THE GARDENS' BULLETIN SINGAPORE

Volume XIX

15th October, 1962 —— 10th December, 1962

To be purchased at the Botanic Gardens, Singapore

Published by Authority

PRINTED BY LIM BIAN HAN, ACTING GOVERNMENT PRINTER, SINGAPORE

1963

CONTENTS

CORRIGENDA — Volume 19

p. 280	last line of legend to Plate 13:	*for* Kep 37183 *read* S.A. 0690
p. 281	line 17:	*after* Beluran *add Sarawak:* S.A. 0690, Nanga Mujan, Batang Ai.
p. 309	2nd paragraph, line 3:	*for* Kep 36027 *read* Kep 30627
p. 311	line 10 from bottom:	*for* 17023 *read* 17025

THE

GARDENS' BULLETIN

SINGAPORE

Vol. XIX, Part I 15th October, 1962

CONTENTS

To be purchased at the Botanic Gardens, Singapore
Price $12 (Malayan)

Published by Authority

PRINTED BY LIM BIAN HAN, ACTING GOVERNMENT PRINTER

1962

THE

GARDENS' BULLETIN

SINGAPORE

Vol. XIX, Part I 15th October, 1962

Diatoms of Malayan Freshwaters

By G. A. PROWSE

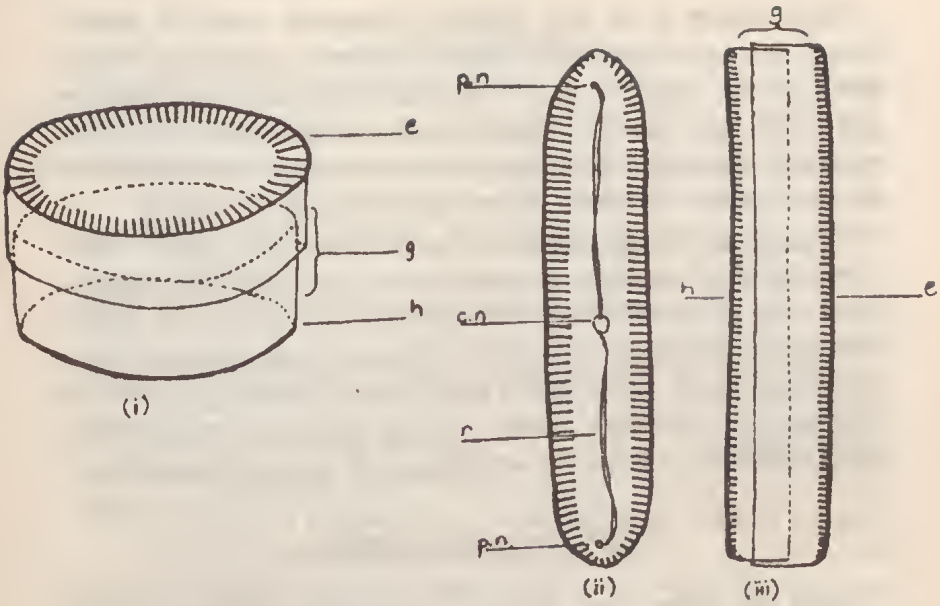
Tropical Fish Culture Research Institute, Batu Berendam, Malacca

DIATOMS or Bacillariophyceae are a class of algae which have probably been studied more thoroughly taxonomically than any other class, but whilst there are extensive accounts of species from Indonesia and other parts of S.E. Asia, little seems to have been published on those species occurring in Malaya itself (I here take as my geographical boundaries the Federation of Malaya and Singapore). Apart from a paper by Ruth Patrick (1936) describing some 73 species and forms from Perak, virtually nothing has been published on Malayan species. This present paper is an attempt to rectify that position, but as it includes only those species which I have seen and drawn myself it can in no way be regarded as a complete account of Malayan freshwater diatoms. Several of the species described by Ruth Patrick are absent from this paper, whilst many others are described which are not mentioned in her paper. A few others which I have seen have been excluded because material has been too scanty and imperfect for accurate identification. A number of species described here are usually regarded as marine forms; whilst it is quite possible that they are of marine origin, they were found in quite non-saline water, fully alive and often dividing, and in some cases occurring together with healthy, dividing specimens of such notorious halophobes as the larger desmids. This fact is not really surprising. Malaya is surrounded by seas which are frequently subjected to torrential rainfall and the coastal waters must become heavy diluted. At times some of the marine organisms must be existing in pockets of almost pure water. Such organisms must be highly adaptable to survive, and if they are carried inland by tidal rivers they might quite easily survive or even multiply in freshwaters inland. Several species of *Coscinodiscus, Stephanodiscus, Cyclotella* and *Nitzschia* fall within this category.

Whilst most species mentioned have been recorded elsewhere, several new taxa are described, but these are forms which have unmistakable characteristics. Some authors may decide others of the forms described should be separated as new taxa, but my own opinion is that the differences from previously described forms are too slight to warrant such separation. Despite the vast amount of work which has been done on the morphology of diatoms, we still know far too little about the physiological development, the genetics and ecology of them. Culture work and statistical studies of morphological forms have shown that in some cases at least so-called varieties are merely nutritional forms, whilst in other cases they have emphasized the differences between closely similar forms. For this reason I have thought it better not to separate off varieties and forms simply on the basis of slight differences in shape and the number of striae.

Since the illustrations in this paper are all original, done under phase contrast with the aid of a camera lucida, any errors or inaccuracies are therefore my own responsibility. Identifications have been carried out with the aid of standard works of A. Cleve-Euler, Hustedt, particularly in "Die Tropischebinnengewasser", De Toni's "Sylloge Algarum" and others, as well as several papers, all of which are quoted in the bibliography. Schmidt's Atlas and Van Heurck's works are not yet available in Malaya, and it has not been possible to refer to them; all identifications have been made through the works of other authors.

The Bacillariophyceae or diatoms form a well-marked class of algae with very distinctive features, and are unicellular, or form simple colonies. Each has a silicified cell wall or *frustule* composed of two distinguishable "halves", one of which overlaps the other rather like a lid on a date box. The cell wall is composed of pectic compounds, usually heavily impregnated with silica; cellulose has been reported, but accounts are rather contradictory, and it is certainly not a regular constituent of the wall. Each "half" consists of a somewhat flattened valve attached at the margins to a connecting band, the girdle or *cingulum*. The *cingulum* extends almost completely round the periphery of the valve, but there is always a gap between the two ends. The longer overlapping valve is known as the *epivalve* or *epitheca*, and the shorter as the *hypovalve* or *hypotheca*. Thus there are two characteristic views of the diatom, the *valve view* with the valve side uppermost, and the *girdle view* with the cingulum lying uppermost. In addition to the cingulum some genera exhibit one or more intercalary bands. The valves, are variously ornamented with coarse or fine *striae, punctae* or *areolae* which radiate from a central point in the centric genera, or bilaterally with respect to an axial field in the pennate genera. The axial field, which may be symmetric or asymmetric with respect to the longitudinal axis, usually appears as a clear



Text fig. 1

Views of diatoms (diagrammatic).
(i) oblique view of a centric diatom *Cyclotella*
(ii) valve view of a pennate diatom *Pinnularia*
(iii) girdle view of *Pinnularia.*

e, epivalve; h, hypovalve; g, girdle or *cingulum;* r, raphe; p.n., polar nodules; c.n., central nodule.

band between the striae. It may be perforated by a complex longitudinal slot or *raphe.* The raphe usually has thickenings in the walls at each end and at the centre, the *polar* and *central nodules.* In the absence of a raphe the axial field is known as a *pseudoraphe.* The ornamentations are usually thin places in the silicified wall, although small pores may perforate the walls within the areolae of some centric diatoms, and in a few pennate species there are longer median or polar perforations.

The chromatophores, which are rarely absent, are usually numerous and discoid or irregular in the Centrales, and single, lobed and perforate, or two and laminate in the Pennales. The colour is usually golden brown, but sometimes bright green, especially in specimens from organic bottoms in ponds and lakes. Pyrenoids, always without a starch sheath, may or may not be present. The photosynthetic pigments consist of chlorophylls a and c, usually obscured by β- and ε- carotene and five xanthophylls; chlorophyll b is absent. Reserve foods include fats in the form of oil droplets, volutin and leucosin, but never starch.

Many pennate diatoms exhibit motility, moving forward and backward in the direction of the long axis of the cell. Movement is confined to those species possessing raphes, and is ascribed to the streaming of cytoplasm between the polar and the central nodules through fissures on the outer wall faces.

Reproduction is by cell division, statospores (cysts or endospores) and auxospores which may be formed without any sexual union, or by fusion either of amoeboid gametes, or of autogamous nuclei, and uni- or biflagellate microspores which have been variously interpreted as zoospores or gametes. In the species so far investigated the nuclei of the vegetative cells are diploid.

Diatoms are widely distributed in fresh and salt waters, often becoming very abundant in colder waters and in colder seasons. They may be free-floating, often pelagic, or they may be sessile forming an important part of the lithophytic and epiphytic flora. In flowing waters many species form copious gelatinous masses on rock surfaces. Although diatoms are mostly aquatic, many species occur within the soil and on wet surfaces of terrestrial substrates.

KEY TO THE GENERA

Since this paper must be very incomplete, only a key to the genera is provided, the species being described under each genus in alphabetical order.

Valves orientated about a central point with ornamentation radial or concentric; raphe or pseudoraphe absent ..	I. CENTRALES.
Valves orientated about a longitudinal axial field, with the ornamentation bilateral to it and not radiating from a central point; raphe or pseudoraphe present	II. PENNALES.

I. ORDER CENTRALES

Cells solitary or united variously into filaments, dendroid or zigzag colonies, free-floating or sessile; cell-shape discoid, cylindric or irregular, with valves round, elliptic, polygonal or irregular; ornamentation radial or concentric about a central point; raphe or pseudoraphe absent, cells immobile, often with spine-like, mamillate or long horn like projections; chromatophores usually numerous, small, discoid and often irregular and laminate, with or without pyrenoids; reproduction by cell formed by rejuvenescence, and enlargement of cells without sexual reproduction; some genera known to have diploid vegetative cells and autogamous sexual reproduction. Largely a marine order, with a few freshwater species.

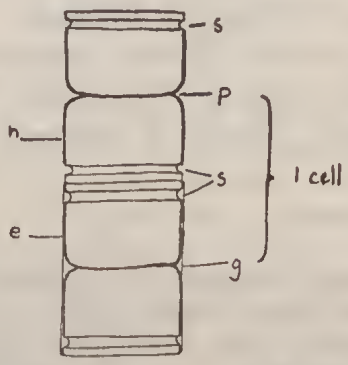
Key to Centrales

(i) Cells united into long filaments ..... (ii)
(i) Cells not united into long filaments; at most short chains (iii)
(ii) Valves circular with short teeth or spines at the periphery 1. *Melosira*
(ii) Valves elliptic with two very long spines at the ends of the longer axis ..... 6. *Chaetoceros*
(iii) Cells a long cylinder with a long terminal spine at each end 7. *Rhizosolenia*
(iii) Cells disc-shaped or squat cylinders with no long terminal spine ..... (iv)
(iv) Valves with coarse areolae ..... 3. *Coscinodiscus*
(iv) Valves punctate, not areolate ..... (v)
(v) Valves with a peripheral ring of short spines. No well marked outer zone of striae or punctae .... (vi)
(v) Valves without a ring of short spines, but with a well marked outer zone of striae or punctae ..... 2. *Cyclotella*
(vi) Peripheral spines very small, striae very fine, hardly visible 4. *Thalassiosira*
(vi) Peripheral spines larger and conical, striae well-marked 5. *Stephanodiscus*

MELOSIRA C. A. Agardh 1824

Cells cylindrical, united into long filaments; valve view circular, with or without marginal teeth, flat or convex, usually with ornamentations in two distinct concentric areas; girdles with *sulcus* or groove, *pseudosulcus* or without either; when sulcus or pseudosulcus absent central area of girdle usually ornamented, when present central area usually smooth; chromatophores numerous, small, discoid, frequently crowded.

Auxospore formation asexual or autogamous; biflagellate zoospores reported.



Text fig. 2

Girdle view of Melosira showing a single cell with a semicell attached at either end. e, epivalve; h, hypovalve; s, sulcus; p, pseudosulcus; g, girdle of parent cell.

1. **Melosira granulata** (Ehrenberg) Ralfs. [Syn.: *Gaillonella granulata* Ehr.; *G. procera* Ehr.; *G. marchica* Ehr.; *Melosira ordinata* Kuetz.; *Orthosira punctata* W. Smith.] Cells 16μ long $\times$ 10μ diameter to 28μ long $\times$ 5μ diameter; sulcus shallow and acute; valves with short marginal teeth, but end cells bearing also a few long marginal spines; punctae of valve view large, scattered; girdle view coarsely punctate, in parallel striations which are straight or only very slightly spiral, 8–11 striae in 10μ. (Pl. I, figs. a & b). The slender form has been separated as var. *angustissima,* but observations here and in the river Nile suggest that it may only be a growth form resulting from decreasing mineral supplies (Prowse & Talling 1958).

   MALAYA Perak: Taiping Lakes.

   Selangor: Common in established fish-ponds.

   Negri Sembilan: Common in established fish-ponds.

   Malacca: Common in established fish-ponds.

   Singapore: Common in established fish-ponds; Botanic Gardens Lake.

   Distribution worldwide.

2. **Melosira italica** (Ehrenberg) Kuetzing. [Syn.: *Gaillonella italica* Ehr.; *Melosira crenulata* Kuetz.; *M. crenulata* Kuetz. var. *italica* Grun.; *M. crenulata* Kuetz. var. *tenuis* Grun.] Gells 16μ long $\times$ 9–10μ diameter to 28μ long $\times$ 5μ diameter; sulcus shallow, acute; valves with prominent marginal teeth, alike on end and intercalary cells, with no long spines; valve view very finely punctate; girdle view finely punctate in spiral striations which are sometimes undulate or intersecting, 10–20 striae in 10μ (Pl. I, figs. g & h). The narrow form is often separated as var. *tenuissima,* but as in *M. granulata* it may be only a growth form.

   MALAYA Perak: Taiping Lakes.

   Selangor: Common in fish-ponds.

   Negri Sembilan: Common in fish-ponds.

   Malacca: Common in fish-ponds.

   Singapore: Common in fish-ponds; Botanic Gardens Lake.

   Distribution worldwide.

3. **Melosira roeseana** Rabenhorst. [Syn.: *Orthosira spinosa* Grev.; *Melosira spinosa* (Grev.) Bréb.]. Cells 16–20μ long $\times$ 20–30μ diameter; sulcus wide, concave and rounded; valve with prominent marginal teeth; valve view with punctae in radial striation with 1–4 central spots; girdle view finely punctate, the punctae being finer and closer together in the central area of

the girdle, the striae being parallel and straight, 15–20 in 10μ in the central area of the girdle, 10–15 in 10μ nearer the valve edges. (Pl. I, figs. c & i).

MALAYA Selangor: Gombak River, rare.

Found in moorland bogs and waterfalls in Europe, Indonesia and the Philippines, and probably elsewhere in Asia.

4. **Melosira ruettneri** Hustedt. Cells 34–38μ long $\times$ 25–26μ diameter; sulcus absent, the wall being straight, but in the middle forming a pseudosulcus; cell wall very thick, thinner near the centre of the valve and at the pseudosulcus, and composed of two membranes, the outer irregularly areolate, with the areolae smaller towards the centre of the girdle, and towards the centre of the valve, the inner very finely punctate, the punctae being in radial striae on the valve face, and spiral on the girdle view; pseudosulcus smooth. (Pl. I, fig. d).

MALAYA Selangor: Feeder stream to Klang Gates Reservoir, rare.

Recorded from Indonesia.

CYCLOTELLA Kuetzing 1834

Cells discoid or drum shaped, solitary or colonial within a mucilaginous envelope; when filamentous the cells not tightly interlocking as in Melosira; valve view circular, or sometimes elliptic; ornamentation of the valve in two very distinct concentric regions, the outer zone radially striate or punctate, the inner zone smooth, or irregularly and finely punctate; girdle view straight or undulate; chromatophores numerous, small and discoid.

Auxospores formed singly within a cell; some species known to be autogamous.

5. **Cyclotella kuetzingiana** Thwaites. Cells 10–28μ in diameter, outer zone with fine radial striae, 15–18 in 10μ about $\frac{1}{4}$ diameter in length; inner zone with a few fine, scattered punctae. (Pl. II, figs. i & j).

MALAYA Pahang: A stream near Kuantan.

Distribution widespread in freshwaters.

6. **Cyclotella meneghiniana** Kuetzing. Cells 10–25μ in diameter; outer zone broad, with thick well-marked striae, 7–9 in 10μ; central zone smooth, or with fine radial striae. (Pl. I, fig. e; Pl. II, fig. h). The form with a smooth central zone is sometimes separated as var. *rectangulata* Grun.

MALAYA Selangor: Common in fish-ponds.
Negri Sembilan: Common in fish-ponds.
Malacca: Common in fish-ponds.
Singapore: Common in fish-ponds; Botanic Gardens Lake.

Widespread in distribution.

7. **Cyclotella striata** (Kuetzing) Grunow. [Syn. *Coscinodiscus striatus* Kuetzing.]. Cells 25–40μ in diameter; outer zone broad with well marked striae, 10–12 in 10μ, every second or third stria marked with a prominent pore; sometimes very short, fine, marginal striae in between the long ones; at a deeper focus submarginal curves often visible between the pores; inner zone with irregular swellings, matt in texture. (Pl. I, fig. f; Pl. II, figs. b & g).

MALAYA Pahang: A stream near Kuantan.

Malacca: Non-saline water of Malacca River.

Widespread, marine in coastal waters and in estuaries in Europe, Asia and America.

COSCINODISCUS Ehrenberg 1838

Cells discoid, solitary or sometimes forming short, very loose mucilaginous chains, valve view circular, ornamented with distinct areolae, which may be radial, tangential or somewhat irregularly arranged, the ornamentation forming one zone only; marginal teeth present or absent. Mainly a marine genus.

8. **Coscinodiscus antiquus** (Grunow) A. Cleve. Cells 60–80μ in diameter; areolae large, polygonal of equal size except at margin, arranged excentrically, on lines curving away from the centre, sometimes almost tangential; marginal teeth absent; marginal striae marked, 6–10 in 10μ. (Pl. II, fig. f).

MALAYA Malacca: Malacca River in non-saline water.

Marine in origin, widespread in coastal water in Europe and America.

9. **Coscinodiscus argus** Ehrenberg. Cells 70–100μ in diameter; areolae large, polygonal, each with a prominent central pore; arranged in a close network, not markedly radial; areolae smaller towards the centre and near the margin; some tendency for the areolae to lie on lines spiralling towards the centre, marginal region small, hardly distinguishable from the sub-marginal areolae; marginal teeth absent. (Pl. I, figs. j, l & m).

MALAYA Pahang: A stream near Kuantan.

Marine in origin, widespread.

10. **Coscinodiscus decipiens** Grunow. [Syn. *Thalassiosira decipiens* (Grun.) Joerg.]. Cells small, 8–20μ in diameter, forming a short mucilaginous chain; valve flat, areolae roundish to polygonal, very excentric, in lines curving away from the centre; inner areolae larger, decreasing in size towards the margin; submarginal teeth prominent. (Pl. III, fig. c).

MALAYA Pahang: A stream near Kuantan, together with desmids.

Marine in origin, widespread in coastal waters.

11. **Coscinodiscus divisus** Grunow. Cells 30–50μ in diameter; valves flat; areolae small, polygonal, arranged in bundles, lines in each bundle parallel to one side and crossed by lines curving towards the centre; marginal zone with fine areolae, about 12–18 in 10μ; a very small spine opposite each bundle. (Pl. II, figs. a & d). This species is very characteristic, with the radial lines parallel to one side of each bundle.

MALAYA Malacca: Malacca River in non-saline water.

Distribution widespread, marine or brackish water.

12. **Coscinodiscus excentricus** Ehrenberg. Cells 20–40μ in diameter, discoid; valve flat; areolae small of equal size, arranged excentrically in lines curving away from the centre; teeth in a marginal ring. (Pl. III, fig. e). This is much smaller than the typical form, but obviously belongs under this species.

MALAYA Pahang: A stream near Kuantan, in non-saline water.

Marine in origin, widespread.

13. **Coscinodiscus griseus** Greville var **gallopagensis** Grunow. Cells 30–40μ in diameter; valves concentrically undulate; areolae small, resembling pores, arranged in radiating rows sometimes crossed by spiral rows; inner rows widely set apart about 6–9 in 10μ, outer ones much closer, or smaller areolae forming marginal striations; marginal teeth absent. (Pl. II, fig. e).

MALAYA Pahang: A stream near Kuantan.

Marine in origin.

14. **Coscinodiscus lineatus** Ehrenberg. Cells large, 80–120μ in diameter; areolae large, hexagonal, more or less equal in size, arranged in linear rows parallel to the diameter 4–5 in 10μ, except near the margin, where the areolae are smaller and irregular; margin wide, striae 10–12 in 10μ; smaller teeth on inner side of margin, about 3 in 20μ. (Pl. I, figs. k & n).

MALAYA Pahang: A stream near Kuantan.
Malacca: Malacca River.

Marine, widespread.

15. **Coscinodiscus lineatus** Ehrenberg var. **van heurckii** P. T. Cleve. Very much smaller than the type, only 15–20μ in diameter; areolae arranged in linear rows, 10 in 10μ; marginal teeth absent. (Pl. III, fig. d).

MALAYA Pahang: A stream near Kuantan.

Marine in origin.

16. **Coscinodiscus symmetricus** Kitton. Cells 80–90μ in diameter; areolae hexagonal, alike in size, 4–5 in 10μ, arranged in wedge-shaped bundles, the rays of each bundle being parallel symmetrically about the middle line; rays crossed by secondary rays curving towards the centre; margin striate, 9–10 striae in 10μ; teeth absent. (Pl. II, fig. c).

MALAYA Pahang: A stream near Kuantan.

Malacca: Malacca River.

Marine in origin.

THALASSIOSIRA P. T. Cleve 1873

Cells discoid or drum shaped, single or united into chains by a central thread; valves circular very finely ornamented; teeth submarginal, usually very fine, often a single unpaired course tooth. Largely a marine genus.

17. **Thalassiosira fluviatilis** Hustedt. Cells 15–20μ in diameter, drum-shaped, solitary; valve slightly convex, very finely punctate in radial striae, not in bundles, teeth submarginal, fine, 10–12 in 10μ, one much larger unpaired tooth or spine. (Pl. II, fig. k).

MALAYA Pahang: A stream near Kuantan, together with desmids.

Widespread in brackish water, both inland and estuarine.

STEPHANODISCUS Ehrenberg 1845

Cells discoid, drum-shaped or cylindric, single and free-floating, rarely in chains; valves circular, radially punctate and with a ring of short, but stout spines near the margin; girdle view generally somewhat undulate, with smooth surfaces and without intercalary bands, chromatophores several small discs or one or two large irregular flat plates. Largely a marine genus.

18. **Stephanodiscus biserialis** Prowse **sp. nov.** Cells drum-shaped, valves circular, 40–50μ in diameter, hollowed in the middle, striae in two series, the outer series finely punctate, 11–12 in 10μ, about one-third radius long, inner series prominent, highly refractive, punctae not visible, each stria a continuation of every alternate outer stria into the hollowed centre, about one-third radius long, outer striae not joined in pairs to inner striae as in *S. astraea;* central area apparently quite smooth; submarginal spines short, prominent, 3½ in 10μ (Pl. III, fig. a).

MALAYA Pahang: A stream near Kuantan. (Type locality).

Holotype No. Prowse 582a is deposited at the Tropical Fish Culture Research Institute, Malacca, Federation of Malaya.

Frustula cylindrica, altitudine brevissima. Valvae orbiculares, 40–50μ in diam., medio concavae. Striae biseriatae, in serie exteriore minute punctatae, 11–12 in 10μ circa tertiam radii partem longae, cum interioribus pariter ut in *S. astraea* non jugatae; striae interiores singulae ex unisquibusque striis alternatis exterioribus orientes, circam tertiam radii partem longae. Area centralis laevissima ut videtur; spinis submarginalibus brevibus, prominentibus, 3½ in 10μ.

MALAYA Pahang, in fluvio proximo urbe Kuantan.

