though this specimen collected by A. Kostermans is the only one and has no inflorescence, these characters mentioned above sufficiently support the author's conclusion that this species is a new one. *N. campanulata* is not a natural hybrid as there is not any known species having these characters which could claim to be its parental species.

Distribution of *N. campanulata* seems limited to a particular area presumably owing to its habitat which is noted as the sand and limestone walls at an altitude of 300 meters by the collector, whereas *N. inermis* was found only on high places (1800–2590 m. alt.) in the mountains in central Sumatra.

5. *Nepenthes caruncuIata* Dans., Bull. Jard. Bot. Buitenz. ser. III, Vol. IX, p. 277 (1928).

SUMATRA: West Sumatra, Mt. Talang, 1900–2000 m alt., *Kurata & Mikil 4218, 4219, 4220, 4221, 4222, 4223.*

Distribution. Sumatra.

Plate 1. *Nepenthes campanulata* Kurata (x 0.5).

Plate 2. *Nepenthes campanulata:* a pitcher (x 1.5).

6. *Nepenthes dubia* Dans., Bull. Jard. Bot. Buitenz. ser. III, Vol. IX, p. 285 (1928).

SUMATRA: West Sumatra, Mt. Talang, 1500–2000 m alt., *Kurata & Mikil 4230, 4231–a, 4231–b, 4233, 4234, 4235, 4236.*

Distribution. Sumatra.

7. *Nepenthes gracilis* Korth., Verh., Nat. Gesch. Bot. p. 22, t. I & IV, ic. 1–38 (1839).

BORNEO: Sabah, Bukit Padang, near Kota Kinabalu, 300 m alt., *Kurata & Mikil 4020, 4021, 4023.* SINGAPORE: MacRitchie Reservoir, 50 m alt., *Kurata & Mikil 4050, 4051, 4052.*

Distribution. Borneo, Sumatra, Celebes, Malaya and Singapore.

8. *Nepenthes mirabilis* Druce, Fl. coch., II, p. 606 (1790).

SUMATRA: West Sumatra, Indarung, 10 km east from Padang, a swampy shrub, 250 m alt., *Kurata & Mikil 4256, 4257, 4258, 4259, 4260, 4261, 4262, 4263.*

Distribution. Southern China, Indochina, Malaya, Singapore, Java, Sumatra, Borneo, Philippines, Moluccas, New Guinea and Australia.

This species varies somewhat on each island. In the case of Sumatran plants the pitcher is very narrow and its peristome has a distinctly flattened surface.

9. *Nepenthes pectinata* Dans., Bull. Jard. Bot. Buitenz. ser. III, Vol. IX, p. 350 (1928).

SUMATRA: West Sumatra, Mt. Singgalang, 2400–2600 m alt., *Kurata & Mikil 4202, 4203, 4204, 4205, 4206;* Mt. Merapi, 2400 m alt., *Kurata & Mikil 4211, 4212, 4213, 4214, 4215, 4216.*

Distribution. Sumatra.

10. *Nepenthes rafflesiana* Jack, Comp. Bot. Mag., I, p. 270 (1835).

BORNEO: Sabah, Bukit Padang near Kota Kinabalu, 300 m alt., *Kurata & Mikil 4006, 4007, 4008, 4009, 4010, 4011, 4012.* SINGAPORE: MacRitchie Reservoir, 50 m alt., *Kurata & Mikil 4040, 4041.*

Distribution. Malaya, Singapore, Borneo and Sumatra.

11. *Nepenthes rhombicaulis* Kurata, **sp. nov.** (Fig. 1) — *Nepenthes rhombicaulis* (nomen nudum) Kurata, The Heredity, Vol. 26, No. 10, p. 44 (1972).

Planta robusta, alte scandens. *Caulis* 5–20 m altus, 5–10 mm crassus, quadratus vel rhomboides, glaber. *Folia* sessilia, 12–22 cm longa, 3–4 cm lata, lanceolata, herbacea, basi $\frac{1}{2}$–$\frac{2}{3}$ amplexicaulia, utrinque glabra, margine ferrugineo-pubescentia, supra lucido-viridia, subtus luteo-viridia, nervi longitudinales utrinque 2–3, nervi transversales obscure, oblique ascendentes; cirrhus tenuis, 10–13 cm longus, cylindricus, glaber, luteo-viridis. *Ascidia inferiora et rosularium* 6–12 cm longa, 2.5–3.5 cm lata, parte inferiore ventricosa, parte superiore cylindrica, rubro- vel pallido-viridia, diffuse purpureo-maculata, coriacea, sparse pubescentia, intus parte $\frac{2}{5}$ inferiore glandulosa, bialata, alis margine dentatis; os orbiculare obliquum; peristomium 3–5 mm latum, subcylindricum, rubrum, margine exteriore expansum, undulatum, margine interiore denticulatum; operculum elliptico-oblongum, 1.7–2.5

Fig. 1. *Nepenthes rhombicaulis* Kurata *A*. upper portion of a climbing stem (x 0.5); *B*. male inflorescence (x 0.5); *C*. female inflorescence (x 0.5); *D*. rosette leaves with pitchers (x 0.5); *E*. male flower (x 5); *F*. capsules (x 1).

cm latum, facie inferiore prope apicem appendiculatum; calcar ca. 5 mm longum, filiforme; *ascidia superiora* ignota. *Inflorescentia* 30–40 cm longa, racemosa, pedunculus 15–20 cm longus, glaber, pedicelli 10–15 mm longi, biflori; sepala 4, elliptica, 4 mm longa, 3 mm lata, extus minute tomentosa; columna staminae 4 mm longa, antherae 8, uniseriatae; capsula 20–25 mm longa, 5 mm lata, fusiformis, brunneo-nitida, leviter puberula, valvae lanceolatae.

Stem climbing up to 20 m high, the part with adult leaves 5–10 mm thick, quadrate or rhomboid, glabrous; often short shoots and rosettes at the base of older plants. *Leaves of the rosettes and short shoots* scattered, the lamina small, several cm long, lanceolate; *Leaves of the climbing stem* scattered, herbaceous, sessile, lanceolate, 12–22 cm long, 3–4 cm broad, the base $\frac{1}{2}$–$\frac{2}{3}$ amplexicaul; both surfaces glabrous, the margin ferrugineous pubescent; the upper surface lucid-green, the under surface yellow-green; longitudinal nerves 2–3 on both sides, pinnate nerves running obliquely ascending; tendril slender, 10–13 cm long, cylindrical, yellow-green, glabrous. *Pitchers of the rosettes and the short shoots* coriaceous, 6–12 cm high, 2.5–3.5 cm broad, ventricose in the lower part, cylindrical in the upper part, with 2 wings, the margins of the wings toothed; mouth oblique, circular; peristome subcylindrical, 3–5 mm broad, reddish, outer margin of the peristome expanded and undulated, interior margin toothed; inner surface of the pitcher glandular in the lower $\frac{2}{5}$ part; the pitcher red- or pale-green with purple-spots, sparsely pubescent; lid elliptic-oblong, 1.7–2.5 cm broad, with an appendage situated nearer to the apex on the under surface; spur filiform, about 5 mm long; *Pitchers of the climbing stem* unknown. *Inflorescence* a raceme, 30–40 cm long, the peduncle 15–20 cm long, glabrous; pedicels 10–15 mm long, 2-flowered, sepals 4, elliptical, 4 mm long, 3 mm broad, the outer surface minute tomentose; staminal column 4 mm long, the anthers 8, uniseriate; capsules fusiform, 20–25 mm long, 5 mm broad, bright-brown, slightly pubescent; valve lanceolate.

Typus: *S. Kurata 4300* [male] and *4301* [female] (Herb. Nippon Dental College, Tokyo); Mt. Pangulubao near Perapat, North Sumatra, 1700–1900 m alt., March 29, 1972.

This species has a peculiar stem with four sharp-angled ridges; two of them are connected with elongated mid-ribs of two leaves while the remaining two are connected with leaf margins. As a result of such characters the cross-section of the stem is either rhomboid or square depending on the level of the stem sectioned. The pitchers are soft and breakable and are found only on the rosette leaves and those of the short shoots. The pitchers do not seem to arise from the leaves of the climbing stem. The rosette leaves and those of the short shoots are sometimes coloured with purple-green and fringed with distinct reddish-brown hairs at the margins.

This plant is comparatively common in the subalpine forest of the western slope of Mt. Pangulubao and its distribution seems widely scattered on the mountains around Lake Toba.

12. *Nepenthes singalana* Becc., Malesia III, p. 4 & 12, t. III (1886).

SUMATRA: West Sumatra, Mt. Singgalang, 2400–2600 m alt., *Kurata & Mikil 4207, 4208, 4209, 4210;* Mt. Merapi, 2500 m alt., *Kurata & Mikil 4211–a, 4211–b.*

Distribution. Sumatra.

13. *Nepenthes tobaica* Dans., Bull. Jard. Bot. Buitenz ser. III, Vol. IX, p. 382 (1928).

SUMATRA: North Sumatra, near Perapat, Lake Toba, 1000 m alt., *Kurata & Mikil 4266, 4267, 4268, 4269, 4270, 4271, 4272;* Mt. Pangulubao, 1500–1700 m alt., *Kurata & Mikil 4273, 4274, 4275, 4276, 4277, 4278, 4279, 4280;* Mt. Sibajak, 1800 m alt., *Kurata & Mikil 4286, 4287, 4288, 4289, 4290, 4291, 4292, 4293.*

Distribution. Sumatra.

Addendum to NEPENTHES CAMPANULATA

A special expedition was organised by Dr. A. J. G. H. Kostermans in 1957 to Mount Ilas Bungaan, an area in N. E. Kalimantan. Kostermans was informed by Dayaks that the rock was named such because it was completely overgrown with flowers (ilas = rock, bungaan = flowering). It took him 14 days to travel through unknown country to reach that rock. The steep 300-ft rockface was completely covered by a yellowish coloured NEPENTHES here described as a new species.

Moreover, when climbing the rockface with cane-ropes, antique rock graves were found with well preserved wooden carved coffins, still containing skeletons of which some were headless.

Annotated list of seed plants of Singapore (I)

by

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Introduction

The first list of plants of Singapore and adjacent islets, entitled "The flora of Singapore", was compiled by H. N. Ridley in 1900, with supplementary notes appearing a year later. These were published in the Journal of the Royal Asiatic Society, Straits Branch, volumes 33 and 34. Subsequently, two separate lists, entitled "List of Dicotyledons in Syonan" and "List of Monocotyledons in Syonan", were compiled by the Botanic Gardens staff during the Japanese occupation (1942–45), but were never published. Only their typed manuscripts were preserved in the Botanic Gardens, Singapore.

The present annotated list is essentially based on specimens accumulated in the herbarium of the Botanic Gardens, on Ridley's Flora of the Malay Peninsula (1922–25), on the lists mentioned above and on my own notes. In addition, numerous monographs, revisions and short articles were consulted. It is my intention to bring the nomenclature of the plant names up to date as far as possible, and admittedly, a number of them may have been overlooked. In some cases, I exercised my own judgement in accepting or rejecting some of the latest nomenclatural changes.

For convenience, the arrangement of the families follows that given in my book "Orders and families of Malayan Seed Plants" (University of Malaya Press in 1969, Kuala Lumpur).

With rapid urbanization and industrialization, a large number of native plants have already vanished or are on the verge of disappearance. On the other hand, however, a number of exotic plants were introduced, and some are already well-established. To differentiate them in the list, native species are printed in *bold face*, while introduced ones are in *italics*. Only native species bear a collection number of the herbarium specimen (often historical). Where available vernacular names in Malay/Chinese are supplied. It must be understood that the list of cultivated plants can not be expected to be complete. For example, among Gymnosperms, it was recorded in the "Index of Plants" of 1912 by J. W. Anderson, that several cycadaceous plants such as *Bowenia, Ceratozamia, Stangeria,* and coniferous plants such as *Cephalotaxus, Sciadopitys, Thujopsis,* etc. were growing in Singapore. None of these have survived, the main reason being that, under local climatic conditions, many of these introduced plants do not produce cones or flowers, let alone viable seeds. The perpetuation of such species would then depend on their ability to propagate by vegetative means or on the recurring introduction of seeds and plants.

The list will be published in instalments, with the intention of eventually combining them into one volume. I would like to express my appreciation to the Director and staff of the Botanic Gardens, Singapore, for their willing cooperation and assistance in the preparation of this list.

I. Gymnosperms

1. Cycadaceae

Artificial Key to the Genera

- A. Leaflets with a midrib *Cycas*
- A. Leaflets without a midrib.
  - B. Leaflets spinescent.
    - C. Spines minute, to 0.25 cm long *Dioon*
    - C. Spines conspicuous, to 1 cm long *Encephalartos*
  - B. Leaflets entire.
    - D. Leaflets 15–20 cm long, not jointed *Macrozamia*
    - D. Leaflets 8–10 cm long; jointed at base *Zamia*

Cycas revoluta Thunb.

A dwarf cycad, with strongly curved or 'revolute' leaflets; introduced from S. China and Japan; often cultivated; sometimes producing cones. 蘇鐵

Cycas rumphii Miq.

Formerly found wild on sandy shores at Changi (*Ridley 4408*), Tempinis, and Tuas, now survived only in cultivation. Dwarf palm-like; stem thick-columnar, rarely branched. Probably not specifically different from *C. circinalis* Roxb. of India and the Pacific Islands. Vern. *Pakis laut, Paku raja,* 南洋蘇鐵

Cycas siamensis Miq.

A native of N. Malaya and Thailand; base of stem bulb-shaped; cultivated occasionally; producing cones. 泰國蘇鐵

Dioon spinulosum Dyer

Native of Mexico; sterile.

Encephalartos villosus Lem.

Native of S. Africa, occasionally producing cones.

Macrozamia denisonii Moore & F. Muell. var. *hopei* Schust.

Native of E. & N. E. Australia, occasionally producing cones.

Zamia floridana A. DC.

Native of Florida, U.S.A., often producing cones. 藏米亞

Zamia media Jacq. var. *gutierrezii* Schust.

Also known as *Z. integrifolia* Hort.; native of Cuba, sometimes producing cones.

Zamia media Jacq. var. *tenuis* Schust.

Also known as *Z. tenuis* Willd.; native of Bahamas, sometimes producing cones.

2. Podocarpaceae

Artificial Key to the Genera from Podocarpaceae to Gnetaceae (adapted from Corner's "Wayside Trees" and modified).

A. Leaves flat, 0.5–10 cm wide, not needle-like.
B. Leaves opposite, usually spreading in one plane; twigs with distinct internodes.
C. Leaves thin, net-veined with a midrib; nodes swollen *Gnetum*
C. Leaves thick, stiff, faintly parallel-veined; nodes not swollen.
D. Terminal buds blunt; resin copious *Agathis*
D. Terminal buds pointed; resin scant *Podocarpus* (in part)

B. Leaves alternately or spirally arranged; internodes always very short.
E. Leave sharply pointed, without a midrib *Araucaria* (in part)
E. Leaves not prickly, with a distinct midrib *Podocarpus* (in part)

A. Leaves needle- or scale-like, 2 mm wide or less.
F. Needless over 15 cm long, 2 or 3 in a bundle *Pinus*
F. Leaves less than 2 cm long, generally much less; not in bundles.

G. Plants with 2 kinds of leaves: some twigs with minute scale-leaves, others with longer needle-leaves.
H. Leaves in 4 rows (or in two, alternating pairs) *Juniperus*
H. Leaves spirally or alternately arranged.
I. Needle-leaves flat, alternate, twisting in one plane; scale-leaves with projecting points *Podocarpus* (*imbricatus*)
I. Needle-leaves not flat; scale-leaves not with projecting points. *Dacrydium*

G. Adult plants with only one kind of leaves, either needle- or scale-shaped.
J. Needle-leaves 1–2 cm long, spirally arranged, with projecting points.
K. Branches in whorls *Araucaria*
K. Branches not in whorls *Cryptomeria*

J. Scale-leaves 2 mm long or less.
L. Small branches with their leaves flattened into one plane *Thuja*
L. Otherwise *Cupressus, Calocedrus, Callitris.*

Dacrydium elatum Wall.

Native of Malayan mountains and elsewhere; remaining sterile; leaves of two forms: needle-shaped and scale-like, often on separate branches. 涙柏

Podocarpus imbricatus Bl.

Native of Malayan mountains and elsewhere; producing male ones only. 爪哇羅漢松

Podocarpus motleyi Dummer

Native of Malayan swamps and elsewhere.

Podo. neriifolius D. Don[1]

Native of Malayan mountains and elsewhere; producing cones and seed. 百日青

Podo. polystachyus R. Br.

A native species, found in Labrador, Kranji (*Ridley 13304*) and other parts of the island near the sea and in mangroves; also growing in gardens. Vern. *Sintada.*

Podo. wallichianus Presl

Collected at Changi and Jurong (*Corner s.n.* Apr. 1933); erroneously known as *Podo. blumei* Endl.; commonly found in Malayan mountains. 大葉竹柏

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[1] Several other species of *Podocarpus* from China, Indonesia and elsewhere are introduced, some even producing viable seeds.

3. Araucariaceae

Agathis dammara (Lamb.) L. Rich.

Native of Malayan mountains and elsewhere; cultivated; producing cones, occasionally viable seeds. A small patch of trees on the back of Raffles Hall, Univ. of Singapore. Variously called *A. loranthifolia* Salisb. or *A. alba* Jaff. in literature. Vern. *Damar minyak,* 貝殼杉

Araucaria bidwilii Hook.

Introduced from Queensland; Australia. Leaves lanceolate, 2-rowed; known as Monkey puzzle.

Arau. cunninghamii Sweet

Native of Australia and New Guinea. Needle in dense spirals, sharp; known as Hoop pine.

Arau. excelsa R. Br.

Native of Norfolk Island, New Zealand. Needles in dense spirals, blunt. Known as Norfolk I. pine; propagated by cutting; one of the commonest *Araucaria* in cultivation. 南洋杉

Arau. kunsteinii K. Soh.

Native of New Guinea, Known as Kling pine.

4. Pinaceae

Pinus merkusii Jungh. & De Vriese[2]

Native of Thailand, Cambodia and Elsewhere. Producing cones and occasionally viable seeds. 末氏松

5. Taxodiaceae

Cryptomeria japonica D. Don

Native to S. China and Japan; sterile, rarely producing male cones. 柳杉

6. Cupressaceae

Callitris macleayana Muell.

Possibly together with one or two other species, is cultivated; all from Australia; sterile. 澳洲柏

Calocedrus formosana Florin

Formerly known as *Libocedrus formosana* Florin; native to Formosa; occasionally producing male cones. 肖楠

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[2] Several other species of pines, such as *P. insularis* Endl. (3-needled, from the Philippines), *P. caribaea* Morelet (3- or 2-needled, from the W. Indies), *P. massoniana* Lamb. (2-needled, from S. China) are sometimes cultivated; often remain sterile, rarely producing male cones.

Cupressus macrocarpa Hort. ex Gordon

Native to N. America; sterile. 大毬柏木

Juniperus chinensis L.

Native of China; several horticultural forms commonly cultivated; sterile or producing male cones only; propagated by cutting. 圓柏

Thuja orientalis L.

Native of N. China; commonly cultivated in gardens; often producing male cones; propagated by cutting. 側柏

7. Gnetaceae

Gnetum gnemonoides Brongn.

Listed in Ridley's Flora as *G. wrayi* Gamble. Recorded from Tuas, Jurong, Chua Chu Kang (*Ridley 6126*), etc. Seeds large, 5–7 cm long.

Gnetum gnemon L.

Shrub or small tree (in contrast to other species listed here being woody climbers) easily mistaken as a dicot. It is either a native or at least was introduced during the immemorable past. Usually only the female plants are cultivated near Malay villages (*Ridley 6106*) because of the edible seeds (erroneously called as "nuts"). Vern. *Meninjau* or *Belinjau,* 樹倪籐

Gnetum latifolium Bl. var. **funiculare** MGF.

Known as *G. kingianum* Gamble in Ridley's Flora. Recorded from Garden Jungle, Tanglin (*Ridley 5688*) Kranji. A big climber, the bark used for making string; leaves large, elliptic. Vern. *Akar tutubo, Akar susurus.*

Gnet. macrostachyum Hook.

Recorded from Siglap and Changi (*Ridley 4822*); leaves elliptic; seeds nearly globose.

Gnet. microcarpum Bl.

Formerly known separately as *G. campestre* Gamb. and *G. sylvestris* Gamb. Recorded from Tanglin, Kranji, Garden jungle, Seletar (*Ridley 3851*), etc. A large climber; seed golden yellow; leaves narrow; relatively common. Vern. *Akar jullah,* 倪籐

Korthalsia hispida Becc. in Malaya

by

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Herbarium Bogoriense, Bogor
Indonesia

On 7th January 1973, while in Singapore, I accompanied Dr. E. A. Heaslett on a one day field trip to Gunung Panti in Johore, Malay Peninsula. Despite bad weather, we were able to observe about 55 taxa of Palmae in the forest of Panti East. This total indicates the richness of the palm flora: amongst those species observed was one novelty, a *Korthalsia* vegetatively distinct from all other Malayan species of *Korthalsia.*

Within the genus *Korthalsia* in Malaya (Furtado 1951) there are two types of ochrea (extension of the leaf sheath beyond the insertion of the petiole); in one type such as that found in *K. scaphigera* Griff., *K. echinometra* Becc. and *K. scortechinii* Becc. (see fig 1 a, b) the ochrea is swollen and hollow and forms a spiny chamber around the leaf sheath of the leaf above, and is favoured by ants as a nesting place. The relationship of the ants with the rattan has been described many times, and it seems likely that particular ants are specific to different *Korthalsia* species. In the other type as found in all other Malayan species of *Korthalsia* such as *K. flagellaris* Miq and *K. rigida* Bl. (see fig 1 c, d), the ochrea is not swollen and forms a tightly sheathing tube around the leaf sheath of the leaf above: this type of ochrea may remain entire or becomes split or tattered, and may be armed or unarmed.

The *Korthalsia* species new to the Malay Peninsula from Panti East Forest Reserve, however, has a third type of ochrea, a type found in four species (see fig 1 e): *K. robusta* Bl. of Sumatra. *K. macrocarpa* Becc. of Borneo, *K. squarrosa* Becc. of the Philippines and *K. hispida* Becc. of Sumatra and Borneo. In these four species, the ochrea is shaped something "like an elongated ass's ear" (Beccari 1918): the ochrea is not sheathing, being open opposite the petiole, the two edges inrolling to produce an open-ended spiny tube, pale straw in colour, diverging from the axis at an angle of about 20 degrees. In *K. squarrosa* the ochreas are slightly different in that they do not diverge far from the stem, but the ochreas visible in Beccari's plate (Beccari loc. cit.) are just below an inflorescence and such ochreas are often slightly abnormal. Within this tube-like ochrea in the Sumatran and Bornean species, ants make their nests. When the rattan is touched, the ants within rustle in unison in each ochrea by banging their heads against the dry ochrea, each ochrea slightly out of phase with the next. I have only heard this rustling noise in *K. robusta, K. hispida* and *K. macrocarpa;* I have not heard it in *K. scaphigera* or *K. echinometra* and it is quite likely that the ant species in these last two are different.

The Gunung Panti plant is indistinguishable from *Korthalsia hispida*, a misunderstood species from West Sumatra, Aceh, and Borneo, first collected by Beccari (P. S. 673 — Beccari 1884) at Ayer Mancur, West Sumatra, and later included by Beccari in *Korthalsia robusta* Bl. non Mart. (Beccari 1918). In July 1972 in Propinsi Jambi, Sumatra, (Dransfield in press) I found specimens of a *Korthalsia*, vegetatively fitting the description and plate of *K. hispida* but with inflorescences totally different from those of the widespread Sumatran taxon, *K. robusta*, the vegetative parts of which were unknown to Beccari. The Jambi specimens are identical to Meijer 2411, Nunukan, Borneo (Meijer 1956). There are hence two species in Sumatra, *K. robusta* and *K. hispida*, and Beccari appears to have confused the two in his monograph (1918) — the fertile specimens referred by Beccari to *K. robusta* belong to *K. robusta;* the vegetative specimens referred to *K. robusta* belong to another species originally described as *K. hispida*. In fact vegetatively *K. hispida* is more distinct than *K. robusta* and *K. macrocarpa* and it is quite possible that these last two represent one widespread variable species common to Sumatra and Borneo.

Because of the confusion in this group of *Korthalsia* it is considered useful to give a complete description of *Korthalsia hispida*. Although the relationship of *Korthalsia macrocarpa* and *Korthalsia robusta* is not yet clear, I am presenting this note in order to draw attention to this easily recognized group of *Korthalsia* species.

Korthalsia hispida Becc.

Beccari, in Malesia *11*, (1884) 71., Beccari, Ann. Roy. Bot. Gard. Calc. XII, 3 (1918) 148. Plate 99. Meijer, W. Penggemar Alam 36 (1957) 60, Fig 3.