19. **Stephanodiscus fenestralis** Prowse **sp. nov.** Cells drum-shaped; valves circular, 40–50μ in diameter, hollowed in the middle; striae 12–14 in 10μ, about half the radius in length, reaching to the edge of the central hollow where they meet the upper edges of the sub-central rectangular refractive "windows" or depressions, each about 5 striae wide and lying 3–4 striae apart on the sloping sides of the central hollow; spaces between the "windows" and the central area of the hollow apparently quite smooth; submarginal spines short, prominent, 3–4 in 10μ. (Pl. III, fig. b).

MALAYA Pahang: A stream near Kuantan. (Type locality).

Holotype No. Prowse 582b is deposited at the Tropical Fish Culture Research Institute, Malacca, Federation of Malaya.

Frustula cylindrica, longitudinae brevissima. Valvae orbiculares, 40–50μ in diam., medio late concavae. Striae 12–14 in 10μ, fere semi-radiales, inter extremitates earum ac cavi marginem centralis caveolulis rectangularibus, refractivis, singulis 5-striae latis, 3–4 striae inter se remotis, in modum fenestrarum dispositis; loculi inter caveolulas et cavus centrales laevissimi ut videtur. Spinae submarginales breves, prominentes, 3–4 in 10μ.

MALAYA Pahang, in fluvio proximo urbe Kuantan.

CHAETOCEROS Ehrenberg 1844

Cells cylindrical, elliptical or circular in valve view, in girdle view rectangular with plane, concave or slightly convex ends; intercalary bands present; cells united in chains, rarely single; each valve bearing two long fine hair like spines which intersect with those of the neighbouring cell; chromatophores small, discoid and numerous. Auxospores formed singly in each cell. Mainly a marine genus.

20. **Chaetoceros amanita** A. Cleve. Cells in girdle view rectangular 8–12μ high $\times$ 15–20μ in widest width, sides straight, end walls curved, separated by lanceolate openings; valve view elliptical; spines long and slender, not differing markedly on

end cells; auxospore with a large primary valve and a smaller secondary valve, both ornamented with short spines. (Pl. III, figs. g & h).

The characteristically shaped auxospore makes it certain that the Malayan specimens belong to this species.

MALAYA Pahang: A stream near Kuantan together with desmids.

Distributed in brackish waters in Europe and the Middle East.

RHIZOSOLENIA Ehrenberg 1843; emend. Brightwell 1858

Cells elongate cylinders, with many intercalary bands, and circular or elliptical in cross-section, free-floating, solitary or sometimes in straight or spirally twisted chains; end of valve calyptra-like, terminating apically in a long centric or excentric spine; walls very finely punctate or without markings, silicification slight; chromatophores small, discoid and scattered. Reproduction by auxospores, statopores and microspores. Mainly marine.

21. **Rhizosolenia eriensis** H. L. Smith. Cells cylindrical, slightly flattened, 5–15μ wide $\times$ 40–150μ long; intercalary bands scale-like and imbricated 2–4 in 10μ; valve end calyptra like, each terminating asymmetrically in a single long spine, shorter in length than the length of the cell body. (Pl. III, fig. f).

MALAYA Malacca: Batu Berendam, in fish-ponds at the Tropical Fish Culture Research Station.

Widespread in lakes in Europe, America and in Indonesia.

II. ORDER PENNALES

Cells solitary or variously united into ribbon like, stellate, zigzag, dendroid or irregular colonies, free-floating, or attached by gelatinous stalks or by other mucilaginous secretions; valves elongate, rarely nearly round, bilaterally symmetric about a median longitudinal line, not radiating from a central point; pseudoraphe or raphe present, if raphe present, cells possess the property of mobility; valves without marginal spines or projections, rarely winged; chromatophores variable, small and discoid, or larger and laminate with pyrenoids; auxospores formed by the conjugation of two cells, or autogamously; vegetative cells diploid.

Key to Pennales

(i) Cells with no true raphe; pseudoraphe on both valves (ii)

(i) Cells with a very short raphe at each end ..... (iii)

(i) Cells with one valve bearing a true raphe, the other with only a pseudoraphe ..... (iv)

(i) Both valves bearing true raphes ..... (v)

(ii) Valves usually narrow and much elongated; cells solitary or in tufted fan-shaped colonies ..... 9. *Synedra*

(ii) Valves usually broader; cells in ribbons, zig-zag bands or stellate colonies, rarely solitary ..... 8. *Fragilaria*

(iii) Cells usually in ribbons; no denticulations on valve edges 10. *Eunotia*

(iii) Cells in branched dendroid colonies, joined end to end; valves with fine denticulations at edge 11. *Desmogonium*

(iv) Valves elliptic to nearly circular; cells transversely curved in girdle view ..... 12. *Cocconeis*

(iv) Valves more elongated; cells longitudinally curved in girdle view ..... 13. *Achnanthes*

(v) Raphe in a distinct keel or wing ..... (vi)

(v) Raphe not in a keel or wing ..... (ix)

(vi) Keel usually attached to one lateral margin of each valve, rarely central, and with a row of circular pores (carinal dots) ..... (vii)

(vi) Keel not attached to valve margin, but straight, sigmoid or excentric to the median longitudinal line, no carinal dots 28. *Tropidoneis*

(vi) Keel usually wing-like attached to both margins of each valve; valve face distinctly costate ..... (viii)

(vii) Both valves having the keel attached on the same adjacent side ..... 29. *Hantzschia*

(vii) Valves having the keels attached on opposite sides 30. *Nitzschia*

(viii) Valve view nearly circular in outline, often bent 33. *Campylodiscus*

(viii) Valve view ovate, elliptic or nearly linear ... 32. *Surirella*

(viii) Valve view distinctly linear, sigmoid .. 31. *Stenopterobia*

(ix) Valve view more or less symmetrical about the median longitudinal line ..... (x)

(ix) Valve view not symmetrical about the median longitudinal line ..... (xviii)

(x) Valve view and girdle view usually symmetrical about the median transverse line ..... (xi)

(x) Valve and girdle view not symmetrical about the median transverse line; one pole usually wider than the other 26. *Gomphonema*

(xi) Raphe enclosed between parallel ribs or horns extending from central nodule ..... (xii)

(xi) Raphe not enclosed between ribs ..... (xiii)

(xii) No longitudinal furrow outside ribs, transverse striations finely punctate, not costate ..... 14. *Frustulia*

(xii) Longitudinal furrow on each side of ribs; transverse striations costate or coarsely punctate ..... 19. *Diploneis*

(xiii) Valve with transverse costae opening inwards; raphe complex, often curved ..... 23. *Pinnularia*

(xiii) Valves punctate; if costate, costae showing punctae and not opening inwards; raphe usually much simpler . (xiv)

(xiv) Striae crossed by longitudinal hyaline lines ..... (xvi)

(xiv) Striae not crossed by hyaline longitudinal lines xv

(xv) Central nodule not reaching margins ..... 22. *Navicula*

(xv) Central nodule reaching both margines ... 20. *Stauroneis*

(xvi) Longitudinal lines parallel to and near the lateral margins (xvii)

(xvi) Longitudinal lines not parallel to lateral margins but zigzagging and coalescing in places .... 21. *Anomoeoneis*

(xvii) Raphe bifurcate at poles and curving in opposite directions at central nodule ..... 18. *Neidium*

(xvii) Raphe not bifurcate at poles and straight or only slightly curved in same direction at central nodule . 17. *Caloneis*

(xviii) Valve view distinctly sigmoid ..... (xix)

(xviii) Valve view curved to one side, lunate or sickle-shaped . (xx)

(xix) Transverse striations crossed by longitudinal lines 15. *Gyrosigma*

(xix) Transverse striations cut by crossed lines at an angle 16. *Pleurosigma*

(xx) Cells in girdle view with parallel sides, more or less rectangular ..... 25. *Cymbella*

(xx) Cells in girdle view with outer margins convex .... (xxi)

(xxi) Transverse striations separated by costae . 27. *Rhopalodia*

(xxi) Transverse striations without costae ..... 24. *Amphora*

FRAGILARIA Lyngbye 1819, Rabenhorst 1864

Cells united into free-floating or sessile colonies, mostly zig-zag chains or ribbons, sometimes flat, stellate colonies; cells rectangular in girdle view, with one or two intercalary bands (sometimes none), without septa or costae; valve view linear to fusiform, bilaterally symmetrical, usually attenuated at the poles, sometimes capitate and often medianly inflated, rarely constricted; transverse striae usually fine, sometimes coarse; pseudoraphe narrow and indistinct to broad and prominent; chromatophores numerous small discoid bodies or one to four laminate plates with pyrenoids.

Auxospores formed singly within the cells.

22. **Fragilaria lapponica** Grunow var. **tetragonalis** Prowse **var. nov.** Valves quadrangular, 45μ long, 40μ wide, with slightly incurved margins. Striae short, thick, marginal, 6–10 in 10μ. (Pl. IV, fig. f).

MALAYA Malacca: Malacca River. (Type locality).

Holotype No. Prowse 183a is deposited at the Tropical Fish Culture Research Institute, Malacca, Federation of Malaya.

Valvae quadrangulares, 45μ longae, 40μ latae, marginibus paulo incurvis. Striae breves, crassae, marginales, 6–10 in 10μ.

MALAYA Malacca, in fluvio.

This is much larger than most forms of the species.

23. **Fragilaria vaucheriae** (Kuetzing) Boye Petersen. [Syn.: *Synedra vaucheriae* Kuetz.; *F. intermedia* Grunow.]. Cells 50–90μ long $\times$ 3–6μ wide, forming closely knit ribbons; girdle view linear—rectangular; valve view elongate—lanceolate, narrowed near the ends, capitate; pseudoraphe narrow; transverse striae marked, 9–12 in 10μ, with a clear central area on one side. (Pl. IV, fig. a).

MALAYA Pahang: Cameron Highlands.
Selangor: Gombak River.
Malacca: Malacca River.

Widely distributed in fresh water.

The Malayan specimens are larger than the type, but it is doubtful if this is of varietal significance.

24. **Fragilaria virescens** Ralfs var. **elliptica** Hustedt. Cells 9–15μ long $\times$ 5–7μ wide, rectangular in girdle view, elliptic-lanceolate in valve view; pseudoraphe narrow, not very distinct; transverse striae fine, parallel or slightly radiate, 15–20 in 10μ; united in short ribbons. (Pl. IV, fig. d).

MALAYA Pahang: Stream near Kuantan, rare.

Widely distributed in freshwater in several countries, but rare.

SYNEDRA Ehrenberg 1830

Cells narrow and much elongated, solitary or in fan-shaped tufts or radiating colonies, free-floating or epiphytic, sessile or stalked; valves linear to lanceolate, straight or sometimes curved, with poles attenuated or not, often capitate; transverse striations lateral to a conspicuous pseudoraphe, which is usually narrow but sometimes broad; central smooth area present or not; girdle view elongate with truncate ends, striated; chromatophores two large plates, usually with 3 or more pyrenoids in each.

Auxosporcs 1–2 in each cell, formed without conjugation.

25. **Synedra tabulata** (C.A. Agardh) Kuetzing, var. **acuminata** (Grunow) Hustedt. [Syn.: *Diatoma tabulatum* C.A. Ag., *S. affinis* Kuetzing var. *acuminata* Grun.]. Cells 50–80μ long $\times$ 3–5μ wide, lanceolate, narrowed to slightly capitate ends; striae 13–15 in 10μ, shorter than the wide pseudoraphe. (Pl. IV, figs. b & c).

MALAYA Pahang: Stream near Kuantan, together with desmids, not common.

Widely spread in brackish waters in various countries.

26. **Synedra ulna** (Nitzsch) Ehrenberg var. **amphirhynchus** (Ehrenberg) Grunow. [Syn.: *Bacillaria ulna* Nitzs., *S. amphirhynchus* Ehr.]. Cells 150–240μ long $\times$ 5–7μ wide, nearly linear, constricted near the poles, which are capitate; pseudoraphe narrow, but well defined, widening in the middle to an elliptic to rectangular, smooth middle area; striae well-marked, 8–10 in 10μ. (Pl. IV, fig. h).

MALAYA Selangor: Fish-ponds.
Negri Sembilan: Fish-ponds.
Malacca: Fish-ponds, Malacca River.
Singapore: Botanic Gardens Lake.

Widespread in freshwaters in various parts of the world.

27. **Synedra ulna** (Nitzsch) Ehrenberg var. **danica** (Kuetzing) Grunow. [Syn.: *Bacillaria ulna* Nitzs., *S. danica* Kuetz., *S. ulna* (Nitzs.) Ehr. var. *chaseana* B. W. Thomas, *S. longissima* W. Smith var. *acicularis* Meister.]. Cells 150–200μ long $\times$ 5μ wide; long, narrow linear-lanceolate, slightly narrowing to the poles which are hardly capitate; pseudoraphe narrow but well defined, widening at the centre into a rectangular, clear middle area; striae well-marked, 9–10 in 10μ. (Pl. IV, fig. g).

MALAYA Selangor: Klang River, fish-ponds.
Negri Sembilan: Fish-ponds.
Malacca: Fish-ponds.
Singapore: Botanic Gardens Lake.

Widespread in freshwater.

EUNOTIA Ehrenberg 1837

Cells rectangular to linear in girdle view, both girdles and valves strongly ornamented, usually with inter-calary bands, free floating or epiphytic, solitary or united valve to valve into ribbons or chains; valves arcuate with similar poles but dissimilar margins: concave side regular, convex side regular, or inflated at the poles or undulate, sometimes nearly straight; raphe very short, extending from the fairly evident polar nodule diagonally to the concave margin, no central nodule; neither costae nor septa present; intercalary bands usually present; transverse striations or punctations present, but without marginal denticulations or dots; chromatophores two, laminate, without pyrenoids.

Auxospores single from the conjugation of two cells.

28. **Eunotia camelus** Ehrenberg. Cells rectangular in girdle view, united in ribbons; in valve view 25–30μ long $\times$ 5μ wide, distinctly arcuate, with two prominent humps on the convex side; ends narrowed on convex side, rounded—sub-capitate, reflexed away from the concave side, nodules small, sub-terminal; striations 11–14 in 10μ. (Pl. V, figs. y & z).

The two forms figured are more arched and with more prominent humps than the type, and the ends are reflexed. They show a marked resemblance to var. *gibbosa* Gandhi and var. *ventricosa* Gandhi, but are regular and not gibbous on concave margin.

MALAYA Malacca: Malacca River.

Distributed in South-east Asia.

29. **Eunotia camelus** Ehrenberg var. **karveerensis** Gandhi. Cells rectangular in girdle view, united in ribbons; on valve view 35–40μ long $\times$ 5–7 wide, strongly arcuate, dorsal edge convex with four strong rounded uniform humps; ends narrowed on dorsal side, produced, rounded, sub-capitate; nodules small, subterminal; striae 11–13 in 10μ. (Pl. V, figs. c & d).

MALAYA Malacca: Malacca River.

Described from India.

A. Berg (1939) has separated the two humped forms as forms of *E. pectinalis* (Kuetz.) Rabh. but there seems no justification for this as the two are unlike *E. pectinalis,* being much less arched, very much less convex on the dorsal side, and with the ends hardly reflexed. Gandhi (1957) has discussed the status of *E. camelus* and I agree with him that both two and four-humped forms should be included as forms of the same species, but unlike him I would take the two-humped forms as the type, since they were so described by Ehrenberg—"E. minoribus, valvus striatis, dorse elati gibbere duplici, ventre concave, apicibus productis attenuatis obtusis." (De Toni, 1889–1924)—and regard the four-humped forms as being varieties.

30. **Eunotia cancellata** A. Berg var. **esseda** A. Berg. Cells small, rectangular in girdle view; in valve view 10–15μ long $\times$ 3–4μ wide, only slightly arcuate, nearly straight on ventral margin, except at the ends where it curves down slightly; dorsal margin straight in the middle, curving away to the rounded, sub-capitate ends, shoulders marked; nodules terminal with well marked inner almost central secondary nodules; striae 15–20 in 10μ. (Pl. V, fig. n).

The Malayan form seems to come closest to the variety *esseda* as described and figured by A. Cleve-Euler (1933).

MALAYA Pahang, a stream near Kuantan.

Described from Europe.

31. **Eunotia diodon** Ehrenberg var. **minor** Grunow. Cells rectangular in girdle view; in valve view 35–40μ long $\times$ 10–12μ wide, very slightly curved on the ventral margin, much more markedly convex on dorsal side, bi-undulate with a slight depression between the two humps, curving down to the non-capitate ends; nodules, prominent, terminal; striations 13–15 in 10μ, slightly radial. (Pl. V, figs. p & q).

MALAYA Pahang: Cameron Highlands.
Malacca: Malacca River.

Widely distributed.

32. **Eunotia exigua** (Brébisson) Grunow. [Syn.: *Himantidium exiguum* Brébisson]. Valves small, 15–20μ long $\times$ 2–3μ wide, linear, slightly arched, both margins parallel in the middle, but the ends rounded-capitate, slightly reflexed to the dorsal margin; nodules terminal; striae fine, 20–24 in 10μ (Pl. V, fig. j).

MALAYA Pahang: Cameron Highlands.

Widely distributed.

33. **Eunotia faba** (Ehrenberg) Grunow var. **densestriata** Oestrup. [Syn.: *Himantidium faba* Ehr.]. Cells small, rectangular tabular in girdle view; in valve view 13–15μ long $\times$ 3–4μ wide, slightly arched, subconcave on the ventral margin, slightly more curved on the dorsal margin; ends rounded, hardly capitate; nodules terminal; striae 19–20 in 10μ. (Pl. V, fig. m).

MALAYA Pahang: Cameron Highlands.

Widely distributed.

34. **Eunotia flexuosa** Kuetzing. Cells linear in girdle view; in valve view 120–270μ long $\times$ 3–5μ wide, linear, straight or slightly broadened; nodules terminal with a short pseudoraphe extending inwards; transverse striations finely punctate, 12–18 in 10μ. (Pl. VI, figs. b & c).

MALAYA Pahang: Cameron Highlands.
Malacca: Swamps.
Singapore.

35. **Eunotia formica** Ehrenberg. Cells rectangular in girdle view; in valve view 40–130μ long $\times$ 10–14μ wide, with parallel margins, ends euncate making the whole valve resemble a bone in appearanee; nodules terminal, with a long pseudoraphe extending inwards from it parallel to the sides; striations 9–14 in 10μ, somewhat irregular, punetate. (Pl. VI, figs. g & h).

MALAYA Pahang: Cameron Highlands.

Selangor: Gombak River.

Malaeea: Malaeca River.

Widely distributed.

36. **Eunotia gracilis** (Ehrenberg) Rabenhorst. [Syn.: *Himantidium gracilis* Ehr.]. Cells in girdle view reetangular; in valve view, 80–110μ long $\times$ 4–6μ wide, linear with parallel sides, distinctly eurved; ends rounded, slightly eapitate, nodules terminal; transverse striae 12–16 in 10μ. (Pl. VII, fig. b).

MALAYA Malacca: Malaeea River.

Widespread in distribution.

37. **Eunotia grunowi** A. Berg var. **uplandica** A. Cleve f. **subundulata** A. Cleve. [Syn.: *E. pectinalis* var. *stricta* (Rabenhorst) Grunow forma]. Cells rectangular in girdle view; in valve view 50–70μ long $\times$ 8–10μ wide, slightly eurved, dorsal side more convex than ventral side with marked shoulders, slightly incurved in the middle; ends rounded, sub-capitate; nodules terminal; transverse striae 10–13 in 10μ. (Pl. V, fig. e).

MALAYA Malacea: Malacca River.

Reeorded from Seandinavia.

The form found in Malaya eomes nearest to that deseribed by A. Cleve-Euler (1953).

38. **Eunotia lunaris** (Ehrenberg) Grunow. [Syn.: *Synedra lunaris* Ehr.]. Cells lincar in girdle view; in valve view 45–80μ long $\times$ 3–4μ wide, lincar with parallel sides, eurved forming a wide are, slightly thinner at the poles; nodules terminal, small; transverse striae 14–18 in 10μ. (Pl. V, fig. f).

MALAYA Pahang: Cameron Highlands.

Widcspread in distribution.

39. **Eunotia lunaris** (Ehrenberg) Grunow var. **capitata** Grunow. Differing from the typc in that the ends are eapitate and slightly reflexed; in valve view 40–80μ long $\times$ 4–5μ wide; transverse striae 15–16 in 10μ. (Pl. V, fig. h).

MALAYA Malaeca: Malacea River.

Widespread in distribution.

40. **Eunotia major** (W. Smith) Rabenhorst var. **emarginata** A. Cleve. [Syn.: *Himantidium majus* W. Smith, *E. major* (W. Smith) Rabh. var. *bidens* (Greg.) A. Cleve.]. Cells in girdle view rectangular; in valve view 60–100μ long $\times$ 10–12μ wide; broadly curved, with slightly cuneate, rounded ends, the dorsal side with two broad flattish humps; nodules terminal; transverse striae somewhat irregular, 10–12 in 10μ. (Pl. VI, fig. f).

MALAYA Perak: Taiping lakes.

Described from Europe.

41. **Eunotia major** (W. Smith) Rabenhorst var. **indica** Grunow. [Syn.: *Himantidium majus* W. Smith, *E. indica* Grun.]. Cells rectangular in girdle view; in valve view 70–90μ long $\times$ 10μ wide, curved, with both margins parallel in the middle but curving down on the dorsal side to the sub-capitate, slightly cuneate, ends; nodules terminal; transverse striae 8–12 in 10μ, irregularly distributed. (Pl. V, fig. i).

MALAYA Malacca: Malacca River.

Described from India and from Sweden, and is probably widely distributed.

42. **Eunotia major** (W. Smith) Rabenhorst var. **linearis** A. Cleve. [Syn.: *Himantidium majus* W. Smith, *E. monodon* Ehr. var. *major* Hust.]. Cells rectangular in girdle view; in valve view 120–150μ long $\times$ 10–12μ wide, broadly curved with parallel sides; ends rounded, slightly wider; nodules terminal, prominent; transverse striae 8–10 in 10μ. (Pl. VII, fig. a).

MALAYA Malacca: Malacca River.

Distribution widespread.

43. **Eunotia monodon** Ehrenberg var. **alpina** Kuetzing. Cells small, 20–25μ long $\times$ 5μ wide in valve view, slightly curved, concave on the ventral side, slightly more convex on the dorsal side, narrowing gently to the rounded, hardly reflexed ends; nodules terminal, small; striae 14 in 10μ. (Pl. V, fig. s).

MALAYA Pahang: Stream near Kuantan.

Distributed in Europe, possibly elsewhere.

44. **Eunotia monodon** Ehrenberg var. **constricta** A. Cleve-Euler. [Syn.: *E. major* (W. Smith) Rabh. v. *hybrida* f. *bidens* A. Cleve]. Cells rectangular in girdle view; in valve view 65–70μ long $\times$ 10–15μ wide, broadly arcuate, with two broad swellings on the dorsal margin, slightly reflexed before the rounded, slightly cuneate ends; nodules terminal, prominent; striae 10–12 in 10μ. (Pl. V, fig. a).

MALAYA Malacca: Fish-ponds at Jasin and Malacca.

Probably widespread in distribution.

45. **Eunotia monodon** Ehrenberg var. **undulata** A. Cleve-Euler. [Syn.: *E. major* (W. Smith) Rabh. var. *undulata* A. Berg]. Cells in girdle view rectangular; in valve view 65–70μ long $\times$ 8–10μ wide, broadly arcuate, with the dorsal margin more convex and with four broad, flattish, equal humps; ends narrower, rounded, not markedly capitate; nodules terminal, small; transverse striae 10–12 in 10μ. (Pl. V, fig. g).

MALAYA Malacca: Malacca River.

Distributed in Europe and probably elsewhere; not common.

This certainly comes nearest to Cleve-Euler's figure and description (1953), but it may possibly belong to another species.

46. **Eunotia pectinalis** (Kuetzing) Rabenhorst. [Syn.: *Himantidium pectinalis* Kuetzing.]. Cells rectangular-tabular in girdle view, in valve view 40–80μ long $\times$ 5–8μ wide, linear, slightly curved, the dorsal margin parallel to the ventral margin, narrowing slightly at the ends to the rounded slightly reflexed but non-capitate poles; nodules terminal, small, transverse striae 9–11 in 10μ, well-marked. (Pl. V, fig. b).

MALAYA Pahang: Cameron Highlands.
Malacca: Widespread.

Widespread in distribution.

47. **Eunotia pectinalis** (Kuetzing) Rabenhorst var. **minor** (Kuetzing) Rabenhorst. [Syn.: *Himantidium pectinalis* Kuetz. var. *minor* Kuetz.]. Much smaller than the type, 15–20μ long $\times$ 1.5–2μ wide. (Pl. V, fig. w).

MALAYA Pahang: Cameron Highlands.

Widespread in distribution.