Slender, clustering, thicket-forming rattan, branching at ground-level. Stems to 1.0 cm in diam. without sheaths, with sheaths 1.5–1.8 cm. Internodes 20–25 cm long. Sheaths bright shiny green when fresh, covered with sparse, scattered, shiny black spines to 2.0 cm long, easily breaking just above the base and minute c. 0.5 mm long, easily detached spiculae. When young, sheath covered with chocolate coloured scurfy indumentum. Ochrea 25–30 cm long, like a very narrow elongate horn, diverging at an angle of c. 20 degrees from the axis, shiny brown within, straw-coloured without, thorny-spiculate and indumentose as the leaf sheath, truncate and shallowly bilobed at the apex, papery in texture, open opposite the petiole, rolled, often filled with vicious biting ants. Leaf to 1.8 m long; cirrus to 90 cm, petiole to 10 cm. Petiole and rachis yellowish-green, semi-circular in cross section, to 5 mm wide, armed with scattered, reflexed black spines below, above, spines in groups 3–5 forming claws, separated by c. 3 cm, distance of separation decreasing above to c. 5 mm at tip of cirrus. Leaflets 7 on each side, alternate below, subopposite above, separated by 7–10 cm, with ansae 6 mm long, the lower two leaflets narrowly cuneate-rhomboid, to 3 cm broad, upper leaflets broader, 15–20 cm long by 7–9 cm broad, irregularly plicate, longly acuminate praemorse at upper margins, bright green above, grey-white indumentose below. Leaves subtending the terminal inflorescence much smaller.

Inflorescence system lax, terminal, single stems dying after flowering, the upper 3–8 nodes producing partial inflorescences. Partial inflorescences to 30 cm long, emerging through splits in the upper leaf sheaths; prophylls and other bracts tubular below, variously split and tattered above, 5–10 cm long, straw-coloured, papery, densely covered in chocolate-coloured indumentum and small spiculae. Bracts on axis subtending branches, each terminating in rhachillae, 2–6 in number.

Fig. 1 OCHREA TYPES IN KORTHALSIA

Swollen ochrea: *a*) *K. scaphigera, b*) *K. echinometra. N.B.* hole made by ants. Non-swollen ochrea: *e*) *K. teysmannia* — ochrea spiny, *d*) *K. sp.* (? juvenile of *K. rigida*, from Dransfield 2725, Central Sumatra) — ochrea unarmed. Horn-shaped ochrea: *e*) *K. macrocarpa*. All but *d* from Kebun Raya, Bogor. Drawing by Damhuri.

Rhachillae pendulous, to 15 cm long, 1.2 cm in diam, clothed in a tight spiral of bracts, adnate laterally, each bract subtending a condensed branching system with one hermaphrodite flower. Bracts to 1 cm wide and 5 mm high, pale brown with deeper brown fugaceous scurfy indumentum, irregularly split and lobed at the apex. Flowers pale brown in colour, exserted between the tight bracts. Sepals 3, free, imbricate, ovate, shiny, straw-coloured, to 3 mm long. Corolla with a tube c. 3 mm long and 3 free imbricate rounded triangular lobes above, 4 mm long and 3.5 mm wide, during growth of the ovary after fertilization, the corolla tube splitting and being carried out of the bract axils on the tip of the ovary, at the base of the style. Anthers 6, 2 x 1 mm, borne on a short staminal tube, this shortly epipetalous. Pollen pale yellow. Ovary at anthesis, to 2 mm high, with style to 4 mm, chestnut brown, scaly. Style grooved longitudinally and tipped with 3 minute approximate stigmatic lobes. Fruit when not damaged crowned with remains of style, surrounded by corolla and stamens, at least 1.2 cm long, and 1 cm wide. Mature fruit unknown.

Specimens examined

Type not seen, though Plate thereof in Beccari (1918) examined.

SUMATRA

Aceh: Nainggolan s.n. April 1931, Bukit Plawi (BO).

Jambi: Dransfield 2620. 22.7.72. Kampung Penetai, Kabupaten Kerinci, streamside, Hill Dipterocarp Forest, alt 200m (BO, L, BH).

BORNEO

East Kalimantan: Meijer 2411. 5.12.53. Nunukan, near S. Binusan. dry lowland Dipterocarp Forest (BO).

MALAY PENINSULA

Johore: Dransfield 3037. 7.1.73. Gunung Panti East. Lowland, freshwater swamp forest. (SING, BO, L, BH).

Korthalsia hispida differs from the other species having long horn-like ochreas, in the hispid appearance of the sheaths, ochreas and inflorescence bracts, produced by the dense minute spiculae, and in the lax, not approximate, slender inflorescence branches. *K. macrocarpa, K. robusta,* and *K. squarrosa* all have squat inflorescences made up of robust, fat, approximate rhachillae, unlike any other *Korthalsia* species (see Beccari 1918).

The presence of this group of long-ochrea *Korthalsia* species in Malaya is not surprising; the absence of collections of it, is, especially as it grows in a very famous, much-visited botanical locality.

Acknowledgements

I should like to thank Dr. E. A. Heaslett for introducing me to Gunung Panti East, and Ahmad Shukur and Samsuri, plant collectors, Botanic Gardens, Singapore for their help in collecting palms on Gunung Panti: thanks are also due to Sdr. Damhuri, draughtsman, Herbarium Bogoriense, for preparing the figures.

Fig. 2 Korthalsia hispida Becc.

Illustration of a node and most of one internode and the subtended partial inflorescence, taken from near the apex of a flowering stem; in all 3, nodes were producing partial inflorescences. *N.B.* the hispidity on all sheaths, ochreas, and bracts. Dransfield 2620, Jambi, Sumatra. Drawing by Damhuri.

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Pollen Viability and Germination in Some Orchid Hybrids

by

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Introduction

Singapore has become an important orchid breeding center producing many well-known hybrids of international acclaim. Such successful results are achieved by the continued efforts of scientists at Botanic Gardens and local horticulturists over a period of three decades. In Singapore the first hybrid that appeared was *Vanda Miss Joaquim* in 1893 (Holttum, 1953). Nevertheless, our knowledge about the cytogenetics and pollen physiology of local orchid hybrids is very limited. The importance of such studies need not be over-emphasized since pollen viability and germination form the essential requirements to produce good and the required hybrids. Not every cross pollination will bear fruit and it is the common experience of every orchid breeder that more than 60 per cent of the pollinations made would end up with no fruits or fruits without seeds. One of the main reasons for such failures could be the pollen sterility and some of these problems are under study (Rao and Goh, 1970).

Very few studies are made on orchid pollen germination. Molisch determined the optimal sucrose concentration for 6 European species (Withner, 1959). Miwa (1937) germinated the pollen of certain orchid species and their hybrids to test the longevity and viability of stored orchid pollen. Curtis and Duncan (1947) studied 11 species in 7 genera. The present paper outlines the morphology of pollinia, pollen structure, viability and germination of some well-known local hydrids.

Materials and Methods

Pollinia of the following hybrids were collected from Mandai Gardens now known as Singapore Orchids Pte. Ltd.: (i) *Arachnis Maggie Oei* var. *Red Ribbon,* (ii) *Arachnis Maggie Oei* var. *Yellow Ribbon,* (iii) *Aranda Hilda Galistan,* (iv) *A. Lucy Laycock* (long spray), (v) *A. Lucy Laycock* (short spray), (vi) *A. Wendy Scott* var. *Greenfield,* (vii) *Aranthera Lilliput,* (viii) *Vanda Poepoe* and (xi) *Vanda Josephine* (from the garden at Botany Department, University of Singapore).

Fresh pollinia from open flowers were collected between 2-3 p.m. and used within 1 hr. after collection, using half a pollinium in each case.

The following culture media were used: (*a*) distilled water as the control medium (*b*) stigmatic extract — the appropriate number of fresh stigmas were ground in 10 mls. of distilled water and the clear filtrate of the mixture was then used for germination. The number of stigmas used in such preparation varied from

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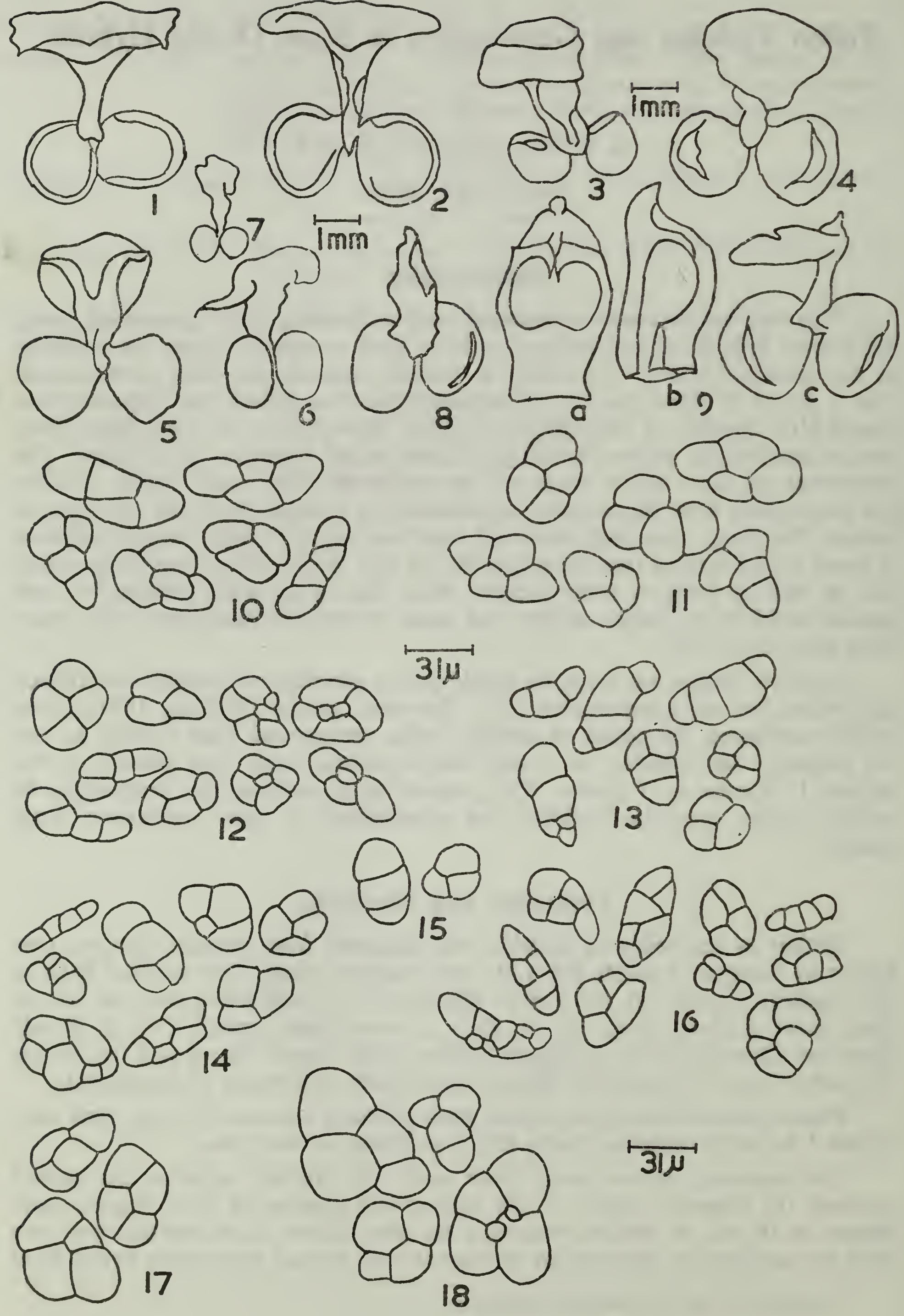
* Currently at Botanic Gardens, Singapore.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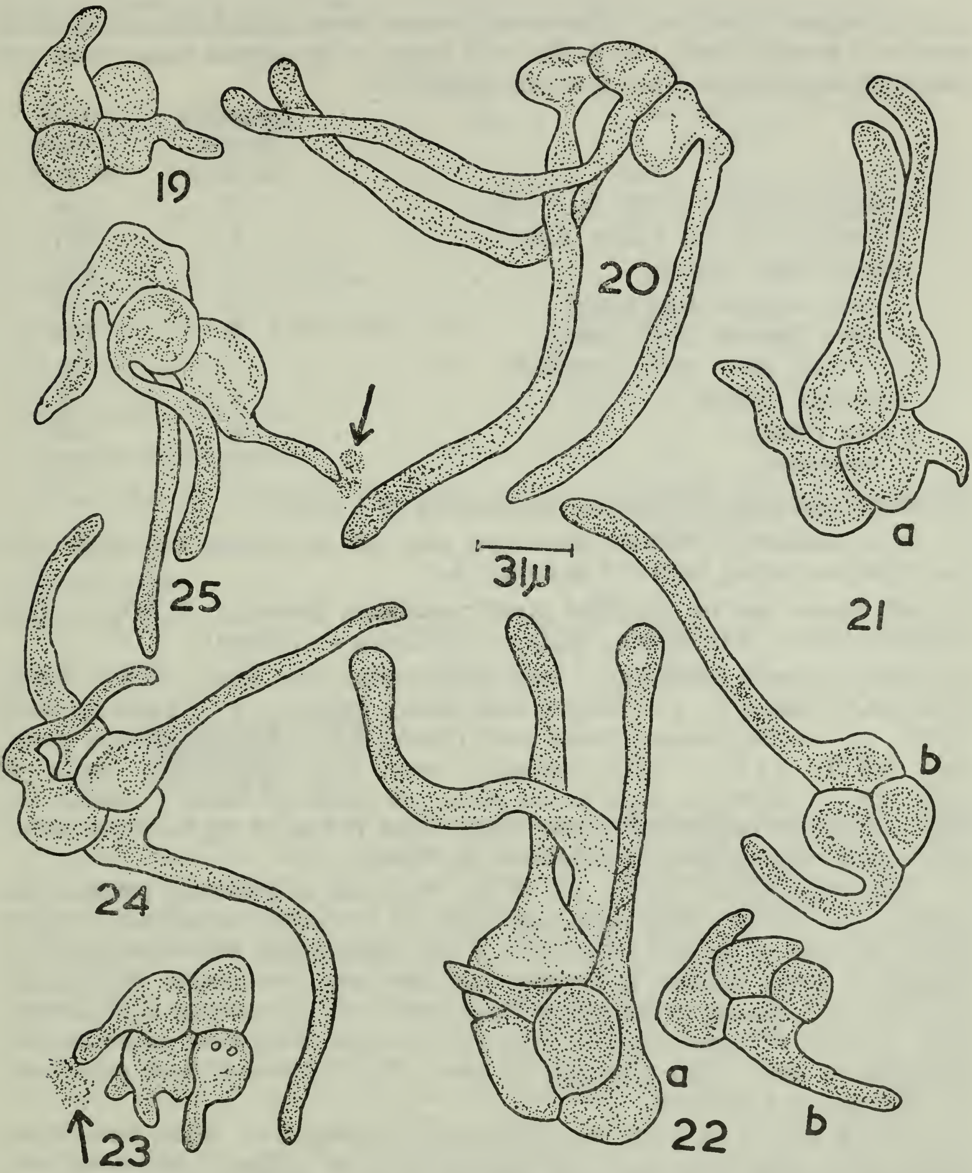


Figures 19–25: Pollen germination in *Vanda Josephine*. Fig. 19: in dist. water, note the short tubes. Fig. 20: in stigmatic medium at 2 stigmas/10 ml of dist. water; all 4 grains in the tetrad germinated. Fig. 21: in 4% sucrose a & b different sized pollen tubes with tapering ends. Fig. 22: in salt-boron medium, a — pollen tubes typical match-stick shaped, some with vacuoles; b — short tube, with broad ends. Fig. 23: in GA (10^{-7} mg/L) medium short pollen tubes with exudates (arrow). Fig. 24: in borax medium, with all the grains in tetrad germinated. Fig. 25: in kinetin (10^{-6}mg/L) medium with pollen exudate (arrow).

See opposite page

Figures 1–18. Figs. 1–9: Pollinia of different orchid hybrids. Figs. 1 & 2: *Arachnis Maggie Oei* var *Red Ribbon* and var. *Yellow Ribbon* respectively. Figs. 3–6: *Aranda Hilda Galistan; Lucy Laycock* (long spray); *Lucy Laycock* (short spray); *Wendy Scott* var. *Greenfield* respectively. Fig. 7: *Aranthera Lilliput*. Fig. 8: *Vanda Poepoe*. Fig. 9: *Vanda Josephine*. a-column, b-$\frac{1}{2}$ stigma, c-pollinia. Figs. 10–18: Tetrads showing microspore arrangement and supernumerary spores. Fig. 10: *Arachnis Maggie Oei* var *Red Ribbon*. Fig. 11: *A. Maggie Oei* var. *Yellow Ribbon*. Fig. 12: *Aranda Hilda Galistan*. Fig. 13: *A. Lucy Laycock* (long spray). Fig. 14: *A Lucy Laycock* (short spray). Fig. 15: *A. Wendy Scott* var. *Greenfield*. Fig 16: *Aranthera Lilliput*, Fig. 17: *Vanda Poepoe*. Fig. 18: *Vanda Josephine*.

½, 1, 2, 3 stigmas/10 mls. of distilled water. In some cases all the four concentrations were used, in others only 1 or 2. The total length of the stigmas ranged from 3-8 mm in different hybrids. Their sizes and weights are:

Plants	*Length of stigma (in mm)*	*Wt. of 1 stigma (in mg)*
Arachnis Maggie Oei var. *Red Ribbon*	8	198
A. Maggie Oei var. *Yellow Ribbon*	8	180
Aranda Hilda Galistan	5	101
A. Lucy Laycock (long spray)	5	96
A. Lucy Laycock (short spray)	5	109
A. Wendy Scott var. *Greenfield*	6	87
Aranthera Lilliput	3	16
Vanda Poepoe	8	84
V. Josephine	8	85

(*c*) Sucrose medium with varying concentration of 1–10%.

(*d*) Borax medium — Sodium tetraborate was used to prepare the media with concentration ranging from 10^{-8} to 10 mg./L.

(*e*) Salt boron medium (modified Knop's medium). Formula: H_3BO_3 — 100, $Ca(NO_3)_2.H_2O$ — 300, $MgSO_4$. $7H_2O$ — 200, KNO_3 — 100mg/L.

(*f*) Different growth substances — well known auxins like: Indole — 3 — Acetic Acid (IAA), Indole — 2 — Butyric Acid (IBA), Indole — 3 — Propionic Acid (IPA), α — Naphthalene Acetic Acid (NAA), 2,4 — Dichlorophenoxy acetic acid (2,4–D), 2,4,5 — Trichlorophenoxy acetic acid (2,4,5–TPA), source of gibberellin — Gibberellic Acid K salt (GA), and source of Kinin — Kinetin (K) were used in the concentrations that ranged from 10^{-8} to 10 mg/L. Either all or only certain concentrations were found to be effective.

Solid watch glasses (4 x 4 x 1.75 cm) were used to germinate pollinia. The pollinia were cut into small pieces and dispersed in 1 ml of the medium. A glass cover was used to prevent evaporation of the medium and the watch glass was placed in a humid chamber to prevent evaporation and condensation. Diffuse light of 235 F. C. S. (during day-time) and temperature of 28°C prevailed in the laboratory. Duration of experiment was limited to 24 hours since most pollen did not germinate or their pollen tubes did not grow after this period. Each experiment was repeated at least twice.

At the end of 24 hours, the percentage germination of pollen tetrads and pollen cells, pollen tube length and morphology were studied. Lactophenol with cotton blue was used for staining. At least 225 tetrads were studied for each treatment to assess the percentage germination and 90 tubes for tube length determination.

Observations and Results

Pollinia and pollen grains: In orchids the pollen tetrads develop into mature structures called compound pollen grains and these are united to form pollinia. In all of them two pollinia are present per flower (Figs. 1–9). The pollinia of different hybrids were excised for comparative study. In size the *Aranthera* pollinium was smallest among the 9 hybrids studied (Fig. 7). Pollinia of *Aranda* hybrids were smaller than those of *Arachnis* or *Vanda* (Figs. 1–6, 8, 9). The disc was flat in *Arachnis,* triangular in *Aranda,* and of irregular shape in *Vanda.* Even among the

Table 1. Morphology of the pollen tetrads, size and arrangement of pollen cells in them.

Names of Orchids	Morphology of Pollen Tetrads					
	Size, μ		Arrangement of grains in tetrads in %			
	L × B	L/B	isobilateral	tetrahedral	T-shaped	linear
Arachnis Maggie Oei var. Red Ribbon	37 × 23	1.61	92	6	1	1
Arachnis Maggie Oei var. Yellow Ribbon	40 × 27	1.48	90	8	2	—
Aranda Hilda Galistan	33 × 24	1.37	82	16	—	2
A. Lucy Laycock (long spray)	34 × 24	1.42	72	22	2	4
A. Lucy Laycock (short spray)	32 × 25	1.28	88	8	2	2
A. Wendy Scott var. Greenfield	38 × 22	1.73	Most of them are supernumerary spores. Normal tetrad — only about 1%			
Aranthera Lilliput	28 × 20	1.40	89	9	1	1
Vanda Poepoe	42 × 27	1.56	68	32	1	1
Vanda Josephine	38 × 27	1.41	72	37	1	—

L — Length of pollen tetrad
B — Breadth of pollen tetrad
L/B — Length/breadth ratio.

Aranda hybrids the pollinia of each hybrid were distinctly different from the others in having disks and stalks of different shape and size (Figs. 3–6). The pollinia were teased to separate the tetrads. These are diagrammatically represented in Figs. 10–18. Each figure shows the variation in size, shape, arrangement as well as the number of cells in each tetrad or the unit (is one which had more than 4 cells). In addition, the cells of the tetrad or unit also varied in size. Some of them e.g. *Vanda Miss Joaquim, Vanda Poepoe, Aranthera Lilliput* had one small and three big grains or vice-versa (Figs. 14, 16–18, 22, 28, 29). Two big and two small grains were also common in some (Figs. 13, 22). Supernumerary spores were also common in many (Figs. 12–14, 16, 18) and the individual unit had 5, 6 or 8 cells. In such units, which had supernumerary spores, at least two of them were big and of comparable size with the spores of the majority of the tetrads and the remaining were generally small (Figs. 12, 13, 18). Pollen tetrads show isobilateral, tetrahedral, linear and 'T' shaped arrangement. The percentage occurrence of each type is recorded in Table 1. Comparatively, the two latter conditions were rare and the isobilateral type was most common. The average size of pollen tetrad ranged from 28 x 28 μ to 42 x 27 μ. The linear tetrads were much smaller in size when compared with the others (Figs. 12, 14, 16).

Pollen germination: Positive responses resulted in the pollen germination of *Vanda* hybrids and these details will be considered first, followed by the results of other hybrids.

(*a*) Distilled water (control medium). In *V. Poepoe* and *V. Miss Joaquim* 27 and 30% of the tetrads germinated with an average tube length of 15 and 19 μ respectively (Tables 2, 3; Figs. 19, 26, 30, 31).

Table 2. *Vanda Poepoe.* Percentage germination and average pollen tube length in different media after 24 hrs. at room temperature.

Media	Concentrations	No. of grains germinated per tetrad, in %				%G	μ L
		1	2	3	4		
Distilled water (control)		18	5	2	2	27	15
Stigmatic extract	1 stigma /10 mls. distilled H_2O	20	21	14	10	65	57
	2 stigmas /10 mls. distilled H_2O	27	30	13	13	83	68
	3 stigmas /10 mls. distilled H_2O	21	20	8	4	53	44
Sucrose	2%	28	20	4	12	64	56
	4%	23	25	24	13	85	75
	6%	8	16	24	41	89	83
	8%	15	11	12	12	50	48
	10%	11	9	11	8	49	40
Borax	1×10^{-5} mg. /L	26	6	2	0	34	18
	1×10^{-4} mg. /L	20	12	2	2	36	21
	1×10^{-3} mg. /L	27	10	0	2	39	36
	1×10^{-2} mg. /L	20	14	4	2	40	36
	1×10^{-1} mg. /L	25	12	8	2	47	38
	1×10^{-0} mg. /L	24	16	8	13	50	55
	1×10^{-1} mg. /L	16	14	8	2	40	37
Salt-boron medium		22	32	10	8	72	72

% G — Perc. germination

μ L — Avg. pollen tube length in μ

Table 3. *Vanda Poepoe*. Percentage germination and average pollen tube length in optimal concentrations of different media, after 24 hrs. at room temperature.

Media	Optimal Concentrations	No. of grains germinated per tetrad, in %				%G	μ L
		1	2	3	4		
Distilled water (control)		18	5	2	2	27	15
IAA	1×10^{-6} mg. /L	27	24	14	6	71	71
IBA	1×10^{-5} mg. /L	21	25	15	9	70	66
IPA	1×10^{-6} mg. /L	24	17	11	3	55	41
NAA	1×10^{-4} mg. /L	27	26	20	5	78	82
2,4-D	1×10^{-6} mg. /L	31	21	15	0	67	60
2,4,5-TPA	1×10^{-6} mg. /L	27	25	6	7	65	40
GA	1×10^{-5} mg. /L	26	23	5	7	61	75
Kinetin	1×10^{-5} mg. /L	24	15	9	7	55	34

% G — Perc. germination

μ L — Avg. pollen tube length in μ

(*b*) Stigmatic extract medium: For both the hybrids the optimal concentration of stigmatic extract was 2 stigmas/10 ml. of distilled water. The percentage germination for *V. Poepoe* and *V. Miss Joaquim* was 83% and 79% with an average tube length of 68 and 87 μ respectively and these results were better than in the control medium (Tables 2, 3; Figs. 20, 27, 33). The response at other concentrations was variable in terms of percentage germination.