48. **Eunotia polydentula** (Brun) emend. A. Berg var. **perminuta** (Grunow) A. Berg. [Syn.: *E. tridentula* Ehr. var. *perminuta* Grun.]. Cells small, 10–20μ long $\times$ 3–4μ wide, slightly arcuate with roughly parallel margins, the dorsal side with 3–4 shallow swellings; ends a little narrower, capitate and slightly reflexed; nodules terminal; transverse striae 16–20 in 10μ. (Pl. V, figs. u & v).

MALAYA Pahang: Cameron Highlands.
Johore: Ayer Hitam.

Described from Europe but probably more widely distributed.

49. **Eunotia praemonos** A. Cleve-Euler var. **inflata** (Grunow) A. Cleve-Euler. [Syn.: *E. praerupta* Ehr. v. *inflata* Grun.]. Cells small, 15–30μ long $\times$ 5–7μ wide, ventral side hardly concave, nearly straight, dorsal side much more convex; ends broadly rounded, slightly reflexed; nodules terminal, well-marked; transverse striae coarse, irregularly arranged, 7–13 in 10μ. (Pl. V, figs. r & l).

MALAYA Pahang: Stream near Kuantan.

Described from Europe but doubtless more widespread.

50. **Eunotia praemonos** A. Cleve-Euler var. **monodon** (Oestrup) A. Cleve-Euler. [Syn.: *E. praerupta* Ehr. var. *curta* Grun. forma *monodon* Oest., *E. praerupta* Ehr. var. *monodon* Oest.]. Cells small, 20–25μ long $\times$ 7–8μ wide; ventral side slightly concave, dorsal side with a marked central wedge-shaped swelling; ends broadly rounded, only very slightly capitate; nodules terminal, well marked; striae coarse, 10–12 in 10μ. (Pl. V, fig. k).

MALAYA Pahang: Stream near Kuantan.

Described from Europe but probably occurs elsewhere.

51. **Eunotia praemonos** A. Cleve-Euler var. **tibetica** (Mereschkowski) A. Cleve-Euler. [Syn.: *E. praemonos* A. Cleve-Euler forma *tibetica* A. Berg, *E. praerupta* var. *tibetica* Mereschkowski *E. praerupta-monos* A. Berg forma *undata* A. Berg, *E. praerupta* var. *bidens* Hust.]. Cells rectangular-tabular in girdle view; in valve view 25–35μ long $\times$ 7–9μ wide, arcuate with two broad humps on the dorsal side, the ends parallel, very bluntly rounded poles, almost truncate; nodules small, terminal; transverse striae irregular with some short ones on the dorsal margin, 10–14 in 10μ. (Pl. VI, fig. i).

MALAYA Malacca: Malacca River.

Described from Tibet and Scandinavia but doubtless occurs elsewhere.

Despite the difference in habitat the Malayan forms seem to fit under no other varicty, and any differences are too slight to justify their separation under a new form.

52. **Eunotia robusta** Ralfs. Cells large, in girdle view rectangular-tabular; in valve view 65–100μ long $\times$ 9–18μ wide, broadly linear, arcuate, with 4–9 broad swellings on the dorsal side; poles broadly rounded; nodules terminal, distinct; transverse striae coarse, punctate, irregular, 9–12 in 10μ. (Pl. VI, figs. a, d & e).

MALAYA Malacca: Malacca River.

Widespread in distribution.

This species is unmistakable, despite the wide variation in the number of dorsal humps.

53. **Eunotia sarekensis** A. Cleve-Euler var. **minor** A. Cleve-Euler. [Syn.: *E. papilio* (Grunow) P. T. Cleve forma *minor* Hustedt.]. Cells small, rectangular in girdle view; in valve view 20–30μ long $\times$ 9–12μ wide, arcuate with the dorsal side prominently raised into two humps, shoulders sharp, sloping suddenly; ends with almost parallel sides, poles bluntly rounded; nodules terminal; transverse striae very irregular with many short ones, 11–14 in 10μ. (Pl. V, fig. o).

MALAYA Pahang: Cameron Highlands.

Described from Europe.

54. **Eunotia sudetica** O. Mueller var. **incisa** (Mayer) A. Cleve-Euler. [Syn.: *E. pectinalis* (Kuetz.) Rabh. var. *incisa* Mayer]. Cells in valve view 15–25μ long $\times$ 7–10μ wide; ventral margin almost straight, dorsal margin markedly convex, ends slightly reflexed to the ventral side making a small depression or nick near each end of the ventral margin; poles rounded; nodules small, terminal; transverse striae slightly radial, 10–14 in 10μ. (Pl. V, figs. t & x).

MALAYA Pahang: Stream near Kuantan.

Described from Europe.

DESMOGONIUM Ehrenberg 1848

Cells united end to end forming branching chains, or often dendroid colonies. In girdle view usually linear, in valve view linear. Raphe short in terminal nodules; transverse striae distinct; margins with small granules or denticulations, often difficult to see.

55. **Desmogonium rabenhorstianum** Grunow. Cells joined end to end, often in pairs or fours, forming characteristic branched chains or dendroid colonies; in girdle view linear with slightly swollen ends; in valve view 100–200μ long $\times$ 5–8μ wide, linear, slightly arcuate, with rounded, slightly capitate poles; nodules terminal with a small pseudo-nodule in the middle of each end; striae 13–16 in 10μ, each alternate one with a small granule or denticulation at each end. (Pl. VII, figs. c & d). The marginal granules are often difficult to see, showing up only under the highest powers of phase contrast. The characteristic habit of the colonies is enough to distinguish the species.

MALAYA Perak: Taiping.

Pahang: Cameron Highlands, and in several coastal streams.

Selangor: Gombak River.

Negri Sembilan: Port Dickson.

Malacca: Swamps.

Johore: Yong Peng.

Singapore.

Distributed in South-east Asia.

COCCONEIS Ehrenberg 1835; Grunow 1868

Cells transversely curved in girdle view, solitary, epiphytic upon submerged aquatic plants; septa incomplete and intercalary bands absent; valve view elliptic, epivalve with an axial pseudoraphe,

hypovalve with a median true raphe which is straight or sigmoid, with central and polar nodules; transverse striae often in distinct punctate rows; chromatophores single, laminate, usually adjoining the epivalve, with one or two pyrenoids.

Auxosporcs single from two conjugated cells, or formed parthenogenetically from a single gamete.

56. **Cocconeis feuerbornii** Hustedt. Valves elliptic with broadly rounded ends, 20–25μ long $\times$ 10–13μ wide; epivalve with a narrow, linear pseudoraphe, striae radial, 17 in 10μ in the middle, 20–25 in 10μ near the poles, punctate with the inner punctae more widely spaced forming wavy longitudinal lines; hypovalve with a linear raphe, axial area narrow linear widening suddenly in the middle to form a stauros reaching half-way to the lateral margins, striae radial, 20–23 in 10μ in the middle, the punctae closer together and more evenly spaced than in the epivalve. (Pl. VIII, figs. k & l).

MALAYA Malacca: Malacca River.

Described from Indonesia.

57. **Cocconeis thumensis** Mayer. Valves elliptic with broadly rounded ends, 13–20μ long $\times$ 5–8μ wide; epivalve with broad lanceolate to nearly straight pseudoraphe, striae radial, 12–15 in 10μ coarsely punctate; hypovalve with linear raphe and narrow linear axial area, striae radial 12–15 in 10μ, coarsely punctate. (Pl. IV, figs. t & u).

MALAYA Malacca: Malacca River.

Reported from Europe and Africa, probably widespread in distribution.

There is some variation in this species, the two examples illustrated being the extremes with many intermediates. There seems no justification for separating the longer forms under a varietal name.

ACHNANTHES Bory 1822

Cells in girdle view rectangular, bent or curved longitudinally, usually attached by gelationous stalks, or sessile and united in bundles at the valves, rarely into filaments, occasionally free-floating and solitary; valve-view generally linear-lanceolate, or elliptic; hypovalve usually concave with raphe, a distinct central nodule and less distinct polar nodules, the central area sometimes transversely widened into a stauros; epivalve generally convex, with a pseudoraphe; transverse striations often somewhat radiate, in some species costate; chromatophores one, two or numerous and discoid. Two auxospores formed from two cells by the conjugation of two pairs of gametes.

58. **Achnanthes brevipes** C. A. Agardh var. **intermedia** Kuetzing. Cells in girdle view rectangular, 38–40μ long $\times$ 11–12μ wide, distinctly bent longitudinally, with marginal rows of very coarse punctae, costate in appearance, the concave margin broken in the middle by a large hyaline space, four longitudinal rows of coarse punctae down the middle, marginal striae 10–11 in 10μ; valve view linear-lanceolate with a very slight constriction in the middle, epivalve with a linear pseudoraphe excentrically placed, striae costate, 10–11 in 10μ, very coarsely punctate; hypovalve with a linear raphe, axial area linear, widening in the middle to form a stauros, striae costate, 10–11 in 10μ, very coarsely punctate. (Pl. VIII, figs. h–j).

MALAYA Selangor: Feeder stream to the Klang Gates reservoir.

Widespread in distribution.

59. **Achnanthes crenulata** Grunow. Cells in girdle view rectangular, longitudinally bent; in valve view linear-lanceolate, 50μ long $\times$ 13–15μ wide, margin distinctly wavy; epivalve with a linear pseudoraphe near one margin, striae 9–10 in 10μ, coarsely punctate, punctae 9–10 in 10μ; hypovalve with raphe, axial area narrow lanceolate widened in the middle to form a stauros reaching the lateral margins, striae 9–10 in 10μ, coarsely punctate, punctae 9–10 in 10μ. (Pl. IV, fig. v).

MALAYA Selangor: Gombak River.

Described also from Perak and Indonesia.

60. **Achnanthes exigua** Grunow. Valves quadratic-elliptic to linear-elliptic, subrostrate, 8–10μ long $\times$ 4–5μ wide; epivalve with median linear pseudoraphe, striae slightly radial, 22 in 10μ; hypovalve with raphe, axial area narrow, linear, widened in the middle to form a stauros, striae slightly radial, 25 in 10μ, with one short stria opposite each limb of the stauros. (Pl. IV, fig. 1). MALAYA Selangor: Feeder stream of the Klang Gates reservoir. Widespread in distribution.

The small form described is much less rostrate than usual and resembles closely the form figured by A. Cleve-Euler (1953) as 544 a & b and called "forma typica." Ruth Patrick (1936) has recorded the rostrate form from Perak.

61. **Achnanthes hauckiana** Grunow var. **rostrata** Schultz. Valves lanceolate, 17–18μ long $\times$ 6–7μ wide, rostrate with rounded poles; epivalve with a linear lanceolate pseudoraphe, striae 12–14 in 10μ prominent, radial, punctae faint; hypovalve with raphe, axial area narrow lanceolate slightly widened in the middle, striae 12–14 in 10μ, prominent, radial punctae faint. (Pl. IV, fig. w).

MALAYA Pahang: Stream near Kuantan.

Widespread, usually in brackish waters.

62. **Achnanthes lanceolata** (Brébisson) Grunow. [Syn.: *Achnanthidium lanceolatum* Brébisson.]. Valves elliptic-lanceolate 15–20μ long $\times$ 7–8μ wide, with bluntly rounded ends, hardly narrowed below the poles; epivalve with a linear pseudoraphe and marked, punctate, transverse striae, 12–14 in 10μ, radial and with a prominent refractive gap in the middle of one side; hypovalve with a straight raphe and linear to narrow lanceolate central area, striae prominent, punctate, 12–14 in 10μ, radial and with a gap in one side corresponding to that of the epivalve, but not refractive. (Pl. IV, fig. r).

MALAYA Pahang: Cameron Highlands.

Widespread in freshwaters.

63. **Achnanthes lanceolata** (Brébisson) Grunow var. **rostrata** Hustedt. Differs from the type in being distinctly rostrate to subcapitate at the poles, 15–20μ long $\times$ 7–9μ wide; pseudoraphe of epivalve linear, striae less marked, punctate, 12–14 in 10μ, with refractive gap in middle of one side; axial area of hypovalve narrow linear with small lanceolate central area, striae 12–14 in 10μ, radial, without a gap on one side. (Pl. IV, fig. s).

MALAYA Pahang: Cameron Highlands.

Widespread in freshwaters.

64. **Achnanthes stauroneiformis** Prowse. **sp. nov.** Frustules oblong-lanceolate, with linear-rostrate poles, truncate at both ends, 30–32μ long $\times$ 25–26μ wide; epivalve with a linear, cruciform pseudoraphe having the transverse arms reaching nearly to the margins, striae 16 in 10μ, distinctly punctate, those opposite the lobes of the stauros being short, marginal 3 on each side; hypovalve similar but with a very distinct raphe, striae closer together, 18–20 in 10μ, punctate, striae opposite the lobes of the stauros short, marginal, 4–5 on each side. (Pl. IV, fig. q).

MALAYA Malacca: Malacca River. (Type locality).

This species closely resembles *Stauroneis* except that only one valve bears a raphe.

Holotype No. Prowse 124a is deposited at the Tropical Fish Culture Research Institute, Malacca, Federation of Malaya.

Frustula oblongo-lanceolata, apice utrinque lineari-rostrata, truncata, 30–32μ longa, 25–26μ lata. Epivalva cum pseudoraphe lineari cruciformi, lobis transversalibus fere ad margines utrinque attingentibus; striae 16 in 10μ, conspicue punctatae, in stauri lobis breves marginales utrinque 3. Hypovalva consimilis, sed raphen clarissimam ferens; striae magis approximatae, 18–20 in 10μ, punctatae, striae in stauri lobis breves marginales utrinque 4–5.

MALAYA Malacca: in flumine principali frequens.

65. **Achnanthes subhudsonis** Hustedt. Valves lanceolate, 10–15μ long $\times$ 3–4μ wide, with acute poles; epivalve with narrow linear pseudoraphe, transverse striae fine, 16–17 in 10μ, lightly radial; hypovalve with straight raphe and lanceolate axial area, transverse striae fine, 18 in 10μ. (Pl. IV, fig. e).

MALAYA Pahang: Cameron Highlands.

Described from East Africa.

66. **Achnanthes tenuissima** Hustedt. Valves linear to rhombic-lanceolate, 18–20μ long $\times$ 3μ wide, with narrow rounded poles; epivalve with a broad lanceolate pseudoraphe, striae short, marginal, very fine, 28–34 in 10μ, slightly radial; hypovalve with a straight raphe and narrow linear axial area, striae very fine, 32–36 in 10μ, parallel. (Pl. IV, fig. p).

MALAYA Malacca: Fish-ponds near Malacca.

Described from Indonesia.

67. **Achnanthes tropica** Hustedt. Valves linear elliptic, 12–15μ long $\times$ 2–3μ wide, with slightly convex to almost parallel sides, and rounded poles; epivalve with a lanceolate pseudoraphe and short marginal striae, 18–20 in 10μ, parallel to slightly radial; hypovalve with a linear-lanceolate axial area, narrower than the pseudoraphe, and a straight raphe, transverse striae slightly closer together 20–22 in 10μ, parallel. (Pl. IV, figs. m, n & o).

MALAYA Malacca: Fish-ponds near Malacca.

Described from Indonesia.

68. **Achnanthes weltereckii** Hustedt. Valves linear to linear-lanceolate, 10–15μ long $\times$ 3–4μ wide, with slightly convex margins and rostrate to capitate poles; epivalve with a lanceolate pseudoraphe, about 1/3 width of valve in the middle, transverse striae 20–24 in 10μ, slightly radial or parallel; hypovalve with a straight raphe and linear axial area, widening in the middle almost to reach the margin, transverse striae radial, 28–30 in 10μ, two or three opposite the central area so that it appears like a stauros. (Pl. IV, figs. i, j & k).

MALAYA Pahang: Cameron Highlands.

Described from Indonesia.

FRUSTULIA C. A. Agardh 1824; Grunow, 1865

Cells solitary and free-floating, or sessile and enclosed in a gelatinous sheath or sometimes a gelatinous tube; in valve view linear-elliptic to rhombo-lanceolate; in girdle view rectangular, without intercalary bands; central nodule longitudinally elongated, prolonged towards each pole as parallel ribs enclosing the raphe,

and uniting apically with the polar nodule; transverse striations crossed by fine longitudinal lines; chromatophores two, sometimes incised longitudinally, one on each side of the girdle and connected by a cytoplasmic bridge.

Auxospores formed in pairs from two cells.

69. **Frustulia javanica** Hustedt. Valves elliptic-lanceolate, 50–60μ long $\times$ 25–26μ wide, with a distinct swelling on each side opposite the central nodule, and suddenly narrowed near the poles, making the margin triundulate; transverse striae fine, 24–27 in 10μ, parallel except at the poles and crossed by fine longitudinal striae 22 in 10μ. (Pl. VIII, fig. c).

MALAYA Pahang: Stream near Kuantan.

Reported from Indonesia and S. Africa.

The Pahang specimens are slightly broader and more lanceolate in shape than those described from Indonesia by Hustedt, but in all other respects they agree.

70. **Frustulia rhomboides** (Ehrenberg) de Toni. [Syn.: *Navicula rhomboides* Ehr.]. Valves rhombo-lanceolate, 50–80μ long $\times$ 12–15μ wide, hardly rostrate at the poles; transverse striae marked 27–28 in 10μ, longitudinal striae fine, 30 in 10μ. (Pl. VIII, figs. a & b).

MALAYA Penang.

Perak: Taiping.

Pahang: Cameron Highlands, Fraser's Hill, and in all of many streams sampled.

Selangor: Kuala Lumpur, Klang Gates, Klang.

Negri Sembilan: Port Dickson.

Malacca: Various localities.

Johore: Muar, Yong Peng, Kota Tinggi.

Singapore.

Worldwide and common in distribution.

71. **Frustulia saxonica** Rabenhorst. [Syn.: *Frustulia rhomboides* (Ehrenberg) de Toni v. *saxonica* (Rabh.) P. T. Cleve]. Valves elliptic, 30–40μ long $\times$ 8–10μ wide, slightly rostrate at the poles; transverse striae slightly radial, fine 35 in 10μ, longitudinal striae fine, 35 in 10μ. (Pl. VIII, figs. f & g).

MALAYA Pahang: Cameron Highlands.

Malacca: Fish-ponds, Malacca River.

Distribution worldwide.

GYROSIGMA Hassall 1845, emend. P. T. Cleve 1894

Cells solitary and free-floating, sometimes in gelatinous tubes; girdle view linear-lanceolate, intercalary bands and septa absent; valve view distinctly sigmoid, usually gradually attenuated to the broadly rounded poles, sometimes sharply narrowed; raphe sigmoid with small central and polar nodules; axial area narrow, with small, usually rounded, sometimes asymmetric, central area; transverse striae crossed by longitudinal striae at right angles; chromatophores two regularly or irregularly shaped plates, generally with several pyrenoids.

72. **Gyrosigma attenuatum** (Kuetzing) P. T. Cleve. [Syn.: *Pleurosigma attenuatum* W. Smith, *Navicula attenuata* Kuetz. var. *attenuata* Kuetz., *Pleurosigma attenuatum* W. Smith var. *caspia* Grun.]. Valves slightly sigmoid, 150–180μ long $\times$ 25–27μ wide, gradually attenuated to the rounded poles; raphe centrally placed, central area asymmetric, transverse striae slightly radial, 12–14 in 10μ, longitudinal striae wider apart, 10–12 in 10μ, (Pl. X, fig. c).

MALAYA Pahang: Stream near Kuantan.

Malacca: Malacca River.

Worldwide distribution.

The Malayan form is slightly wider than the type and might possibly be referred to var. *hippocampus* W. Smith.

73. **Gyrosigma distortum** (W. Smith) P. T. Cleve. [Syn.: *Pleurosigma distortum* W. Smith]. Valves sigmoid, 100μ long $\times$ 20–22μ wide, broad in the middle but sharply narrowed towards the poles; raphe centrally placed, central area elliptic; transverse striae marked, 15–16 in 10μ, longitudinal striae finer, 19–20 in 10μ. (Pl. X, fig. b).

MALAYA Pahang: Stream near Kuantan.

Widespread in distribution.

74. **Gyrosigma distortum** (W. Smith) P. T. Cleve var. **parkeri** (Harrison) P. T. Cleve. [Syn.: *Pleurosigma parkeri* Harrison]. Differs from the type in the much more sharply narrowed ends; valves distinctly sigmoid, 150–180μ long $\times$ 30–35μ wide, very sharply narrowed towards the poles; raphe central, central area elliptic; transverse striae marked, 15–17 in 10μ, longitudinal striae finer, 19–22 in 10μ. (Pl. IX, fig. e).

MALAYA Pahang: Stream near Kuantan.

Widespread in distribution.

75. **Gyrosigma excentricum** Prowse **sp. nov.** Valves linear sigmoid, 110–120μ long $\times$ 12–13μ wide, gradually narrowed towards the rounded poles; raphe very oblique, sigmoid, disappearing into the convex margins below the poles, central area elliptic, polar nodules very small, intra-marginal and almost invisible; longitudinal striae very fine, 20–22 in 10μ, transverse striae slightly wider apart, 18–20 in 10μ. (Pl. X, fig. d).

MALAYA Pahang: Stream near Kuantan. (Type locality).

Holotype No. Prowse 582c is deposited at the Tropical Fish Culture Research Institute, Malacca, Federation of Malaya.

Valvae lineari-sigmoidea, 110–120μ longae, 12–13μ latae, apicem versus utrinque gradatim attenuatae, summo rotundatae; raphe conformis, ex nodulo centrali ellipsoideo infra polum in marginem convexam utrinque evanescens; noduli polares minuti, in margine fere inconspicui; striae longitudinales gracillimae, 20–22 in 10μ, transversales distantiusculae 18–20 in 10μ.

MALAYA Pahang, in fluvio proximo urbe Kuantan.

This species is very distinct with its extremely oblique raphe. *G. rectum* (Donk.) P. T. Cleve, which has a similarly oblique raphe, is not sigmoid but is quite straight.

76. **Gyrosigma fasciolum** (Ehrenberg) P. T. Cleve var **arcuatum** (Donkin) P. T. Cleve. [Syn.: *Pleurosigma arcuatum* Donk., *Pleurosigma fasciola* W. Smith]. Valves markedly sigmoid, 90–100μ long $\times$ 13–15μ wide, very sharply narrowed towards the ends so that for a quarter of the length it is linear at each end and only 2–3μ wide; raphe central, central area almost circular; transverse striae 24–26 in 10μ, longitudinal striae about equally spaced. (Pl. X, fig. a).

MALAYA Pahang: Stream near Kuantan.

Described from N. Europe and usually regarded as marine, but many other Baltic forms have been found in fresh water.

77. **Gyrosigma scalproides** (Rabenhorst) P. T. Cleve var **eximium** (Thwaites) P. T. Cleve. [Syn.: *Schizonema eximium* Thwaites, *Colletonema eximium* Thwaites, *Endosigma eximium* Brébisson, *Pleurosigma eximium* van Heurck.]. Valves linear sigmoid, 50–55μ long $\times$ 10–12μ wide, margins parallel except near the poles where one margin is sharply bent to the rounded wedge-shaped pole, the other margin only very slightly concave; raphe central, curving at the poles towards the concave margin, central area elliptic; transverse striae 22–24 in 10μ, longitudinal striae 26–28 in 10μ. (Pl. IX, fig. 1).

MALAYA Pahang: Stream near Kuantan.

Cosmopolitan; reported from Indonesia.

78. **Gyrosigma spencerii** (W. Smith) P. T. Cleve var. **smithii** (Grunow) A. Cleve-Euler. [Syn.: *Pleurosigma spencerii* W. Smith var. *smithii* Grunow.]. Valves slightly sigmoid, 100–120μ long $\times$ 13–15μ wide, gradually narrowed to the rounded poles; raphe central, central area elliptic; transverse striae prominent, 18–22 in 10μ, longitudinal striae closer, 22–24 in 10μ. (Pl. IX, fig. f).

MALAYA Malacca: Malacca River.

Widespread in distribution.

PLEUROSIGMA W. Smith 1852, emend. P. T. Cleve 1894

Cells solitary, elliptic-lanceolate in girdle view, intercalary bands and septa usually absent; valves sigmoid, gradually tapering to rounded or sub-acute poles; raphe sigmoid, with small central and polar nodules; axial area narrow, central area usually round; striations consisting of transverse striae crossed obliquely in two opposite directions by other striae thus making 3 series of striations; chromatophores two, four, or many, regular or irregular plates.

Two auxospores formed from the conjugation of two cells.