(*c*) Sucrose medium: For *V. Poepoe* the optimal concentration of sucrose was 6% and 89% of the tetrads germinated with an average tube length of 83 μ (Fig. 28). In *V. Miss Joaquim* 92% of the tetrads germinated in 4% sucrose medium (optimal concentration) with an average tube length of 74 μ (Fig. 21a, b). Other variations observed in media with higher or lower concentrations are given in Tables 2, 3 and in all the concentrations used the response was better than in the control medium.

(*d*) Borax medium: In media with different concentrations of borax better results than control were obtained in *V. Poepoe.* The optimal concentration for the two hybrids were 1 and 0.1 mg/L respectively (Figs. 24, 34) and the response of *V. Miss Joaquim* was much better than *V. Poepoe* (Tables 2, 3).

(*e*) Salt-boron medium: When compared with control or borax medium the values obtained in this medium were better in the case of *V. Poepoe* (Table 2). In case of *V. Miss Joaquim* the percentage germination was almost like that of control but tube length improved. These results were poor when compared with those obtained in optimal concentration of borax medium (Table 3, Fig. 22a, b).

Table 4. *Vanda Josephine*. Percentage germination and pollen tube length in different media after 24 hrs. at room temperature.

Media	Concentration	No. of grains germinated per tetrad, in %				%G	μ L
		1	2	3	4		
Distilled H_2O (control)		29	5	2	0	36	19
Stigmatic extract	½ stigma /10mls. distilled H_2O	21	11	2	4	39	55
	1 stigma /10mls. distilled H_2O	12	9	6	21	48	77
	2 stigmas /10mls. distilled H_2O	15	6	20	28	79	87
	3 stigmas /10mls. distilled H_2O	7	19	21	2	39	47
Sucrose	2%	8	15	31	21	75	62
	4%	5	8	22	57	92	74
	6%	9	21	14	36	80	37
	8%	16	1	2	1	20	21
	10%	11	0	0	0	11	14
Borax	1×10^{-3} mg. /L	28	17	0	1	46	27
	1×10^{-2} mg. /L	44	8	8	0	60	41
	1×10^{-1} mg. /L	24	19	24	18	85	84
	1×10^{0} mg. /L	21	13	6	3	43	63
	1×10 mg. /L	9	2	1	1	13	19
Salt-boron medium		26	6	5	1	38	32

% G — Perc. germination

μ L — Avg. pollen tube length in μ

(*f*) Media with different growth substances: Cultures in NAA (10^{-4} mg/L) showed the highest percentage germination than in other auxin media, attaining 74% and the longest tube length of 82 μ. Effect of IBA was similar of that of IAA giving better results than 2,4–D and 2,4,5–TPA media (Table 4). In case of *V. Poepoe* for IAA, IPA, 2,4–D and 2,4,5–TPA the optimal concentration was 10^{-6} mg/L. Of these four auxin media the highest percentage (71%) germination and the longest tubes (71 μ) were formed in IAA medium and the lowest percentage germination was obtained in IPA medium (55%); the shortest tubes were produced in 2,4,5–TPA medium (40 μ).

Table 5. *Vanda Josephine*. Percentage germination and pollen tube length in optimal concentration of different media after 24 hrs. at room temperature.

Media	Optimal Concentrations	No. of grains germinated per tetrad, in %				%G	μ L
		1	2	3	4		
Distilled water (control)		29	5	2	0	36	19
IAA	1×10^{-5} mg./L	33	12	12	7	64	43
IBA	1×10^{-5} mg./L	32	12	6	2	52	35
IPA	1×10^{-5} mg./L	20	15	11	3	49	59
NAA	1×10^{-5} mg./L	22	14	12	3	51	47
2,4-D	1×10^{-5} mg./L	19	18	11	3	51	51
2,4,5-TPA	1×10^{-5} mg./L	33	18	6	3	60	45
GA	1×10^{-6} mg./L	29	16	5	1	51	39
Kinetin	1×10^{-6} mg./L	14	15	18	17	64	64

% G — Perc. germination
μ L — Avg. pollen tube length in μ

The optimal concentration for GA and K was 10^{-5} mg/L (GA), resulting in 61% germination and 75 μ tube length and 55% germination and 34 μ tube length respectively (Table 4). The different auxin, gibberellin and kinetin media, at various optimal concentration, gave better results than the control medium. When compared with borax medium, poorer results were obtained in the two auxin media, i.e. IPA or 2,4,5–TPA. In all the others, including GA medium, better results were recorded. Kinetin medium was less favourable than the borax medium and similarly, gibberellin and kinetin media were not so favourable when compared with stigmatic extract or sucrose media (Tables 2, 3).

In case of *V. Miss Joaquim* germination and elongation of pollen tubes increased appreciably in auxins, GA and K media, when compared with the control or salt-boron medium. The optimal concentration was between 10^{-5} and 10^{-6}mg/L. Higher concentrations were inhibitory for germination and tube growth. This was true in all the media except in case of IAA where even at 0.1 mg/L the percentage germination and tube length were very similar to that of the control (Table 5). In IAA and kinetin media better germination resulted when compared with the other auxins or GA media. The media with auxins, GA or K (at optimal concentrations) were not so favourable as stigmatic extract, sucrose or borax media (Tables 4, 5).

Hybrids other than Vanda

The pollen germination studies in case of: (*a*) *Arachnis Maggie Oei* var. *Red Ribbon,* (*b*) *Arachnis Maggie Oei* var. *Yellow Ribbon,* (*c*) *Aranda Hilda Gallistan,* (*d*) *Aranda Lucy Laycock* (long spray), (*e*) *Aranda Lucy Laycock* (short spray), (*f*) *Aranda Wendy Scott* var. *Greenfield* and (*g*) *Aranthera Lilliput,* gave very poor results in the different media used. In most of them no germination was seen with the exception of *Arachnis* Maggie Oei var. *Yellow Ribbon* the pollen of which showed small protrusions in the control medium. In borax medium there was good germination and pollen tube growth at two lower concentrations i.e. 10^{-5} (25% G, 11 μ) and 10^{-4} (61% G, 32 μ) mg/L. In salt boron medium 52% germination and 29 μ tube length resulted. In other media (stigmatic extract with 1, 2 or 3 stigma/10 ml of H_2O; sucrose 2-10%) there was no germination. Likewise, the different hybrids did not germinate in the auxin, GA or K media at various concentrations mentioned previously.

Morphology of pollen tubes:

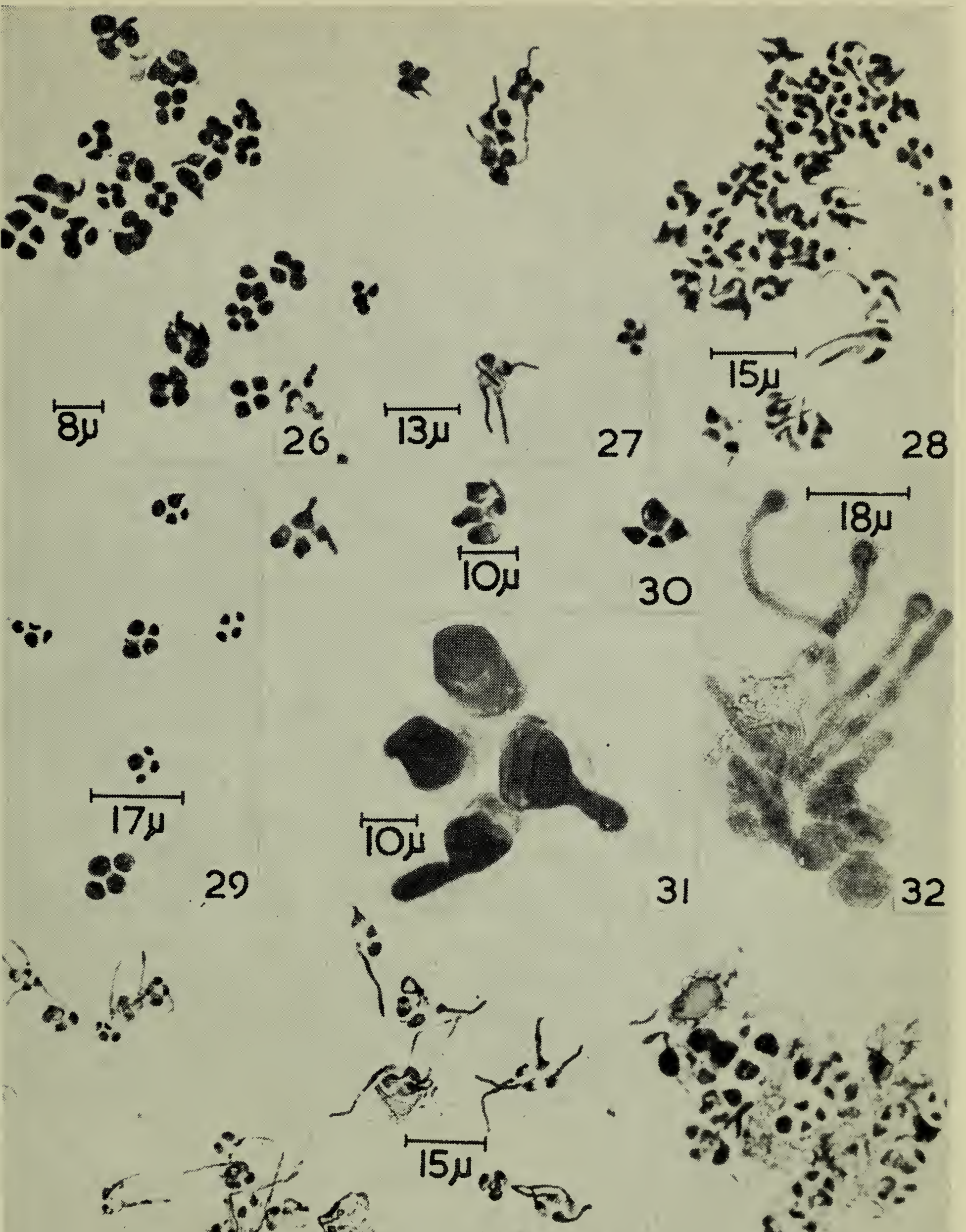
Certain variations were noticed. In *V. Peopoe* a single case of branching was observed in NAA medium (10^{-4} mg/L) and slight swellings of pollen tubes were common in NAA and 2, 4-D media (10^{-6} mg/L). Tips of pollen tubes were pointed in sucrose medium. In *V. Miss Joaquim* oil globules were present in the grains and pollen tubes. Tips or middle portion of pollen tubes were swollen in salt-boron and IAA media (Fig. 22a, 32) and forking of the tube was seen in kinetin medium (10^{-6} mg/L). Exudates were common in GA and K media (Figs. 23, 25).

Discussion

Structural variation of pollinia in different orchids has been described and the present study reveals the fact that hybrids retain the same genetic characters of parents (Adams, 1959). Further study of other hybrids may substantiate this fact since very few hybrids are critically examined from this point of view. Occurrence of pollen tetrads is common in Orchidaceae (Withner, 1959). The presence of supernumerary spores, frequency of their occurrence, and an analysis of their structure has been studied in the diploid and tetradploids of *Vanda* hybrids (Kamemoto, 1956). In five of the nine hybrids studied presently the supernumerary spores were present and it is interesting to record that only few of them germinated when compared with the regular tetrads.

Of the nine hybrids investigated germination was seen only in *Vanda Poepoe, V. Miss Joaquim* and to a certain extent in *Arachnis Maggie Oei* var. *Yellow Ribbon.* Others did not germinate in the different media used. This loss of germinability may result from immaturity of pollen, long preservation, or it can be an inherent property resulting from complicated and forced hybridisation (Miwa, 1937). It is possible that the reason mentioned last is applicable here since fresh pollinia were used in all the experiments. Except *Vanda,* most of the other hybrids studied presently do not set fruits either by self or cross pollination.

In control medium the percentage germination was low and tube lengths shorter in both the hybrids of *Vanda.* In those cases where the pollen grains germinate with short tubes, it is said that the grains contain a certain amount of nutrients that promote initial growth but this is insufficient for the growth of longer tubes (Brink, 1924a). All the growth adjuncts used presently, both organic



Figures 26–35: *V. Poepoe.* Fig. 26: Germination in dist. water (control). Fig. 27: in stigmatic extract (2 stigmas/10 ml of dist. water). Fig. 28: in 6% sucrose medium, note beak like tubes. Figs. 29-35: *V. Miss Joaquin.* Fig. 29: Tetrads of different sizes. Figs. 30 & 31: Germination in dist. water (control) and one of the tetrads enlarged to show short tubes in Fig. 31. Fig. 32: Germination in IAA medium (10^{-5}mg/L), showing pollen tubes with bulbous tips. Fig. 33: in stigmatic extract (2 stigmas/10 ml dist. water). Fig. 34: in borax medium (10^{-1} mg/L). Fig. 35: Aborted grains of different sizes.

and inorganic, were found to be stimulatory when compared with the control medium. Their effects on percentage germination and tube growth were of different magnitude. Better results were obtained for *Vanda* hybrids in stigmatic extract medium which indicated that the necessary stimulii required for germination and tube growth were present. The stimulatory effect of stigmatic extract on pollen germination was observed in other orchids studied earlier (Curtis and Duncan, 1947; Rao and Lee, 1972). Details pertaining to other angiosperms are also reviewed (Johri and Vasil, 1961).

Sucrose undoubtedly had a stimulatory effect on germination and tube growth of *Vanda hybrids*. The optimal concentration varied from 4–6% and best results were obtained in sucrose media. This is in conformity with earlier findings of other workers (Miwa, 1937; Curtis and Duncan, 1947). Externally supplied sugars do serve as a source of nutrition for pollen germination in most of the species studied so far and the important role of sugars is vividly discussed (Johri and Vasil, 1961; O'Kelly, 1955, 1957; Visser, 1955).

In case of *V. Miss Joaquim*, very good germination and tube growth resulted in boron medium. *Vanda Poepoe* showed an improvement both in germination and tube growth but the effect was not as good as stigmatic extract or sucrose media. *Arachnis* Maggie Oei var. (*Yellow*) *Ribbon* also showed good germination in the presence of low concentration of borax but the tube growth was poor.

Salt-boron medium was more effective than borax medium in *V. Poepoe* and it was contrary in case of *V. Miss Joaquim*. In case of the latter the presence of salts reduced both the percentage germination and tube length, though boron was present as part of the medium. In case of *V. Poepoe* borax alone was not stimulatory but its synergistic action with the salts was obvious. Certain salts, especially calcium (ions), have a stimulatory effect on pollen germination in majority of angiosperms so far investigated (Brewbaker and Kwack, 1964; Mascarenhas and Machlis, 1964; Vasil, 1960, 1964). Negative chemotropic response to calcium ions has also been observed in *Lilium, Zea* and others (Rosen, 1968, Cook and Walden, 1965). The results obtained in *Vanda Miss Joaquim* support the above observations.

The fact that pollen grains are naturally endowed with auxins is wellknown and in certain cases like *Antirrhinum, Bryophyllum* the auxin concentration is so high that it is inhibitory to germination (Curtis and Duncan, 1947; Smith, 1942; Vasil, 1960). In the two *Vanda* hybrids studied, all the auxins (concentration 10^{-7} to 10^{-4} mg/L) had a stimulatory effect on germination and tube growth. The results obtained presently are similar to the observations made in other angiosperms like *Cucumis melo, Eriobotrya japonica, Triticum* and others (Loo and Hwang, 1944; Dikshit, 1956; Vasil, 1960). Curtis and Duncan (1947) found that NAA did not increase pollen germination in the three orchids namely, *Cyrtopodium punctatum, Cattleya guatmalense,* and *Phalaenopsis* hybrid. However, this could be attributed to the comparatively high concentrations used (0.1 – 10 mg/L) when compared with present studies.

Though the effect of gibberellic acid and other gibberellins on germination and elongation of pollen tubes has been extensively studied in other angiosperms, they have not been used before for orchid pollen (Chandler, 1957; Kato, 1955). In both the hybrids of *Vanda* the percentage germination and tube growth improved in low concentration of GA media. Johri and Vasil (1961) postulated that incorporation of kinetin in nutrient medium together with auxins may hasten the division of generative cell. Kinetin improved the percentage germination as well as tube growth of *Vanda Miss* Joaquim and the results were much better than in control, salt-boron, or certain auxin media and similar results were recorded in

V. Poepoe. Thus the present studies would indicate that in the *Vanda* hybrids the organic nutrients would improve the pollen germination and tube growth to a greater extent than the inorganic or the other growth substances. As for the pollen of other hybrids they are viable as indicated by selective staining. Different physical conditions or growth adjuncts than the ones used presently may be necessary to induce their germination and these are being investigated.

Summary

A study of pollen morphology, structure and germination is made in the well-known orchid hybrids. They are *Arachnis Maggie Oei* var. *Red Ribbon, Arachnis Maggie Oei* var. *Yellow Ribbon, Aranda Hilda Galistan, A. Lucy Laycock* (long spray), *A. Luck Laycock* (short spray). *A. Wendy Scott* var. *Greenfield, Aranthera Lilliput, Vanda Poepoe* and *Vanda Josephine.* Experiments were conducted to germinate them in the laboratory conditions. Of these, only *Vanda Poepoe, Vanda Miss Joaquim* gave positive results and very limited results were obtained in case of *Arachnis Maggie Oei* var. *Yellow Ribbion.* Pollen of other hybrids did not germinate. Different substances that are recognised to promote pollen germination were used at different concentrations and distilled water formed the control medium. Percentage germination, tube length, and morphological variations of such structures are determined and described. In these hyrbids, for pollen germination the organic sources (sucrose, stigmatic extract) appear to be most effective than the inorganic ones (Borax, salt-boron combination, auxins, GA or K). Auxins improved the germination and of all the auxina used IAA was most effective. Similarly GA and K improved the germination in both the hybrids of *Vanda.*

Grateful acknowledgment is made to Mr. John Ede who permitted us to collect the orchids from Mandai garden and Mr. A. G. Alphonso, Acting Director, Singapore Botanic Gardens for the correct identification of the hybrids and some technical information. We are thankful to Mr. R. Tay, Mr. D. Teow and Mrs. M. Goh for their technical assistance.

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A Review of the Genus Creaghiella Stapf.
(MELASTOMATACEAE)

by

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Abstract

A new species of *Creaghiella* is described from Borneo. *Anerincleistus philippinensis* Merr. is transferred to the present genus as *Creaghiella philippinensis* (Merr.) Nayar. A key to the species so far known is also presented.

Introduction

Stapf (in Hook. f. Ic. Pl. 25: t. 2455, 1896) established the genus *Creaghiella* on the basis of the specimen *Creagh* s.n. from Maruda Bay, Sandakan in honour of Creagh, Governor of Sabah. The genus *Creaghiella* is allied to *Anerincleistus* but differs from it in having subequal or unequal stamens with dorsally gibbose and ventrally 2-lobed connective, whereas in *Anerincleistus* the connective is inappendiculate ventrally and minutely spurred or tuberculate.

The three species *C. purpurea* Stapf, *C. setosa* Nayar and *C. philippinensis* (Merr.) Nayar form a homogeneous group, having similar facies with densely setose or tomentose, usually purplish branches, 4-merous flowers, subequal or unequal stamens with dorsally gibbose and ventrally 2-lobed connective.

The purplish branches, leaves and inflorescence give colour to the different species of this genus and this can be introduced as a garden plant. This is an endemic genus with two species (*C. purpurea* Stapf. and *C. setosa* Nayar) in Sabah region of Borneo and a single species *C. philippinensis* (Merr.) Nayar in Palawan Island of Philippines. Palawan Island represents the nearest land-bridge from Borneo to other islands of Philippines. *Creaghiella* is a genus of densely hirsute shrubs growing in creeks and sand dunes near sea-shore.

Key to the species of *Creaghiella*

I. Inflorescence terminal, umbellate.
    II. Calyx tube shaggy tomentose, calyx lobes long; inflorescence axis short, stout; flowers and capsules larger ... *C. purpurea*
    II. Calyx tube shortly setose, calyx lobes short; inflorescence axis long, slender; flowers and capsules smaller ... *C. setosa*
I. Inflorescence axillary, fascicled ... *C. philippinensis*

Enumeration of species

1. **Creaghiella purpurea** Stapf in Hook. f. Ic. Pl. 25: t. 2455, 1896. (*Creagh* s.n. Holotype K.)

Distribution: Endemic to Borneo. Borneo: Sabah, Maruda Bay, Tanjong Batu, Sandakan, 5 May 1895. *Creagh* s.n. (K) Kg. Malanta, alt. 6 m., 30 May 1933 *Olik NBFD 3327* (K, L.); Elopura, Sandakan F.D., alt. 20 m., 18 Dec. 1947, *Kadir NBFD A.672* (K); Ibid., alt. 50 m., 20 Jun. 1949, *Castro NBFD A.478* (K); Ibid., *Kadir NBFD A.944* (K); Elopura, Sandakan, Kabili F.R., *Austin Cuadra NBFD A.515* (K); Ibid., *Keith NBFD 4529* (K, L.); Kabili-seilok F.R., alt. 2 m., 12 Jul. 1937, *Enggoh NBFD 7298* (K, L.) Batu Sapi road, Sandakan, 19 Aug. 1960, *W. Meijer SAN 21542* (K.).

This is a beautiful shrub of 2–4 m. tall with red flowers and pinkish branches and inflorescence.

2. **Creaghiella setosa** Nayar, **sp. nov.** Affinis *C. purpureae* Stapf. sed floribus capsulisque minoribus, lobis calycinis minoribus, calycis tubo minute setoso, pedunculis longioribus tenuibus differt.

Frutex Rami teretes, dense hirsuto-tomentosi. *Folia* ovata, 10–20 cm × 6–13 cm, basi rotunda vel subcordata, apice acuminata, margine denticulata, supra velutino-hispida, subtus hispida, 7-nervia, venulis transversis supra et subtus distinctis, membranacea; petiolus 2–6 cm longus, dense hirsuto-tomentosus. *Inflorescentia* terminalis, 7–15 cm longa, pseudoumbellata, dense hirsuta. *Calycis tubus* campanulatus, 5–5.5 mm longus, dense setosus, setis 0.5 mm longis limbus 4 lobatus, lobis triangularibus, 1–2 mm longis. *Petala* oblonga, 2.5–3 mm × 1–1.5 mm, apice ciliata. *Stamina* 8, subaequalia, filamentis 6–7 mm longis, antheris lanceolatis 6–8 mm longis, apice rostratis, connectivo non producto, antice 2 lobato, postice gibboso. *Ovarium* calycis tubo septis 8 adnatum, coronatum. *Capsula* 4 × 3.5 mm, dense setosa. *Semina* minuta, 0.3–0.4 mm longa, numerosa.

TYPUS: *G. Mikil SAN 31422* (Holotype L.)

Shrub. *Branches* terete, densely hirsute tomentose. *Leaves* ovate, 10–20 cm × 6–16 cm, base rotund or subcordate, apex acuminate, margin denticulate, upper surface velvety hispid, under surface hispid, 7-nerved, transverse venules on the upper and lower surface distinct, membranaceous; petiole 2–6 cm long, densely hirsute tomentose. *Inflorescence* terminal, 7–15 cm long, pseudoumbellate, densely hirsute. *Calyx tube* campanulate, 5–5.5 mm long, densely setose, bristles 0.5 mm long, 4-lobed, lobe triangular, 1–2 mm long. *Petals* oblong, 2.5–3 mm × 1–1.5 mm, apex ciliate. *Stamens* 8, subequal, filament 6–7 mm long, anther lanceolate 6–8 mm long, apex rostrate, connective not produced, connective ventrally 2-lobed and dorsally gibbose. *Ovary* adnate to the calyx tube by 8 septa, disc present. *Capsule* 4 × 3.5 mm, densely setose. *Seeds* minute, 0.3–0.4 mm long, numerous.

Distribution: Borneo: Sabah. Klias, Beaufort Dist., Sept. 1962, *G. Mikil SAN 31422* (L); Beaufort, alt. 66 m., 28 Sept. 1932, *Bakar NBFD 3399* (K, L.); Padas gorge, south side, Tenom Dist., Sept. 1959, *W. Meijer SAN 19827* (K, L.); Pangi, Tenom Dist., alt. 500 m., 5 Sept. 1954, *G. H. S. Wood & Wyatt Smith SAN A.4311* (L.).

C. setosa is closely allied to *C. purpurea,* but it is immediately recognisable by its smaller flowers, smaller capsule and short setose hairs in the calyx tube and long slender inflorescence axis and smaller calyx lobes; whereas in *C. purpurea* the flowers and capsule are larger, calyx tube is shaggy tomentose and inflorescence axis is short and robust.

3. **Creaghiella philippinensis** (Merr.) Nayar **comb. nov.**

Anerincleistus philippinensis Merr. in Philipp. Journ. Sc. Bot. 12: 337, 1917. Distributon: Philippines: Palawan, Malampuya, Sept. 1910, *Merrill 7241* (Syntypes K, BM.); Ibid., May 1913, *Merrill 9412* (Lectotype K); Mt. Capoas, Apr. 1913, *Merrill 9552* (Syntype K.).

In the original description it is mentioned that the stamens are dorsally tuberculate and ventrally inappendiculate. On careful scrutiny it is seen that the anthers are dorsally gibbose and ventrally 2-lobate; whereas in the genus *Anerinceistus* the subulate anthers end dorsally in a tubercle and ventrally they are inappendiculate. Besides the nature of floral parts, the nature of its leaves and its habit indicate that this taxon is allied to *Creaghiella purpurea* and *C. setosa* of Sabah, Borneo.

In *C. purpurea* and *C. setosa* the inflorescence is terminal, whereas in this taxon the inflorescence is axillary. But in all the three species the flower buds in juvenile stage are subsessile and the pedicels prominently elongate during anthesis. *C. philippinensis* is allied to *C. purpurea,* but is easily distinguished by its axillary inflorescence, larger petals (1.5 cm × 1.1 cm) and short ventral appendages; whereas in *C. purpurea* the inflorescence is terminal, petals are much smaller (3.5–4 mm × 2 mm) and the ventral appendages are prominent.

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New Plant Disease Records for Sarawak for 1970 and 1971

by

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Lists of plant disease records for Sarawak have been given by Johnston (1960) and Turner (1963, 1964, 1966, 1967, 1969 and 1971). The list below consists of previously unrecorded fungal diseases together with diseases caused by algae and plant parasitic nematodes, observed or collected by the writer from the time of his taking over the office of Plant Pathology Section of Semongok Agricultural Research Centre in mid August, 1970 until the end of 1971. Thirteen of these records appear in the Annual Report of the Research Branch, Department of Agriculture, Sarawak, for the year 1970.

The causal organisms are listed under their respective host plants which are arranged in alphabetical order of their botanical names. The frequency of occurrence is given together with the Commonwealth Mycological Institute Herbarium serial number, where identification has been performed by the Institute. Two species of fungi and one nematode species were identified at the Royal Botanic Gardens, Kew, and the Commonwealth Institute of Helminthology, Herts, respectively.

In the list that follows, *One, Occ., Comm.* stand for One record, Occasionally and Common respectively.

Alternanthera bettzickiana var. *spathulata*			
Wilt	*Corticium rolfsii* Curzi	One	—
Ananas comosus Merr. (Pineapple, Nanas)			
Leaf rot	*Curvularia eragrostidis* (P. Henn.) J. A. Meyer	One	142889
Annona squamosa L. (Sweet Sop)			
Red rust	*Cephaleuros virescens* Kunze	One	—
Arachis hypogaea L. (Groundnut, Kachang Tanah)			
Wilt	*Fusarium solani* (Mart.) Sacc.	One	159548
Begonia glabra Ruiz. et. Pav.			
Wilt	*Corticium rolfsii* Curzi	One	—
Bixa orellana L. (Annatto)			
Leaf blight	*Pestalotiopsis theae* (Saw.) Steyaert	One	163728a
Leaf blight	*Colletotrichum capsici* (Syd.) Butler & Bisby	One	163728b
Brassica juncea Coss. (Kai Choy)			
Leaf rot	*Choanephora cucurbitarum* (Berk. & Rav.) Thaxt.	Occ.	—

Canangium odoratum Baill. (Kenanga)			
Velvet blight	*Septobasidium* sp.	One	—
Capsicum annuum L. (Chilli, Chabai)			
Leaf spot	*Leptosphaerulina trifolii* (Rostrup) Petr.	One	153073
Capsicum frutescens L. var. *baccatum* (Ornamental pepper)			
Leaf spot	*Cercospora capsici* Heald & Wolf	Occ.	163286
Carica papaya L. (Papaya)			
Leaf spot	*Sphaerulina* sp.	One	159602b
White root disease	*Fomes lignosus* (Klotzsch) Bres.	One	—
Chrysanthemum sp.			
Flower blight	*Cladosporium oxysporium* Berk. & Curt.	One	160403a
Flower blight	*Fusarium equiseti* (Corda) Sacc.	One	160403b
Leaf spot	*Cercospora chrysanthemicola* Yen	One	163291a
Leaf spot	*Septoria chrysanthemella* Sacc.	One	163291b
Citrus microcarpa Bunge (Musk-lime, Limau kesturi)			
Pink disease	*Corticium salmonicolor* Berk. & Br.	One	—
Cocos nucifera L. (Coconut, Kelapa)			
From roots of wilting palm	*Cunninghamella echinulata* (Thaxt.) Thaxt. ex Blakeslee	One	159555
From roots of wilting palm	*Ceratocystis paradoxa* (Dade) Moreau	One	159557
From roots of wilting palm	*Fusarium moniliforme* Sheld.	One	159562
From fabric bark of wilting palm	*Fusarium solani* (Mart.) Sacc.	One	159556 & 159559
Codiaeum variegatum Blume (Garden Croton)			
Velvet blight	*Septobasidium* sp.	One	163287
Coffea robusta Linden (Robusta coffee, Kopi)			
Leaf blight	*Glomerella cingulata* (Stonem.) Spauld. & Schrenk	One	163289
Elaeis guineensis Jacq. (Oil palm)			
Stem rot	? *Thielaviopsis* sp.	One	148041
Dry basal rot	*Ceratocystis paradoxa* (Dade) Mareau	Occ.	159563
Ficus glossularioides Burm. f.			
Leaf spot	*Glomerella cingulata* (Stonem.) Spauld. & Schrenk	One	163726
Ficus uncinata Becc.			
Leaf spot	*Cercospora* sp.	One	163727
Fimbristylis globulosa Kunth (Globular Fimbristylis, Rumput sandang)			
Inflorescence smut	*Cintractia exicola* (Berk.) Cornu	Occ.	163730a & 163729
Inflorescence stalk blight	*Stauronema* sp.	One	163731
Inflorescence smut	*Fusarium heterosporum* Nees ex Fr.	One	163730b
Inflorescence smut	*Fusarium oxysporum* Schlecht.	One	163730c

Fimbristylis miliacea Vahl (Lesser Fimbristylis, Rumput tahi kerbau)			
Wilt	*Corticium rolfsii* Curzi	One	—
Flemingia congesta Roxb. (Bush cover crop)			
Thread blight	*Marasmiellus scandens* (Mass.) Dennis & Reid	One	—
Glycine max (L.) Merr. (Soybean)			
Leaf spot	*Phyllosticta glycinea* Tehon & Daniels	One	160402e
Leaf spot	*Ascochyta* sp.	One	160402f
Leaf blight	*Choanephora circinans* (Nag. & Kawak.) Hess. & Benj.	Occ.	160402a
Leaf blight	*Curvularia eragrostidis* (P. Henn.) J. A. Meyer	One	160402d
Associated with leaf blight	*Fusarium equiseti* (Corda) Sacc.	One	160402c
Guizotia abyssinica (L.f.) Cass. (Niger seed)			
Collar rot	*Corticium rolfsii* Curzi	Occ.	—
Impatiens balsamina L. (Balsam)			
Leaf spot	*Cercospora fukushiana* (Mats.) Yam.	One	163734
Wilt	*Corticium rolfsii* Curzi	Occ.	—
Imperata cylindrica Beauv. (Lalang)			
Leaf spot	*Colletotrichum graminicola* (Ces.) Wilson	One	163282
False smut	*Cerebella andropogonis* Ces.	One	154092a
Inflorescence mould	*Curvularia pallescens* Boedijn	One	154092b
Leersia hexandra Swartz. (Tiger's tongue grass, Rumput lidah rimau)			
Leaf spot	*Pyricularia oryzae* Cav.	Comm.	—
Mangifera indica L. (Mango)			
Leaf anthracnose	*Glomerella cingulata* (Stonem.) Spauld. & Schrenk	One	163733
Manihot utilissima Pohl. (Cassava, Tapioca, ubi Kayu)			
Leaf blight	*Pestalotiopsis* sp.	Comm.	163292a
Leaf spot	*Phyllosticta manihot* Speg.	Occ.	163292b
Tuber rot	*Sphaerostilbe repens* Berk. & Br.	One	—
Wilt	*Corticium rolfsii* Curzi	One	—
Michelia alba DC. (White chempaka, Chempaka puteh)			
Thread blight	*Marasmiellus scandens* (Mass.) Dennis & Reid.	One	—
Musa sapientum L. (Banana, Pisang)			
Leaf speckle	*Periconiella musæ* M. B. Ellis	One	153071
Leaf spot	*Pestalotia leprogena* Speg.	One	153070
Heart leaf disease	*Drechslera musæ-sapientum* (Hansf.) B. Ellis	One	163281
Myristica fragrans Houtt. (Nutmeg, Buah pala)			
From roots	*Gliocladium* sp.	One	159551

Nephelium lappaceum L. (Rambutan)

Fruit blight	*Fusarium* sp.	One	163279

Oryza sativa L. (Rice, Padi)

Brown grain	*Pithomyces sacchari* (Speg.) M. B. Ellis	One	159593b
On grain	*Pestalotiopsis* sp.	One	159593c
Wilt	*Corticium rolfsii* Curzi	Occ.	—
Leaf spot	*Curvularia eragrostidis* (P. Henn.) J. A. Meyer	One	142890
Leaf spot	*Pestalotiopsis ? disseminata* (Thum.) Steyaert	One	142891
Brown grain	*Pestalotiopsis palmarum* (Cooke) Steyaert	One	159549

Pachyrrhizus erosus Urban. (Yam bean)

Wilt	*Colletotrichum capsici* (Syd.) Butler & Bisby	One	163280

Panicum repens L. (Creeping panic grass, Rumput halia)

Wilt	*Corticium rolfsii* Curzi	Occ.	—
Blast	*Pyricularia oryzae* Cav.	Comm.	—

Paspalum scrobiculatum L. (Carpet grass)

Seed blight	*Fusarium heterosporum* Nees ex Fr.	Comm.	154093b

Pennisetum purpureum Schum. & Thonn. (Napier grass)

Leaf spot	*Curvularia eragrostidis* (P. Henn.) J. A. Meyer	Occ.	163288a
Leaf spot	*Cochliobolus lunatus* Nelson & Haasis	One	163288d
Leaf spot	*Pithomyces chartarum* (Berk. & Curt.) M. B. Ellis	One	163288c
Leaf spot	*Septoria* sp.	One	163288b
On dead stems & leaves	*Volvariella esculenta* (Massee) Sing.	One	—

Peperomia pellucida H.B. & K.

Wilt	*Corticium rolfsii Curzi*	One	—

Piper betle L. (Betel, Sireh)

Pink disease	*Corticium salmonicolor* Berk. & Br.	One	—

Piper nigrum L. (Black pepper, Lada Hitam)

On dead branches	*Pleurotus* (*Hohenbuehelia*) *testudo* Berk.	One	Kew
On dead spikes, leaves & branches	*Marasmius campanella* Holterm.	One	Kew
Black spike	*Cochliobolus geniculatus* Nelson	One	159552
Leaf spot	*Glomerella cingulata* (Stonem.) Spauld. & Schrenk	One	159553

Pogostemon cablin Benth. (Patchouli)

White root	*Fomes lignosus* (Klotzsch) Bres.	One	—
Root knot	*Meloidogyne javanica* (Treub., 1885) Chitwood, 1949	Occ.	CIH
Wilt	*Corticium rolfsii* Curzi	One	—

Ricinus communis L. (Castor oil plant)

Leaf spot	*Alternaria ricini* (Yoshii) Hansford	Occ.	159600b
Fruit blight	*Colletotrichum capsici* (Syd.) Butler & Bisby	One	154094a
Leaf spot	*Ascochyta* sp.	One	159600a
Fruit blight	*Fusarium oxysporum* Schlecht.	One	154094b
Fruit blight	*Botryodiplodia theobromae* Pat.	One	154094c
Fruit blight	*Glomerella cingulata* (Stonem.) Spauld. & Schrenk	One	154094d
On *Clypeolella ricini*	*Cicinobella* sp.	One	159601b

Rosa sp. (Rose)

Leaf spot	*Mycosphaerella* sp.	One	159597b

Sanchezia nobilis Hook. f. (Kadok gajah)

Leaf rot	*Corticium solani* (Prill. & Delacr.) Bourd. & Galz.	One	—

Sorghum sudanense Stapf (Sudan grass)

Leaf spot	*Fusarium* sp.	One	163278b

Sorghum vulgare Pers. (Sorghum)

Leaf spot	*Cercospora sorghi* Ell. & Ev.	One	153068
Panicle disease	*Fusarium semitectum* Berk. & Rav.	One	153069b
Panicle disease	*Alternaria longissima* Deighton & MacGarvie	One	153069c
Collar rot	*Corticium rolfsii* Curzi	One	—

Uncaria gambir Roxb. (Gambir)

Leaf rot	*Corticium solani* (Prill. & Delacr.) Bourd. & Galz.	One	—

Vanda vars. (Orchid)

Leaf spot	*Cochliobolus geniculatus* Nelson	One	153074

Vanilla planifolia Andr. (Vanilla)

Rust	*Uredo scabies* Cke.	One	159596

Zea mays L. (Maize, Jagong)

Leaf spot	*Curvularia senegalensis* (Speg.) Subram.	One	163284a
Leaf spot	*Diplodia zeicola* Saccas	One	163284b

Zingiber officinale Rosc. (Ginger, Haliya)

Leaf scorch	*Hendersonia zingiberi* Sawada	One	163285a
Leaf spot	*Coniothyrium fuckelii* Sacc.	One	163285b
Leaf spot	*Ophiobolus* sp.	One	163285c
Leaf scorch	*Tetraploa aristata* Berk. & Br.	One	163283b
Leaf scorch	*Leptosphaeria* sp.	One	163283c
Leaf blight	*Pyricularia zingiberi* Nishikado	One	159594b
Red rust	*Cephaleuros virescens* Kunze	One	159594c
Leaf blight	*Leptosphaeria typhae* Karst.	One	159594a
Leaf spot	*Phyllosticta zingiberi* Ramakrishnan	Comm.	153072a 163283d
Leaf blight	*Cochliobolus geniculatus* Nelson	Comm.	153072b 163283a

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Notes on the Systematy of Malayan Phanerogams XVIII — XXII *

by

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Abstract

Calophyllum austrocoriaceum and *C. rupicolum* var. *elatum* are new taxa. *C. intramarginale* is reduced to *C. inophylloide* var. *singapurense.*

A division of Malayan *Garcinia* into groups is described. *G. burkillii, G. cantleyana* and its var. *grandifolia, G. cataractalis, G. hendersoniana* and *G. murtonii* are new species. *G. dumosa* (and its Malayan allies), *G. nigrolineata, G. penangiana, G. bancana, G. opaca* and *G. pyrifera* are annotated with several new synonyms proposed; *G. opaca* var. *dumosa* is proposed as a new variety.

In *Mesua* notes are provided on the alliances of *M. assamica, M. elegans, M. kunstleri* and *M. lepidota;* and *M. kochummeniana, M. nivenii, M. nuda* and *M. purseglovei* are new species.

Barringtonia payensiana is a new species.

Crudia viridiflora is a new species, with simple leaves.

In Olacaceae, *Strombosia maingayi* is shown to be the legitimate name for the tree long known as *S. rotundifolia;* the differences from *S. multiflora* are discussed.

In Proteaceae, *Heliciopsis cockburnii, H. montana* and *H. whitmorei* are described as new species.

This fourth instalment of our series of notes completes the taxonomic groundwork for volume 2 of the *Tree Flora of Malaya,* which takes the project over the half way mark. The longest note is on the Guttiferae, mainly *Garcinia,* the second biggest family (after Euphorbiaceae) treated in volume 2. Yet another new leguminous species has been discovered, this time a simple-leaved *Crudia.* Once again we express our thanks to Dr. B. C. Stone for help with the latin descriptions.

XVIII. GUTTIFERAE

T. C. Whitmore

Calophyllum

Calophyllum austrocoriaceum Whitmore **sp. nov.**

C. sp. 10 in Henderson & Wyatt-Smith Gdns' Bull. Sing. 15 (1956) 313, plate VIII, Fig. 3 E.

Arbor parva, ramulis crassis, laevibus, leviter complanatis, furfuraceis; gemmis terminalibus crassis, lanceolatis, acutis, subtiliter tomentosis, usque 15 mm longis, *foliis* valde coriaceis, oblongis vel anguste ovate-ellipticis (7 × 3) – 11 × 3 – 16 × 5 cm, apice rotundato vel obtuso, base cuneato, leviter decurrenti, costa lato

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* continued from *Gdns' Bull. Sing.* 26: 49–61.

pagina infera prominenti pagina supra prope basim interdum canaliculato, nervis utrinque conspicuis subdistantibus, petiolo 2–3 cm crasso. *Inflorescentiae* axillares pauciflorae. *Flores* ignoti. *Fructus* subglobosa, usque 23 mm longa apiculata, pericarpio crasso duro siccitate brunneo sublaevi, pedicello crasso 1 cm, pedunculo crasso 15 mm.

JOHORE: G. Panti *FRI 7846* (holotype KEP); *FRI 7729, 13819, SFN 29969;* G. Belumut *KEP 98038, FRI 7512, 7789, 8722, 8809.*

Not seen: *SFN 10723,* cited by Henderson and Wyatt-Smith.

This is close to *C. coriaceum* of the mountains of the Main and east coast ranges and replaces it on the southermost mountains of the Peninsula. The name is chosen to reflect this affinity. It is also closely related to *C. tahanense* of G. Tahan. From both of its relatives *C. austrocoriaceum* conspicuously differs in the nerves being prominent and coarse on both surfaces, the short, few-flowered, axillary racemes and the apiculate unbeaked fruit.

Calophyllum inophylloide var. **singapurense** Henderson et Wyatt-Smith Gdns' Bull. Sing. 15 (1956) 316, plate IX, Fig. 4 D-H.

C. intramarginale Henderson et Wyatt-Smith loc. cit. 342, plate XXII, Fig. 13A, B. **syn. nov.**

The latter species is said to differ in its smaller leaves with intramarginal vein, shorter inflorescences with all the flowers apical on the peduncle, and its montane habitat.

It appears that Henderson and Wyatt-Smith drafted the monograph when only the type of *C. intramarginale* was known, a collection from a small tree from 4000 ft on G. Padang; and that *KEP 67753,* from 1020 ft in Rasau Kerteh F.R., was added later, but neither the key nor notes were amended to allow for its lowland station.

I have since made a second collection from G. Padang (*FRI 12644*) in which the intramarginal nerve is very difficult to see. Three other collections have recently been made which have an intramarginal nerve on one or a few leaves (*FRI 4114, 8839, 10840*) and these are all big trees which in leaf shape, bark, exudate colour and the possession of buttresses resemble *C. inophylloide* var. *singapurense.* They come from W. Kelantan, N. E. Johore and Trengganu respectively.

The flowers of *C. inophylloide* var. *singapurense* arise in a cluster from the top of the peduncle and sometimes, on long racemes, there are also 1–2 lateral pairs. In *C. intramarginale* these lateral pairs are always lacking.

I do not believe *C. intramarginale* can be maintained and therefore reduce it.

C. inophylloide var. *singapurense* differs mainly from the typical variety in its smaller leaves.

Calophyllum rupicolum var. **elatum** Whitmore **var. nov.**

C. rupicolum var. in HENDERSON & WYATT-SMITH Gdns' Bull. Sing. 15 (1956) 347, plate XXVII, Fig. 13 M, N.

A varietas typica elatiore usque 18 m, in *foliis* maioribus, latioribus, 8 × 2.7 – 11 × 3.5 cm, differt.

KELANTAN: *FRI 2538* (holotype of var. at KEP). TRENGGANU: Ulu Brang *FRI 15256*. G. Tebu F. R. *FRI 2513, 2516*. Bt. Rambai F. R. *FRI 11401*. KEDAH: Ulu Muda F. R. *FRI 6757*. PAHANG: Rompin *KEP 29648*. PERAK: Dindings, Telok Kopia F. R. *FRI 3105*. JOHORE: Kangka Sedili Kechil, Corner s.n. 17. VI. 34; Mawai, *SFN 34706, 34747*.

Henderson & Wyatt-Smith left this as an undescribed variety. More material has now been collected and I feel confident in describing it, but as a variety of the river-bed bush *C. rupicolum* and not as a full species. Apart from the relatively broader leaves, and the habit and habitat it comes very close to *C. rupicolum*, and there is some overlap in leaf.

All the collections are of small trees away from rivers except *FRI 12526*, described as a riverside bush, yet with leaves 11 × 3.5 cm, the largest seen.

I have studied *C. rupicolum* on the Sg. Tahan near K. Tenor. There it grows as a small, sinuous tree to 6 m tall on earth river banks at shingle shallows. Leaf size was greatest at the top of the crown and tiny at the crown base, below the level of the highest floods. The collection, *FRI 15985*, clearly shows the narrow leaves of the typical variety, they are up to 8 cm long.

Garcinia

I have found it useful to divide Malayan *Garcinia* into six groups, named A-F, based on the structure of the male flower. These groups are a refinement of the numbered sections proposed by King in the key to his account in the Materials (*J. As. Soc. Beng.* 59, 1890, 148–72) and which were more or less copied by Ridley in his *Flora* (1, 1922, 167–80). To some extent they are natural, though groups B and C very probably are not (species of subgroups Bi and Ci are very similar and easily confusable). A guide to the groups in the form of a key appears in my account for the *Tree Flora* and this should also be consulted. It must be emphasised that the groups are informal ones, and are based on a study only of Peninsula material; they are published here because I believe they might perhaps provide a useful starting point for other students of this big and intricate genus, but they certainly should not be regarded as definitive statements on the taxonomy of the whole of *Garcinia*. The subgroups, where such are defined, are species which are closely similar in one or several respects, i.e. 'circles of affinity', and not all species fall into clear subgroups. Further notes on individual species, including the subgroups, can be found in the *Tree Flora*.

In these studies I have not found helpful the groupings proposed by Anderson (in Hk. f. *Fl. Brit. Ind.* 1, 1884, 259–70) or those proposed by Pierre (*For. Fl. Cochinch.* 1, 1883, i–xlii).

The groups are defined on the structure of the male flower. Other characters common to the component species are also given in the descriptions below. There is a final artificial group, G, of 3 incompletely known species.

Group A. Sepals and petals 4. Stamens numerous, on 4 fleshy processes, anther cells 2 (4 in *G. cuspidata*, fide King), pistillode present.

Subgroup Ai. Leaves reminiscent of *Eugenia*, with fine, rather close, parallel, secondary nerves arising nearly at right angles to the midrib. Flowers small, in small inflorescences or clusters, axillary or behind the leaves.

G. cuspidata King, *G. eugeniaefolia* Wall., *G. merguensis* Wight, *G. rostrata* Wall., *G. sp. A1.*

A closely knit alliance for which I have only been able to give a provisional account; species delimitation needs a critical reappraisal on a monographic basis. See also the notes under *G. rostrata* below.

The following species, dissimilar from each other and from members of the Subgroup Ai, are also in group A:

G. diversifolia King, *G. holttumii* Ridley, *G. monantha* Ridley, *G. murtonii* Whitmore, *G. sp. A2*, *G. sp. A3.*

Group B. Sepals and petals 4. Stamens numerous, joined in a sometimes 4-lobed ring, surrounding a central pistillode; anther cells 2. Flowers terminal, males several, females solitary.

Subgroup Bi. Most easily defined as a close knit alliance of spp. extremely similar to the well known mangosteen; virtually indistinguishable when sterile and differing most noticeably in stigma.

G. hombroniana Pierre, *G. malaccensis* Hk. f., *G. mangostana* L.

Species of this alliance occur throughout the East Indies, the best taxonomic treatment of the variation remains to be ascertained from a monographic base.

Subgroup Bii. *G. costata* Hemsley ex King, *G. maingayi* Hk. f. Two species similar in their coarsely ribbed leaves.

Subgroup Biii. Male flowers in a short, terminal raceme, females solitary. Leaves drying thin, green-black.

G. atroviridis Griff ex T. Anders. Very distinctive.

Group C. Flower structure just as in Group B but with no pistillode, so the stamens as a central mass. Flower position various.

Subgroup Ci. Flower position as in Group B. Leaves drying with a distinct reddish or orange tint.

G. murdochii Ridley, *G. opaca* King, *G. penangiana* Pierre, *G. sp. C1* (?).

This Subgroup is very close to Bi above. It is discussed further below, under *G. penangiana.*

Subgroup Cii. Flowers mostly behind the leaves, in clusters. Leaves leathery, drying with a distinct reddish tint, or drying thin and green to green-black in *G. forbesii*, *G. griffithii.*

G. bancana (Miq.) Miq., *G. clusiaefolia* Ridley, *G. forbesii* King, *G. griffithii* King, *G. sp. C2.*

Subgroup Ciii. Leaves with rather open, reticulate nervation, drying brown-green. Flowers minute, in axillary racemes.

G. minutiflora Ridley.

Not placed: *G. montana* Ridley.

Group D. Sepals and petals 4. Stamens numerous, as a central mass; no pistillode; anther cells 4. Flowers small, in clusters in axils and behind leaves. Leaves drying thin, commonly pinkish grey-brown and with a fine pattern of black dots and dashes.

G. cowa Roxb., *G. nigrolineata* Planch. ex T. Anders., *G. parvifolia* (Miq.) Miq.

Corner (*Gdns' Bull. Str. Settl.* 10, 1938, 36–8) sorted out the Malayan members of this small group.

Group E. Sepals and petals 4. Stamens not very numerous, connective peltate with the anther cells marginal, often confluent, their dehiscence circumscissile; pistillode absent. Fruits thinly woody. Leaves often drying greenish.

Subgroup Ei. Flowers and fruits clustered on small tubercles, axillary and behind the leaves. Leaves usually thin. Often small shrubs.