79. **Pleurosigma elongatum** W. Smith. [Syn. *Pleurosigma angulatum* W. Smith var. *elongatum* W. Smith.]. Valves long, slightly sigmoid, uniformly narrowed to the rounded poles, 140–150μ long $\times$ 18–20μ wide; raphe central, central area small, rhombo-elliptic in shape; transverse striae 18–20 in 10μ, most clearly visible at the margins, oblique striae wider apart 16–19 in 10μ. (Pl. X, fig. f).

MALAYA Pahang: Stream near Kuantan.

Widespread, usually in brackish water.

80. **Pleurosigma salinarum** (Grunow) P. T. Cleve. [Syn.: *Pleurosigma delicatulum* W. Smith var. *salinarum* Grunow.]. Valves broad, slightly sigmoid, gradually narrowed to the rounded poles, 130–150μ long $\times$ 23–26μ wide; raphe central, central area small elliptic; transverse striae 20–22 in 10μ, oblique striae finer and closer together, 22–24 in 10μ. (Pl. X, fig. e).

MALAYA Pahang: Stream near Kuantan.

Widespread in brackish water. Reported from Indonesia.

CALONEIS P. T. Cleve 1891

Cells solitary, free-floating, linear or lanceolate, usually with convex sides and sometimes with marginal inflations in the valve view; girdle view rectangular; raphe straight with rounded central

and polar nodules; transverse striations crossed by one or more longitudinal lines or hyaline areas parallel to the valve margin; intercalary bands absent; chromatophores usually two, irregular, each commonly with two pyrenoids.

81. **Caloneis ladogensis** P. T. Cleve var. **cuneata** A. Cleve. Valves linear elliptic, small 20–25μ long $\times$ 8–10μ wide, margins almost parallel in the middle, narrowing to almost cuneate poles; axial area narrow, central area abruptly widened to form a rectangle or stauros not reaching the margins; striae 16–19 in 10μ, punctate and crossed near each margin by two hyaline longitudinal lines parallel to the margin. (Pl. XVIII, fig. m).

MALAYA Pahang: Cameron Highlands.

Reported from N. Europe.

This form can only come here, corresponding in all ways—shape, rectangular central area and density of striations.

82. **Caloneis silicula** (Ehrenberg) P. T. Cleve var. **minuta** P. T. Cleve. [Syn.: *Navicula ventricosa* Ehr. forma *minuta* Grunow, *Caloneis silicula* (Ehr.) P. T. Cleve var. *gibba* Mayer.]. Valves small, 28–30μ long $\times$ 7–8μ wide, linear lanceolate with triundulate margins and wedgeshaped poles; axial area narrow, central area a wide stauros reaching the margins; striae parallel, 19–21 in 10μ, finely punctate and crossed by a hardly visible longitudinal line close to each margin. (Pl. XIV, fig. n).

MALAYA Malacca: Fish-ponds.

Described from freshwater of Europe, not common.

NEIDIUM Pfitzer 1871

Cells usually solitary and free-floating; girdle view rectangular without intercalary bands; valve view linear, lanceolate, elliptic or irregularly undulate with poles acute, rounded, nearly capitate or rostrate, axial field usually narrow, with rounded or elliptic central area; raphe straight, usually bifurcated at the poles, with central ends facing in opposite directions; transverse striae punctate, crossed near the margin by narrow longitudinal hyaline spaces or lines; chromatophores two, longitudinally incised and thus often appearing as four, each with a pyrenoid.

Auxospores two, formed by the conjugation of two approximated cells.

83. **Neidium hitchcockii** (Ehrenberg) P. T. Cleve. [Syn.: *Navicula hitchcockii* Ehr.]. Valves linear, 65–70μ long $\times$ 16–18μ wide, with three prominent undulations on each margin, narrowing to the cuneate, sub-acute poles; axial area narrow, widening at

the poles, central area obliquely ellipsoid; striae punctate, oblique, 18–20 in 10μ, crossed near each margin by a longitudinal hyaline line. (Pl. IX, fig. a).

MALAYA Malacca: Fish-ponds in Malacca and Jasin.

Widespread in distribution.

Hustedt (1938) has described *N. gracile* from Indonesia, and for geographical reasons the Malayan forms should be included under that name. However Hustedt's reasons for separating off the species on the grounds of a narrow axial area and it being tropical, are so unconvincing that I would prefer to keep the species as *N. hitchcockii*. Ehrenberg's original description makes no reference to the width of the axial area, and other descriptions of *N. hitchcockii* from north temperate areas (A. Cleve-Euler 1955, Tiffany & Britton 1952) refer to a narrow axial area; so there seems to be no difference between the forms found in temperate waters and those found in the tropics.

84. **Neidium iridis** (Ehrenberg) P. T. Cleve var. **ampliatum** (Ehrenberg) P. T. Cleve. [Syn.: *Navicula iridis* Ehr., *Navicula ampliata* Ehr., *Navicula affinis* Greg., *Neidium iridis* (Ehr.) P. T. Cleve var. *intercedens* Mayer.]. Valves elliptic lanceolate, 35–90μ long $\times$ 10–20μ wide, subrostrate at the poles, thus differing from the type species; axial area narrow, widening at the poles, central area obliquely elliptic; striae punctate, parallel to oblique, 16–18 in 10μ, crossed near each margin by a longitudinal hyaline line. (Pl. IX, figs. c & d).

MALAYA Malacca: Malacca River, fish-ponds in Malacca town area.

Widespread in distribution.

85. **Neidium productum** (W. Smith) P. T. Cleve [Syn.: *Navicula producta* W. Smith, *Neidium productum* Hustedt, *Neidium capitatum* A. Cleve, *Neidium capitatum* A. Cleve var. *prolongata* A. Cleve.]. Valves linear-elliptic, with only slightly convex sides, 75–80μ long $\times$ 18–20μ wide; distinctly rostrate with rounded poles; axial area narrow, wider at the poles, central area round; striae punctate, parallel, 15–18 in 10μ, crossed near each margin by a prominent, longitudinal, hyaline line. (Pl. IX, fig. b).

MALAYA Malacca: Malacca River, fish-pond near Jasin.

Probably more widespread in Malaya.

Distribution worldwide.

86. **Neidium productum** (W. Smith) P. T. Cleve var. **minor** A. Cleve. Smaller than the type, 40–45μ long $\times$ 8–10μ wide, with practically straight valve margins and markedly rostrate to subcapitate poles; striae 19–20 in 10μ, crossed near each margin by a longitudinal, hyaline line. (Pl. XII, fig. p).

MALAYA Pahang: Cameron Highlands.

Widespread in distribution.

DIPLONEIS Ehrenberg 1844

Cells solitary, rectangular in girdle view, valves usually elliptic, sometimes linear, or with a median constriction; central nodule quadrate, prolonged towards each pole as a pair of parallel horns or ribs enclosing the raphe and with a longitudinal furrow on each side of the horns and central nodule; transverse striations costate or with coarse punctae or alveolae, often crossed by longitudinal costae or rows of punctae; chromatophores two, sometimes longitudinally incised.

87. **Diploneis bombus** Ehrenberg var. **minor** P. T. Cleve. [Syn.: *Navicula gemina* Ehrenberg.]. Valves linear elliptic, 40–46μ long $\times$ 9–10μ wide, markedly constricted in the middle to give the shape of a broad figure eight, narrowing gradually at the poles to a rounded wedge shape; central nodule large and the paired ribs or horns straight or only slightly curved; transverse costae radial, 7–9 in 10μ, each with coarse alveoli, a row of punctate on each side of the central furrows; costae crossed by longitudinal costae, 4 in the widest part and 2 at the poles. (Pl. XIII, fig. g).

MALAYA Pahang: Stream near Kuantan.

Described from N. Europe in brackish and marine waters, but in Malaya found in non-saline water, although near the coast.

88. **Diploneis decipiens** A. Cleve var. **parallela** A. Cleve. [Syn.: *Diploneis elliptica* (Kuetz.) P. T. Cleve var. *linearis* A. Cleve.]. Valves linear-elliptic, small, 18–20μ long $\times$ 10μ wide, ribs or horns narrow, straight, not widened at the central nodule, longitudinal furrows straight; transverse costae nearly parallel in the middle, radial near the poles, 12 in 10μ, each with a row of coalescing punctae, a single row of punctae on either side of the central furrows. (Pl. IX, fig. i).

MALAYA Pahang: Stream near Kuantan.

Described from brackish water in N. Europe.

89. **Diploneis interrupta** (Kuetzing) P. T. Cleve. [Syn.: *Navicula interrupta* Kuetzing.]. Cells elliptic, constricted in the middle, small, 27–30μ long $\times$ 10–12μ wide; ribs or horns almost straight, central furrows straight; transverse costae radial, absent opposite the central nodule, 10–12 in 10μ, each with 4 large coarse punctae or alveolae in the widest part of the valve, 2 at the poles, and a row of smaller punctae each side of the central furrows. (Pl. IX, fig. k).

MALAYA Pahang: Stream near Kuantan.

Described from brackish water in N. Europe.

90. **Diploneis oblongella** (Naegeli) P. T. Cleve var. **baltica** A. Cleve. [Syn.: *Navicula oblongella* Naeg., *Diploneis ovalis* (Hilse) P. T. Cleve var. *oblongella* Fontell, *Diploneis oblongella* (Naegeli) Cleve var. *fossilis* (Pantoscek) A. Cleve, *Navicula ovalis* var. *fossilis* Pantoscek.]. Valves linear—elliptic, 30–40μ long $\times$ 15–17μ wide, margins only slightly convex, nearly parallel, poles smoothly rounded; ribs or horns narrow, straight, furrows narrow, slightly widened in the middle; costae prominent, almost parallel in the middle, radial at the poles, 12–13 in 10μ, punctate with 12–14 punctae in 10μ short costae of 2–3 punctae either side of the furrows. (Pl. IX, fig. j).

MALAYA Pahang: Stream near Kuantan.

Widespread in freshwaters.

91. **Diploneis ovalis** (Hilse) P. T. Cleve. [Syn.: *Navicula ovalis* Hilse.]. Valves broadly elliptic, 20–25μ long $\times$ 12–15μ wide, tapering gradually to the rounded poles; central nodule large, ribs or horns narrow, furrows narrow, widening markedly opposite the central nodule; costae radial, 12–16 in 10μ, punctate, with 16–20 punctae in 10μ, a row of costae with 1–4 punctae on each side of the central furrows. (Pl. IX, fig. h).

MALAYA Pahang: Cameron Highlands, and a stream near Kuantan.

Selangor: Gombak River.

Malacca: Malacca River.

Doubtless to be found elsewhere in Malaya.

Distribution worldwide in freshwaters.

92. **Diploneis parma** P. T. Cleve. Valves elliptic, 23–26μ long $\times$ 14–15μ wide, tapering gradually to the rounded poles; central ribs narrow, slightly wider near the central nodule, central nodule small; furrows expanded in the centre to enclose a lanceolate central area about 1/3 the width of the valve; costae radial, 11–13 in 10μ, each with two alternating rows of fine punctae, a row of short prominent costae on each side of the central furrows. (Pl. XIII, fig. l).

MALAYA Pahang: Stream near Kuantan.

Distribution in European freshwaters.

This species closely resembles *D. smithii* (Bréb.) P. T. Cleve, but is much smaller, with a smaller central nodule and finer punctae.

STAURONEIS Ehrenberg 1843

Cells solitary or united valve to valve in short filaments; girdle view rectangular, sometimes with intercalary bands; valve view elliptic, lanceolate or rhombic, often capitate, sometimes with longitudinal septa visible at the poles; raphe usually straight, axial area usually narrow, occasionally wider, always widened suddenly in the middle to form a stauros reaching the margins; striae parallel or slightly radial, finely punctate; chromatophores two with two to four pyrenoids.

Auxospores formed in pairs between two conjugating cells.

93. **Stauroneis acuta** W. Smith. Cells joined at the valves to form short filaments; valves rhombo-lanceolate, 65–75μ long $\times$ 18–20μ wide, somewhat inflated in the middle and tapering to rounded poles; raphe straight, axial area moderately wide, in the middle expanded to the margins to form a stauros, central area of stauros rhombic in shape, lateral limbs wider at the margin; poles with visible septa; striae radiate, 14–18 in 10μ, punctate. (Pl. XIII, fig. f).

MALAYA Malacca: Malacca River.

Widespread in freshwater, although not common.

This is a very characteristic species, especially in shape. The Malayan specimens have a slightly finer structure than the type, but hardly sufficiently so to warrant erecting a new variety.

94. **Stauroneis anceps** Ehrenberg. Valves lanceolate, 90–110μ long $\times$ 18–20μ wide, with distinctly capitate poles; raphe straight, narrow, axial area narrow, widened in the middle to form a stauros reaching the margins; striae radial, 16–18 in 10μ, punctate. (Pl. XIII, fig. d).

MALAYA Malacca: Malacca River.

Widespread in freshwater.

95. **Stauroneis anceps** Ehrenberg var. **gothica** A. Cleve-Euler. Valves elliptic-lanceolate, 28–30μ long $\times$ 8–9μ wide, with markedly rostrate to sub-capitate poles; axial area narrow, stauros wide, wider at the margins, each limb with 5 short marginal striae; striae radial, 18–20 in 10μ, finely punctate. (Pl. XIII, fig. j).

MALAYA Pahang: Cameron Highlands.

Described from N. European freshwaters.

96. **Stauroneis anceps** Ehrenberg var. **hyalina** A. Brun and Peragallo. Valves lanceolate, 45–50μ long $\times$ 8–9μ wide, with poles hardly rostrate but almost acute; axial area very narrow, limbs of stauros very narrow, only 2 or 3 striae wide; striae fine, hardly visible, 25–30 in 10μ. (Pl. XIII, fig. k).

MALAYA Pahang: Stream near Kuantan.

Widespread in freshwaters.

97. **Stauroneis obtusa** Lagerstedt. Valves linear lanceolate, 40–50μ long $\times$ 8–10μ wide, narrowing gradually to the broadly rounded almost truncate poles, with visible septa at the poles; axial area narrow, in the middle widening to a prominent stauros the limbs of which are wider at the margins; striae punctate, radial, 19–20 in 10μ. (Pl. XIII, fig. i).

MALAYA Pahang: Stream near Kuantan.

Widespread in freshwaters but not common.

98. **Stauroneis phoenicenteron** (Nitzsch) Ehrenberg var. **elegans** Prowse **var. nov.** Valves linear-lanceolate, 90μ long $\times$ 12μ wide, slightly constricted in the middle, narrowed very slightly below the rounded apices; axial area narrow, expanded in the middle to form a stauros opposite each limb of which are 4–5 short, marginal striae, striae punctate, distinctly radial 18–25 in 10μ. (Pl. XII, fig. d).

MALAYA Malacca: Fish-ponds.

Holotype Prowse No. 504a is deposited at the Tropical Fish Culture Research Institute, Malacca, Federation of Malaya.

Valvae lineari-lanceolate, 90μ longae, 12μ latae, medio leviter constrictae, infra apices rotundatos paululo angustatae. Striae punctatae, manifeste radiales, 18–25 in 10μ. Area centralis circum raphen sita, angusta, medio in staurum dilatata, 4–5 striis brevibus marginalibus adversus eum ornata.

MALAYA Malacca, in stagnis piscosis.

99. **Stauroneis phoenicenteron** (Nitzsch) Ehrenberg var. **halmei** Moelder forma **marginestriata** A. Cleve-Euler. Valves broadly lanceolate, 29–30μ long $\times$ 9–10μ wide, with broad, very slightly rostrate poles; axial area narrow, widening in the middle to a stauros with 3 short marginal striae opposite each limb of the stauros; striae lightly radial, punctate, 17–20 in 10μ. (Pl. XIII, fig. c).

MALAYA Pahang: Cameron Highlands.

Described from freshwaters in N. Europe.

The Malayan specimens are much smaller than the type. They are however obviously a form of *S. phoenicenteron* and apart from size agree closely with var. *halmei* f. *marginestriata*.

100. **Stauroneis phoenicenteron** (Nitzsch) Ehrenberg var. **intermedia** (Dippel) A. Cleve-Euler. [Syn.: *S. phoenicenteron* var. *vulgaris* Dippel forma *intermedia* Dippel, *S. phoenicenteron* var. *brevis* A. Cleve.]. Valves broadly lanceolate, 70–120μ long $\times$ 15–25μ wide, with rounded lightly rostrate poles; axial area

linear, moderately wide, widening in the middle to form a stauros reaching the lateral margins; striae radial, punctate, 13–16 in 10μ. (Pl. XIII, figs. e & h).

MALAYA Selangor: Gombak River.

Malacca: Fish-ponds.

Probably widespread in Malaya.

Cosmopolitan in distribution.

101. **Stauroneis pusilla** A. Cleve var. **franconica** (Mayer) A. Cleve-Euler. [Syn.: *S. anceps* Ehrenberg var. *pusilla* A. Cleve, *S. franconica* Mayer.]. Valves lanceolate, 30–45μ long $\times$ 7–11μ wide, capitate at the poles, axial field narrow, widening in the middle to form a stauros reaching the margins; striae difficult to see, visible only with phase contrast under oil immersion, more than 30 in 10μ. (Pl. XIII, figs. a & b).

MALAYA Pahang: Cameron Highlands.

Reported from European freshwaters.

The Malayan specimens are slightly larger than the type, but the extremely fine striae, and the shape, make it reasonable to include them under the above variety.

ANOMOEONEIS Pfitzer 1871

Cells generally solitary, rectangular in girdle view, in valve view lanceolate to rhombic and elliptic, regularly with convex sides and sometimes with a median inflation, poles acute, rounded or capitate; axial area usually narrow, with a circular or rhombic central area, but sometimes widening into a large lyrate area; raphe straight; transverse striations crossed by longitudinal, zig-zag, hyaline lines; intercalary bands absent; chromatophore single, laminate, longitudinally incised. Two auxospores formed from the union of gametes in pairs from two sister cells enclosed in a gelatinous envelope.

102. **Anomoeoneis brachysira** (Brébisson) Grunow. [Syn.: *Navicula brachysira* Brébisson.]. Valves broadly rhombo-lanceolate, 20–25μ long $\times$ 7–8μ wide, poles broadly rounded; axial area narrow, central area round-rhombic; transverse striae 25–27 in 10μ crossed by two zig-zag hyaline longitudinal lines on each side of the raphe. (Pl. XI, fig. j).

MALAYA Pahang: Cameron Highlands.

Widespread in freshwaters.

103. **Anomoeoneis serians** (Brébisson) P. T. Cleve var. **acuta** Hustedt. [Syn.: *Frustulia serians* Bréb., *Navicula serians* (Bréb.) Kuetz.]. Valves rhombo-lanceolate, 40–50μ long $\times$ 8–9μ wide, uniformly narrowed to the acute poles; axial area narrow, central area round-rhombic; transverse striae 24–27 in 10μ, crossed by 2–3 zigzag, hyaline longitudinal lines. (Pl. XI, figs. b & c).

MALAYA Malacca: Fish-ponds and swamps.

Described from Indonesia.

NAVICULA Bory 1822, emend. P. T. Cleve 1894

Cells generally solitary and free-floating, sometimes aggregated into irregularly radiating clusters, occasionally joined valve to valve to form ribbons; girdle view rectangular, with smooth girdles and without intercalary bands; valve view elongate, lanceolate to elliptic, sometimes with undulate margins, frequently attenuated to capitate, rostrate or rounded poles; axial field usually narrow, central area variable, occasionally expanded and fusing to form large, lyrate, hyaline areas; raphe straight, simple, with polar and central expansions; transverse striations medianly radial to parallel, sometimes with regular or irregular cross lines, in some species pseudocostate through the coalescence of coarse punctae, but the costae without internal openings. Chromatophores laminate, two, rarely four to eight, occasionally with one or more pyrenoids.

Auxospores formed in pairs by the fusion of two gametes from each of two approximated cells.

A very large and variable genus, probably the largest amongst the freshwater diatoms and often divided into subgenera.

104. **Navicula amphibola** P. T. Cleve. Valves elliptic-lanceolate, 28–30μ long $\times$ 12–13μ wide, narrowing suddenly to rostrate poles; axial area narrow, central area rectangular, almost stauroid; striae radial, punctate, 13–16 in 10μ, shorter in the middle. (Pl. XI, figs. k & l; Pl. XII, fig. h).

MALAYA Malacca: Malacca River.

Widespread in freshwaters.

The Malayan form is distinctly smaller and more finely punctate than the type and perhaps it ought to be separated off as a variety. However the shape, proportions and density of the striae correspond closely to those of the species.

105. **Navicula anglica** Ralfs. [Syn.: *Navicula tumida* W. Smith var. *genuina* Grunow, *Navicula gastrum* Ehrenberg var. *anglica* Grunow.]. Valves elliptic-lanceolate, 25–28μ long $\times$ 7–9μ wide,

poles rostrate; axial area narrow, central area small, round; striae radial well marked, 10–14 in 10μ, shorter in the middle. (Pl. XI, fig. u).

MALAYA Selangor: Stream near Klang Gates Reservoir.

Widespread in freshwaters.

106. **Navicula antiqua** A. Cleve. [Syn.: *Navicula dicephala* (Ehr.) W. Smith var. *subcapitata* Mayer, *Navicula pinnularioides* Oestrup var. *continua* A. Cleve.]. Valves linear, 18–22μ long $\times$ 7–8μ wide, with parallel or slightly concave sides and decidedly wedge-shaped poles; axial area narrow, central area round; striae slightly radial, 8–12 in 10μ. (Pl. XI, fig. s).

MALAYA Pahang: Cameron Highlands.

Found in N. European freshwaters.

The Malayan specimens fit best into this species, although no forms with concave sides have been reported from Europe.

107. **Navicula arenaria** Donkin. [Syn.: *Navicula lanceolata* Kuetz. var. *arenaria* (Donk.) P. T. Cleve.]. Cells in girdle view with distinctly convex sides, slightly constricted in the middle opposite the central nodules; in valve view lanceolate with acute poles, 45–50μ long $\times$ 9–10μ wide, often lying slightly tilted laterally due to the convexity of the valve and the poles then appearing to curve slightly to one side; raphe straight, following the central line of the valve and curving in to the central nodule, appearing to curve slightly to one side when the valve is tilted laterally; axial area narrow, central area small; striae prominent, coarsely punctate, radial, 8–9 in 10μ, broken by a short, hyaline longitudinal line on one side of the central area. (Pl. XII, fig. a).

MALAYA Pahang: Stream near Kuantan.

Usually regarded as marine, but here described from non-saline water where it was in company with many healthy large desmids. In some respects the Malayan forms resemble *Navicula lanceolata* (Ag.) Kuetzing, but the valves in that species are straight in girdle view, not convex as in the present forms. Thus the Malayan forms more closely agree with *Navicula arenaria* Donk. from which they differ only by the break in the striae on one side of the central area. Whether this difference is sufficiently consistent for varietal status remains to be seen.

108. **Navicula brasiliensis** Grunow var. **minor** Prowse **var. nov.** Valves elliptic lanceolate, 35–40μ long $\times$ 17–18μ wide, slightly rostrate at the poles; axial field narrow, central area small, round; striae slightly radial, 9–12 in 10μ, punctate; the punctate closer together at the margins forming short transverse

marginal lines, inner punctae wider apart on wavy longitudinal lines. Differs from the type in being much smaller and with more rostrate poles. (Pl. XII, fig. g).

MALAYA Pahang: Stream near Kuantan. (Type locality).

Holotype Prowse No. 582d is deposited at the Tropical Fish Culture Research Institute, Malacca, Federation of Malaya.

This species is usually regarded as marine but is here found in non-saline water.

A forma typica haec varietas differt natura minore et plure rostratorum apicorum.

Valvae ellipticae-lanceolatae, apicibus rostratiusculis, 35–40μ longae, 17–18 latae; area axialis angusta, area centralis minuta rotunda; striae radialiusculae, 9–12 in 10μ, punctatae, puncta in marginem propinquitatioria versus marginem lineis brevibus transversalibus formatis, et puncta versus partem mediam distantiuscula lineis longitudinalibus sinuosis formatis.

MALAYA Pahang: in fluvio proximo urbe Kuantan.

109. **Navicula cancellata** Donkin var. **apiculata** Grunow. Cells in girdle view with curved edges, concave at poles, slightly concave in the middle, valve view linear, 40–50μ long $\times$ 8–10μ wide, with acute wedge-shaped poles appearing one sided when valve is slightly tilted laterally; axial area narrow, suddenly widened at the central nodule where there is one short marginal stria on each side; striae very prominent, 8–10μ, parallel and formed by coalescing coarse punctae longitudinally streaked. (Pl. XI, fig. w).

MALAYA Pahang: Stream near Kuantan.

Usually regarded as marine, but here found in non-saline water.

110. **Navicula confervacea** Kuetzing. Cells united valve face to valve face to form short ribbons; valves lanceolate, 18–25μ long $\times$ 7–9μ wide; axial area lanceolate, slightly widened at the central area; transverse striae fine, radial, 18–20 in 10μ. (Pl. XII, figs. n & o).

MALAYA Malacca: Fish-ponds, attached to the roots of *Eichornia.*

Widespread, especially in the tropics.

This is most easily recognised by its ribbon like habit.

111. **Navicula crucifera** Grunow. [Syn.: *Navicula apiculata* Brébisson, *Navicula apiculata* Brébisson var. *maculifera* Grunow.]. Cells in girdle view with convex margins, sometimes slightly concave in the middle; valves linear-lanceolate, 45–50μ

long × 14–16μ wide, tapering to acute poles; axial area narrow, central area wide, rectangular; striae somewhat radial 6–8 in 10μ very prominent, longitudinally streaked through the coalescence of coarse punctae, striae opposite central area much shorter and sometimes unequal in length. (Pl. XI, fig. p).

MALAYA Pahang: Stream near Kuantan.

Generally regarded as marine but here found in freshwater in the company of large desmids.

112. **Navicula cryptocephala** Kuetzing var. **veneta** (Kuetzing) Grunow. [Syn.: *Navicula veneta* Kuetzing, *Navicula lancettula* Schumann, *Navicula cryptocephala* Kuetz. var. *lancettula* van Heurck, *Navicula cryptocephala* Kuetz. var. *pumila* (Grun.) P. T. Cleve.]. Valves linear-lanceolate to rhombo-lanceolate, 23–25μ long × 5–7μ wide, evenly tapered to the roundish poles; axial area narrow, central area very small; only slightly widened; striae somewhat radial, fine, 15–16 in 10μ. (Pl. XI, fig. r).

MALAYA Pahang: Cameron Highlands.

Widespread in distribution, often in brackish water, but here in decidedly non-saline water far from the sea.

113. **Navicula cuspidata** Kuetzing var. **ambigua** (Ehrenberg) P.T. Cleve. [Syn.: *Navicula ambigua* Ehr.]. Valves lanceolate, 95–100μ long × 25–30μ wide, tapering to markedly rostrate to sub-capitate poles; axial area narrow, central area hardly wider, but elongated; transverse striae parallel, 17–18 in 10μ, distinctly punctate and crossed by longitudinal striae, 22–25 in 10μ. (Pl. XII, fig. e).

MALAYA Malacca: Malacca River.

Widespread but not common.

114. **Navicula disparata** Hustedt. Valves elliptic-lanceolate, 20–25μ long × 8–10μ wide, tapering to slightly rostrate poles; axial area lanceolate, widening in the middle to a roundish central area about 1/3 width of the valve; striae radial, fine, 20–22 in 10μ at the poles, wider spaced in the middle. (Pl. XII, fig. m). MALAYA Pahang: Stream near Kuantan.

Described from Indonesia.

The Malayan specimens are slightly larger than Hustedt's, but in all other respects agree.

115. **Navicula elegantoides** Hustedt. Valves elliptic-lanceolate, 75–80μ long × 30–35μ wide, tapering to the distinctly rostrate poles; axial area widish, very much widened in the middle to

form a circular central area; striae slightly radial in the middle, convergent at the poles, 5 in 10μ, thick but apparently smooth. (Pl. VIII, fig. d).

MALAYA Malacca: Malacca River.

Described from the Philippines.

The species looks almost costate, but cannot be classed as a *Pinnularia* because the pseudocostae have no internal openings.

116. **Navicula feuerborni** Hustedt. Valves narrow-lanceolate, 40–48μ long $\times$ 6–8μ wide, evenly tapered to the rounded poles; axial area moderately narrow, asymmetrical, central area a long ellipse not clearly set off and distinctly asymmetrical in shape; raphe straight except at the poles where it is clearly hooked; striae fine but distinct, radial in the middle, convergent at the poles; 10–12 in 10μ in the middle, slightly closer together at the poles; sometimes of uneven length opposite one side of the central area. (Pl. XI, fig. f).

MALAYA Pahang: Cameron Highlands.

Described from Indonesia.

117. **Navicula gastrum** Ehrenberg. Valves broadly elliptic lanceolate, 25–30μ long $\times$ 11–15μ wide, with short broadly rostrate poles; axial area narrow, central area irregularly roundish to rectangular, raphe straight; striae radial, 8–12 in 10μ, of irregular lengths opposite the central area. (Pl. XI, fig. v).

MALAYA Malacca: Malacca River.

Cosmopolitan in freshwater.

118. **Navicula glacialis** P. T. Cleve var. **septentrionalis** P. T. Cleve. Valve broadly elliptic-lanceolate, 45–50μ long $\times$ 25–30μ wide; axial area narrow, central area rectangular; striae 9–10 in 10μ, punctate with the punctae close together forming short marginal transverse lines, and the inner punctae much wider apart forming wavy longitudinal lines. (Pl. XI, fig. h).

MALAYA Pahang: Stream near Kuantan.

Generally described as marine, but here definitely in freshwater.

119. **Navicula grevillei** (C. A. Agardh) P. T. Cleve. [Syn.: *Schizonema grevillei* C. A. Agardh, *Schizonema comoides* van Heurck, *Navicula rhombica* Donkin). Cells in girdle view with curved margins, convex at the poles, slightly concave in the middle; valve-view lanceolate to rhombo-lanceolate, 45–55μ long $\times$ 12–15μ wide, tapered to the rounded poles; axial area narrow, central area small, elliptic; striae fine, punctate, slightly radial, 18–20 in 10μ, much wider apart opposite the central area. (Pl. XII, fig. b).

MALAYA Pahang: Stream near Kuantan.

Generally regarded as marine, but here found in freshwater.

120. **Navicula halophila** (Grunow) P. T. Cleve var. **subcapitata** Oestrup. Valves lanceolate, 30–35μ long $\times$ 8–9μ wide, tapering to sub-capitate poles, axial area narrow, central area hardly wider; transverse striae parallel, finely punctate, 19–20 in 10μ. (Pl. XI, fig. t).

MALAYA Malacca: Malacca River.

Widespread in distribution, mainly in brackish water.

121. **Navicula hungarica** Grunow var. **luneburgensis** Grunow. Valves lanceolate, 19–20μ long $\times$ 5–6μ wide, tapering to almost acute poles; axial area narrow, central area slightly widened; striae very prominent, 10 in 10μ, radial and longitudinally striated through the coalescence of the coarse punctae. (Pl. XI, fig. c1).

MALAYA Pahang: Stream near Kuantan.

Widespread in distribution.

122. **Navicula hustedtii** Krasske. Valve elliptic-lanceolate, 15–20μ long $\times$ 5–6μ wide, constricted beneath the distinctly capitate poles; axial area narrow, central area small, round; striae radial, 26–30 in 10μ, slightly wider apart opposite the central area. (Pl. XII, fig. k).

MALAYA Malacca: Fish-ponds.

Widespread in distribution.

123. **Navicula lagerheimi** P. T. Cleve var. **intermedia** Hustedt. Valves rhombic, 24–28μ long $\times$ 8–9μ wide, evenly tapered to the broadly rounded poles; axial area narrow, central area rectangular, stauroid; striae radial, 20–22 in 10μ distinctly punctate, very short opposite the central area and with a single prominent pore on one side of the central area. (Pl. XI, fig. n).

MALAYA Malacca: Malacca River.

Described from Indonesia.

Perhaps this species and its varieties ought to be merged with *Navicula mutica* Kuetzing, from which they show little difference.

124. **Navicula lyra** Ehrenberg var. **dilatata** A. Schmidt. Valves elliptic, 50–60μ long $\times$ 30–35μ wide, very slightly rostrate at the rounded poles; axial area linear, widening at the centre to join the lateral longitudinal hyaline spaces, the lateral hyaline areas diverging from the middle and then slightly converging again near the poles, thus forming a lyrate area; striae punctate, slightly radial, 11 in 10μ. (Pl. XII, fig. c).

MALAYA Pahang: Stream near Kuantan.

Generally regarded as marine, but here found in non-saline water. A very characteristic form.

125. **Navicula lyra** Ehrenberg var. **ehrenbergii** P. T. Cleve. [Syn.: *Navicula lyra typica* van Heurck.] Valves elliptic, 55–60μ long $\times$ 23–25μ wide, markedly rostrate at the poles and slightly constricted in the middle of the sides; axial area linear, fusing in the centre with the lateral longitudinal hyaline areas, lateral areas diverging only very slightly in the middle and converging slightly at the poles, forming a lyrate shape; striae punctate, slightly radial, 12–14 in 10μ. (Pl. XI, fig. o).

MALAYA Pahang: Stream near Kuantan.

Usually regarded as marine.

126. **Navicula microcephala** Grunow. Valves narrow-lanceolate, 18–30μ long $\times$ 3μ wide, with sub-capitate poles; axial area narrow, linear to linear lanceolate; transverse striae fine, 30 or more in 10μ, strictly parallel. (Pl. XII, fig. q).

MALAYA Malacca: Fish-ponds.

Widespread in freshwaters, but not common.

127. **Navicula minima** Grunow. Valves linear-elliptic, 14–16μ long $\times$ 4–5.5μ wide, with broad rounded poles; axial area narrow, central area rectangular; transverse striae somewhat radial, 26 in 10μ, shorter and wider spaced opposite the central area. (Pl. XI, fig. z).

MALAYA Malacca: Malacca River.

Widespread in freshwaters.

128. **Navicula minuscula** Grunow. Valves lanceolate, 12–15μ long $\times$ 4–5μ wide, narrowing gradually to the slightly rostrate, rounded poles; axial area very narrow, central area no wider or even slightly constricted; striae hardly radial, fine, more than 30 in 10μ. (Pl. XI, fig. y).

MALAYA Malacca: Malacca River.

Widespread in freshwaters.

129. **Navicula ostenfeldii** Oestrup. Valves small, lanceolate, 25–28μ long $\times$ 6–7μ wide, with capitate poles; axial area narrow, central area only slightly wider; striae fine, strictly parallel, 25–30 in 10μ. (Pl. XII, fig. 1).

MALAYA Malacca: Malacca River.

Freshwater, widespread.

The Malayan forms are slightly larger than the type.

130. **Navicula placenta** Ehrenberg var. **obtusa** Meister. Valves broadly elliptic-lanceolate, 50–55μ long $\times$ 25–30μ wide, gradually narrowing to the broadly rounded poles; axial area narrow, central area small, round; striae punctate forming three

series consisting of transverse lines crossed by two sets of oblique striae and punctae widest apart in the middle and much closer together near the margins and the poles. (Pl. XI, fig. g).

MALAYA Malacca: Malacca River.

So far only described from Asia, including Indonesia.

An unmistakable form.

131. **Navicula platystoma** Ehrenberg. [Syn.: *Stauroneis platystoma* Ehrenberg.]. Valves broadly lanceolate, 20–25μ long $\times$ 10–14μ wide, distinctly rostrate at the poles; axial area narrow, central area lanceolate, laterally elongated; striae radial, 15–19 in 10μ, shorter opposite the central area. (Pl. XI, fig. i).

MALAYA Selangor: Mountain streams near Klang Gates Reservoir.

This form closely resembles var. *minor* Schulz, from which it differs only in being much smaller. Whether it should be classed as a separate variety is a moot point.

132. **Navicula punctulata** F. Smith. Valves elliptic, 24–27μ long $\times$ 14–15μ wide, with broadly rounded poles; axial area narrow, central area circular; striae radial, 12–14 in 10μ, punctate with the punctae equidistant on the striae. (Pl. XI, fig. d1).

MALAYA Pahang: Stream near Kuantan.

Most forms described from marine or brackish water habitats. The present form is small and was found in non-saline water. Possibly it should be separated as a variety.

133. **Navicula pupula** Kuetzing var. **capitata** Hustedt. Valves linear or almost so, 40–45μ long $\times$ 10μ wide, with slightly convex margins and slightly sub-capitate poles; axial area narrow, but widening at the poles; central area somewhat rectangular, but lateral "wings" wider near the margins; striae radial, 13–15 in 10μ in the middle, 22–24 in 10μ near the poles, short opposite the central area, and distinctly curving outwards near the pole leaving a wide polar area. (Pl. XI, fig. a).

MALAYA Malacca: Fish-ponds.

Widespread in distribution.

The present form is somewhat intermediate between var. *capitata* Hustedt and var. *rectangularis* (Greg.) Grunow, but comes closer to the former.

134. **Navicula pusilla** W. Smith. Valves elliptic-lanceolate, 35–40μ long $\times$ 18–20μ wide, distinctly rostrate, almost citriform in appearance; axial area narrow, central area moderately large,

elliptic; striae punctate, radial 12–18 in 10μ, widest apart in the middle with mixed long and short striae opposite the central area, punctae closer together, 18–22 in 10μ. (Pl. XII, fig. f).

MALAYA Pahang: Stream near Kuantan.

Widespread in brackish water but also reported from freshwater. The present form must come here, even though the central area is of different shape.

135. **Navicula radiosa** Kuetzing var. **minutissima** (Grunow) P. T. Cleve. [Syn.: *Navicula tenella* Brébisson var. *minutissima* Grunow.]. Valves narrow-lanceolate, 27–30μ long $\times$ 5–6μ wide, with rounded poles; axial area narrow, central area round; striae radial in the middle, convergent at the poles, 18–19 in 10μ. (Pl. XI, fig. m).

MALAYA Perak: Taiping lakes.

Widespread in freshwaters.

136. **Navicula rhyncocephala** Kuetzing. Valves lanceolate, 28–30μ long $\times$ 6–8μ wide, with slightly elongated, capitate poles; axial area narrow, central area elliptic to circular; striae well-marked, radial in the middle, somewhat convergent at the poles, 12–14 in 10μ, closer together at the poles. (Pl. XI, figs. d & q).

MALAYA Pahang: Cameron Highlands.

Widespread in freshwaters.

The Malayan form is a small form, but differs only in size.

137. **Navicula rotaeana** (Rabenhorst) Grunow. [Syn.: *Stauroneis rotaeana* Rabenhorst, *Stauroneis ovalis* Gregory.]. Valves small, broadly elliptic, 14–16μ long $\times$ 8–9μ wide, with broadly rounded poles; axial area moderately wide, central area stauroid, not reaching the margins; striae fine, somewhat radial, 25–28 in 10μ, shorter and slightly wider apart opposite the central area. (Pl. XI, fig. x).

MALAYA Selangor: Mountain stream near Klang Gates reservoir.

Widespread in distribution.

138. **Navicula schroeteri** Meister. Valves linear-elliptic, 40–50μ long $\times$ 8–10μ wide, with broadly rounded poles; raphe straight with a one-sided central pore; axial area narrow, central area fairly large, elliptic; striae distinctly radial, 12–14 in 10μ, coarsely punctate, but the punctae coalescing to give each stria a longitudinal line effect. (Pl. XI, fig. e).

MALAYA Malacca: Fish-pond, Lorong Pandan, Malacca.

Described from Asia, including Indonesia.

139. **Navicula subtilissima** P. T. Cleve. Valves linear, 20–25μ long $\times$ 3–5μ wide, with capitate poles; axial area narrow, central area only slightly wider; striae fine, only slightly radial, more than 40 in 10μ, hardly visible except in the middle where they are slightly wider apart. (Pl. XII, fig. i).

MALAYA Negri Sembilan: Swamps at Port Dickson.

Malacca: Fish-ponds and swamps.

Johore: Swamps at Yong Peng.

Singapore: Swamps.

Probably widespread.

Cosmopolitan.

140. **Navicula tenera** Hustedt. [Syn.: *Navicula uniseriata* Hustedt.] Valves elliptic, 13–18μ long $\times$ 6–8μ wide, with broadly rounded poles; raphe straight, central poles rather wide apart, axial area lanceolate, asymmetric with a row of punctae on one side of the raphe ending at the central pore; transverse striae radial, 16–18 in 10μ, broken on each side by a longitudinal hylaine curved line parallel to the margin. (Pl. IX, figs. g & m).

MALAYA Pahang: Stream near Kuantan.

Described from Indonesia.

A very characteristic form with the asymmetrical row of punctae.

141. **Navicula toornensis** P. T. Cleve. Valves small, 17–18μ long $\times$ 7–9μ wide, rhombic-elliptic with hardly rostrate, rounded poles; axial area narrow, central area small, hardly wider than the axial area; striae radial, 14–16 in 10μ, distinctly punctate, punctae about 14 in 10μ. (Pl. XI, fig. a_1).

MALAYA Pahang: Stream near Kuantan.

N. Europe in lightly brackish to freshwater.

142. **Navicula tridentula** Krasske. Valves small, 11–14μ long $\times$ 2–3μ wide, linear lanceolate with distinctly triundulate margins narrowing to the rounded rostrate poles; axial area narrow linear, widening in the middle and sometimes almost reaching the margins; transverse striae extremely fine, not distinguishable even under phase contrast. (Pl. XII, fig. j).

MALAYA Malacca: Swamps.

Widespread in boggy regions.

143. **Navicula trituberculata** Prowse **sp. nov.** Valves elliptic, 20μ long $\times$ 10μ wide, laterally sinuate, three-humped on each side, attenuate and rounded at the poles; raphe straight; axial area

narrow, in the middle expanded to form a stauros; striae 18–19 in 10μ, distinctly radial, the central ones being shorter. (Pl. XI, fig. b1).

MALAYA Pahang: Stream near Kuantan. (Type locality).

Holotype Prowse No. 582e is deposited at the Tropical Fish Culture Research Institute, Malacca, Federation of Malaya.

Valvae ellipticae, lateraliter sinuatae utrinque trituberculatae, apice utrinque attenuatae, rotundatae, 20μ longae, 10μ latae. Raphe recta; area axialis angusta medio stauro-formiter ampliata; striae 18–19 in 10μ, manifeste radiales, in centro breviores.

MALAYA Pahang: in fluvio proximo urbe Kuantan.

PINNULARIA Ehrenberg 1840

Cells solitary and free-floating, rarely in short filaments, symmetric and rectangular in girdle view, girdle smooth, without intercalary bands; valves usually with straight or nearly straight sides, sometimes medianly inflated or undulate, usually with broadly rounded poles; axial field usually broad, expanded both at the poles and in the middle, with a complex sigmoid or straight raphe; face of valve crossed by distinct transverse costae with internal openings; costae smooth, radial or parallel (usually convergent at the poles, and with two longitudinal lines often visible in the costate part of the valve; chromatophores two, laminate, usually with pyrenoids.

144. **Pinnularia appendiculata** (C. A. Agardh) P. T. Cleve var. **budensis** Grunow. [Syn.: *Frustulia appendiculata* C.A. Ag.] Valves lanceolate, 40μ long $\times$ 8–9μ wide, slightly convex on the margins, slightly constricted below the sub-capitate poles; axial area narrow but broadening to a lanceolate central area, with a wide stauros reaching the margins; raphe straight, curved slightly only at the polar and central nodules; costae distinctly radial, convergent at the poles, 18–20 in 10μ. (Pl. XIV, fig. k).

MALAYA Pahang: Cameron Highlands.

Cosmopolitan.

145. **Pinnularia biceps** Gregory var. **minor** (Boye Petersen) A. Cleve. [Syn. *Pinnularia interrupta* W. Smith f. *minor* Boye Petersen, *Pinnularia interrupta* W. Smith v. *stauroneiformis* Hustedt.]. Valves linear, 30–35μ long $\times$ 7–8μ wide, with straight margins sharply narrowed to the sub-capitate poles; axial area narrow, widening to a lanceolate central area with a very wide stauros reaching the margins; costae radial, convergent at the poles, 14–16 in 10μ. (Pl. XIV, fig. m).

MALAYA Malacca: Fish-ponds and the Malacca River.

Cosmopolitan.

146. **Pinnularia bogotensis** (Grunow) P. T. Cleve var. **continua** A. Cleve. [Syn.: *Navicula bogotensis* Grun.]. Valves linear, 90–100μ long $\times$ 13–15μ wide, with the middle slightly swollen, ends straight, poles broadly rounded; raphe straight, doubly forked at the polar nodules; axial area narrow, central area wide, elliptic; costae radial, convergent at the poles, 14–16 in 10μ. (Pl. XIV, fig. h).

MALAYA Malacca: Fish-ponds.

Cosmopolitan.

147. **Pinnularia borealis** Ehrenberg. Valves linear-elliptic. 40–45μ long $\times$ 9–10μ wide, with broadly rounded poles; raphe slightly curved, with one sided central pores and bifurcate at the poles; axial area narrow, slightly widened in the middle; costae practically parallel, shorter in the middle, very thick, 4–6 in 10μ. (Pl. XIV, fig. q).

MALAYA Malacca: Malacca River.

Widespread in freshwaters.

148. **Pinnularia braunii** (Grunow) P. T. Cleve. [Syn.: *Navicula braunii* Grun.]. Valves elliptic-lanceolate, 65–70μ long $\times$ 10–12μ wide, narrowing slightly below the sub-capitate poles; raphe straight, axial area more or less wide lanceolate, widening to the margin in the centre to form a wide stauros with very short lateral arms; costae radial, convergent at the poles shorter near the middle, 10–12 in 10μ. (Pl. XIV, fig. a).

MALAYA Perak: Taiping lakes.
Pahang: Cameron Highlands.
Malacca: Fish-ponds.
Probably widespread in Malaya.

Cosmopolitan.

149. **Pinnularia braunii** (Grunow) P. T. Cleve var. **amphicephala** (Mayer) Hustedt. [Syn. *Pinnularia amphicephala* Mayer.]. Valves linear-lanceolate, 35–75μ long $\times$ 8–11μ wide, with less convex margins and more capitate poles than the type; axial area wide, lanceolate, central area a wide stauros with short lateral limbs; costae radial, convergent at the poles, shorter near the middle, 10–14 in 10μ. (Pl. XIV, fig. l; Pl. XV, fig. e).

MALAYA Perak: Taiping lakes.
Pahang: Cameron Highlands.
Malacca: Fish-ponds.
Probably widespread in Malaya.

Cosmopolitan.

150. **Pinnularia brébissonii** (Kuetzing) P. T. Cleve var. **hybrida** (Grunow) A. Cleve. [Syn.: *Navicula brebissonii* Kuetz., *Navicula bicapitata* (Lagerstedt) P. T. Cleve var. *hybrida* Grunow.]. Valves linear elliptic, 25–30μ long $\times$ 7–9μ wide, with slightly convex margin narrowing sharply to the subrostate poles; axial area narrow, widening in the middle to a stauros reaching the margins; costae radial in the middle, convergent at the poles, 9–13 in 10μ. (Pl. XIV, fig. o).

MALAYA Perak: Taiping lakes.

Distribution worldwide.

151. **Pinnularia brevicostata** P. T. Cleve. Valves linear, 90–100μ long $\times$ 18–20μ wide, with broadly rounded poles; axial area very wide, much more than 1/3 width of the valve, lanceolate; costae short, marginal, parallel to very slightly radial, 8–10 in 10μ. Pl. XV, fig. g).

MALAYA Perak: Taiping lakes.

Widespread in distribution.

152. **Pinnularia gibba** W. Smith var. **interrupta** A. Cleve-Euler. Valves narrow linear-lanceolate, 65–70μ long $\times$ 8–10μ wide, slightly swollen in the middle and tapering gradually to the broadly sub-capitate poles; raphe linear, hooked at the poles; axial area narrow, widening slightly towards the middle where it reaches the margin over a wide area; transverse costae radial in the middle, becoming parallel nearer the poles and convergent at the apices, 9–11 in 10μ. (Pl. XIV, fig. b).

MALAYA Perak: Taiping lakes.

Distribution worldwide.

153. **Pinnularia hemiptera** (Kuetzing) Rabenhorst. [Syn.: *Navicula hemiptera* Kuetzing, *Pinnularia hemiptera* Mayer, *Pinnularia hybrida* A. Cleve.]. Valves linear-lanceolate, 65–70μ long $\times$ 12–15μ wide, narrowing slightly to the rounded poles; raphe linear, hooked at the poles; axial area lanceolate, about 1/3 width of the valve; costae parallel to very slightly radial, convergent at the poles, 8–12 in 10μ. (Pl. XV, fig. e).

MALAYA Perak: Taiping lakes.

Widespread in distribution.

154. **Pinnularia legumen** Ehrenberg. Valves linear, 70–75μ long $\times$ 12–15μ wide, with triundulate margins, narrowing below the broadly capitate poles; raphe slightly curved, hooked at the poles, curved to one side at central pores; axial area wide, about 1/3 width of the valve, central area large, rhombic, almost reaching the margins; costae markedly radial in the middle, convergent at the poles, 8–12 in 10μ. (Pl. VIII, fig. e).