G. dumosa King, *G. scortechinii* King, *G. urophylla* Scortechini ex King, *G. sp. E3.*

This Subgroup is discussed below, under *G. dumosa.*

Subgroup Eii. Fruits solitary, mainly in leaf axils, some behind the leaves. Leaves usually leathery. Mainly mountains.

G. burkillii Whitmore, *G. cantleyana* Whitmore, *G. hendersoniana* Whitmore, *G. uniflora* King, *G: Sp. E1* (?), *G. Sp. E2.*

This Subgroup shows partly allopatric, partly sympatric distribution patterns in the mountains which are discussed in the *Tree Flora.*

Group F. Sepals and petals 5. Stamens in 5 bundles around a small central pistillode. Male and female (and hermaphrodite ?) flowers sometimes mixed. Fruits usually drying shiny brown-black, intricately, sinuously wrinkled. Leaves commonly drying with a greenish or yellowish tinge.

G. dulcis (Roxb.) Kurz, *G. nervosa* (Miq.) Miq., *G. prainiana* King, *G. pyrifera* Ridley, *G. xanthochymus* Hk. f.

Long recognised, and at one time gave generic status as *Xanthochymus* Roxb.

Group G. Incompletely known species.
G. cataractalis Whitmore, *G. sp. G1, G. sp. G2.*

Garcinia burkillii Whitmore **sp. nov.**

Arbor parva, *foliis* subcoriaceis, ovatis 7.5 × 4.5 – 15 × 7 cm, acutis, base late cuneato vel rotundato, minime decurrenti, siccitate fuscis, marginibus leviter recurvatis, nervis lateralibus tenuibus. *Flores* ignoti. *Fructus* axillaria solitaria ovoidea, 2 cm longa, usque ad 12 mm diam., siccitate castanea, laevia, tenuiter lignosa, cum sepalis persistentibus ovatis 6 mm latis longisque, stigmatis integro tholiformi 3 mm diam. subsessili subtiliter papillato, axillari, solitario.

TRENGGANU: Sg. Loh, K. Datok, *FRI 12003.* PAHANG: Tahan River, *Ridley 2239;* G. Tapis *FRI 10911* (holotype KEP).

In leaf this is close to *G. uniflora* King of the Main Range, to which I believe it is related (though the flowers remain unknown). The fruiting stigma is, however, quite different. It is also quite clearly a very close relative of *G. hendersoniana* described below, and differs mainly in the fruit and its stigma.

Garcinia cantleyana Whitmore **sp. nov.**

Arbor parva, *foliis* parvis, crasso coriaceis, ovatis, 5.5 × 3 – 10 × 5 cm, apice late rotundato interdum apiculato, base late cuneato, marginibus valde revolutis; nervis lateralibus tenuissimis, petiolo crasso 14 mm. *Flores* (femineis ignotis) in axillas foliorum delapsorum poxiti, sessiles, sepalis 4 ovatis 4 × 4 mm, petalis 4 quam sepalis aliquantam minoribus, masculi cum staminibus numerosis androecium globosum centralium formantibus, filamentis crassis 1 mm, antheris peltatis 1 mm latis rima lata dehiscentibus, filamentis 1 mm longis spissibus, pistillodio nullo. *Fructus* subglobosa 3 cm diam., siccitate brunnea, sessilia, calyce persistenti lignoso insidens, stigmatis 3 mm diam. integro tholiformi grosse papilloso sessili.

PAHANG: Fraser's Hill, *FRI 5819* (holotype KEP). PERAK: G. Korbu, *SFN 16301, KEP 45976;* Cameron Highlands, *SFN 20603.*

G. cantleyana var. **grandifolia** Whitmore **var. nov.**

A varietate typica in *foliis* maioribus, 17 × 10 cm, *fructibus* interdum ovoideis differt.

PAHANG/SELANGOR: crest of Main Range, road to G. Ulu Kali, *FRI 12576* (holotype KEP), *FRI 16185.*

Garcinia cataractalis Whitmore **sp. nov.**

Frutex humilis, foliis lineari — lanceolatis 6 × 0.5 cm. *Flores* ignoti. *Fructus* axillaria, carmina, subglobosa, 2–3 lobata, vivo 2.5 cm diam. (siccitate valde vietis, grosse rugosa, 1.5 cm diam.), valde 8 mm rostrata, stigmate nigro 4 — lobato undulato minute papilloso leviter procurrenti, seminibus valde complanatis in pulpa aquosi translucenti inclusis.

TRENGGANU: Sg. Kerbat at Jeram Petang: *FRI 20350* (holotype KEP); Sg. Nipah at Jeram Gajah: *SFN 25913.*

Well known to the local boat men on the Sg. Kerbat as *gelugor batu;* a highly distinctive rheophyte.

Garcinia dumosa King

G. tenuifolia Ridley Kew Bull. (1928) 72 **syn. nov.**

Garcinia scortechinii King

G. gaudichaudii var. *minor* Ridley Flora 1 (1922) 177 **syn. nov.**

Garcinia urophylla King

All King's three species were described in the Materials (*J. As. Soc. Beng.* 59, 1890, 166–8). They are only weakly differentiated by the descriptions. The only syntype at Singapore is a sheet of *Curtis 1249, G. scortechinii.* I am able provisionally to maintain these species on the weak differential characters given in the *Tree Flora* but they are undoubtedly close, with apparently little difference in their reproductive parts. A monographer will have to reconsider this group together with its Indo-Chinese relatives. I do not see that Ridley was justified in reducing *G. scortechinii* to the Indo-Chinese *G. gaudichaudii* Planch. et Triana, as he did not make the necessary critical comparative studies of this whole alliance, I therefore do not follow him and, further, I reduce his var. *minor* of *G. gaudichaudii* to synonymy, having seen the Johore syntype. *G. tenuifolia* from the islands off Pahang is simply superfluous, I see no difficulty in reducing this species to *G. dumosa.*

Garcinia hendersoniana Whitmore **sp. nov.**

Arbuscula vel arbor parva, *foliis* percoriaceis, ovatis, 8 × 5.5 – 14 × 8.5 cm, apice acuto, base late cuneato vel rotundato, marginibus revolutis, nervis lateralibus tenuibus attamen manifestis, petiolo 1–2 cm longo. *Flores* (masculis ignotis) sessiles, solitarii, in axillas foliorum delapsorum poxiti, sepalis 4 ovatis, exterioribus (2) 9 × 8 mm, interioribus (2) 5 × 8 mm, petalis 4 ovatis unusquisque 5 × 5 mm, staminodiis peltatis circulatim dispositis, ovario cylindrico 4 mm longo × 3 mm diam., stigmate sessili tenui integro circulari-discoideo paullo convexo grosse papilloso paullo projectenti 4 mm diam. *Fructus* (? immaturi) ampulliformia vel rotundata, 3 cm longa, siccitate nigro-cinerea laevia, tenuiter lignosa, sepalis persistentibus.

TRENGGANU: G. Padang *SFN 31065, 31824; FRI 12718;* G. Mandi Angin *FRI 10813* (holotype KEP), *FRI 10826, 12103*. PAHANG: G. Tapis *FRI 10994*. PAHANG/SELANGOR: G. Ulu Kali *FRI 16206*.

Garcinia murtonii Whitmore **sp. nov.**

Frutex vel arbuscula, vel arbor parva, *foliis* glabris, coriaceis, ellipticis vel ovato-ellipticis, 5 × 2 – 8 × 3.8 – (8.5 × 4.5) cm, apice acuto, base longe cuneato, leviter decurrenti, nervis lateralibus approximatis (inter se 2 mm) parallelis rectis prope marginem bifurcatis gracilis utrinque prominentibus, costa striato utrinque prominenti. *Flores* (masculi) in racemis *c.* 1 cm longis congestibus, spissibus, axillaribus aggregatis, pedicellis 2 mm longis, sepalis 4 ovatis 2 mm latis caduceis, petalis 4 simillimis, staminibus in 4 fasciculos dispositis, pistillodio fungiformi. Flores feminei ignota. *Fructus* globosa, 2 cm diam., nigricans, laevia, stigmate disciformi aliquantam quadrato integerrimo grosse papilloso 2 mm diam. prominulenti, sepalis nec persistentibus caduceis.

JOHORE: G. Belumut, *KEP 33830, KEP 33850* (holotype KEP), *FRI 7511, 8730, 8737, 17825, SFN 10990*. PERAK: G. Korbu, *KEP 31486*.

Garcinia nigrolineata Planch. ex T. Anders. Fl. Brit. Ind. 1 (1874) 263.

G. kunstleri King J. As. Soc. Beng. 59 (1890) 165 **syn. nov.**

King cites collections by Wray and Scortechini. Ridley (*Flora* 1, 1922, 177) adds no others. I have seen at Singapore *Wray 828, Scortechini 271, 1852* and s.n., probably all the syntypes. The fruit is not grooved and ridged, the stigma is 2.5 – 3.5 mm wide, papillose and slightly raised, but not on an umbo; the female flowers are 3 mm across on slender, 5 mm pedicels and contain a globose, very young fruit. *G. kunstleri* has not been recollected. Apart from the very small female flowers it fits well Corner's diagnosis of *G. nigrolineata* in *Gdns' Bull. Str. Settl.* 10 (1938) 36–8, and I have little hesitation in suggesting that it is but a weakly differentiated form of that species, best reduced to synonymy.

On the Scortechini sheets I have seen have no locality notes. I do not know what led Ridley (loc. cit.) to say they came from the big limestone hill at Kuala Dipang. There is no limestone near Tapah, the Wray locality.

The G. penangiana group (Group C)

Pierre (*Fl. For. Cochinch.* fasc. 6, 1883, 37) described *G. penangiana* from Wallich's collector (Porter) *4852D*, a collection with male flowers in bud. He pointed out that Hooker had already mentioned it as distinct from *G. cornea* L. in a parenthetical addition to Anderson's account of *Garcinia* in *Fl. Brit. Ind.* 1

(1874) 260. King saw further collections and amended the description in his account of *Garcinia* in the Materials (*J. As. Soc. Beng.* 59, 1890, 158). I follow what I believe to be King's circumscription, although he does not precisely state which collections he saw, except for *Kunstler 3853,* which is not at Singapore.

I have examined at Bogor, *Teysmann* s.n. from Riouw, P. Bientang, the type of *G. caloneura* Boerl. *Cat. Hort. Bot. Bogor* 68 (2) 1901. It looks very similar to *G. penangiana.*

Dr. Kostermans has for some years now been labelling as *G. celebica* L. all specimens of this species-group in the herbaria he has visited.

All these species are of very similar appearance and I see no prospects of resolving their limits without monographic study.

There has been confusion between the *G. penangiana* group and the *G. hombroniana* alliance, my Subgroup Bi; this might indicate close affinity, implying that, as I indeed suspect, my species-groups, although convenient, are not entirely natural aggregates.

G. bancana (Miq.) Miq. Fl. Ind. Bat. Suppl. (1861) 494. **G. bancana** var. **curtisii** (Ridley) Whitmore **stat. nov.**

Basionym of variety: *G. curtisii* Ridley, Flora 1 (1922) 175, quoad syntypus *Curtis 691* = lectotypus.

G. curtisii Ridley differs from *G. bancana,* after which Ridley places it in his *Flora,* consistently in the fruits with the stigma protruding, more or less lobed and more or less coarsely papillose. The leaves tend to be narrower and are consistently pointed. It is undoubtedly very closely related and I reduce it to a variety. The fruits are exactly like those of *G. penangiana* which, however, always has its flowers borne terminally; in this variety a few are terminal, but most are in fascicles behind the leaves, as in *G. bancana.*

I have selected one of the syntypes as lectotype of my variety. The other, *Curtis 240,* is typical *G. penangiana.*

Collections seen:

PENANG: *Curtis* s.n. May 1880, s.n. July 1890, *677; SFN 3034, 35322.* JOHORE: *SFN 25854.* SINGAPORE: *Ridley 6194.*

I provisionally also place *FRI 4150* from W. Kelantan here, though it differs in its fruits drying less wrinkled and with sunken stigma.

Garcinia opaca King J. As. Soc. Beng. 59 (1890) 160.

Apparently a rare species. I have not seen the syntype(s) from which King described the flowers; *King's Collector 5460* at Singapore, which I believe to be a syntype, is in fruit.

G. opaca closely resembles *G. hombroniana* but (fide King) has no pistillode in the male flower, thus it falls in my Group C, whereas *G. hombroniana,* with pistillode, falls in Group B. As already noted I am not convinced B and C are natural groups, although they are very convenient ones. Both these species have the fruit wall thinly woody, and tending to fracture in the herbarium, this feature is more marked in *G. opaca* and especially so in its var. *dumosa* described below. Typically, *G. hombroniana* has a depressed globose fruit with the stigma on a distinct apical umbo, but sometimes the fruit is slightly elongate. In what I have described as variety A (see *Tree Flora*) the fruit is much longer than broad as in *G. opaca*, but I am not sure of the true affinity of this variety; its flowers have yet to be found.

G. opaca var. **dumosa** Whitmore **var. nov.**

A varietas typica in *habitu* plerumque fruticoso, *foliis* minoribus, ellipticis, 9 × 3.5 – 13 × 5 — 17 × 7 cm, petiolo graciliore breviore, 8–10 mm, *calyce in fructu* parvo demum cadenti, differt.

PAHANG: Bt. Terom, Ulu Keniyam *Mohd. Shah 1560* (holotype SING); G. Benom *KEP 97842;* Chini F. R. *FRI 11066*. JOHORE: Bt. Kuing *SFN 28653;* S. Berassau, *Corner* s.n. 18.IV.32; G. Chabang Tiga *Jumali & Heaslett 4114;* Mersing, Sg. Sarah working circle, *KEP 77731*. SELANGOR: Genting Sempah *KEP 10941.*

KEP 97842 is a tree, all the others are shrubs, except that the sheet I have seen (at SING) of *KEP 10941* has no note on stature.

Garcinia pyrifera Ridley J. Str. Br. Roy. As. Soc. 73 (1916) 140 (sphalm '*pyriferum*').

G. densiflora King J. As. Soc. Beng. 59 (1890) 171 (non *G. densiflora* Vieill. ex Pierre Fl. For. Cochinch. 5 (1883) 25) **syn. nov.**

Ridley noted that his species was close to King's except for certain foliage differences which he specified. I have compared the type of *G. densiflora* (*King's Collector 5933*) with that of *G. pyrifera* (*Curtis 3094*) and all the subsequent gatherings of the latter and can see no good differences, though two of the three leaves of the Singapore sheet are oblong-ovate, an unusual shape.

In *Flora* 1 (1922) 179 Ridley reduced King's species to *G. glomerata* Vesque (in DC. Monog. Phan. 8 (1893) 320), which predates his own *G. pyrifera*. I have been unable to check this because there is no authentic material of *G. glomerata* at Singapore or Bogor. Provisionally therefore I recognise *G. pyrifera* as the name for this tree.

The flowers of *G. pyrifera* remain unknown. The description in the Tree Flora is taken from King's of *G. densiflora* flowers, so far as I could confirm it from the poor specimen at Singapore.

G. pyrifera is a species with the Gestalt of the other Malayan species of the Xanthochymus group (*G. nervosa, G. dulcis, G. prainiana*) and quite clearly distinct from them in detail.

Garcinia rostrata and its allies (Subgroup Aii)

Garcinia rostrata (Hassk.) Miq. Ann. Mus. Bot. Lugd. Bat. 1 (1864) 209.

G. wrayi King J. As. Soc. Beng. 59 (1890) 152, **syn. nov.**

Garcinia eugeniaefolia Wall. ex T. Anders. Fl. Brit. Ind. 1 (1874) 268.

I provisionally keep *G. rostrata* and *G. eugeniaefolia* apart, not having seen the types of the former, on the stigma differences given by King, which are 'flat to concave, smooth' and 'flat to domed, papillose' respectively. The two syntypes of *G. wrayi* at Singapore (*Wray 267, 362*) show it clearly belongs to this aggregate. Unfortunately all the flowers have fallen; King's description of the stigma as 'hemispheric, *smooth,* entire' (my italics) suggests it belongs with *G. rostrata.* Ridley (in *Flora* 1, 1922, 169) reduced *G. wrayi* to *G. merguensis,* but I believe that is a fairly distinct species (see key in the *Tree Flora*) on foliage as well as flowers and that my placing of it is more probably correct. This whole complex, my Subgroup Ai, needs careful monographic investigation.

Garcinia merguensis Wight Illustrations of Indian Botany (1831) 122.

G. lanceolata Ridley Flora 1 (1922) 170, **syn. nov.**

I have examined the material at Kew, Kepong and Singapore and believe these two to be the same.

Mesua

The Mesua assamica group

Mesua aff. **assamica** (King et Prain) Kosterm.

Kayea assamica King et Prain Ind. Forester 27 (1901) 62.

Symington first recorded this for Malaya when, at Kew in July 1939, he matched *KEP 4643* (sterile), *KEP 5495* (fruiting) and possibly *KEP 10600* to *H. G. Young* s.n. December 1899 and 29 June 1900, two of the syntypes of *K.* (*M.*) *assamica.* Symington (ms. notes preserved at Kepong) observed "These, I think, differ [from *M. ferruginea*]. They are not riparian trees and the fruits are probably smaller than *K.* (*M.*) *ferruginea.* They more closely resemble *K.* (*M.*) *assamica* K. et P. than anything else but the leaves are less cuneate and acuminate and the veination [sic] is less conspicuously dryobalanoid".

I have placed a whole group of collections here which match *KEP 4643* and *5495* in leaf, habit, habitat, and most especially in having the fruit enclosed in two, strongly adpressed, enlarged sepals. The fruits are long-stalked and solitary in *5495* but in open panicles in most of the new collections. King and Prain describe *K. assamica* as possessing panicles 3–6 in. long. The size of the fruit varies, as does the sepal surface texture and, slightly, the shape. I attach no importance to variation in the degree of splitting of the 2 sepals which I believe to be developmental.

I have not seen the types of *K.* (*M.*) *assamica,* and following the caution expressed by Symington, name our material as aff. *assamica.* It is slightly heterogeneous but is held together by the nature of the fruiting calyx, and, though further collections may reveal it to comprise more than one taxon, I have little doubt all these collections are related.

FRI 12033 is an anomalous high altitude collection (780 m,G. Mandi Angin) with possibly galled young fruits which, on present evidence, comes here; and the sterile collection *FRI 9347,* from 960 m on G. Inas, Kedah matches it in leaf.

I have segregated from the above a number of sheets as *Mesua sp. D.* These puzzle me not a little. They differ in having smaller leaves with more slender stalk, and smaller fruits, also more slenderly stalked. Fuller descriptions are given in the *Tree Flora.* At the extreme this taxon is rather distinct and *KEP 110395, FRI 2617, 8106* approach *S21745, 22469, 22507* from Sarawak named by Ashton (unpublished ms.) as *M. acuminatissima* (Merrill) Kosterm., but it merges into typical Malayan *M.* aff. *assamica.* Two collections, *FRI 8851, 10891,* have the fruits solitary, the other collections have panicles.

The problems of this species-group can only be finally resolved by a monographer who will, I suspect, need more collections than yet exist.

Collections seen:

M. aff. *assamica*

KEDAH: *FRI 9347*. KELANTAN: *FRI 4054, 4099*. TRENGGANU: *Corner* s.n. 7 Nov. 35, 12 Nov. 35, *FRI 12033*. PAHANG: *KEP 4643, 5495, 77710*.

JOHORE: *Kiah* s.n. 19 Oct. 35, *SFN 25973, 26140, 29272, Lake & Kelsall* s.n., 28 Oct. 1892.

M. sp. D.

PAHANG: G. Tapis *FRI 10071, 10115, 10891; FRI 8106*. JOHORE: *KEP 110395, FRI 2617, 8851*.

In the absence of flowers or fruits collections of the *M. assamica* group from Malaya are very difficult to distinguish from *M. ferruginea* on morphology. On the basis of size and habitat the following collections of fallen leaves are put under the *M. assamica* group:

M. aff. *assamica*

TRENGGANU: *KEP 81070, 93779*. KEDAH: *KEP 81329*. NEGRI SEMBILAN: *KEP 105202*. JOHORE: *FRI 5088*.

M. sp. D.

SELANGOR: *KEP 76378*.

Mesua sp. E.

Possibly this is another relative of *M. assamica* from which it differs conspicuously in the shiny leaves with very faint nervation and not or scarcely reticulate. *KEP 94924* has remarkable fruits enclosed in 2 big woody sepals plus, alternating with them, 2 lanceolate ones. In other respects this collection seems similar to *KEP 76086* with fruits with the type of calyx found in *M.* aff. *assamica*. *FRI 8125* is again similar in leaf. Its flowers are larger than in the collections of *M.* aff. *assamica*.

The taxon is known from the east coast as follows:

TRENGGANU: Bt. Bauk: *KEP 76086*.

PAHANG: Bt. Beserah: *KEP 94924;* Ulu Sg. Anak Endau: *FRI 8125*.

Mesua elegans (King) Kostermans Reinw. 7 (1969) 427.

Kayea elegans King J. As. Soc. Beng. 59 (1890) 183 basionym

Kayea caudata King loc. cit., **syn. nov.**

Mesua caudata (King) Kostermans loc. cit. 426, **syn. nov.**

The leaves of *M. elegans*, based on one flowering collection (King's Collector *7346*, K!), differ from those of *M. caudata*, based on one fruiting collection (King's Collector *7937*, K!). They are lanceolate, tapering gradually into a pronounced drip tip, the secondary nerves are faint, and a fine, faint reticulum can be made out with the aid of a lens on the undersurface. The leaves of the type collection of *M. caudata* are much broader, taper suddenly into a drip tip, have the secondary nerves prominent, and the reticulum is almost invisible. In both, the leaves dry khaki-brown, the twigs are slender and tiny, and subulate 'stipules' and hypsophylls are present.

The two species are close, but on these collections they can be distinguished, as indeed King does distinguish them in his key.

The numerous gatherings which have been made since 1885 show a complete range of intermediates, and I do not believe that more than one species exists. I have chosen to call it *M. elegans* because other species of *Mesua* in Malaya also have caudate leaves.

M. elegans is in many ways a delicate version of *M. kunstleri.*

Collections seen (all at KEP and SING except the types):

PERAK: Batang Padang district: *King's Collector 7937* (type of K. caudata), G. Bubu: *King's Collector 7346* (type of *K. elegans*); Keladang Saiong F. R.: *FRI 5998;* Parit F. R.: *KEP 39492;* Tapah: *Ridley 14085.* SELANGOR: Ulu Langat: *FRI 12203;* Klang Gates: *KEP 532, 33224, 47132, Ridley 13521, 13527.* PAHANG: Kemasul F. R.: *KEP 10608, 10876.* JOHORE: G. Panti: *KEP 99232.* SINGAPORE: Garden's Jungle: *Furtado* s.n. 13 I 1931, *Ahmad* s.n. 10 III 1926.

Mesua kochummeniana Whitmore **sp. nov.**

Arbor magna, usque ad 36 m alta, 3 m diametro, ligno duro (ferreo); ramulis crassis angulosis subsparse squamatis, *foliis* ovato-oblongis, *c.* 22 × 9 cm, base rotundatis, apice rotundato-apiculatis, marginibus revolutis, laminis infra glaucis, supra nitide castaneis, nervis lateralibus approximatis parallelis, ex costa subperpendicularibus, leviter curvatis, distaliter incurvato-approximatis arcuatis, petiolo crasso rugoso *c.* 12 mm longo. *Inflorescentia* racemosa, racemis 3–10 terminalibus, 4–7 cm longis, 3–6 floriferis, *floribus* subapicalibus, pedicellis 5 mm longis, bracteolis 1 mm longis oppositis dettoideis; sepalis 4 ovatis 6 mm longis, petalis caducis (non vidi), staminibus caespitosis exsertis, filamentis tenuibus 7 mm longis. *Fructus* (probabiliter immaturi) *c.* 3 cm diametro, includentibus in sepalis duobus globosis truncatis dilatatis sublignosisque in base connatis, in sicco rugosis, parte basali styli crassi (2 mm longo) protrudento.

Type: *Corner SFN 29430,* 14 May 1935, Johore, 13½ mile Mawai-Jemaluang Road. Holotype in SING.

Also examined:

JOHORE: 13 mile Mawai-Jemaluang Road. *Corner* s.n. 31 Dec. 1934; 21 mile Mersing-Kota Tinggi Road. *KEP 70811;* Jemaluang F. R. *FRI 2773, KEP 69992, KEP 71895.* SOUTH PAHANG: G. Lesong F. R. *KEP 83464, 86903.*

Probably the huge woody fruits 7 cm across (at KEP), collected without leaves as *KEP 79193* from G. Lesong F. R. compt. 20, are this. All the collections cited except the type are at KEP only and all are sterile twigs or fallen leaves except *KEP 69992* in flower.

I name this fine tree in honour of the Forest Botanist at Kepong Mr. K. M. Kochummen. It is common in east Johore and the adjacent part of Pahang. Corner, in making the collection I have chosen as type, noted '2½ hrs of sheer cutting to fell this tree . . . wood exceedingly hard, like iron, as "penaga" ' and that it is common on hillocks and drier parts of swamp around Sg. Kayu Ara and Sg. Buloh Kasap.

Mesua kunstleri (King) Kostermans Reinw. 7 (1969) 427.

Kayea kunstleri King J. As. Soc. Beng. 59 (1890) 182; basionym.

Kayea rivulorum Ridley J. As. Soc. Str. Br. 54 (1909) 22. **syn. nov.**

Mesua rivulorum (Ridley) Kostermans loc. cit. 429, **syn. nov.**

King described his *Kayea kunstleri* in the Materials from four collections: *King's Collector 3301, 6850, Curtis 1419* and *Maingay 176*. I have seen sheets of the first three of these syntypes at Singapore.

I have no doubt that Ridley's *K. rivulorum* belongs here, although it is known only from two syntypes, both in fruit, whereas all the collections I have seen of *M.* (*K.*) *kunstleri* are sterile or in flower. The argument for this conclusion is deferred until after the emended description of *M. kunstleri* var. *curtisii* below.

In describing *K. kunstleri* in the *Materials* King noted 'a shrubby form of this occurs in Penang (Curtis, Nos. 805, 1418) and in Perak (King's Collector, No. 1345) in which all the parts are smaller and the leaves are less acuminate at the apex, and rounded instead of much attenuated at the base'. I have seen (also at Singapore) the two Curtis numbers and confirm King's description.

In 1894 in another publication, King raised the Penang form to species status as *Kayea curtisii* based on one of the sheets cited in the Materials, *Curtis 805,* plus another collection *Curtis 748,* which I have also seen at Singapore, and which is a good match. He made several serious mistakes in his description in firstly saying 'leaf . . . base acute' whereas it is rounded, secondly 'flowers . . . leaf opposed', whereas they are actually terminal, and thirdly 'petals slightly smaller than the sepals', whereas actually they are twice as long. The earlier note in the *Materials* and the syntypes clearly show however what was intended by *K. curtisii.* Ridley in *Flora* 1 (1922) 191 sunk *K. curtisii* into *K. kunstleri* commenting that *Curtis 1418* (of King's original note) is 'obviously the same plant' (? taxon) as *K. curtisii,* yet retained under *K. kunstleri* by King.

Since 1890 numerous additional collections have been made, all from Penang and Kedah. King's original note is amply confirmed, that there are two distinguishable taxa, the extreme forms being very distinct. There are however few substantial differences, and the placing of a few collections has to be rather arbitrary. Nevertheless I think it convenient and useful to give recognition to the 'shrubby Penang form'. I therefore accordingly reduce *K. curtisii* to varietal status. The necessary formulation is set out below with a new latin diagnosis, necessary because of King's mistakes.

Mesua kunstleri (King) Kostermans var. **curtisii** (King) Whitmore **stat. nov.**

Kayea curtisii King Ann. Bot. Gard. Calcutta 5 (1896) 144, t. 174B basionym.

Mesua curtisii (King) Kostermans Reinw. 7 (1969) 426. **syn. nov.**

A varietas typica in *foliis* minoribus, basi rotundato, nervis lateralibus abaxialis obscurioribus, differt.

Lectotype *Curtis 805.*

Although, as noted above, I have seen no fruiting collections of *M. kunstleri* I have seen several of *M. kunstleri* var. *curtisii*. These have the fruit wall thin but not brittle, smooth, and irregularly covered with tiny, fawn, corky scales; the fruits are mostly round, tipped by the 1–2 mm long style base, the largest is 3.3 cm across. The fruit is seated on the persistent sepals which are not enlarged. Both syntypes of *Kayea rivulorum* Ridley are in fruit, young in *Ridley 7349*, and, in *Goodenough 1976*, 4.5 cm long and ellipsoid, including a stout 1 cm apical beak. The wall is wrinkled and bears the same tiny scales typical of *M. kunstleri* var. *curtisii*. These fruits differ from those of *M. kunstleri* var. *curtisii* in drying wrinkled and in their shape. King, in his description of *M. kunstleri* and later as plate 173 in Ann. Roy. Bot. Gdn. Calcutta 5 (1896), depicts fruits of this shape, and there is a single Curtis collection of *M. kunstleri* var. *curtisii* at Singapore with neither number nor date which has them (this sheet I have labelled X). I consider the resemblance in fruit and leaf adequate to justify reduction of *K. rivulorum*. The types of *K. rivulorum* have the leaf base slightly rounded, whereas in the types I have seen of *K. kunstleri* it is long cuneate (and is thus described in the type description and depicted in plate 173 in *Ann. Roy. Bot. Gard. Calcutta* 5, 1896). There are 3 collections of *Curtis 5571* at Singapore, of these 2 have cuneate and one slightly rounded leaf bases. All are dated March 1901 and all bear flowers. I think in this case we can assume they come from a single gathering of one tree, though Curtis often did place different gatherings under one number. Amongst the other abundant material at Kepong and Singapore this character breaks down. I do not think the shape of the leaf base is useful in this case to distinguish two taxa.

M. kunstleri is in many respects a coarse kind of *M. elegans* with bigger leaves and flowers. It differs from *M. nervosa* (in the circumscription of which I have been assisted by manuscript notes made by Symington at Kew) in the lack of harsh red tomentum. Monographic study is necessary to delimit more closely these two species.

Mesua lepidota Anderson Fl. Brit. Ind. 1 (1874) 278. KING J. As. Soc. Beng. 59 (1890) 185.

Anderson based *M. lepidota* on *Griffith* (K.D.) *845* from Malacca. King added *Scortechini 183b* and *King's Collector 4551, 5881*, recording that these differ in smaller leaves, more slender twigs and slightly thinner pericarp. He went on to note that these collections might be a second species, also possessing the very remarkable woody reflexed fruiting calyx which had prompted Anderson to suggest his species was 'probably a new genus between *Kayea* and *Mesua*'.

The abundant gatherings which have now been made show there clearly are two taxa, but a few collections are intermediate (*KEP 32163, 71830, 76734, FRI 11321*). It is convenient to give a name to the delicate form especially as it is very similar in the sterile state to *M. nuda;* the two are common together in the Ulu Gombak F. R. None of the cited material is represented in the Far East. Symington however has matched *KEP 12906* to *Griffith 845* and *KEP 37290* to the slender variety.

In fact, I believe, from examination of *Burn-Murdoch* (=CF=FMS=KEP) *382*, the single sheet extant of *Kayea parviflora* Ridley (kindly loaned to me at Kepong by Kew) that this little known taxon is the same thing in young flower bud, and it therefore provides the epithet for the variety, as follows:

Mesua lepidota var. **parviflora** (Ridley) Whitmore **stat. nov.**

Kayea parviflora Ridley J. As. Soc. Str. Br. 82 (1920) 170, basionym.

Mesua parviflora (Ridley) Kostermans Reinw. 7 (1969) 428 **syn. nov.**
Type: *Burn-Murdoch 382* (at K).
Also examined (at KEP and SING):

PERAK: *FRI 11937*. TRENGGANU: *Corner* s.n. 9 XI 35, *SFN 30480*. SELANGOR (all Ulu Gombak): *KEP 10919, 13064, 12633, 12855, 37290, 93292, 94717, 94718, FRI 1154, Hume 9270*. MALACCA: *Derry 63, 902*, collection ∝ (at SING, no name or date). JOHORE, G. Blumut: *SFN 10790*.

In the Perak collection the fruit is young and has not developed a woody calyx. The Johore collection has the leaves 5 × 1 cm and broadest near the base with a long narrowed upper portion. These collections may represent slightly divergent populations. The Trengganu collection, *SFN 30480*, is the only one I have seen of the variety with the flowers in racemes.

The collections I have examined suggest the typical variety inhabits plains, and var. *parviflora* is a tree of the hills. The four intermediate collections cited all come from hilly places.

Mesua nivenii Whitmore **sp. nov.**

A *M. wrayi* valde simillime sed in floribus sessilibus et foliis infra conspicue reticuloso-venulosis differt.

Arbor parva, *foliis* ovato-oblongis, *c.* 9 × 4 cm, basi late-cuneatis, apice acutis, coriaceis, nitidis, nervis lateralibus subtus tenuibus prominulentibus; pagine infra reticulato, nervis tertiariis valde approximatis, petiolo 1 cm longo ruguloso. *Inflorescentia* racemoso-paniculata, racemis ramificatis, pedunculis 1 cm longis, pedicellis obsoletis (floribus sessilibus) trifloriferis, sepalis ovatis rotundatis convexis in sicco nigris rugosis 6 mm longis, petalis *c.* 10 × 6 mm obovatis rotundatis, staminibus exsertis caespitosis. *Fructus* (submaturus?) includentibus in sepalis duobus paribus, sepalis maturitate incrassatis coriaceis rugosis turbinatis, parte basalari stylo 2 mm protrudento.

Type: *Whitmore FRI 12100*, 12 July 1968. Trengganu, G. Mandi Angin, Summit ridge north of birop (trig. point), 1425 m. Holotype in KEP, isotypes K, L, SING, ARN. In flower.

Also examined:

TRENGGANU: leading E. ridge G. Mandi Angin: *FRI 10815;* G. Padang *SFN 31064, 33909* (in fruit).

First collected by Moysey and Kiah on their pioneering journey up the Ulu Brang to G. Padang in 1937. Found in full flower by myself, and a delightful sight, on the summit ridge of G. Mandi Angin in 1968. Named for the part-time Superintendent of the first Singapore Botanic Garden who 'had a fine eye for design' (Purseglove).

Mesua nuda Kostermans ex Whitmore **sp. nov.**

Arbor, ramulis gracilibus teretibus plerumque griseis, *foliis* ellipticis (5 × 1.5) – 6 × 2 — 8 × 3 cm, base cuneatis, apice cuspidatis, subcoriaceis, nervis lateralibus utrinque tenuissimis approximatis parallelis leviter arcuatis ex costa subperpendicularibus, petiolis gracilibus 3 mm longis. *Flores* (in alabastro) cum pedicellis 2 mm longis. *Fructus* solitarius, axillaris, pedunculo incrassato (a 5 mm), pedicello 2 mm longo, maturitate oblongo-ovoideis 4 cm longis 2.5 cm latis, apice interdum rostellatis, base rotundatis, paricarpio fructi tenuoso-fragile bubalino laeve squamulis minutis suberosis obtectis, sepalis caducis. Semen unicum in fructu, testa fusco nitido.

Type: *Whitmore FRI 3440,* 24 March 1967. Pahang, G. Benom, Ulu Sg. Krau, ridge crest 270 m. Holotype in KEP, isotypes K, L, SING, ARN.

Also examined:

KELANTAN: *KEP 98807, FRI 2333, 2339, 7255.* TRENGGANU: *SFN 30390, FRI 10682.* PAHANG: *KEP 4059, 29682, 100105, 108974, FRI 15333.* Baloh F. R.: *KEP 3149, 97913, FRI 3798.* KEDAH: *KEP 105354.* PENANG: *Curtis 748.* PERAK: *KEP 29928;* s.n. *Wyatt-Smith* 25 Jan. 1953. SELANGOR: *Hashim* s.n. (SING), *Burn Murdoch* (KEP ?) *278 = 14248.* Ulu Gombak F. R.: *KEP 10942, 11220, 18163, 18165, 98401, FRI 2555.* MALACCA: (illegible) *851, Alvins 1066, Derry 1003* no locus; Symington *KEP 18163.* NEGRI SEMBILAN: *KEP 104871, FRI 11347.* JOHORE: *KEP 69996.*

Mesua nuda is a very common species, apparently endemic, which unfortunately has never been found in full flower. It is highly distinctive in its brittle, buff, naked fruits. The name is in wide usage but as far as I can discover Kostermans has never published it. Young fruits are sometimes globose, leaf size is slightly variable as is the clarity of the secondary nerves, but I have little doubt that all the collections cited belong to this species.

Mesua purseglovei Whitmore **sp. nov.**

Arbor excelsa, *foliis* coriaceis lanceolatis, 13 × 4 cm, lamina prope basin quam apicem latiore, base rotundato, apice acuminatissimo; nervis lateralibus majoribus ex costa subperpendicularibus parallelibus leviter curvatis distaliter incurvato conjunctatis subtus conspicuis supra inconspicuis subdepressis, nervis lateralibus secundariis minoribus (1–3 aggregatis cum majoribus alternantibus) subtus inconspicuis, nervis tertiariis (reticulationis) evidentibus. *Flores* ignoti. *Fructus* solitarius (variter geminatus), axillaris, pedicello crasso 1 cm longo, pedunculo 4 cm longo, in sepalem ± inclusus (sepalis 4 maturitate valde dilatatis ovatis subcoriaceis furfuraceis depresso globosi diametro 3–3.5 cm).

Type: Holttum *SFN 31233,* 14 May 1936, Pahang, Cameron Highlands, mile 47 Telom Rd. Holotype in SING.

This is a high mountain species and I think likely to prove to be endemic, I therefore describe it, despite its being known from only one collection, in fruit. *M. purseglovei* is similar to *M. wrayi* but conspicuously differs in leaf characters.

XIX. LECYTHIDACEAE

T. C. Whitmore

Barringtonia payensiana Whitmore **sp. nov.**

Species nova, a speciebus ommibus generis Barringtoniae in fructibus pyramidalibus differt.

Arbor parva, *foliis* obovatis acuminatis chartaceis vel subcoriaceis, *c.* 21 × 6.5 – 50 × 14.5 cm, base longe decurrente, marginibus leviter revolutis, apicem versus leviter dissitiserratis, nervis lateralibus in paribus *c.* 26, petiolo 15 mm. *Inflorescentiae* et *flores* ignotae. *Fructus* pyramidata usque ad 4.5 cm lata, *c.* 4.5 cm longa, base omnino plano, plus minusve quadrata in sectione, superficie ruguloso, calyce persistenti usque ad 15 mm diametro.

SELANGOR: Ulu Batang Kali *FRI 4550* (holotype SING).

PERAK: Pangkor Island *SFN 31658.*

Named in honour of the recent monographer, Dr. J. P. D. W. Payens.

XX. LEGUMINOSAE (d)

T. C. WHITMORE

Crudia viridiflora Whitmore **sp. nov.**

Arbor, foliis simplicibus subcoriaceis, glabris, oblonge-ovato, 15 × 6 – 22 × 8 cm, base cuneato, apice rotundato, apiculato, costa supra canaliculata, nervis lateralibus *c.* 9 paribus, pagina inferiore valde prominentibus, pagina superiore obscuris, nervis lateralibus secundariis reticulisve similiter, petiolo crasso rugoso 5 mm. *Flores* congesti, viridi, in racemos terminales, solitarios vel — 4 fasciculatos, 7–12 cm longi, rhachidi aureo pubescenti, bracteis minutis aureo tomentosis, pedicello 3 mm aureo tomentoso, sepalis ovoideis 6 × 4 mm exteriore ad basim leviter tomentosis, staminibus 8 exsertis, filamentis filiformibus 10 mm, ovario 5 mm longo aureo lanato, stylo gracili 5 mm. *Fructus* ignoti.

PAHANG: (G.) Lesong F. R., Sg. Jekatih *FRI 15949* (holotype KEP); *Samsuri 540.*

This distinctive new species was discovered too late for inclusion with the Leguminosae in vol. 1 of the *Tree Flora* and will have to go into a supplement later. It comes near to *C. gracilis* Prain apud King and *C. subsimplicifolia* Merr. in De Wit's monograph (*Bull. Jard. Bot. Buitenz.* sér 3, 18, 1950 407–34) but differs from both. It can easily be distinguished from all the other Malayan species from its simple leaves. I did not see any compound leaves on the limbs which were cut for me from the crown of the tree from which the type collection was made.

XXI. STROMBOSIA (OLACACEAE)

T. C. WHITMORE

Strombosia maingayi (Masters) Whitmore **comb. nov.**

Anacolosa maingayi Masters Fl. Brit. Ind. 1 (1872) 580 basionym.

Strombosia rotundifolia King J. As. Soc. Beng. 64 (1895) 103 **syn. nov.**

Both names are based on the same type sheet, Maingay (Kew Distribution No. 1019), and the former clearly has priority. When King transferred Masters' species to *Strombosia* he incorrectly coined a new epithet for it. Ridley (*Flora* 1, 1922, 425) cites *A. maingayi* as a synonym of King's species.

Strombosia multiflora King J. As. Soc. Beng. 64 (1895) 102; syntypes Perak, King's Collector *7824;* Penang, *Curtis 859.*

King described this and his *S. rotundifolia* (see above) at the same time, noting that they are closely related. The name *S. multiflora* has never entered currency. The abundant material at Kepong and Singapore appears very homogeneous. I can see in it no significant difference in the three differential characters given by King, namely the number of flowers per cymose fascicle (the pedicels, it should be noted, are brittle and flowers easily break off), flower size (all have tiny flowers only *c.* 3 mm long, on a 1.5 mm pedicel), or leaf shape and size (King's contrast of rotund, 2.5 × 2 in., versus 2.5 × 1.5 – 4 × 2 in. seems in any case to be weak). There is variation between collections with sessile, round to oblong, fruits and those with stalked, round fruits. The former group has small, very woody fruits which might perhaps be galled.

Mr. L. L. Forman has kindly made a very thorough examination of the Kew material of *S. maingayi* (*rotundifolia*) and *S. multiflora*. Not one collection is in fruit. He could see no leaf or twig differences and the material was too incomplete to study the buds. He did however find a substantial difference in the flowers, along the lines indicated by King; to quote 'the Kew isotype of *Str. multiflora* has dense bunches of flowers with petals 5 mm long and styles 3.5 mm. *Str. rotundifolia* on the other hand has petals only half that length and a very short style less than 1 mm . . . These species are surely distinct'. He later reported that in both species the flowers have 1.5 – 2.0 mm pedicels. The Singapore isotypes which had been mislaid were subsequently rediscovered, examination of them confirmed Forman's careful observations.

The problem facing us in Malaya is thus a very tricky one. On the one hand, the two species appear to differ substantially in flower but the types are inadequate to discern any other differences. On the other hand, all the collections in the East (many of them duplicated at Kew) appear to represent one species, except Curtis 1371 from Pangkor Island, but they are mostly sterile or in fruit. That some collections have sessile fruits does not help as both species have pedicellate flowers, and in addition such fruits are suspected possibly to be galled.

Since King described *S. multiflora* no further collections have been added to the species, except *Curtis 1371*, just mentioned, which was misnamed '? *Anacolosa sp.*' Ridley in his Flora cites just the two syntypes. All the abundant material at Kepong and Singapore has been named *S. rotundifolia* (=*maingayi*). The few flowering collections amongst this abundance have the tiny flowers and short stigmas of *S. maingayi*, and are a good match for the fruiting and sterile collections.

I conclude that the pragmatic solution is to name all these collections *S. maingayi*. Although *S. multiflora* differs conspicuously in flower more collections than have been assembled in the last 76 years will be needed to discover if these two species can be differentiated in any other way. Thus, in summary, I propose to follow the practice since 1895, in putting our material into *S. rotundifolia*, but have had to revert to the earlier epithet for this taxon which becomes therefore *S. maingayi*.

Curtis 1371 from Lumut, Pangkor (Perak) at Singapore might represent *S. multiflora* in that the style is very long (4 mm) and thread-like, but the flowers are only 2 mm long.

XXII. HELICIOPSIS (PROTEACEAE)

K. M. Kochummen

Three new species of this small genus, only differentiated from *Helicia* in 1955, have been discovered in preparing the account for the *Tree Flora*.

Heliciopsis cockburnii Kochummen **sp. nov.**

Arbor ad 24 m alta, 60 cm diam., ramulis striatis junioribus ferrugineis, *foliis* (foliis pinnatisectis adhuc ignotis) ellipticis vel anguste obovatis, 9.5 × 2.8 – 21 × 7 cm, apice obtuso, base angustato decurrenti, nervis lateralibus 6–11 paribus arcuatis, petiolo 1–4 cm longo base incrassato. *Flores* adhuc ignoti. *Infructescentiae* 10 cm longae rhachidi striata rubiginosa gracili 2 mm diam., bracteis linearibus 6 mm longis rubiginosis sub-persistentibus, bracteolis bracteis similibus 3 mm longis, pedicellis 4 mm longis 2 mm crassis. *Fructus* oblonga nitida siccitate brunneola 2.5 cm longa 2 cm diam., stylo vestigio, exocarpio tenuissimo, mesocarpio radiato fibroso, 3 mm crasso, endocarpio tenuissimo. *Semina* leaves, testa brunneola.

PAHANG: G. Tapis 800 m *FRI 10934* (holotype KEP). PERAK: Keladang Saiong F. R. *KEP 2900, KEP 32181.* UPPER PERAK: *FRI 594.*

Heliciopsis montana Symington ex Kochummen **sp. nov.**

Arbor 26 m alta, 60 cm diam., ramulis striatis cum cicatricibus foliorum delapsorum notati, *foliis simplicibus* coriaceis, ellipticis vel anguste oblongis, (9 × 3.5) — 15 × 6 — 21 × 10 - (40 × 20) cm, apice obtuso, base cuneato raro inaequilatero, nervis lateralibus 6 - 10 (- 14) paribus arcuatis, pagina supra nitida, petiolo 2 — 4.5 cm longo, ad base gibboso, *foliis pinnatisectis* 48 × 24 - 54 × 27 cm, lobis 3–5 paribus oblongis 17 × 3 — 19 × 7 cm, apice acuto, nervis lateralibus 9–11 paribus arcuatis, petiolo 10–13 cm longo. *Flores* adhuc ignoti. *Infructescentiae* rhachidi crassa 5 mm diam. striata ferruginea, bracteis adhuc ignotis (? cadicis), pedicellis crassis 6 mm longis 3 mm diam. *Fructus* siccitate purpurea vel brunneola oblonga 2.8 — 3.8 cm longa × 2.5 — 3.5 cm diam., exocarpio coriaceo tenuissimo, mesocarpio fibroso 3 mm crasso, endocarpio tenuissimo leavis.

PAHANG: Fraser's Hill *FRI 16172* (holotype KEP). Cameron Highlands *KEP 27194, 30966, SFN 32871.* PERAK: G. Korbu *KEP 32248.*

A species of mountain forests at 300 m and above. Endemic. Symington named this *Helicia montana* in manuscript.

Heliciopsis whitmorei Kochummen **sp. nov.**

Arbor 18–21 m alta, trunco usque ad 40 cm. diam., ramulis striatis, junioribus ferrugineis, *foliis simplicibus* coriaceis ellipticis vel oblongis 7.5 × 2.5 - 21 × 7 cm, siccitate viridiflavis, apice acuto, base acuto, nervis lateralibus 9–12 paribus, arcuatis, utrinque inconspicuis, costa supra conspicua, petiolo 2–5 cm longo base incrassato, *foliis pinnatisectis* 46 × 28 — 60 × 30 cm, lobis *c.* 11 paribus, oppositis, 12.5 × 2 — 15 × 3 cm, petiolo 9–14 cm longo. *Flores* adhuc ignoti. *Infructescentiae* 15 cm longae, rhachidi striata glabra 3–4 mm diam. *Fructus* cylindrico-truncata 18–20 mm longa 8–11 mm lata, stylo persistenti 1 mm longo, exocarpio tenuissimo. mesocarpio radiato fibroso 1 mm crasso, endocarpio 0.3 mm crasso.

TRENGGANU: G. Mandi Angin *FRI 12062* (holotype KEP). Ulu Sg. Trengganu 900 ft *FRI 10544.* Ulu Bendong Kemaman, 700 ft *SFN 30193.*

A survey of the occurrence of epiterranean soil algae in Singapore Island

by

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Epiterranean soil algae found in the upper layers of soil are of considerable importance in soil economy since they increase the organic content of the soil by photosynthesis, disintegrate soil particles to increase the water-holding capacity of the soil and secrete mucilaginous material binding surface particles together to form a matrix; while heterocystous blue-green algae fix atmospheric nitrogen increasing the nitrogen content of the soil (Johnson, 1962). Subterranean soil algae which live in complete darkness and may lose their photosynthetic pigment (Tiffany, 1951) are less important to soil economy.

Few investigations have been made on the soil algae of tropical areas and include those of Fritsch (1970) in Ceylon; Prasad (1949), Gonzales and Valavigi (1960), Singh (1940-41), Sulaiman (1944) and Ghose (1923) in India; Bristol (1919) in Malaysia and Johnson (1962, 1969) in Malaysia and Singapore.

Over a large area of Singapore Island the soil is derived from sedimentary parent rocks of the Triassic or Carboniferous period, with small areas derived from igneous rocks of acid or basic composition, as well as alluvial soils in swamps or valley bottoms. Most areas in the West of the Island the soil was derived from argillaceous series including red iron-rich strongly lateritic soil, light coloured to white iron-poor shale-derived soil, as well of soils mixed composition (Panton, 1955). Sedimentary soils of arenaceous series are commoner in the East of the Island including both coarse and find-grained series. The red colour of laterized soils is due to their high iron content since laterisation leads to an accumulation of iron and aluminium in the upper layers (Becking, 1961). Most of the iron is unavailable to the plants being in the form of insoluble iron-aluminium sequioxides or ironstone concretions. Most soluble cations such as calcium, magnesium, potassium and sodium have been leached away, and Singapore soils are extremely deficient in cations. The soils are also low in available phosphate due to loss by leaching and have a rather low pH. The rapid decomposition of organic matter under tropical conditions and subsequent leaching make them typically moderately low in nitrogen.