MALAYA Perak: Taiping lakes.

Worldwide in distribution.

155. **Pinnularia macilenta** (Ehrenberg) P. T. Cleve. [Syn.: *Navicula macilenta* Ehr.]. Valves linear, 130–170μ long $\times$ 20–25μ wide, with broadly rounded poles and parallel margins; raphe wide, bifurcate at the poles, polar areas circular; axial area wide, linear, about 1/3 the width of the valve; costae parallel, 7–9 in 10μ, crossed on each side by a longitudinal band. (Pl. XVIII, fig. f).

MALAYA Malacca: Malacca River.

Widespread in distribution.

156. **Pinnularia mesolepta** (Ehrenberg) W. Smith. [Syn.: *Navicula mesolepta* Ehrenberg.]. Valves linear, 100–115μ long $\times$ 18–20μ wide, with markedly triundulate margins, slightly wider in the middle, and with broadly capitate poles; raphe straight, bifurcate at the poles, polar areas circular; axial area narrow linear, central area round rhombic, not reaching the margins; transverse costae radial, shorter in the middle, convergent at the poles, 10–13 in 10μ. (Pl. XVI, fig. p).

MALAYA Perak: Taiping lakes.

Widspread in distribution.

The Malayan forms are much larger than the type, and in the specimens so far examined have alternating short and long costae opposite the middle of the central area. It remains to be seen whether these differences are sufficiently consistent to warrant separation of these forms as a distinct variety.

157. **Pinnularia microstauron** (Ehrenberg) P. T. Cleve. [Syn.: *Stauroneis microstauron* Ehr.]. Valves linear to linear lanceolate, 50–70μ long $\times$ 10–14μ wide, with parallel or slightly convex margins narrowing to subrostrate rounded poles; axial area narrow, linear, widening near the middle to a lanceolate area reaching the margins, forming a stauros; costae radial in the middle, convergent at the poles, 10–13 in 10μ. (Pl. XIV, figs. c & e).

MALAYA Malacca: Fish-ponds and the Malacca River.

Widespread in distribution.

158. **Pinnularia microstauron** (Ehrenberg) P. T. Cleve var. **ambigua** Meister. Differing from the type in that the margins are slightly triundulate, and the poles more markedly rostrate; valves 75–80μ long $\times$ 14–16μ wide; transverse costae 10–13 in 10μ. (Pl. XIV, fig. d).

MALAYA Malacca: Malacca River.

Widespread in distribution.

159. **Pinnularia microstauron** (Ehrenberg) P. T. Cleve var. **brébissonii** (Kuetzing) Hustedt. [Syn. *Navicula brébissonii* Kuetz. pro parte.]. Valves linear elliptic with only slightly convex sides, tapering very smoothly to the non-rostrate poles, 60μ long $\times$ 10μ wide; axial and central area as in type; costae as in type, 10–13 in 10μ. (Pl. XIV, fig. f).

MALAYA Malacca: Malacca River.

Widespread in freshwaters.

160. **Pinnularia parva** (Gregory) P. T. Cleve var. **parvula** (Ralfs) A. Cleve-Euler. [Syn.: *Navicula parvula* Ralfs, *Pinnularia parvula* (Ralfs) A. Cleve, *Pinnularia parva* Gregory.]. Valves lanceolate, 50μ long $\times$ 10μ wide, with subrostrate poles; raphe narrow, hooked at the poles; axial area wide, rhombic lanceolate; costae slightly radial in the middle, convergent at the poles, 9–11 in 10μ. (Pl. XV, fig. b).

MALAYA Perak: Taiping lakes.

Widespread in freshwaters.

161. **Pinnularia polyonca** (Brébisson) P. T. Cleve. [Syn.: *Navicula polyonca* Brébisson, *Pinnularia mesolepta* (Ehr.) W. Smith var. *polyonca* (Bréb.) Cleve, *Navicula mesolepta* Ehr.]. Valves lanceolate, 85–90μ long $\times$ 12–15μ wide, a triundulate margin, distinctly swollen in the middle, and slightly constricted beneath the capitate poles; raphe narrow, bifurcate at the poles and with distinct central pores; axial area wide, lanceolate, central area a wide stauros reaching the margins; costae radial in the middle, convergent at the poles, 10–12 in 10μ. (Pl. XVI, fig. o).

MALAYA Malacca: Malacca River.

Widespread in freshwaters.

162. **Pinnularia stauroptera** (Grunow) P. T. Cleve var. **subparallela** Mayer. [Syn.: *Navicula stauroptera* Grun.]. Valves linear, 95–100μ long $\times$ 11–14μ wide, with parallel margins slightly constricted beneath the sub-capitate poles; raphe straight, slightly forked at the poles, and curved at the central pores, axial area fairly wide, 1/3 valve width, central area rhombic, reaching the margins to form a stauros; costae radial in the middle, convergent at the poles, 10–11 in 10μ. (Pl. XV, fig. f).

MALAYA Perak: Taiping lakes.

European freshwaters, not common.

163. **Pinnularia stomatophoroides** Mayer var. **nuda** A. Cleve-Euler. Valves sub-linear, 90–95μ long $\times$ 14–15μ wide, with triundulate margins, slightly broader in the middle and slightly constricted below the rounded sub-capitate poles; raphe straight,

forked at the poles, central pores conspicuous; axial area about 1/3 valve width, central area rhombic, reaching the lateral margins over a narrow area; costae markedly radial in the middle, convergent at the poles, 10–11 in 10μ (Pl. XV, fig. a).

MALAYA Perak: Taiping lakes.

European freshwaters, not common.

164. **Pinnularia stricta** Hustedt. Valves linear, 18–30μ long $\times$ 6–7μ wide, with almost straight margins, sometimes very slightly concave, and broadly rounded poles; raphe straight, curved to one side at the central pores; axial area narrow, widening in a lanceolate manner to the very wide stauros reaching the lateral margins; costae strictly parallel, 12–14 in 10μ. (Pl. XIV, figs. i, j & p).

MALAYA Pahang: Cameron Highlands.

Described from Indonesia.

165. **Pinnularia tabellaria** Ehrenberg. Valves linear, 85–90μ long $\times$ 10–13μ wide, slightly swollen in the middle, with sub-capitate poles; raphe straight, hooked at the poles, curved to one side at the central pores; axial area moderately wide, ¼–1/3 valve width, central area elliptic; costae slightly radial in the middle, convergent at the poles, 12–14 in 10μ. (Pl. XIV, fig. g).

MALAYA Perak: Taiping lakes.

Tropical freshwaters.

166. **Pinnularia trigonocephala** P. T. Cleve. Valves large, linear, 130–140μ long $\times$ 25–28μ wide, slightly wider in the middle and at the slightly wedgeshaped, sub-capitate poles; raphe straight, forked at the poles, and with one sided central pores; axial area less than ¼ valve width, widening in the middle to the elliptic central area; costae radial in the middle, convergent at the poles, 7–8 in 10μ. (Pl. XV, fig. d).

MALAYA Malacca: Malacca River.

Worldwide in distribution, but not common.

AMPHORA Ehrenberg 1840

Cells usually sessile; girdle view broadly elliptic with truncate ends, the concave faces of the valves being attached, girdles usually separated by several punctate or striate intercalary bands; valve view lunate, longitudinally asymmetric; striae transverse, punctate, with a strongly excentric axial field nearer the concave margin; raphe usually nearer the concave margin, with central nodule almost adjacent to the margin; chromatophores single or 2–4.

Auxospores formed in pairs between two conjugating cells, or formed singly by the union of gametes in a single cell.

167. **Amphora acutiuscula** Kuetzing. [Syn.: *Amphora lineata* Gregory, *Amphora coffaeiformis* C. A. Agardh var. *salinarum* Grunow, *Amphora coffaeiformis* C. A. Agardh var. *acutiuscula* (Kuetzing) Grunow.]. Cells in girdle view elliptic, narrowed slightly before the truncate ends, girdle with several intercalary bands which are striated, 18–20 striae in 10μ; valve semi-lanceolate, 30–60μ long $\times$ 6–8μ wide, with only a slightly concave to straight ventral margin, dorsal margin moderately convex, narrowing slightly below the sub-capitate poles; raphe close to the ventral margin, axial area narrow; dorsal striae finely punctate, 14–18 in 10μ, ventral striae short and fine, closer together. (Pl. XVII, figs. e, f, n, q, v & w; Pl. XVIII, fig. b).

MALAYA Pahang: Stream near Kuantan.

Widespread in brackish water, but here found in non-saline water.

168. **Amphora angusta** (Gregory) P. T. Cleve emend. Cells in girdle view elliptic-lanceolate, with narrowly rounded ends and without intercalary bands; valve semi-lanceolate, 18–40μ long $\times$ 2–4μ wide, with acute poles, ventral face only slightly concave, valve resembling *Cymbella;* raphe straight, close to ventral face, axial area wider on the dorsal side of the raphe; dorsal striae 15–17 in 10μ, ventral striae very short, more or less equal in number to the dorsal striae. (Pl. XVII, figs. g & i; Pl. XVIII, fig. g).

MALAYA Pahang: Stream near Kuantan.

Usually regarded as marine but here found in non-saline water.

169. **Amphora bitumida** Prowse **sp. nov.** Frustules in girdle view broadly elliptic, 18–23μ long $\times$ 11–12μ wide in the middle, ends truncate, 3–4μ wide, under each pole slightly arcuate; girdle with many intercalary bands; valves lunate, 18–23μ long $\times$ 5–6μ wide in the middle, markedly convex on the dorsal side, ventrally distinctly tumid and slightly concave opposite the central nodule, poles rostrate to almost subcapitate; raphe simple, not sigmoid, axial area narrow on the dorsal side, sometimes slightly wider near the central nodule, wider and semi-lanceolate on the ventral side, widest in the middle; dorsal striae 17–18 in 10μ, radiate, punctate, ventral striae short, fine 22–25 in 10μ. (Pl. XVII, figs. a, b & c).

MALAYA Pahang: Stream near Kuantan. (Type locality).

Holotype Prowse No. 582f is deposited at the Tropical Fish Culture Research Institute, Malacca, Federation of Malaya.

Frustula aspectu zonali lato-elliptica, apice utrinque truncata 3–4μ lata, infra apicem singulam arcuatiuscula, 18–23μ longa, medio 11–12μ lata, laciniae intercalares plures. Valvae lunate, 18–

23μ longae, medio amplissimae 5–6μ latae, dorso fortiter convexae, ventre manifeste tumidae et nodulum centralem adversus concaviusculae, apice utrinque rostratae, fere capitellatae.

Raphe simplex, haud sigmoidea; area centralis dorso angusta, interdum apud nodulum centralem latiuscula, ventraliter latior, semi-lanceolata, medio latissima. Striae dorsales 17–18 in 10μ, radiatae, punctatae; eae ventrales breves, graciles 22–25 in 10μ.

MALAYA Pahang: in fluvio proximo urbe Kuantan.

170. **Amphora coffaeiformis** C. A. Agardh. Cells in girdle view elliptic, slightly narrowed below the truncate ends, girdles with several intercalary bands; valves lunate, 25–30μ long $\times$ 4–6μ wide; with slightly concave ventral margin and convex dorsal margin narrowed slightly below the rostrate poles; axial field very narrow, raphe straight, near the ventral margin; dorsal striae 20–24 in 10μ, ventral striae very short and fine. (Pl. XVII, fig. h & o).

MALAYA Pahang: Stream near Kuantan.

Widespread, generally in brackish waters.

171. **Amphora exigua** Gregory. Cells in girdle view lanceolate, slightly narrowed before the rounded-truncate ends, girdles with several intercalary bands which are finely striate; valve view semi-lanceolate, 25–30μ long $\times$ 6–7μ wide, with a straight to slightly convex ventral margin and a convex dorsal margin, both sides being slightly arcuate beneath the sub-capitate poles; axial area narrow, raphe straight, close to the ventral margin; dorsal striae slightly radial, 11–13 in 10μ, punctate, ventral striae very short, fine and closer together, absent opposite the central nodule. (Pl. XVII, fig. d).

MALAYA Pahang: Stream near Kuantan.

A so-called marine species here found in freshwater. It has been recorded from brackish water in S. Africa (Cholnoky 1959).

172. **Amphora holsatica** Hustedt. Cells in girdle view elliptic-lanceolate, slightly narrowing before the truncate ends, girdles with several intercalary bands which are coarsely punctate; valve semi-lanceolate, 40–45μ long $\times$ 7–9μ wide, ventral margin straight or nearly so, dorsal side convex, both sides slightly narrowing to the small sub-capitate poles; raphe close to the ventral margin, straight; dorsal striae coarsely punctate, 12–13 in 10μ, punctate about 12 in 10μ, ventral striae very short and fine, closer together, absent opposite the central nodule. (Pl. XVII, fig. m).

MALAYA Pahang: Stream near Kuantan.

Widespread, usually in brackish water.

173. **Amphora holsatica** Hustedt var. **malayana** Prowse **var. nov.** Differing from the type by the punctae of the dorsal striae united into lines nearer the raphe, elsewhere distinct, and below each stria a dot separated by a hyaline gap. (Pl. XVII, fig. l).

MALAYA Pahang: Stream near Kuantan. (Type locality).

Holotype Prowse No. 582g is deposited at the Tropical Fish Culture Research Institute, Malacca, Federation of Malaya.

A forma typica haec varietas differt punctis striarum dorsalium alioqui distinctis, raphen versus in lineas unitis et infra unasquisque lineas punctis singulis per intervallos conspicous sejunctis.

174. **Amphora libica** Ehrenberg. [Syn.: *Amphora ovalis* Kuetz. var. *libica* P. T. Cleve.]. Cells in girdle view elliptic, with truncate ends; valve view lunate, 20–25μ long $\times$ 6–7μ wide, with concave ventral margin, convex dorsal margin, tapering gradually to the rounded poles; raphe near the ventral margin, curving very slightly towards the dorsal margin at the central nodule; dorsal striae punctate, 15–18 in 10μ, much shorter near the central nodule, ventral striae short, shortest at the middle, fine and closer together. (Pl. XVII, fig. p).

MALAYA Pahang: Stream near Kuantan.

Widespread in distribution.

175. **Amphora normani** Rabenhorst. Cells in girdle view long-elliptic, slightly narrowed below the truncate ends, girdles with several fine intercalary bands; valve view lunate, 30–40μ long $\times$ 8–10 μ wide, slightly constricted below the broad sub-capitate poles; raphe some distance away from the ventral margin, leaving a wide space, central nodule curving dorsalwards, dorsal axial area very narrow; dorsal striae radial, 17 in 10μ, shorter opposite the central nodule, ventral striae very short. (Pl. XVII, fig. r).

MALAYA Pahang: Stream near Kuantan.

Widespread in freshwaters.

176. **Amphora perpusilla** Grunow. Cell very small, in girdle view elliptic, 8–12μ long $\times$ 4–5μ wide, in the present form very slightly constricted in the middle; valve view lunate, 8–12μ long $\times$ 1½–2μ wide, with convex dorsal side, with a very shallow kink in the middle, ventral side straight or hardly concave; raphe straight, close to the ventral margin; axial area on dorsal side very narrow, central area unmarked; dorsal striae 20–24 in 10μ slightly radial, and slightly wider apart in the middle, ventral margin smooth. (Pl. XVII, fig. j).

MALAYA Pahang: Stream near Kuantan.

The Malayan form differs slightly from the type, both in the slight median constriction and in the slightly wider spacing of the striae in the middle. Should these characters prove constant it should be separated as a variety.

177. **Amphora proteus** Gregory. Cells in girdle view linear-elliptic to almost rectangular with lightly convex margins and broad flat truncate ends, girdles without intercalary bands; valve view lunate, 40–60μ long $\times$ 7–10μ wide, only slightly curved, with broad rounded poles; raphe in the middle of the valve distinctly curved ventralwards from the poles to the central nodule, and hooked slightly dorsalwards at the central nodule; dorsal striae slightly radial, 10–13 in 10μ, very coarsely punctate, punctae arranged more or less in longitudinal lines as well as in transverse striae occasionally with a hyaline area opposite the central nodule, ventral striae as long similarly punctate and similarly spaced but absent opposite the central nodule. (Pl. XVII, fig. u; Pl. XVIII, fig. a).

MALAYA Pahang: Stream near Kuantan.

Generally regarded as marine, but here definitely in freshwater.

CYMBELLA C. A. Agardh 1830

Cells solitary and free-floating or attached at the ends of gelatinous stalks, or confined in branched gelatinous tubes; girdle view rectangular with smooth girdles, intercalary bands absent; valve view asymmetric, sometimes only slightly so, lunate or more rarely nearly elliptic, rhombic or naviculoid, dorsally convex, ventrally concave, straight or somewhat convex; axial area wide or narrow, nearer the ventral margin, central area with or without dots; raphe curved, with well defined nodules; transverse striations radiate, sometimes crossed by longitudinal lines; chromatophores a single expanded plate.

Auxospores formed in pairs between the conjugating cells.

178. **Cymbella cuspidata** Kuetzing. Valves broadly lanceolate, 35–40μ long $\times$ 15–16μ wide, asymmetrical, narrowing beneath the subrostrate poles; raphe almost central, slightly curved, axial area narrow, central area round-rhombic; striae radial, fine, 9–11 in 10μ in the middle, 12–15 in 10μ near the poles. (Pl. XVII, fig. z).

MALAYA Malacca: Malacca River.

Widespread in freshwaters.

179. **Cymbella javanica** Hustedt. Valves lanceolate, 15–20μ long $\times$ 4μ wide, asymmetric, with a markedly convex dorsal margin and a slightly convex ventral margin, narrowing slightly beneath the subrostrate poles; raphe hardly curved, axial area narrow, widening in the middle to form a lanceolate area; striae prominent, radial, 11–12 in 10μ, slightly wider apart on the ventral margin. (Pl. XVII, fig. k).

MALAYA Malacca: Malacca River.

Described from Indonesia.

180. **Cymbella kolbei** Hustedt. Valves broadly lanceolate, asymmetric, 25–30μ long $\times$ 9–11μ wide, dorsal margin very convex, ventral margin less so, tapering smoothly to the rounded poles; raphe central, slightly curved, axial area narrow, widening near the middle to an elliptic central area; striae finely punctate, 11–12 in 10μ, slightly radial in the middle, more so at the poles; a single puncta in the middle of the central area. (Pl. XVII, fig. y).

MALAYA Malacca: Malacca River, fish-ponds and swamps.

Described from the Middle East and S. Africa, but probably more widespread. The Malayan forms seem to fit best into this species.

181. **Cymbella lanceolata** (Ehrenberg) van Heurck. [Syn.: *Cocconema lanceolata* Ehrenberg.]. Valves distinctly asymmetrical, naviculoid, 70–80μ long $\times$ 15–20μ wide, with a convex dorsal margin, and concave ventral margin slightly tumid in the middle, tapering smoothly to the rounded poles; raphe excentric, slightly curved; axial area narrow, widening slightly towards the middle; striae at right angles to the raphe in the middle, radial at the poles, 9–11 in 10μ, markedly punctate, punctae 15–18 in 10μ. (Pl. XVIII, fig. 1).

MALAYA Malacca: Swampy water.

Widespread in distribution.

182. **Cymbella sumatrensis** Hustedt. Valves broadly lanceolate, 35–40μ long $\times$ 9–10μ wide, distinctly asymmetric, with a very convex dorsal margin and a less convex ventral margin, tapering to the blunt, rounded poles; raphe nearly central, slightly convex towards the dorsal margin; axial area narrow, widening in the middle to form an elliptic central area; striae coarsely punctate, radial, in the middle of the dorsal side 10 in 10μ, closer together near the poles and on the ventral sides; a single isolated pore opposite the middle ventral stria. (Pl. XVIII, fig. h).

MALAYA Malacca: Malacca River.

Described from Indonesia.

183. **Cymbella tumida** (Brébisson) van Heurck. [Syn.: *Cocconema tumidum* Brébisson, *Cocconema stomatophorum* Grunow.]. Valves broadly lunate, 50–70μ long $\times$ 18–20μ wide, with a very convex dorsal margin, ventral margin straight or slightly concave, swollen in the middle region, narrowing slightly at the ends beneath the broad, blunt poles; raphe almost central, a little nearer the ventral margin, slightly curved; axial area linear, widening in the middle to the large, broadly rounded central area; striae coarsely punctate, radial, 8–10 in 10μ in the middle of the dorsal side, closer together elsewhere; a single large pore in the middle of the ventral half of the central area. (Pl. XVII, fig. a1).

MALAYA Pahang: Cameron Highlands.

Selangor: Gombak River.

Widespread in freshwaters.

A very characteristic species.

184. **Cymbella turgida** Gregory. [Syn.: *Encyonema turgidum* (Greg.) Grunow.]. Valves lunate, 35–40μ long $\times$ 11–12μ wide, with a very convex dorsal margin and a straight ventral margin, with more or less sub-acute poles; raphe excentric, straight except at the poles, where it curves sharply towards the ventral margin; axial area narrow, linear, only slightly wider in the middle; striae on dorsal side radial, 8–10 in 10μ, coarsely punctate, punctae 17–20 in 10μ, on ventral side convergent and closer together. (Pl. XVII, fig. x).

MALAYA Malacca: In a swamp.

Widespread in freshwaters.

185. **Cymbella ventricosa** Kuetzing. Valves lunate, 15–25μ long $\times$ 5–7μ wide, with a distinctly convex margin and a straight to slightly convex ventral margin, poles rounded acute; raphe near the ventral margin, straight; axial area narrow, only slightly wider in the middle; striae slightly radial, 14–16 in 10μ, finely punctate. (Pl. XVII, figs. s & t).

MALAYA Pahang: Cameron Highlands.

Widespread in freshwaters.

GOMPHONEMA C. A. Agardh 1824

Cells usually epiphytic on the ends of dichotomously branched gelationous stalks, sometimes sessile, more rarely solitary and free floating; girdle view transversely asymmetrical, cuneate, the narrower end being the point of attachment; valve view also transversely asymmetrical, cuneate, clavate, lanceolate or nearly straight with one pale broader than the other, and often capitate; axial field narrow, straight, with a straight raphe and conspicuous central and

polar nodules; striations transverse, parallel or radial; central area sometimes extending to the margins, with an asymmetrically placed dot or pore; chromatophore a single lobed plate, usually with a single pyrenoid.

Auxospores formed in pairs between two conjugating cells.

186. **Gomphonema gracile** Ehrenberg. Valve view rhombic-lanceolate, 40–50μ long $\times$ 8–10μ wide, almost isopolar with narrow rounded poles; axial area narrow, linear, with a small roundish central area, with a single isolated pore on one side; striae slightly radial to almost parallel, 12–15 in 10μ, not markedly punctate. (Pl. XVI, figs. a & e).

MALAYA Malacca: Fish-pond.

Widespread in freshwaters.

187. **Gomphonema longiceps** Ehrenberg var. **subclavata** Grunow forma **gracilis** Hustedt. Valves narrow linear rhombic, 65–70μ long $\times$ 9–10μ wide, margins slightly concave between the middle and the narrow rounded poles; axial area narrow, central area small, with a short marginal stria on each side and an isolated pore on one side; striae slightly radial, 10–12 in 10μ, lightly punctate. (Pl. XVI, fig. m).

MALAYA Pahang: Cameron Highlands.

Widespread in freshwaters, but not common.

188. **Gomphonema parvulum** (Kuetzing) van Heurck. [Syn.: *Sphenella parvula* Kuetzing.]. Cells small, valves elliptic lanceolate, 15–30μ long $\times$ 4–7μ wide, more or less rostrate to subcapitate at the free pole (i.e. not attached to the gelatinous stalk) and slightly constricted above the attached pole; axial area narrow, central area small, one-sided, with a single isolated pore on one side; striae slightly radial to nearly parallel, 13–17 in 10μ, lightly punctate. (Pl. XVI, figs. c, d, g, h & i).

MALAYA Pahang: Cameron Highlands.
Selangor: Gombak River.
Malacca: Swamps.

Widespread in freshwaters. A very variable species of which several varieties have been named. The Malayan material has too many intermediate forms to justify separating any varieties.

189. **Gomphonema subtile** Ehrenberg. Valves slender, narrow-lanceolate, 50–65μ long $\times$ 7–8μ wide, convex in the middle but narrowing and slightly concave towards the poles; free pole distinctly broadly capitate, the attached pole narrow, rounded; axial area narrow, central area wider, lanceolate, with shorter

striae on one side, and usually with a single isolated pore, sometimes with more, sometimes with none; striae slightly radial, 12 in 10μ, punctate. (Pl. XVI, figs. b, j, k & l).