Singapore Island was originally covered with tropical lowland forest with dipterocarps as the dominant type of trees. During the second half of the nineteenth century considerable areas of the Island were cleared for the planting of gambier and pepper (Jackson, 1968). The soil rapidly became exhausted leaving a very infertile soil. When gambier and pepper cultivation was abandoned early this century, the land was allowed to revert to grassland and scrubland (belukar). In other areas the top soil has been removed in reclamation operations and exposed subsoil (B layer) remains. Forest is extremely limited in extent. Cultivated areas support vegetable crops, and estates have rubber, coconuts, rambutans and other fruit. Disturbed areas are city dumps, abandoned building sites, army camps etc.

Materials and Methods

Surface soil was collected from 100 habitats in the rural area of Singapore to a depth of 2 cm. Two series of cultures were set up for each type of soil: —

(i) *Plate culture,* consisting of soil placed to a depth of 1 cm. in sterile petri-dishes, moistened with sterile distilled water and

(ii) *Liquid culture,* consisting of small quantities of soil introduced into sterile Knop's solution in conical flasks under sterile conditions. Both types of culture were exposed to 12 hours natural light per day. Observations on the algae appearing in the cultures continued for two months.

After setting up the cultures the remaining soil was air-dried and sieved through a 2 mm. sieve before analysis. The soil type was characterised into clay, clay-loam, loam, sandy-loam, loamy-sand, sand and sandy-clay according to the method of Leamy and Panton (1966). The soil was analysed for percentage of water, percentage of organic matter, ppm. nitrate, phosphate, calcium, ammonium nitrite, magnesium, iron, aluminium, sulphate, chloride, potassium and carbonate using the methods of Jackson, 1958 and those of the Edwards Laboratory, Ohio. pH was determined by use of a pH meter on soil paste. Colour was determined using standard Munsell Colour Charts to give hue, colour value and chroma on both wet and dry soils.

Results

1. *Soil type*

The soil type characterised according to Leamy and Panton (1966) in different habitats is seen in Table I. Surface soil consisted predominately of clay (24%) or clay loam (39%). Sandy loam and loamy sand amounted to 10% and 13% respectively. Sands (6%), sandy clays (2%) and loams (6%) are rare. Forest soil is usually clay loam (66.7%) but clays and loams occur. Alluvial soil is usually clay (57.2%) with some occurrence of clay loam, loam and sandy loam. Exposed subsoil (B-layer) is usually clay or clay loam with rare occurrence of loamy sand and sand. Grassland may be found on all types of soil. Scrubland (belukar) occurs on all except sand and sandy clay. Estate soil (rubber, banana, rambutans etc.) included no example of clay or sandy clay; while disturbed soil (dumps etc.) may be found on clay, clay loam or sandy loam.

Note. In the tables the following abbreviations are used for different habitats: —

F = forest soil; A = alluvial soil; E = exposed sub-soil (B-layer);

G = grassland; S = scrubland (belukar); C = cultivated soil;

Est. = estate soil; D = disturbed soil (city dumps etc.).

Samples were collected in the Jurong, Bukit Panjang, Serangoon and Katong districts of Singapore.

TABLE 1

Percentage samples with different types of soil

———	F	A	E	G	S	C	Est.	D	Total
CLAY	16.7	57.2	35.4	25.2	10	33.3	..	16.7	24
CLAY-LOAM	41.7	14.3	47.2	43.0	40	22.1	9.1	66.7	39
LOAM	41.7	14.3	..	2.9	10	11.1	9.1	..	6
SANDY-LOAM ..	..	14.3	..	2.9	30	11.1	27.3	16.7	10
LOAMY-SAND ..	..	..	5.9	17.4	10	11.1	36.3	..	13
SAND	..	..	11.8	2.9	..	11.1	18.2	..	6
SANDY-CLAY ..	..	..	..	5.8	..	..	..	..	2

2. *Soil Analysis*

The percentage water in air-dried soil, percentage organic matter; and nitrate, phosphate, calcium, ammonium, nitrite, magnesium, iron, aluminium, sulphate, chloride and potassium in ppm. are given in Table 2. No soluble manganese was detected by the methods used. The percentage of soils containing carbonate is given in Table 3.

The water holding capacity of dry soil is closely correlated with the organic content being high in forest soils and alluvial soils but low in all other soils. Nitrate and calcium levels were normally at moderate to moderately low levels especially in alluvial or cultivated soils but all other ions were at extremely low levels. The values for phosphate, sulphate and potassium are critically low in most soils.

Most soils are acid, forest soils having an average pH of 3.83 with the pH somewhat higher in other types of soil especially in disturbed soil where an average pH of 6.45 was observed. This is correlated with the higher levels of potassium, calcium and carbonate in this type of soil.

Carbonate was detected in only 17% of the samples. It is completely absent from alluvial and estate soil, but occurrs in 83.3% of disturbed soil (dumps etc.). There are no calcareous rocks on Singapore Island.

TABLE 2

Soil Analysis. Mean values for different soils

———	F	A	E	G	S	C	Est.	D	Total
% water (dry soil)	6.29	10.81	1.47	1.54	2.33	1.92	1.09	1.45	2.53
% organic matter	18.09	12.62	4.95	7.66	6.29	7.17	5.19	6.47	7.18
NO_3 (ppm.)	8.6	14.16	6.00	9.56	11.00	21.11	13.60	17.50	10.04
PO_4	0.16	1.08	0.23	0.56	0.70	1.33	1.50	0.33	0.66
Ca	10.00	11.66	14.12	14.37	8.00	13.30	12.70	13.30	13.09
NH_4	2.33	0.67	0.70	1.87	2.40	3.50	3.60	2.33	1.95
pH	3.83	4.88	4.95	5.80	5.00	5.67	5.40	6.45	5.26
NO_2	0.50	..	..	0.66	..	0.11	0.09	0.17	0.08
Mg	0.66	4.83	1.88	2.31	1.80	2.66	3.70	3.00	2.41
Fe^{++}	1.66	1.00	1.65	0.65	0.80	0.89	1.80	0.33	1.02
Al	..	..	..	0.17	0.40	..	..	1.33	0.18
Mn	..	..	..	..	..	..	..	..	..
SO_4	..	6.67	3.53	2.35	..	..	3.60	6.66	2.41
Cl	..	3.33	1.76	0.03	..	0.11	1.80	0.83	0.86
K	..	..	..	..	1.50	1.67	..	5.00	0.60
Colour value (dry)	5.0	5.3	6.7	6.0	5.9	5.9	6.1	6.3	5.9
(wet)	3.3	4.0	4.7	4.2	4.3	4.2	4.6	4.0	4.2
Chroma (dry)	2.8	4.3	4.9	3.6	3.6	3.0	3.0	3.1	3.5
(wet)	2.3	1.2	4.7	4.0	3.2	2.7	3.5	4.1	3.2

TABLE 3

Percentage Samples Containing Carbonate

———	F	A	E	G	S	C	Est.	D	Total
+ CO_3	16.7	..	11.8	9.4	30	33.3	..	83.3	17
− CO_3	83.3	100	88.2	90.6	70	66.7	100	16.7	83

3. *Soil Colour*

The colour values in Table 2 reflect the somewhat lower values of alluvial and forest soil, and the relatively higher values for exposed and estate soil. The chroma is lowest in forest soils. The hue of wet soils all occurred on the YR colour range of the Munsell colour charts (Table 4). In spite of the uniformity of hue with 60% of the soils in the 10 YR range, Singapore soils are very variable in colour (Table 5).

TABLE 4

Distribution of hue in 100 samples (wet soil)

Hue	F	A	E	G	S	C	Est.	D	Total
10 YR	6	5	4	24	4	6	8	3	60
5 YR	0	1	5	3	4	0	3	3	19
5 YR	0	1	3	6	2	1	0	0	13
2.5 YR	0	0	5	1	0	2	0	0	8
									100

TABLE 5

Number of soils with different surface colour (Standard Munsell terminology-wet soil)

—	F	A	E	G	S	C	Est.	D	Total
Strong brown			2	1				2	5
Dark brown	1		1	2		2	3	2	11
Brown	1	1	1	6	2	1	2	1	15
Pale brown					1	1			2
Very pale brown							1		1
Very dark greyish brown	3			4	1				8
Dark greyish brown	1	1		1	3			1	7
Greyish brown			1	2		1			4
Dark Reddish brown	1								1
Reddish brown				4	2	1			7
Light reddish brown		2							2
Dark yellowish brown	1								1
Yellowish brown		1	2			1			4
Pale yellowish brown			1		1				2
Black			2						2
Very dark grey	2						2		4
Dark grey	1	1			1				3
Red		4	1						5
Yellowish red		2	3		1				6
Pink		1							1
Reddish yellow		1	2	1					4
Brownish yellow			3			1			4
Light yellowish brown						1			1
									100

4. *Soil Algae*

(*a*) *constancy of occurrence.* The appearance of algae in sterile culture indicates the presence of these algae, at least as resting spores, in the soil. As has been reported frequently, the frequency of algal species in culture does not necessarily reflect their frequency in the soil since the conditions of culture may favour some species more than others. Although frequency estimates of growth in culture were made, these were considered to have no direct relationship with the actual frequency in the soil and these results are not reported here. The *constancy* rather than the frequency of occurrence of algal species was considered to be of greater significance since it gives a measure of the number of soil samples in which the algal species occurs.

80 species of algae were recorded in the cultures and they were distributed with constancies shown in Table 6. The soil examined show a great diversity of algal flora with very few constant species. The typical J-shaped curve of constancy/ no. of species is common in tropical floras (Johnson, 1966).

TABLE 6

Contancy and number of species

(Constancy = no. of samples; total no. of samples = 100)

Constancy ..	85	29	19	17	7	6	5	4	3	2	1
No. of species ..	1	1	1	1	5	1	1	5	7	14	43

Total no. of species = 80

Table 7 gives the habitat occurrence of species with a constancy of more than 5% (only 11 species have a constancy of more than 5%). Although the list includes 5 species of blue-green algae (with asterisk) none of these are capable of fixing nitrogen under aerobic conditions.

TABLE 7

Number of Occurances of Algal species with a constancy of more than 5%

———	F	A	E	G	S	C	Est.	D	Total
DESMOCOCCUS VULGARIS Brand.	5	5	15	30	7	8	10	5	85
PALMELLA MINATA Näg. ..	2	1	7	10	3	2	4	..	29
HORMIDIUM FLACCIDUM (Kütz.) Br.	0	1	2	13	0	1	1	1	19
*OSCILLATORIA JASORVENIS Vouk.	0	2	0	11	3	0	0	1	17
*OSCILLATORIA OBSCURA Brühl. et Biswas ..	0	0	1	1	0	3	1	1	7

TABLE 7 — *continued.*

Number of Occurances of Algal species with a constancy of more than 5%

———	F	A	E	G	S	C	Est.	D	Total
*SYNECHOCOCCUS AERUGINOSUS Näg.	0	0	4	2	0	1	0	0	7
TROCHISCIA ASPERA (Reinsch) Hansg.	1	0	0	1	2	1	1	1	7
PINNULARIA sp. . .	0	2	0	3	0	0	2	0	7
NAVICULA sp.	0	0	2	1	0	1	1	2	7
*CHROOCOCCUS MINUTUS (Kütz.) Näg. . .	0	2	2	0	0	0	2	0	6
*CHROOCOCCUS TURGIDUS (Kütz.) Näg. . .	0	0	1	3	1	0	0	0	5

(*b*) *Blue-green algae.* As in other tropical soils, blue-green algae (Cyanophyceae) form a conspicuous part of the algal flora. In this investigation 41 species of blue-green algae are reported from Singapore soils. These may be divided into the non-heterocystous algae which do not normally fix nitrogen under aerobic conditions, and the heterocystous algae which are capable of nitrogen fixation.

Of the 26 species of non-heterocystous blue-green algae (Table 8) none are found in forest and only 3 in estates. They are characteristic of open areas such as exposed sub-soil, grassland and scrubland where the light-intensity is high.

TABLE 8

Number of Occurrences of non-heterocystous blue-green algae

———	F	A	E	G	S	C	Est.	D	Total
CHROOCOCCUS MINUTUS (Kütz.) Näg. . .		2	2				2		6
C. TURGIDUS (Kütz.) Näg. . .		1	3	1					5
C. SCHIZODERMATICUS West				1					1
CHROOCOCCUS sp. . .			1		1				2
MICROCYSTIS AERUGINOSA Kütz.			1			1			2
CHAMAESIPHON FUCUS (Restaf.) Hangs. . .			1						1
OSCILLATORIA JASORVENSIS Vouk.		2		11	3			1	17

TABLE 8 — *continued.*

Number of Occurrences of non-heterocystous blue-green algae

———	F	A	E	G	S	C	Est.	D	Total
O. OBSCURA Brühl. et Biswas			1	1		3	1	1	7
O. ANNAEA Van Goor ..		1	1			2			4
O. CHALYBYA (Mertens) Gom.			1	3					4
O. FREMYI De Toni ..					2	1			3
O. MINIATA (Zanard) Hauck		1		1		1			3
O. TEREBRIFORMIS Ag. ..				1			1		2
O. CHLORINA Kütz. ..					1	1			2
O. OKENI Ag.		1			1				2
O. LIMOSA Ag.		1	1						2
O. SUBTILLISSIMA Kütz. ..				1					1
O. GEITLERIANA Elenkin. ..				1					1
SYNECHOCOCCUS AERUGINOSUS Näg.			4	2		1			7
ARTHROSPIRA TENUIS Stikenb.			1		1				2
SPIRULINA LABYRTHIFORMIS (Menegh.) Gom. ..		1							1
PHORMIDIUM TRUNICOLA Ghose			1						1
PH. SUBINCRUSTATUM Fritsch and Rich			1						1
LYNGBYA POLYSIPHONAE Frémy					1				1
L. BIRGEI Smith			1						1
TOTAL NO. OF SPECIES	0	7	15	10	9	7	3	2	26

Table 9 shows the occurrence of 16 heterocystous blue-green algae which are capable of nitrogen-fixation. They occur in just over a quarter of the soil samples. None are found in forest soil but at least one species of nitrogen-fixing algae has been found in all other types of habitat. Their occurrence is sporadic in these habitats and nearly three quarters of the samples showed no evidence of the presence of nitrogen-fixing algae.

TABLE 9

The Occurrence of heterocystous blue-green algae

———	F	A	E	G	S	C	Est.	D	Total
ANABAENA FERTILISSIMA Rao		1				1	1		3
ANABAENA SPIROIDES Kleb. ..		1						1	2
ANABAENA FUELLEBORNII Schmidle		1							1
ANABAENA ORYZAEA Fritsch				1					1
ANABAENA ANOMALA Fritsch					1				1
ANABAENA sp.				1					1
NOSTOC MICROSCOPICUM Carm.							1		1
N. MUSCORUM Ag. ..				1					1
N. PUNCTIFORME (Kütz.) Hariot				1					1
TOLYPOTHRIX PHYLLOPHILA West			1					1	2
SCYTONEMA HOFMANNI Ag.						1			1
CYLINDROSPERMUM SPHAERICA Prasad								1	1
AULOSIRA AERIGMATICA Frémy			1						1
HAPALOSIPHON WELWITSCHII West				1					1
NOSTOCOPSIS RADIANS Bharadn.				1					1
WESTIELLOPSIS PROLIFICA Janet				2		1			3
TOTAL NO. OF SPECIES	0	3	2	7	1	3	2	3	16

(*c*) *Green algae*. The occurrence of green algae (Chlorophyceae, Xanthophyceae, Euglenophyceae) is seen in Table 10. The highly constant species *Desmococcus vulgaris, Palmella miniata* and *Hormidiun flaccidum* are widely distributed, but most of the 31 species are very sporadically distributed and include some species as *Gonium pectorale* and *Euglena elongata* which are characteristic of freshwater habitats.

TABLE 10

(Cholorphyceae, Xanthophyceae and Euglenophyceae).

——	F	A	E	G	S	C	Est.	D	Total
Desmococcus vulgaris Brand.	5	5	15	30	7	8	10	5	85
Palmella miniata Näg.	2	1	7	10	3	2	4	..	29
Hormidium flaccidum (Kütz.) Br.	..	1	2	13	..	1	1	1	19
Trochiscia aspera (Reinsch) Hansg.	1	..	..	1	2	1	1	1	7
Muriella terrestris Petersen	..	..	..	4	..	..	..	..	4
Euglena elongata Schewiakoff	..	..	1	..	..	1	1	..	3
Chlamydomonas sp.	..	..	1	..	..	1	1	..	3
Scenedosmus flexusos (Lemm.) Ahlstrom	..	..	..	3	..	..	..	..	3
Cylindrocystis sp.	..	..	3	1	..	..	..	..	4
Bumilliera exilis Kleb	..	1	1	..	..	..	2	..	4
Spongiochloris spongiosa (Vischer) Starr	..	..	1	1	..	..	..	..	2
Microspora sp.	1	..	..	..	1	..	..	..	2
Gonium pectorale Müll	..	..	..	1	..	..	..	..	1
Oedocladium sp.	..	..	..	..	..	..	1	..	1
Euastrum torum	..	..	..	1	..	..	..	..	1
Binuclearia tectorum (Kütz.) Beger	..	..	..	1	..	..	..	..	1
Leptosiropsis torulosa Jao	..	..	..	..	..	..	..	1	1
Dictyochloris fragrans Vischer	..	..	..	..	1	..	..	..	1
Zygogonium sp.	..	..	..	1	..	..	..	..	1
Trentepohlin aurea (L.) Mart.	..	..	..	1	..	..	..	..	1
Stigeoclonium sp.	..	..	..	1	..	..	..	..	1
Ankistrodesmus falcatus (Corda) Ralfs	..	..	..	1	..	..	..	..	1

Table 10 — *continued*

(Cholorphyceae, Xanthophyceae and Euglenophyceae)

———	F	A	E	G	S	C	Est.	D	Total
Cedercureutziella savonensis Vischer	..	1	..	..	..	..	..	..	1
Dactylococcus infusionum Näg.	..	..	1	..	..	..	..	..	1
Macrochloris dissecta Korch.	..	..	..	..	..	1	..	..	1
Penium sp.	..	..	..	..	..	..	1	..	1
Scenedesmus obliqus (Turp.) Kütz.	..	1	..	..	..	..	..	..	1
Asterosiphon terrestre Dangeard	..	1	..	..	..	..	..	..	1
Pleurastrum insigne Chad.	..	1	..	..	..	..	..	..	1
Scenedesmus falcatus Chad.	..	1	..	..	..	..	..	..	1
Closteriopsis sp.	..	1	..	..	..	..	..	..	1
No. of species	4	10	9	15	5	7	9	4	31

(*d*) *Diatoms.* Diatoms are surprisingly rare in Singapore soils. Owing to the absence of a definite taxonomic work on terrestrial diatoms of this area, they were difficult to identify. Nevertheless their rarity is evident from Table 11.

Table 11

Number of Occurrences of diatoms

———	F	A	E	G	S	C	Est.	D	Total
Pinnularia sp.		2		3			2		7
Navicula sp.			2	1		1	1	2	7
Navicula pygmea Kutz.	1								1
Navicula confervacea Kütz.			1						1
Navicula hudstedtii Krasske		2							2
Gomphonema sp.		1							1
Frustulia sp.			1						1
Total no. of species	1	3	3	3	0	1	2	1	7

(*e*) *Diversity of algal flora.* Table 12 shows the occurrence of different kinds of algae in the different habitats. Tree communities tend to lack diversity in algal flora. In forest only 4 species are present, none of which is blue-green. Scrubland and disturbed land have 15 and 16 species respectively. Algal flora is best developed in exposed sub-soil (29 species) and grassland (35 species). As mentioned above nitrogen fixing blue-green algae may occur in all kinds of habitat except forest.

TABLE 12

Summary Table for number of species of different groups of algae

———	F	A	E	G	S	C	Est.	D	Total
Non-heterocystous blue-greens	0	7	15	10	9	7	3	2	26
Heterocystous blue-greens ..	0	3	2	7	1	3	2	3	16
Green algae	4	10	9	15	5	7	9	4	31
Diatoms	1	3	3	3	0	1	2	1	7
Total no. of species ..	5	23	29	35	15	18	16	10	80

Discussion

Although 80 species of algae have been found in the soil of Singapore Island in this investigation, most of these show low constancy of occurrence in the Island as a whole or in an individual type of habitat. The phenomenon of a large diversity of species distributed with low frequency is familiar amongst tropical organisms and occurs amongst such diverse groups as lowland tropical forest angiosperms, beetles (Wallace, 1969) and tropical fish.

When the natural vegetation is completely cleared and the top soil removed by man or erosion, an exposed sub-soil is devoid of any type of higher plant vegetation. This is subject to excessive leaching by torrential rain, strong isolation from the tropical sun and considerable temperature fluctuation day and night (Hill, 1966). Despite these severe conditions 29 species of soil algae were found some of which may act as first colonisers of the bare ground before the establishment of a higher plant flora. Non-heterocystous blue-green algae predominate in this habitat.

When colonisation by higher plants commences, grassland becomes established. The soil surface becomes protected from excessive leaching and there is an increase in available ions for plant growth (Table 2.) Light intensity is still high but there is less fluctuation in temperature day and night. 35 species of soil algae were found including 7 species of heterocystous blue-green and 15 species of green algae.

Grassland progressively develops into scrubland (belukar) with colonisation by woody species such as *Adinandra dumosa* Jack and *Melastoma malabathricum* Linn. These species increase the shading of the ground layer. The light intensity decreases and there is an increase in available nitrate. The algal flora loses some of its diversity and only 1 species of heterocystous blue-green algae was found.

In the undisturbed forest the organic matter content is high but most cations and anions remain low, since the ionic reserve in tropical forest is directly absorbed by the shallow feeding roots of the trees and does not persist in the soil (Jackson, 1968). The light intensity is very low being only about 0.1% of the illumination outside the forest (Johnson, 1970). No blue-green algae are found here and there are only four species of green algae and one diatom.

Cultivated soil in Singapore has been subjected to various manures and organic fertilisers and usually has a relatively high nitrate level. The algal flora is limited but heterocystous blue-green algae can occur. Estates are also subject to disturbance by man. Since these are predominately tree crops (e.g. rubber, banana, coconut, rambutans, durian, citrus etc.), the light intensity is usually lower than in cultivated soil; but, since such estates are quite open, about 10% light penetrates. The algal flora is limited but less so than in undisturbed forest.

Disturbed soil has been subject to all kinds of dumping and building operations by man, including industrial pollution and general devastation. The occurrence of such areas near a city of over two million population is to be expected. Chemical analysis of the soil gives very erratic results often with high figures for one or more ions. Ten species of algae were found in this kind of habitat.

Summary

The surface soil was collected in 100 localities in the rural area of Singapore. The samples were cultured by liquid and plate culture to determine the algae occurring, and the soil was subjected to physical and chemical analysis.

The surface soil consisted predominately of clay and clay-loam, with some sandy loam and loamy sand, other types of soil being rare. The water-holding capacity of dry soil is closely correlated with organic content being high in forest and alluvial soils but low in all other types of soil. Nitrate level was normally at moderate to moderately low levels, but the values for phosphate, sulphate and potassium are critically low in most soils. Most soils are acid, forest soils having an average pH of 3.83 with pH somewhat higher in other types of soil. Carbonate was detected in only 17% of the samples. Although the soils were somewhat uniform in hue with 60% soils in the 10YR range, they were very variable in colour.

80 species of soil algae were found in the soil. Tree communities lack diversity in algal flora, which was best developed in exposed subsoil and grassland. Most species show low constancy of occurrence in the Island as a whole or in individual habitats.

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Pollination in Dioecious Figs

Pollination of *Ficus fistulosa* by *Ceratosolen hewitti*

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ABSTRACT

Pollination in the dioecious fig *Ficus fistulosa* was studied in Singapore. The pollinator, *Ceratosolen hewitti* (Agaonidae), possesses closed thoracic pockets and coxal combs. Pocket filling with pollen from detached anthers previously cut by the male wasps occurs in the almost ripe male figs. Pollen is lifted from the anther to the underside of the thorax by means of the arolia of the fore legs and then shoveled backwards into the pockets by the combs. In the male figs, pollination of the stigmata occurs at the end of oviposition prior to the withdrawal of the ovipositor. Pollen is taken directly from the pockets by the fore-legs and is carried downwards onto the stigmata. The behaviour of the female wasps in the female syconia is very similar except that the oviposition act does not culminate with actual egg-laying. The significance of pollination in short-styled, gall-producing flowers and of ovipositor insertion into the styles of long-styled, seed-producing flowers is discussed.

Introduction

It is known that the symbiotic wasps (Agaonidae, Chalcidoldea) which serve as pollen vectors in the genus *Ficus* carry out in the figs two types of activities namely, pollination of the long-styled flowers and oviposition into the pistils of the short-styled ones. Hence, the former produce seeds whereas the ovaries of the latter develop into galls and give rise to the next generation of wasps. Both activities are indispensable for the existence of fig symbiosis. There is no evidence of the presence of apomixis in *Ficus* so that pollination, too, appears to be essential for seed production. The question arises as to the occurrence of pollination in the short-styled flowers and oviposition into the long-styled ones.

In the common fig (*F. carica* L.), the most extensively studied *Ficus* sp. (Grandi, 1929), the situation is comparatively simple. Here, pollen is passively carried on the body of the female wasp *Blastophaga psenes* L. from one fig to another so that pollination of both long- and short-styled flowers takes place indiscriminately; on the other hand, the long styles, which so markedly differ in structure from the short styles, do not appear to be suitable for oviposition.

The situation is not always as simple in other *Ficus* spp. There is considerable variation in structure and behaviour of the pollinators of different species of *Ficus*, in spite of an overall resemblance. Unique organs used by various spp. of wasps as containers for transporting pollen from male figs (phase D*) to young receptive female figs (phase B*) were recently discovered (Ramirez, 1969; Galil and

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* According to Galil and Eisikowitch (1968) the developmental phases of figs were named as follows:

Phase A (Pre-female): Young syconium prior to the opening of the ostiole.
Phase B (Female): Ostiolar scales loosen, female flowers ripen, sycophilous wasps penetrate into the syconium and oviposit into the ovaries.
Phase C (Interfloral): Wasp larvae and fig embryos develop within their respective ovaries. Ovaries occupied by the larvae are transformed into galls.
Phase D (Male): Male flowers mature, wasps reach the imago stage, fertilized female wasps leave syconia via channels bored by the males.
Phase E (Post-floral): Both syconia and the seeds inside them ripen.

Eisikowitch 1969; Galil and Snitzer-Pasternak, 1970; Galil et al., 1974). In these figs, the pollination process consists of "deliberate" loading of the containers and, upon entering the young figs, extracting the pollen and pollinating the female flowers. Actual pollination takes place at the end of the oviposition act, before the wasp withdraws her ovipositor from the pistil. Hitherto, pollination by wasps with specialized pollen containers was exclusively studied in monoecious figs that contain both long- and short-styled female flowers (the so-called seed- and gall-flowers, respectively) in the same syconium. Because of the dense packing of the flowers within such figs, it is very difficult to observe the behaviour of the wasps in regard to the different flower types. Nevertheless, there is some information available. Johri and Konar (1956) discovered fig embryos up to the octant stage in the short-styled ovaries of *F. religiosa* L. This is clear evidence of fertile pollination of the short styled flowers. "Seed figs" in which both long- and short-styled flowers bear normal seeds that are occasionally found in various species (Galil and Eisikowitch, 1971), provide further evidence of normal pollination in both types of flowers. On the other hand, the blackening of the upper part of the style in long-styled flowers of *F. religiosa,* observed by the same authors, indicates that the wasps insert their ovipositors into such pistils as well.

Direct observations of the behaviour of the wasps in long- and short-styled flowers in regard to pollination and oviposition were hitherto carried out only in the monoecious figs of *F. sycomorus* L. (Galil and Eisikowitch, 19769). However, since the two flower types in that species are very similar and cannot be distinguished from the above without destroying the fig, only a few sporadic observations could be made.

Dioecious fig species, in which long- and short-styled female flowers develop in different syconia, lend themselves more easily to detailed observations on wasp behaviour with regard to the two flower types. For such observation *Ficus* spp. whose pollinators are equipped with specialized pollen containers which are actively loaded and emptied must be chosen.

The dioecious figs of *F. fistulosa* Reinw. ex Bl. (Fig. 5) which belong to the *Sycocarpus* section of subgenus *Ficus* and are pollinated by *Ceratosolen hewitti* Waterston, possessing thoracic pockets for pollen transport, prove suitable for the present study.

Materials and Methods

The study was carried out in June-July, 1971 in Singapore. The chief object, *F. fistulosa,* is a small tree, 3 to 4 m. high, that grows abundantly along road edges in the suburbs of the town and on the borders of the jungle.

Generally, the study of pollination in dioecious figs is more complicated than in monoecious species since it is necessary to find wasp-releasing D-phase male figs and receptive B-phase figs of both sexes simultaneously in the same vicinity. The month of June proved to be very suitable since it is a period of overlapping of the two main crops of figs in *F. fistulosa.* Hence, all of the required developmental phases of the figs were available (for Hong Kong, see also Hill, 1967). During the study, no ripening female figs were found, but these were not indispensable for carrying out the necessary observations.

The cauliflorous figs of *F. fistulosa* develop in great numbers, provide abundant and easily accessible material. The timing of observations was adjusted to the activities of the wasps in the male and female phases of the fig. Hence, the observations on pocket filling were carried out in the early morning, between 3 and 5 a.m.

For observing the behaviour of the wasps in young figs during oviposition and pollination, B-phase figs, male and female separately, were enclosed in plastic vials covered with insect-proof netting together with wasp-releasing D-phase male figs. The emerging wasps which penetrated the receptive B-phase figs provided good material for observation of wasp behaviour during oviposition and pollination.

Observations

Syconia and pollinators

The figs develop on small lateral shoots on the trunks and branches (Fig. 6). The receptive (phase B) figs of both sexes are pear-shaped with a short neck and are borne on distinct peduncles that are up to 25 mm long (Fig. 7). The male figs are somewhat larger than female figs, 14 x 16 mm as compared to 11 x 13 mm. The ostiole is depressed and is sealed by imbricate scales. The structural features of the fig are especially prominent when bisected figs are viewed from the inner side (Figs. 8, 9). The different components have different colours: the ostiolar scales are orange and the pale stigmata stand out on the background of crimson ovaries. The internal cavity of the fig is wide and distinct.

The male figs contain a large number of short-styled female flowers ("gall flowers") covering almost the entire inner surface of the fig and 30 to 35 ostiolar male flowers arranged in one to two rows (Fig. 8). The male flowers are relatively prominent and easily discernable, but are still closed and unripe. The "gall flowers" are almost hidden within the fused perianth lobes (Fig. 1, II). The short (about 0.3 mm) and relatively thick style and the funnel-shaped stigma at its end project out of the perianth. The broad and dense stigmata form a continuous surface around the fig cavity but do not coalesce into a single "synstigma".

The long-styled female flowers ("seed flowers") which cover the entire inner surface of the female figs are quite different from the short-styled ones. The perianth is much reduced thus forming a narrow ring at the base of the ovary (Fig. 1, III). Consequently, the pistils are naked and visible for their entire length in bisected figs. The ovary is smaller and the style is narrower and much longer (about 1 mm) than their counterparts in the short-styled flowers. The stigma is cylindrical, thick and long (0.16 x 0.3 mm).

At the wasp-releasing stage (phase D), the male figs are almost globose (Fig. 10), somewhat broader than high (20 x 25 mm). The holes in the empty gall-ovaries from which the wasps have already emerged have rounded lids which are shifted to the side (Fig. 12).

Upon ripening of the male flowers, the filament of the single stamen elongates so that the anther is pushed through the top of the fused perianth (Fig. 1, I). At this stage, the males of the pollinating wasps approach the male flowers and cut off some of the anthers causing them to be scattered within the cavity of the fig. Thus, the emerging female wasps encounter cut anthers in addition to the intact stamens remaining *in situ* around the ostiole (Fig. 11). At the end of phase D, a large hole is cut through the scales in the centre of the ostiole by the male wasps (Fig. 12). The pollen loaded females emerge from the fig through this hole.

After the liberation of the wasps, the fig grows rapidly, and at ripening (Phase E) it reaches about 30 mm in diameter. It becomes yellowish and attains a characteristic smell which is typical for bat-dispersed fruit.

As noted above, no ripe female figs of *F. fistulosa* were found throughout the period of the present study. Hill (1967) states that the ripe female figs are somewhat smaller than the male figs, but are more succulent and their yellow colour is more pronounced.

The pollinator, *Ceratosolen hewitti* Waterston (Wiebes, 1963, 1966; Grandi, 1963) is a small agaonid wasp about 1.5 mm long (Fig. 2). Only those characteristics of the female wasp that pertain to pollination will be described below.

Of the two types of specific pollen containers hitherto described in pollinators of *Ficus*, namely "coxal corbiculae" and "thoracic pockets" (Ramirez, 1969; Galil et al., 1974), the female of *C. hewitti* possesses the latter only. In whole mounts of the ventrum of the body, the pockets appear on both sides of the mesothorax as triangular depressions that are entirely covered by continuous flaps (Fig. 3). Generally, the structure of the pockets is quite similar to that of the corresponding organs described in *C. arabicus* Mayr, the pollinator of *F. sycomorus* L. in East Africa (Galil and Eisikowitch, 1969). It appears that the pockets open and close along their inner suture facing the median axis of the body through changing in the position of the covering flaps.

Coxal corbiculae such as described by Ramirez (1969) and Galil et al. (1974) were not found on the fore coxae of *C. hewitti*. There are no depressions along the coxae; only the comb, namely the row of stiff bristles which usually fringe the depression on its inner side, is found here. In *C. hewitti*, the comb is a distinct organ formed from a straight row of about 18.38μ-long bristles (Fig. 4).

The length of the ovipositor of the pollinating wasp is of decisive importance in fig symbiosis. As seen from the side, the ovipositor of *C. hewitti* scarcely projects beyond the apex of the body. In fact, the ovipositor is not short but arises at some distance forwards, on the under side of the abdomen. Its real length may be seen during egg-laying when its shaft is released from the protecting valves and is directed towards the stigmata.

Pocket loading

Detailed observations of the filling of pockets of *C. hewitti* in D-phase male figs of *F. fistulosa* are not easy. Figs with ostiolar male flowers are usually suitable for such observations. However, in *F. fistulosa* the situation becomes more complicated because of the early emergence of the female wasps from their galls and the filling of the pockets prior to the tunnelling of the syconial wall by the male-wasps. For successful observation of pocket loading, the figs must be cut and studied during a comparatively short lapse of time when the anthers are still attached but sufficiently ripe, and the fertilized females have not yet left their galls.

When the figs are cut at the appropriate time, the female wasps become active, emerge from the galls, approach the male flowers and start filling their pockets from the anthers which protrude out of the floral perianth.

Lifting of the pollen from the anthers to the side of the thorax is accomplished by rapid alternating movements of the forelegs. Similar movements were observed in the pollinators of monoecious figs previously studied. Clumps of pollen are

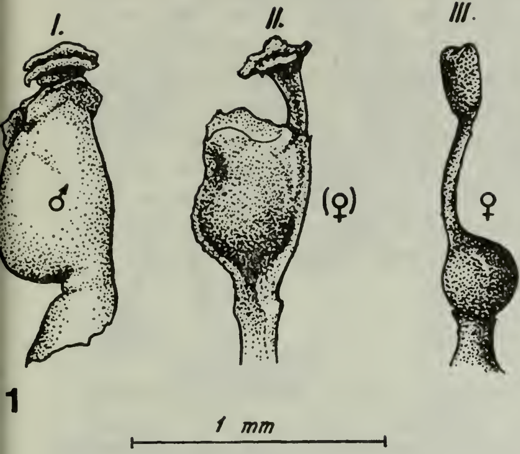

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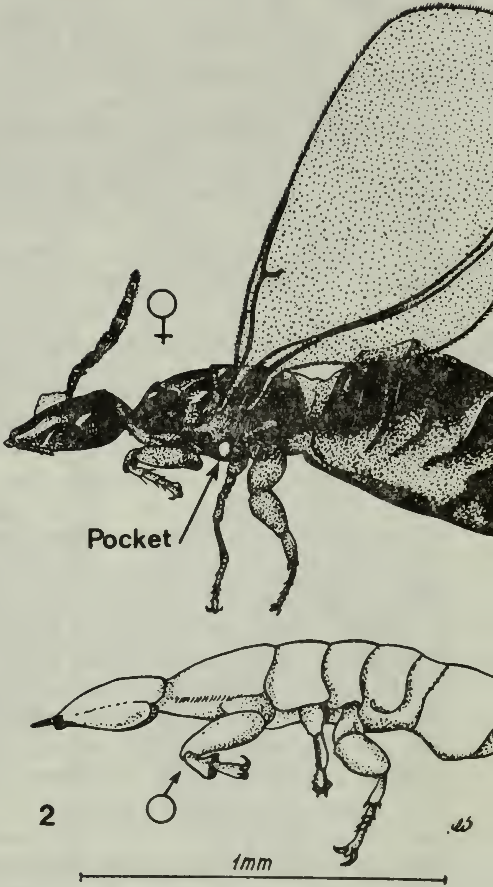
Fig. 1. *Ficus fistulosa,* flowers: I — male flower; II — short-styled female flower (♀); III — long-styled female flower ♀.

Fig. 2 *Ceratosolen hewitti* (♀ and ♂).

Fig. 3. Mesothorax of *Ceratosolen hewitti* (from below) showing pollen pockets.

Fig. 4. Fore leg of *Ceratosolen hewitti,* with comb.



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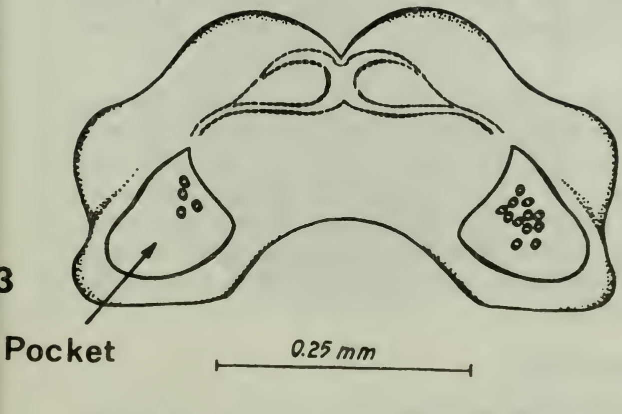

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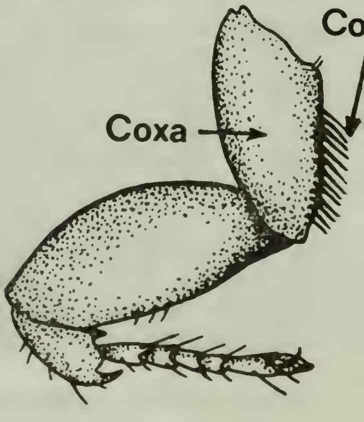

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placed between the body wall and the fore coxae which move up and down when the pollen is lifted by the bending legs. Shovelling movements of the fore coxae and combs by which the pollen is brushed backwards from the underside of the thorax to the thoracic pockets occur after each sequence of pollen liftings. The coxal comb is clearly a unique organ and even in the absence of the coxal depression ("corbicula"), it has a particular role in pocket filling. The shovelling movements are rapid but can be clearly seen. The role of the combs in the brushing of the pollen is evident from the pollen grains which are found on the bristles. When the quantity of pollen in the anther does not suffice for the filling of the pockets, the wasp moves to a second anther and begins a new series of liftings and shovelling movements.

Pocket emptying: pollination in male figs

The observations on the behaviour of the female wasps during oviposition and pollination were especially successful in the early morning when B-phase receptive figs were enclosed in plastic vials together with wasp-releasing D-phase male figs. As in the monoecious *Ficus* spp. previously studied (Galil and Eisikowitch, 1969; Galil et al., 1974), the impregnated and pollen-carrying female wasp starts to oviposit and to pollinate the stigmata immediately after its entrance into the receptive fig. In *C. hewitti,* as usual in the agaonid wasps, the ovipositor shaft is released from the protecting valves at the beginning of oviposition act and is supported and guided to the stigmata by the sternites that fold lengthwise to form a triangular, gutter-shaped, body. The total length of the ovipositor is about 0.8 mm., i.e. its length is intermediate between that of the styles in long- and short-styled flowers. After several probing movements for an appropriate oviposition site, the ovipositor sinks into one of the funnel-shaped stigmata of the short-styled flowers. It remains in the style only for 15 to 18 seconds which is a very short time compared to the duration of the act in pollinators of other figs previously studied, i.e. about 60 seconds in *C. arabicus,* and 3 to 3.5 minutes in *Blastophaga estherae* Grnd., the pollinator of *F. costaricana* (Liebm.) Miq. (Galil et al., 1974) Almost immediately after the insertion of the ovipositor into the pistil of the flower, the female wasp begins to perform typical pollination movements. The forelegs fold upwards upon themselves one after the other intermittantly, thereby bringing the arolia into contact with the pollen pockets on the under side of the mesothorax.

The pollen grains are taken up by the legs directly from the pockets; in any case, no shovelling of pollen from the pockets by means of the combs of the fore coxae were observed. The pollen-carrying legs open downwards one ofter the other and touch the stigmata beneath. It is apparent that normal pollination of the short-styled flowers takes place systematically at the end of each oviposition act. During oviposition and pollination, the head of the female wasp remains motionless and no biting of the stigmata takes place, as observed in *C. arabicus* (Galil and Eisikowitch, 1969).

Pocket emptying: pollination in female figs

In spite of the distinct differences in the structure of the pistils in the female flowers of the male and female figs, the behaviour of the wasps was almost alike. As in the male figs, the female wasps moved on the surface of the stigmata, inserted the ovipositors into them one by one and performed the characteristic pollination movements at the end of each insertion. The retention of the ovipositor

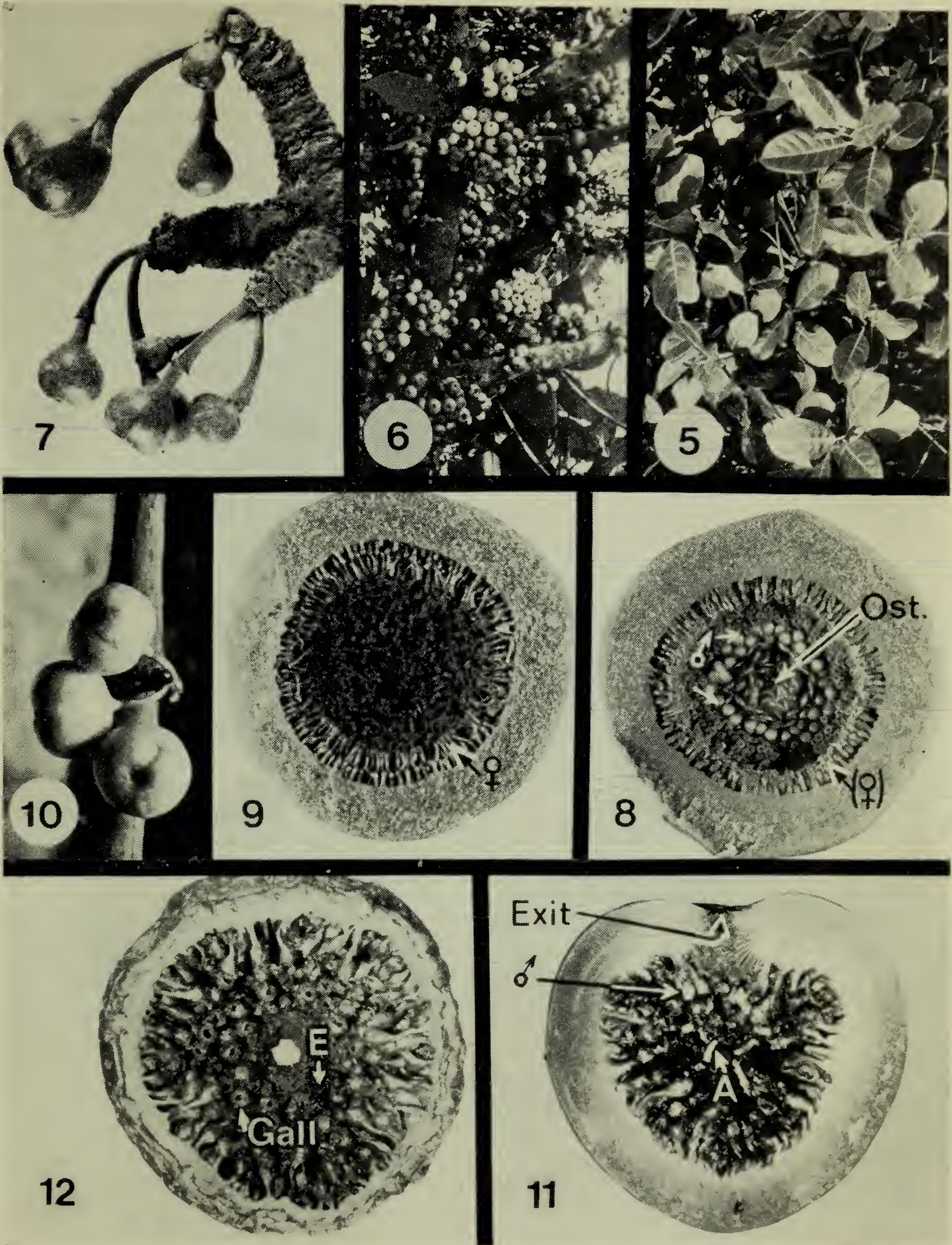

Plate 1.

Figs. 5–12 *Ficus fistulosa*

Fig. 5. Leafy branches. Fig. 6. Fruiting stem. Fig. 7. Short branch with male figs at Phase B. x 0.7. Fig. 8. Cross section through male fig at phase B. (♀) — short-styled female flowers. ♂ — unripe male flowers . x 3.7. Fig. 9. Cross section through female fig at phase B. ♀ — long-styled female flowers. Fig. 10. Male figs at phase D. x 0.6. Fig. 11. Longitudinal section through male fig after release of wasps. ♂ — attached anthers; A — detached anthers; x 2.3. Fig. 12. Cross section through male fig at phase D showing bare area E around ostiole. x 2.3.

within the style was shorter than in the short-styled flowers and lasted barely 8 to 10 seconds. Here also pollen is transferred directly from the thoracic pockets onto the stigmata of the long-styled female flowers by the arolia of the fore legs.

During these observations, several cases of unusual behaviour of the wasps in the female figs were encountered. Exhausted female wasps, which have already completed their usual activities, continued to move their fore legs in vain efforts to extract pollen from the pockets and to deposit it on the stigmata.

In order to observe this phenomenon more closely, pollen loaded female wasps were taped in a supine position on a glass slide and observed through the dissecting microscope immediately after they emerged from the D-phase male figs. Most of the wasps made vain attempts to get off the glass; however, in a few cases, the wasps started to perform the characteristic pollination movements during which they folded the fore legs onto the thorax and inserted the arolia into the widely gaping pollen pockets. Pollen grains could be clearly seen on the arolia. No such movements have hitherto been seen in the pollinators of the monoecious figs in which pollination has been studied.

Discussion

In spite of numerous structural differences between the syconia of dioecious *F. fistulosa* and monoecious *F. sycomorus* (Galil and Eisikowitch, 1969) which belong to different subgenera of *Ficus,* namely subgenus *Ficus* and subgenus *Sycomorus* respectively, the two have several biological features in common. Of particular significance is the relatively small number of male flowers which reflects the efficiency of the pollen vectors in pollen transfer. In both *Ficus* taxa, the pollinating wasps are species of *Ceratosolen* possessing closed thoracic pollen pockets of similar structure and coxal combs without corbiculae, and behave very similarly in relation to the figs. In both species, the male wasps cut the stamens and the females emerge from their galls, fill their pockets with pollen from the detached anthers and gather in the fig cavity before the syconial wall is tunnelled by the males. Also the behaviour of the female wasps during pocket filling and emptying, i.e. pollination, is similar. Such likenesses indicate that physiological conditions within the figs are probably also similar in both cases (Galil et al., 1973).

In *F. fistulosa,* the behaviour of the female wasps in the short- and long-styled female flowers (in different figs!) is almost identical in spite of the structural differences between them. In the two types of flowers, both insertion of the ovipositor into the style and deposition of pollen on the stigmas take place. Essentially, it is the same process although eggs are not likely to be laid within the long-styled pistils. In *F. sycomorus,* serial microtome sections through long-styled pistils in pollinated figs failed to reveal any remnants of *Ceratosolen* ova. The pistils of the long-styled flowers of *F. fistulosa* have not been similarly investigated but there are some indirect indications that here too, no real oviposition takes place. The relatively much shorter time that the ovipositor remains in the long styles is significant. It appears that for effective oviposition, the stimulus which the flower ovary exerts on the tip of the ovipositor is indispensable. Consequently, when the style is too long and the ovary is beyond the reach of the ovipositor, there is no egg-laying.

The behaviour of the wasp in the male and female figs raises two questions which may be of fundamental importance for the understanding of fig biology: 1. What is the biological purpose of pollination of the short-styled pistils which are in any case destined to develop into wasp-galls? and 2. Is there any significance to the futile insertions of the ovipositor into the long-styled pistils? In *F. religiosa*, where the first problem was studied more thoroughly, the selective advantage of pollination of the gall-producing short-styled flowers is evident. In unpollinated short-styled flowers, the biological equilibrium is destroyed because of paucity of food, resulting from the failure of normal endosperm development, causes high mortality in female wasp larvae (Galil and Eisikowitch, 1971). It is likely that in *F. fistulosa* the situation is similar.

As yet, there is no satisfactory answer to the significance of the ovipositor insertion ("stinging") into the pistils of the long-styled flowers. Perhaps the changes caused by wounding of the tissue has some impact on pollen germination or pollen tube growth. It should be borne in mind that attraction of the wasps to the female figs and the activities of the wasps within the female figs are of no apparent immediate advantage to the insect. Identical chemo-attractants, produced by both types of figs, could cause the wasps to mistake the female figs for the male figs, which provide the necessary brooding place for the new generation. Thus, it is also possible that insertion of the ovipositor into the long-styled pistils has nothing to do with the biological processes in the female figs but represents a link in an automatic, instinctive chain of activities, orignally concerned with short-styled flowers in male figs.

It should be noted that a strict coordination between the pollination movements and oviposition in both male and female figs is not always sustained. The numerous pollen-extraction movements observed in dying female wasps and the repeated pollen withdrawals from the pockets observed in taped wasps hint at a possible disruption of such coordination. Consequently, normal intermittent pollination which is regularly interrupted by search for new sites of oviposition and insertions of the ovipositor into the stigmata may be replaced by a continuous act, consisting of mere emptying of the pockets.

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