MALAYA Perak: Taiping lakes.

Widespread in freshwaters.

The shape is very characteristic, but the usual form has no isolated pore in the central area; in the Malayan material the other forms seem equally common.

190. **Gomphonema subventricosum** Hustedt. Valves lanecolate, 32–40μ long $\times$ 7–8μ wide, broadest above the middle, tapering gently towards the subrostrate free pole, narrowing very much below the middle towards the narrowly rounded pole of attachment; axial area narrow, widening slightly in the middle, where the striae are shorter and with a single isolated pore on one side; striae slightly radial, 10–12 in 10μ, markedly punctate, with the punctae drawn out longitudinally. (Pl. XVI, figs. f & n).

MALAYA Selangor: Stream near the Klang Gates Reservoir.

Described from Indonesia.

RHOPALODIA O. Mueller 1895

Cells usually solitary and free-floating; girdle view with two faces, a convex face much wider than the other straight or concave face; girdle view linear, nearly elliptic, clavate or almost rounded, often medianly inflated and sometimes with a median notch; valve view lunate to sickle-shaped, convex margin often inflated, with acute ends, sometimes elongate, surface distinctly ridged towards the convex margin; axial field in valve ridge, with raphe bearing central and polar nodules; both valve and girdle view transversely costate, with intermediate finer striae; intercalary bands present or absent; chromatophores single, laminate, with irregular margins.

Auxospores formed in pairs between two usually different sized cells, elongating perpendicular to the long axis of the cells.

191. **Rhopalodia gibberula** (Ehrenberg) O. Mueller. [Syn.: *Epithemia gibberula* Ehr.]. Girdle view elliptic, 40–45μ long $\times$ 22–25μ wide, narrowing to the bluntly rounded ends; valves sickle-shaped with a very convex dorsal margin having a notch in the middle and a slightly concave ventral margin; costae radial, 3–4 in 10μ, each pair with 4–6 striae between them, striae 15–18 in 10μ on the ventral margin. (Pl. XXII, fig. a).

MALAYA Selangor: Stream near Klang Gates Reservoir.

Widespread usually in brackish water, but here in undoubtedly freshwater.

192. **Rhopalodia musculus** (Kuetzing) O. Mueller. [Syn.: *Epithemia musculus* Kuetzing.]. Girdle view broadly elliptic, almost circular, 20μ long $\times$ 18μ wide, with broadly rounded poles; valves broadly lunate, with a very convex dorsal margin, ventral margin straight except at the poles where it curves sharply ventralwards; costae 3–4 in 10μ, with 3–5 striae between each pair, striae 16–18 in 10μ on the ventral margin. (Pl. XXII, fig. f).

MALAYA Pahang: Stream near Kuantan.

Widespread, usually in brackish water.

193. **Rhopalodia parallela** (Grunow) O. Mueller. [Syn.: *Epithemia gibba* Kuetz. var. *parallela* Grunow.]. Girdle view linear, 65–80μ long $\times$ 14–15μ wide, with sides nearly parallel and only slightly narrowed at the truncate ends; valves half linear-lanceolate, with a very slightly convex, almost straight dorsal margin, slightly constricted in the middle, and straight ventral margin; costae slightly radial, 6–8 in 10μ, with 2–4 striae between each pair, striae 12–15 in 10μ (Pl. XXII, fig. b).

MALAYA Pahang: Stream near Kuantan.

Widespread, usually in brackish water.

TROPIDONEIS P. T. Cleve 1894

Cells usually solitary and free-floting; girdle view nearly rectangular with a median constriction, to broad hour-glass shaped, a keel curving in on each margin from the poles to the central nodule, intercalary bands present or absent; valve view lanceolate, usually acute at the poles, with the raphe in a wing or keel which may be strictly central, or which may be sigmoid from one pole to the other; axial field narrow, central area small, transverse striae marked, sub-parallel to radial. Chromatophores 2, parallel to the girdle. Mainly a marine genus.

194. **Tropidoneis lepidoptera** (Gregory) P. T. Cleve. [Syn.: *Amphiprora lepidoptera* Gregory.]. Cell in girdle view long-rectangular, 40–80μ long $\times$ 23–25μ wide, markedly constricted in the middle, poles truncate, rounded; valves linear-lanceolate, 40–80μ long $\times$ 12–15μ wide, with narrowed sub-acute poles; wing containing raphe central, usually seen obliquely slightly to one side of the longitudinal axis; axial field very narrow, central area small, round; transverse striae slightly radial, fine, 16–22 in 10μ. (Pl. XVIII, figs. c, d, e & i).

MALAYA Pahang: Stream near Kuantan.

Usually regarded as marine, but here found in freshwater.

HANTZSCHIA Grunow 1877

Cells curved in both valve and girdle view, thus having a dorsal and ventral margin; girdle view elongate-rectangular, somewhat attenuate; valve view linear-lanceolate to linear, more or less attenuated to rostrate or capitate poles; raphe of each valve in a keel near the ventral margin, so that both keels are on the same side of the longitudinal axis, raphe with circular pores ("carinal dots") opening towards the interior of the cells; valves transversely striate; chromatophore single near one side of the girdle.

195. **Hantzschia amphioxys** (Ehrenberg) Grunow var. **capitata** O. Mueller. [Syn.: *Eunotia amphioxys* Ehr.]. Valves linear-lanceolate, 35–40μ long $\times$ 5μ wide, slightly curved, and narrowing to the small capitate poles; carinal pores 8 in 10μ, much wider apart in the middle and with a prominent central nodule; striae 22–25 in 10μ. (Pl. XIX, fig. t).

MALAYA Selangor: Stream near Klang Gates reservoir.

Widespread in freshwaters.

196. **Hantzschia amphioxys** (Ehrenberg) Grunow var. **vivax** (Hantzsch) Grunow. [Syn.: *Eunotia amphioxys* Ehr., *Nitzschia vivax* Hantzsch, *Nitzschia elongata* Hantz. var. *minor* Mayer.]. Valves linear, 180–225μ long $\times$ 10μ wide, slightly curved and attenuated to the sub-acute rostrate poles, ventral margin constricted in the middle; carinal pores 6 in 10μ, central nodule prominent, striae 18–20 in 10μ. (Pl. XIX, fig. r).

MALAYA Malacca: Malacca River.

Widespread in freshwaters.

NITZSCHIA Hassall 1845

Cells solitary and free-floating or densely clustered in simple or unbranched gelatinous tubes; girdle view elongate-rectangular, or sigmoid, with somewhat attenuated poles; valves usually longitudinally asymmetric, rarely symmetric, very variable in shape, straight, sigmoid, linear, elliptic, sometimes undulate, with or without median constriction, poles acute, rostrate or capitate, often much attenuate; raphe in keel which is usually near one margin, rarely central with small nodules and a row of carinal dots opening towards the interior of the cell, keels of the two valves on opposite sides of the longitudinal axis, except where the keel is central; valve transversely striate or punctate and sometimes costate.

Two auxospores formed by the conjugation of two cells in somewhat crossed opposition.

197. **Nitzschia acicularis** (Kuetzing) W. Smith. [Syn.: *Synedra acicularis* Kuetzing.]. Valves 60–65μ long $\times$ 5μ wide, spindle-shaped with markedly attenuate straight ends; carinal pores small, 12–16 in 10μ, transverse striae more than 30 in 10μ, very fine, only just visible with phase contrast. (Pl. XIX, fig. m).

MALAYA Malacca: Swampy rice field.

Widespread in freshwater.

198. **Nitzschia amphibia** Grunow var. **acutiuscula** Grunow. Cells small, valves 18–22μ long $\times$ 4μ wide, lanceolate with acute, wedge-shaped poles; carinal pores small, 7–9 in 10μ, transverse striae 17–20 in 10μ, punctate. (Pl. XIX, fig. g).

MALAYA Malacca: Fish-ponds.

Widespread in fresh to brackish water.

199. **Nitzschia closterium** (Ehrenberg) W. Smith. [Syn.: *Ceratoneis closterium* Ehr.]. Valves 35–40μ long $\times$ 2–3μ wide, spindle-shaped in the middle, but curved in a sickle shape with very long narrow attenuated ends; carinal pores 15–16 in 10μ, transverse striae extremely fine and hardly visible. (Pl. XX, fig. n).

MALAYA Pahang: Stream near Kuantan.

Usually reported from brackish or sea water, but here in freshwater.

A very characteristic form.

200. **Nitzschia communis** Rabenhorst var. **abbreviata** Grunow. Cells very small, valves 6–8μ long $\times$ 2.5–3μ wide, elliptic with narrow rounded poles; carinal pores 12–14 in 10μ, with a gap in the middle, striae fine, 30 in 10μ. (Pl. XIX, fig. j).

MALAYA Pahang: Stream near Kuantan.

Widespread.

201. **Nitzschia constricta** (Gregory) Grunow. [Syn.: *Tryblionella constricta* Greg.]. Valves linear-elliptic, 18–22μ long $\times$ 8–9μ wide, with slightly constricted margins and wedge-shaped poles; carinal pores small, 10 in 10μ striae 16–20 in 10μ, distinctly punctate, the punctae forming oblique lines sloping in opposite directions to the longitudinal axis. (Pl. XIX, fig. d).

MALAYA Pahang: Stream near Kuantan.

Usually regarded as marine.

202. **Nitzschia diducta** Hustedt. Valves broadly linear, 38–40μ long $\times$ 7–8μ wide, with slightly concave to parallel margins, wedge-shaped ends, and narrow rounded, almost acute poles; carinal pores 8–10 in 10μ, wider apart in the middle; transverse striae well marked, 30 in 10μ. (Pl. XIX, fig. x).

MALAYA Pahang: Stream near Kuantan.

Described from Indonesia.

203. **Nitzschia fonticola** Grunow. Cells small, valves 12–15μ long $\times$ 2–4μ wide, lanceolate, narrowing to the sub-rostrate to sub-acute poles; carinal pores 12–14 in 10μ, transverse striae fine but clearly visible, 28–30 in 10μ. (Pl. XIX, figs. a, b & c).

MALAYA Negri Sembilan: fish-ponds.

Malacca: fish-ponds, Malacca River.

Widespread throughout the world.

204. **Nitzschia gandersheimiensis** Krasske. Valves linear, 90–100μ long $\times$ 4μ wide, slightly narrowing to the rounded, hardly rostrate poles; carinal pores very irregular, 8–9 in 10μ, transverse striae very fine, just visible with phase contrast, more than 30 in 10μ. (Pl. XIX, fig. u).

MALAYA Malacca: Fish-ponds in Malacca and the Malacca River.

Widespread.

205. **Nitzschia granulata** Grunow. Valve elliptic-lanceolate, 20μ long $\times$ 11μ wide, with rounded poles; carinal pores 7–8 in 10μ, transverse striae 7–8 in 10μ, with very coarse punctate, 6 in 10μ. (Pl. XIX, fig. i).

MALAYA Pahang: Stream near Kuantan.

Usually regarded as marine.

Cleve-Euler (1952) mentions very short marginal double rows of fine punctae as well as the coarse ones. These were not visible in the Malayan material, which agrees in all other respects. It would however be very difficult to see the fine punctae in a complete specimen, since the coarse punctae of one valve would hide the fine punctae in the others. I was not able to observe single valves, only complete frustules.

206. **Nitzschia heufleuriana** Grunow. Valves linear, 90–100μ long $\times$ 4–5μ wide, often slightly curved and distinctly constricted beneath the capitate poles; carinal pores 9–10 in 10μ, slightly wider apart in the middle, transverse striae prominent, 15–20 in 10μ. (Pl. XIX, fig. v).

MALAYA Malacca: Swamp in Malacca.

Widespread.

207. **Nitzschia ignorata** Krasske. Cell in girdle view linear, sigmoid; valve view linear-lanceolate, 60–70μ long $\times$ 4μ wide, distinctly sigmoid and narrowing evenly to the rounded poles; keel very excentric, slightly kinked in the middle; carinal pores 7–10 in 10μ, wider in the middle, transverse striae fine, about 30 in 10μ. (Pl. XIX, fig. s).

MALAYA Malacca: Malacca River.

Widespread, usually in brackish water.

208. **Nitzschia littoralis** Grunow var. **tergestina** Grunow. Valves broad linear-elliptic, 28–30μ long $\times$ 9–10μ wide, with parallel to slightly concave margins and wedge shaped ends tapering to rounded sub-rostrate poles; carinal pores 7–8 in 10μ with a distinct central nodule; transverse striae 20 in 10μ, with a central narrow, lanceolate, clear longitudinal field less than 1/3 width of the valve. (Pl. XX, fig. k).

MALAYA Pahang: Stream near Kuantan.

Usually found in brackish water.

This may be identical with *Nitzschia calida* Grunow.

209. **Nitzschia lorenziana** Grunow var. **subtilis** Grunow. Valve long, linear-lanceolate, 100–110μ long $\times$ 4–5μ wide, distinctly sigmoid with curved ends tapering to the narrow rounded poles; keel excentric, carinal pores 8 in 10μ, transverse striae 20 in 10μ. (Pl. XIX, fig. q).

MALAYA Malacca: Malacca River.

Widespread in fresh to slightly brackish water.

210. **Nitzschia marginulata** Grunow. Valve broad linear, 100–110μ long $\times$ 18–20μ wide, with wedge-shape ends tapering to narrow, rounded poles; carinal pores 9–10 in 10μ, striae 19–22 in 10μ, punctate, valve face with a very broad, smooth, linear-lanceolate central area stretching from pole to pole. (Pl. XXI, fig. b).

MALAYA Pahang: Stream near Kuantan.

Usually found in brackish water.

211. **Nitzschia microcephala** Grunow. Valves linear, 10–15μ long $\times$ 2.5–3μ wide, with parallel or slightly convex margins, sharply narrowed to slightly attenuate sub-capitate poles; carinal pores 12–14 in 10μ, transverse striae fine, 32–36 in 10μ. (Pl. XIX, fig. f).

MALAYA Pahang: Stream near Kuantan.

Widespread in freshwaters, but not common, possibly overlooked because of its small size.

212. **Nitzschia navicularis** (Brébisson) Grunow. [Syn.: *Surirella navicularis* Bréb.]. Valves elliptic, 30–35μ long $\times$ 15–16μ wide, with smoothly rounded poles; carinal pores 7–8 in 10μ; valve face with marginal transverse costae and a central longitudinal clear area lanceolate in shape, two rows of alternating punctae on each costae, costae 7–8 in 10μ. (Pl. XX, fig. o).

MALAYA Pahang: Stream near Kuantan.

Usually marine or in brackish water. The Malayan specimens have slightly longer costae than the type, but there is no doubt that they belong under this species.

213. **Nitzschia obtusa** W. Smith. Cells long linear, slightly sigmoid; valves linear, 180–230μ long $\times$ 10–11μ wide, very slightly constricted in the middle, ends rounded sometimes slightly wedge-shaped, curving slightly to one side to make the valve slightly sigmoid; keel excentric, notched in the middle with a prominent central nodule, carinal pores 5–8 in 10μ, transverse striae fine, 26 in 10μ. (Pl. XX, fig. c).

MALAYA Pahang: Stream near Kuantan.

Usually in brackish water or marine.

214. **Nitzschia obtusa** W. Smith var. **scalpelliformis** Grunow. Much smaller than the type, and with a very sharp convex curve on one side of each end so that the actual pole is narrow and sometimes almost acute; valves 25–80μ long $\times$ 4–5μ wide; carinal pores 8–9 in 10μ, central nodule less well-marked, transverse striae 28–30 in 10μ. (Pl. XIX, fig. o; Pl. XX, fig. d).

MALAYA Pahang: Stream near Kuantan.

Marine or in brackish water.

215. **Nitzschia palea** (Kuetzing) W. Smith. [Syn.: *Synedra palea* Kuetz.]. Valves linear, 30–50μ long $\times$ 3–5μ wide, with ends narrowing to the hardly sub-rostrate to sub-capitate poles; carianl pores 10–14 in 10μ, transverse striae very fine 33–40 in 10μ. (Pl. XIX, fig. k).

MALAYA Perak: Taiping lakes.

PAHANG: Cameron Highlands.

Malacca: Fish-ponds and Malacca River.

Probably widespread.

Common throughout the world in freshwaters.

216. **Nitzschia parvula** Lewis. [Syn.: *Nitzschia obtusa* W. Smith var. *brevissima* Grunow.]. Cells small, linear-rectangular in girdle view, hardly sigmoid; valve view linear, 30–40μ long $\times$ 4–5μ wide, slightly constricted in the middle, narrowing at the ends to the rostrate poles, which curve in opposite drections making the valve slightly sigmoid; carinal pores 6–8 in 10μ, transverse striae 29–30 in 10μ. (Pl. XIX, fig. h).

MALAYA Pahang: Cameron Highlands.

Europe in fresh to slightly brackish water.

217. **Nitzschia paradoxa** (Gmelin) Grunow. [Syn.: *Bacillaria paradoxa* Gmelin.]. Cells united valve face to valve face to form ribbons which zigzag by one cell gliding longitudinally on the next; girdle view linear-rectangular, valve view linear, 60–90μ

long × 5–8μ wide, narrowing in a wedge-shape to the subacute poles; keel central, carinal pores 8–9 in 10μ, transverse striae 20–24 in 10μ. (Pl. XX, fig. b; Pl. XXI, fig. d).

MALAYA Malacca: Malacca River.

Widespread, usually in brackish water but has been reported from freshwater elsewhere.

This is better known as *Bacillaria paradoxa* Gmelin, the genus *Bacillaria* having been erected on the basis of the central keel. In *Nitzschia* there are several intergrades from the extreme excentric position, and it seems rational to include this group under *Nitzschia*. The peculiar zigzag gliding motion makes this species easy to identify and serves to distinguish it from all other species, including those with centrally placed keels.

218. **Nitzschia plana** W. Smith. Valves linear, 80–90μ long × 12μ wide, slightly narrowed in the middle and with wedge-shaped poles; keel very excentric, carinal pores 4–6 in 10μ; transverse striae 18–22 in 10μ, with a linear central area about 1/3 width of valve. (Pl. XX, fig. e).

MALAYA Pahang: Stream near Kuantan.

Found in brackish to freshwater as well as in the sea, but not common.

219. **Nitzschia punctata** (W. Smith) Grunow var **apiculata** A. Cleve-Euler. [Syn.: *Tryblionella punctata* W. Smith.]. Valves elliptic, 20–25μ long × 12–13μ wide, narrowed at the ends to the apiculate poles; keel excentric, carinal pores 8–9 in 10μ, not marked; transverse striae marked, 9–10 in 10μ, curving near the poles, and almost like costae in appearance. (Pl. XIX, fig. w).

MALAYA Pahang: Stream near Kuantan.

Brackish water in Europe, not common.

220. **Nitzschia punctata** (W. Smith) Grunow var. **malayana** Prowse **var. nov.** Differs from the type in being broad, with concave margins and broad wedge-shaped ends.

Valves broadly lanceolate, 31μ long × 21μ wide, almost hexagonal, with slightly concave margins and broad wedge-shaped ends; keel very excentric, carinal pores 8 in 10μ; transverse striae prominent, punctate, slightly radial from central line of valve, 14–16 in 10μ. (Pl. XX, fig. h).

MALAYA Pahang: Stream near Kuantan. (Type locality).

Holotype Prowse No. 582h is deposited at the Tropical Fish Culture Research Institute, Malacca, Federation of Malaya.

A forma typica haec varietics differt natura latissima, cum marginibus concavis et apicibus latis cuneatis.

Valvae late lanceolate, 31μ longae, 21μ latae, fere hexagonales, marginibus concavulus et apicibus latis cuneatis. Carina valde excentrica, dentibus 8 in 10μ. Striae transversales prominentes, punctatae, ab axi centrale radiusculae, 14–16 in 10μ.

MALAYA Pahang, in fluvio.

221. **Nitzschia romana** Grunow. Valves lanceolate to linear-lanceolate, 20–35μ long $\times$ 4–5μ wide, tapering evenly at the ends to the acute poles; carinal pores 11–13 in 10μ, not very prominent, transverse striae 24–26 in 10μ. (Pl. XX, figs. i & j).

MALAYA Pahang: Stream near Kuantan.

Widespread in freshwaters.

222. **Nitzschia scalaris** (Ehrenberg) W. Smith. [Syn.: *Synedra scalaris* Ehr.]. Cells very long, valves linear, 450–500μ long $\times$ 16–17μ wide, with wedge-shaped poles, very slightly hooked to one side; carinal pores prominent, irregular, drawn out transversely to irregular lengths, 3–5 in 10μ, transverse striae prominent, fine punctate, 9–11 in 10μ. (Pl. XX, fig. g).

MALAYA Pahang: Stream near Kuantan.

Usually marine or brackish.

This is a very characteristic species and one of the largest.

223. **Nitzschia sigma** (Kuetzing) W. Smith. [Syn.: *Synedra sigma* Kuetz.]. Cell in girdle view sigmoid with somewhat narrowed ends; valves linear, 60–100μ long $\times$ 3–5μ wide, tapering to the narrow poles; more or less sigmoid; keel excentric, carinal pores 7–10 in 10μ, transverse striae 24–28 in 10μ. (Pl. XX, figs. a & m).

MALAYA Pahang: Stream near Kuantan.

Widespread in both brackish and freshwater.

The smaller forms have often been separated off as var. *rigidula* Grun., but the differences are not really sufficient to merit such a separation.

224. **Nitzschia sigma** (Kuetzing) W. Smith var. **clausii** (Hantzsch) Grunow. [Syn.: *Nitzschia clausii* Hantzsch.]. Cells much shorter; valves linear, 40μ long $\times$ 4μ wide, with parallel or slightly concave margins narrowed at the ends to the short rostrate poles, which point in opposite directions making the valve slightly sigmoid; carinal pores 10–11 in 10μ, transverse striae very fine, more than 30 in 10μ. (Pl. XIX, fig. l).

MALAYA Malacca: Malacca River.

Widespread in both brackish and fresh water.

225. **Nitzschia stagnorum** Rabenhorst. Cells in girdle view linear with parallel, slightly convex or slightly concave margins and truncate ends; valve view linear, 40–45μ long $\times$ 6μ wide, tapering at the ends to the rostrate or sub-rostrate poles; keel narrow, carinal pores 7–9 in 10μ, transverse striae 25–26 in 10μ. (Pl. XIX, fig. n).

MALAYA Malacca: Swamps and the Malacca River.

Widespread in freshwaters.

226. **Nitzschia subtilis** (Kuetzing) Grunow. [Syn.: *Synedra subtilis* Kuetz.]. Valves linear-lanceolate, 90–130μ long $\times$ 3–5μ wide, evenly narrowed to the almost acute poles; keel excentric, carinal pores 8–10 in 10μ, transverse striae 28–32 in 10μ. (Pl. XIX, fig. p; Pl. XX, fig. f).

MALAYA Malacca: Malacca River and fish-ponds.

Widespread in fresh water.

227. **Nitzschia surirelloidea** Prowse **sp. nov.** Valves broadly linear, 270–280μ long $\times$ 18μ wide, long sub-cuneate towards both poles, slightly narrowed towards the middle; keel very excentric; valve face with costae, striae prominent, solitary in each costa, 5 in 10μ, reaching almost to the central axis; punctae very weak, 9–10 in 10μ; carinal pores (teeth) as many as the striae 5–10μ; central area narrow. (Pl. XXI, fig. e).

MALAYA Malacca: Malacca River (Type locality).

Holotype Prowse No. 198a is deposited at the Tropical Fish Culture Research Institute, Malacca, Federation of Malaya.

Superficially this resembles *Surirella,* but is very long and narrow. The one keel on each valve clearly distinguishes it as a *Nitzschia.*

Valvae late lineares, 270–280μ longae, 18μ latae, apicem versus utrinque longae subcuneatae, medium versus paululo angustatae. Carina valde excentrica. Striae prominentes, in unaquaque costa solitariae, 5 in 10μ, fere axin centralem attingentes; punctis indistinctis, 9–10 in 10μ; dentibus quot striae, 5 in 10μ. Area centralis angusta.

Superficialiter aspectum *Surirellae* accedens, sed haec species longissima ac angustissima.

MALAYA Malacca, in fluvio.

228. **Nitzschia towutensis** Hustedt. Valves small, elliptic, 12–15μ long $\times$ 4–6μ wide, with distinctly convex sides and short narrow rostrate poles; keel very excentric, carinal pores small, 15–16 in 10μ, transverse striae fine, 28–30 in 10μ. (Pl. XIX, figs. y & z; Pl. XX, fig. l).

MALAYA Pahang: Stream near Kuantan.

Described from Celebes.

229. **Nitzschia tryblionella** Hantzsch var. **victoriae** Grunow. Valves broad, linear-elliptic, 35–40μ long $\times$ 16–17μ wide, with concave margins and broad wedge-shaped ends; face of valve costate, costae slightly radial from central line of valve, 5–6 in 10μ; keel very excentric, carinal pores 7–9 in 10μ, transverse striae very fine, hardly visible, even with phase contrast. (Pl. XIX, fig. e).

MALAYA Pahang: Stream near Kuantan.

Widespread in both brackish and fresh water, but not common.

STENOPTEROBIA Brébisson 1867

Cells long, linear, sigmoid; valves linear with a very narrow wing on both margins containing raphes, each wing containing a series of canals connecting to the interior ("wing canals") separated by semi-circular membranes; thus each valve has two raphes; face of valve with transverse striae and a central pseudo raphe.

230. **Stenopterobia intermedia** (Lewis) Fricke. [Syn.: *Surirella intermedia* Lewis.]. Valve long, linear, 110–130μ long $\times$ 6–8μ wide, sigmoid and tapering gently near the ends to the rounded poles; wing canals 4–5 in 10μ, transverse striae 20–24 in 10μ. (Pl. XXI, fig. a).

MALAYA Malacca: Malacca River.

Widespread in freshwaters.

SURIRELLA Turpin 1828

Cells solitary and free-floating; valves elongate, lanceolate, elliptic or ovate, longitudinally symmetrical, transversely symmetrical or asymmetrical, valve face flat, undulate or curved; girdle view rectangular, sinuate or irregular; raphe in a prominent keel or wing on each margin of the valve, connected by a series of canals opening to the interior ("wing canals") separated by semi-circular membranes, valve face with costae corresponding to the wing canals; chromatophore single, laminate or appearing as two expanded lobes.

231. **Surirella angusta** Kuetzing. Cells in girdle view rectangular with nearly flat ends, valve view isopolar, linear, 30–50μ long $\times$ 9–10μ wide, with parallel sides, and wedge-shaped ends; valve wing narrow; costae 6–7 in 10μ, reaching almost to the middle line, costae and intercostal regions about as wide as each other. (Pl. XXIII, figs. b & i).

MALAYA Pahang: Cameron Highlands.

Widespread in freshwaters.

232. **Surirella angusticostata** Hustedt. Cells isopolar, girdle view linear rectangular with curved corners and flat ends; valve view elliptic-lanceolate, 75–80μ long $\times$ 19–20μ wide, tapering to more or less wedge-shaped poles; wing narrow, wing canals small, costae very narrow, 4–5 in 10μ, much narrower than the intercostal region and reaching the middle line. (Pl. XXIII, fig. c).

MALAYA Pahang: Cameron Highlands.

Described from Sumatra.

233. **Surirella biseriata** Brébisson. Cells very large, isopolar, in girdle view rectangular with rounded ends; valve view linear to elliptic-lanceolate, 200–370μ long $\times$ 50–80μ wide, with parallel or slightly convex sides and somewhat wedge-shaped poles; wings prominent, costae 10–18 in 100μ, almost reaching the middle line, radial at the poles, costae and intercostal areas equidistant. (Pl. XXII, fig. d).

MALAYA Malacca: Malacca River and swamps near Malacca town.

Widespread in freshwater.

234. **Surirella capronii** Brébisson. Cells large, heteropolar, in girdle view broadly wedge-shaped; valve view ovate, 160–200μ long $\times$ 60–80μ wide, with bluntly rounded poles; wing very prominent, costae 10–15 in 100μ, nearly reaching the middle line, radial at the ends, intercostal area narrower than the costae; a prominent bulbous-based spine near each end on the middle line. (Pl. XXII, fig. e).

MALAYA Malacca: Malacca River.

Widespread in freshwaters.

An unmistakable species.

235. **Surirella lemmermanni** Hustedt. Cells medium large, valve view slightly heteropolar, lanceolate, 90–100μ $\times$ long 20μ wide, with keel-shaped ends tapering to narrow poles; wing narrow, costae 55–70 in 100μ, reaching the middle line and radial at the ends, costae much wider than the intercostal areas. (Pl. XXII, fig. c).

MALAYA Malacca: Malacca River.

Widespread in freshwaters, but not common.

236. **Surirella linearis** W. Smith. Cells isopolar; valves linear, 40–100μ long $\times$ 12–20μ wide, with parallel or slightly convex sides and bluntly rounded sub-cuneate ends; wing usually well-marked, costae 20–40 in 100μ, wider than the intercostal distances, almost reaching the middle line, radial at the poles. (Pl. XXIII, figs. g & f; Pl. XXIV, figs. a & c).

MALAYA Penang: Fish-ponds.

Malacca: Malacca River.

Probably widespread in Malaya.

World-wide distribution in freshwaters.

There is some variation in the forms from all parts of the world, and some of the Malayan forms have a higher ratio of costae than usual, but there is so much intergrading that it seems unjustifiable to separate them.

237. **Surirella muelleri** Hustedt. [Syn.: *Surirella constricta* O. Mueller.]. Cells large, isopolar; valve view linear, 200–300μ long $\times$ 45–55μ wide, with markedly concave sides and more or less bluntly rounded, wedge-shaped ends; wings not very marked; costae 16–18 in 100μ, about equal in width to the intercostal distance, almost reaching the central line, radial at the poles. (Pl. XXIV, fig. d).

MALAYA Malacca: Malacca River.

Described from Africa.

The Malayan forms agree so closely with those from Africa that it is doubtful if they could be included under any other species.

238. **Surirella robusta** Ehrenberg. Cells large, distinctly heteropolar; in girdle view wedge-shaped with flat ends; valve-view oval-elliptic, 150–250μ long $\times$ 50–80μ wide, distinctly heteropolar with blunt rounded ends; wings very marked, costae prominent, 8–15 in 10μ, slightly wider than the intercostal distance, radial at the poles and nearly reaching the middle line. (Pl. XXI, fig. c).

MALAYA Pahang: Cameron Highlands.

Malacca: Malacca River and swamps near Malacca town.

Widespread in freshwaters.

A characteristic form.

239. **Surirella robusta** Ehrenberg var. **splendida** (Ehrenberg) van Heurck. [Syn.: *Navicula splendida* Ehr., *Surirella splendida* W. Smith.]. Cells smaller than the type, with the costae closer together; valves oval-elliptic, 80–120μ long $\times$ 25–35μ wide, distinctly heteropolar, with bluntly rounded ends; wings prominent, costae 20–25 in 100μ, nearly reaching the middle. (Pl. XXIII, fig. d, Pl. XXIV, fig. b).

MALAYA Pahang: Cameron Highlands.

Selangor: Gombak River.

Malacca: Malacca River, swamps near Malacca Town.

Widespread in freshwaters.

240. **Surirella spiralis** Kuetzing. Cells isopolar, spirally twisted around the longitudinal axis, in girdle view shaped like a figure 8 with bluntly rounded ends; in valve view linear-elliptic, 50–70μ long $\times$ 25–30μ wide, spirally twisted into a figure 8, with with rounded wedge-shaped poles; wings prominent, costae 20–30 in 100μ, wider than the intercostal distance, not reaching the middle line, central area more or less linear-lanceolate. (Pl. XXIII, fig. 1).

MALAYA Malacca: Malacca River, swamps and fish-ponds near Malacca Town.

Probably widespread in Malaya.

Distribution worldwide in freshwaters.

241. **Surirella tenera** Gregory. Cells heteropolar, in girdle view narrow wedge-shaped with truncate ends; valve view linear ovate, 100–130μ long $\times$ 25–30μ wide, heteropolar, tapering at the ends to the bluntly rounded poles; wings prominent, costae 20–30 in 100μ, wider than the intercostal distance, radial at the poles, almost reaching the middle line. (Pl. XXIII, fig. e).

MALAYA Malacca: Malacca River.

Described from Africa and reported from Indonesia.

242. **Surirella tenuissima** Hustedt. Cells small, heteropolar, in girdle view narrow wedge-shaped, with bluntly rounded ends; valve view narrow ovate, 18–35μ long $\times$ 7.5–11μ wide, heteropolar with rounded truncate poles; wings narrow to moderately marked, costae 40–70 in 100μ, wider than the intercostal distance, reaching or nearly reaching the central line, transverse striae sometimes visible on valve face. (Pl. XXIII, figs. a, h, j & k).

MALAYA Pahang: Cameron Highlands.

Reported from Indonesia and S. America.

CAMPYLODISCUS Ehrenberg 1840

Cells solitary and free-floating, circular or nearly so in outline, or saddle-shaped, bent in valve face, girdle view varying; raphe in a narrow wing round valve margin, valves with radiating costae converging to a hyaline punctate or striate centre; a single broad laminate chromatophore.

243. **Campylodiscus clypeus** W. Smith. Valve medium large, a slightly squarish circle in shape, 45μ in diameter; wing narrow, costae wide, short, marginal, 15–35 in 100μ, radial and subtended by radiating rows of coarse punctae, 7 rows in 10μ, with a large squarish, smooth, central area; valve face undulate bulging in from the costae and out again to the centre, so that some of the punctae appear faint. (Pl. XXII, fig. g).

MALAYA Malacca: Malacca River.

Found in slightly brackish to freshwater in Europe.

Addendum

MASTOGLOIA Thwaites 1856

Cells solitary or in gelatinous tubes, often in structureless gelatinous envelopes; girdle view rectangular, septate with internal part of septa fusiform and divided into chambers; valve view lanceolate, elliptic or rhombic, poles broadly rounded, acute or rostrate, with marginal septa and inner septa divided into a series of submarginal chambers lying in a longitudinal row; axial field narrow, raphe straight, with small central and polar nodules, valve face transversely striate; chromatophores two with extensive lateral projections.

Auxospores formed in pairs by the conjugating of two cells.

244. **Mastogloia exigua** Lewis. Cells small, in girdle view rectangular with flat ends; valve view elliptic lanceolate 20–25μ long $\times$ 7–8μ wide, with rounded poles; septum marginal except at the poles, chambers 4 on each side, slightly rounded on the inner side; axial field narrow, striae fine, sub-parallel 20–24 in 10μ. (Pl. XVIII, figs. j & k).

MALAYA Pahang: Stream near Kuantan.

Usually described from brackish water, but here in quite freshwater.

Acknowledgements

To Dr. C. F. Hickling, Fisheries Adviser to the Secretary of State for the Colonies of the United Kingdom Government, and first Acting Director of the Tropical Fish Culture Research Institute in Malacca, and to the Colonial Office, I wish to express my thanks for all the encouragement given in this research, and for permission to publish the results. To Mr. H. M. Burkill, Director of the Botanic Gardens, Singapore, I am deeply grateful for all the samples he has collected for me, for affording me facilities for work in the Botanic Gardens in my early days in Singapore, and for permitting this paper to be published in the *Gardens' Bulletin*. I am also very grateful to Dr. D. S. Johnson and students of the Zoology Department in the University of Malaya in Singapore for the algal samples they collected in the Cameron Highlands and elsewhere. To Professor H. B. Gilliland and the Department of Botany at the University of Malaya in Singapore I am extremely grateful for all the encouragement and help in this research which they have afforded me. To the University of Malaya library department I am particularly grateful for the facilities they have given me. I am also very grateful to all those people, too numerous to list here, who have sent me reprints of various papers. To Dr. J. Lund of the Freshwater Biological Association in England I am

indeed grateful for the help he has given in identifications. Nor must I forget Mr. S. F. Owen, of the Public Works Department of the Federation of Malaya, who so kindly arranged facilities for me to work in Malacca before the present laboratories were completed, and who later sent me so many interesting algal samples. To Mr. Ratnasabapathy, lately of King Edward VII School, Taiping, and now in New Zealand, I am very grateful for the extremely interesting collections he made in Taiping. To Mr. Frank Manley, lately of the office of the Commander Royal Engineers, Malacca, I owe special thanks for collecting so many samples on the east side of Malaya. Thanks are also due to my various colleagues, in particular Mr. George Tay, my laboratory assistant, who has helped so much in collecting and culturing algae.

Lastly but not least, my thanks are due to Dr. C. X. R. Furtado of the Botanic Gardens, Singapore, and his son, Mr. J. Furtado of the Research Institute here, both of whom have so kindly undertaken the translation into Latin of the diagnoses of new species and varieties.

BIBLIOGRAPHY

(*this includes only literature actually consulted.*)

ABDUL-MAJID, M. 1935. The Freshwater Algae of the Punjab, Part 1 Bacillariophyta (Diatomeae) pp. 44 & 6 pl. University of the Punjab.

CHOLNOKY, B. J. 1957. Neue and seltene Diatomeen aus Afrika III Diatomeen aus dem Tugeln-Flusssystem, hauptsachlich aus dem Drakensbergen in Natal. Oest. Bot. Zeitschr. 104 (1–2): 25–99.

CHOLNOKY, B. J. 1957. Beiträge zur kenntnis der Suedafrikanischen Diatomeenflora I. Port. Act. Biol. (B) 6 (1): 53–93.

CHOLNOKY, B. J. 1957. Uber die Diatomeenflora einiger Gewaesser in den Magalies-Bergen nahe Rustenburg (Transvaal). Bot. Not. 110 (3): 325–362.

CHOLNOKY, B. J. 1958. Beiträge zur kenntnis der Sudafrikanischen Diatomeenflora II: Einige Gewässer in Waterberg—Gebiet, Transvaal. Port. Act. Biol. (B) 6 (2): 99–160.

CHOLNOKY, B. J. 1958. Hydrobiologische Untersuchungen in Transvaal II: Selbstreinigung in Jukskei-Crocodile Flusssystem. Hydrobiologia 9 (3–4): 205–266.

CHOLNOKY, B. J. 1959. Neue und seltene Diatomeen aus Afrika IV. Diatomeen aus der Kaap-Provinz. Oest. Bot. Zeitschr. 106 (1–2): 1–69.

CHOLNOKY, B. J. 1960. Beiträge zur kenntnis der Diatomeenflora von Natal (Sud Afrika). Nova Hedwigia 2: 1–128.

CLEVE-EULER, A. 1951. Die Diatomeen von Schweden und Finnland Pt. I. Kungl. Svenska. Vetenskap. Handl: Fjärde Series 2 (1) 163 pp. 54 pl.

CLEVE-EULER, A. 1952. Die Diatomeen von Schweden und Finnland Pt. V—Schluss. Kungl. Svenska. Vetenskap. Handl: Fjärde series 3 (3) 255 pp. 46 pl.

CLEVE-EULER, A. 1953. Die Diatomeen von Schweden und Finnland pt. II: Arraphideae, Brachyraphideae. Kungl. Svenska Vetenskap. Handl: Fjärde series 4 (1) 158 pp. 36 pl.

CLEVE-EULER, A. 1953. Die Diatomeen von Schweden und Finnland pt. III: Monoraphideae, Biraphideae 1. Kungl. Svenska Vetenskap. Handl: Fjärde series 4 (5) 153 pp. 41 pl.

CLEVE-EULER, A. 1955. Die Diatomeen von Schweden und Finnland pt. IV: Biraphideae 2. Kungl. Svenska Vetenskap Handl: Fjärde series 5 (4) 232 pp. 50 pl.

FORTE, A. & DE TONI, G. G. 1903. Pugillo de Diatomie Bentoniche del Lago Njebel (Giava). Bull. Soc. Bot. Ital. (1903): 133–141.

FRITSCH, F. E. 1935. The Structure & Reproduction of the Algae Volume I. Cambridge University Press.

GANDHI, H. P. 1956. A preliminary account of the soil Diatom flora of Kolhapur. S. Indian Bot. Soc. 35 (4): 402–408.

GANDHI, H. P. 1957. A contribution to our knowledge of the Diatom genus *Pinnularia*. J. Bombay Nat. Hist. Soc. 54 (4): 845–852.

GANDHI, H. P. 1957. The Freshwater Diatoms from Radhanagari-Kolhapur. Ceylon J. Sci. (Biol. Sc.) 1 (1): 45–57.

GANDHI, H. P. 1957. Some common freshwater Diatoms from Gersoppa falls. J. Univ. Poona Sci. Sect.: 13–21.

GANDHI, H. P. 1958. Freshwater Diatoms from Kolhapur and its immediate environs. J. Bombay Nat. Hist. Soc. 55 (3): 493–511.

GANDHI, H. P. 1959. Freshwater Diatoms from Sagar in the Mysore State. J. Indian Bot. Soc. 38 (3): 305–331.

GANDHI, H. P. 1959. Freshwater Diatom flora of the Panhalgarh Hillfort in the Kolhapur District. Hydrobiologia 14 (2): 93–129.

GANDHI, H. P. 1959. Notes on the Diatomaceae from the Ahmedabad & its environs II: On the Diatomflora of the Fountain-reservoirs of the Victoria Garden. Hydrobiologia 14 (2): 130–146.

GONZALVES, E. A. & GANDHI, H. P. 1952. A systematic account of the Diatoms of Bombay & Salsette, Part I. J. Indian Bot. Soc. 31 (3): 117–151.

GONZALVES, E. A. & GANDHI, H. P. 1953. A systematic account of the Diatoms of Bombay & Salsette, Part II. J. Indian Bot. Soc. 32 (4): 239–263.

GONZALVES, E. A. & GANDHI, H. P. 1954. A systematic account of the Diatoms of Bombay & Salsette, Part III. J. Indian Bot. Soc. 33 (4): 338–350.

HUBER-PESTALOZZI, G. 1942. Das Phytoplankton des Susswassers. Die Binnengewasser 16 (2) pp. 549. Stuttgart.

HUSTEDT, F. 1930. Bacillariophyta (Diatomeae) in A. Paschers Die Süsswasserflora Mitteleuropas 10. Jena.

HUSTEDT, F. 1938. Systematische und oekologische Untersuchungen ueber die Diatomeen-Flora von Java, Bali und Sumatra nach dem Material der Deutschen Limnologischen Sunda-Expedition. Arch. Hydrobiol. Suppl. 15: 131–177, 187–295, 298–506, 638–790.

HUSTEDT, F. 1942. Süsswasser-Diatomeen des indomalayischen Archipels und der Hawaii Inseln nach dem Material der Wallacea-Expedition. Int. Rev. Ges. Hydrobiol. Hydrogr. 42: 1–252.

LUND, J. W. D. 1945. Observations on Soil Algae I: The ecology, size and taxonomy of British Soil Diatoms. New Phytol. 44 (2): 196–110.

LUND, J. W. D. 1950. Contributions to our knowledge of British algae. Hydrobiologia 2 (3): 281–284.

LUND, J. W. D. 1951. Contributions to our knowledge of British algae. Hydrobiologia 3 (1): 93–100.

OESTRUP, E. 1902. Freshwater Diatoms in Schmidts' Flora of Koh Chang. Bot. Tidskr. 25: 28–41.

PATRICK, R. 1936. A taxonomic and distributional study of some diatoms from Siam and the Federated Malay States. Proc. Acad. Nat. Sci. Philadelphia 88: 367–470.

PROWSE, G. A. & TALLING, J. F. 1958. The seasonal growth and succession of plankton algae in the White Nile. Limn. & Ocean. 3 (2): 222–238.

SKVORTZOW, B. W. 1930. Notes on Ceylon Diatoms I. Ann. Roy. Bot. Gard. Peradineya 9 (3): 251–260.

SKVORTZOW, B. W. 1930. Notes on Ceylon Diatoms II. Ann. Roy. Bot. Gard. Peradineya 9 (4): 333–337.

TIFFANY, L. H. & BRITTON, M. E. 1952. The Algae of Illinois, University of Chicago Press.

DE TONI, G. B. 1889–1924. Sylloge algarum omnium hucusque cognitarum V. 2: Sylloge bacillariearum: 1–1556 Patavi.

VENKATARAMAN, G. 1939. A systematic account of some S. Indian Diatoms. Proc. Ind. Acad. Sci. (B) 10: 293–369.

VOIGT, M. 1951. A further contribution to the knowledge of the Diatom genus *Mastogloia*. J. Roy. Micr. Soc. 71: 440–449.

VOIGT, M. 1955. Some *Mastogloia* from Pakistan. J. Roy. Micr. Soc. 75 (3): 189–193.

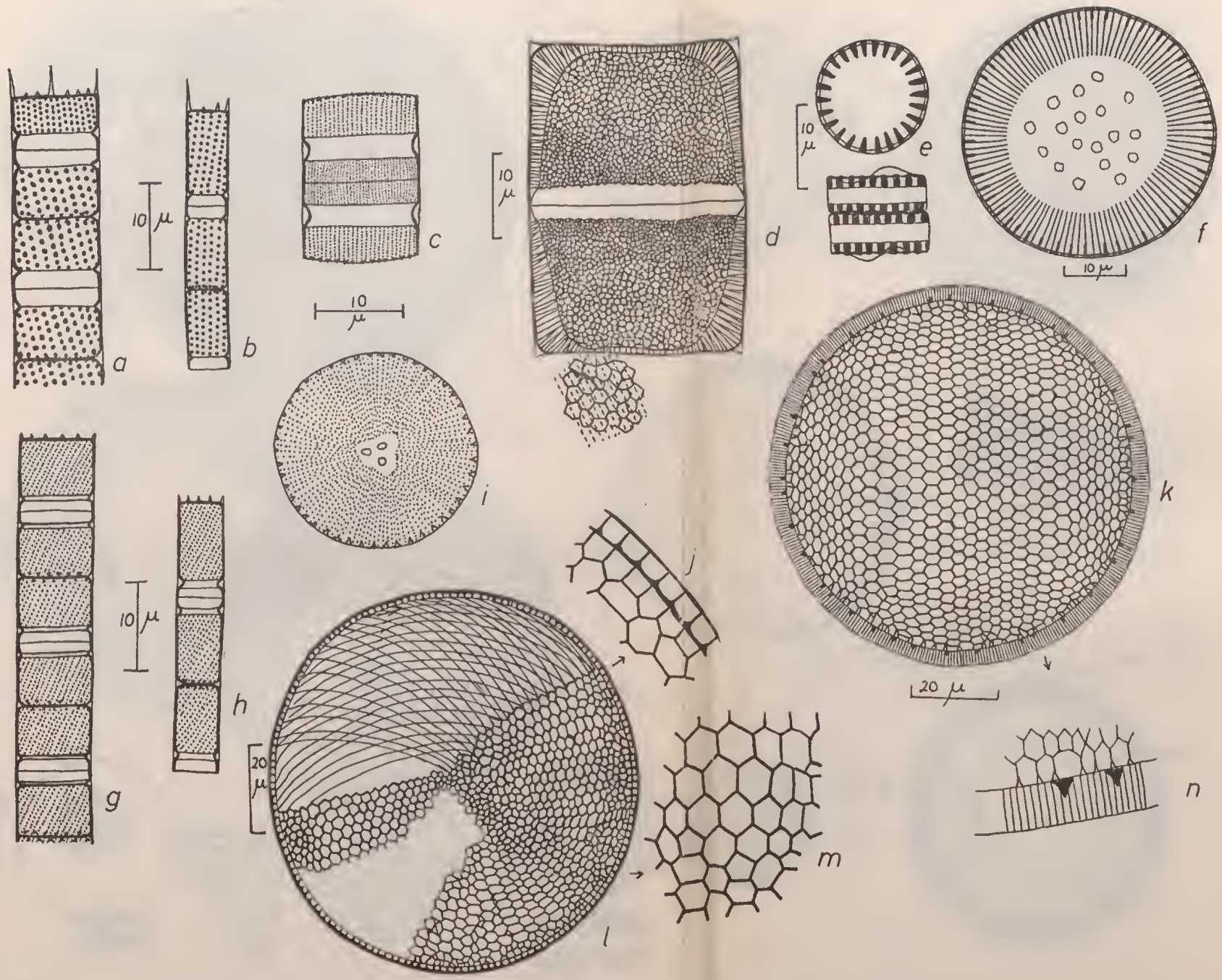


Plate I.

(*a* & *b*) *Melosira granulata* (Ehrenberg) Ralfs; (*c* & *i*) *Melosira roeseana* Rabenhorst; (*d*) *Melosira rüettneri* Hustedt; (*e*) *Cyclotella meneghiniana* Küetzing; (*f*) *Cyclotella striata* (Küetzing) Grunow; (*g* & *h*) *Melosira italica* (Ehrenberg) Küetzing; (*j*, *m* & *l*) *Coscinodiscus argus* Ehrenberg; (*k* & *n*) *Coscinodiscus lineatus* Ehrenberg.

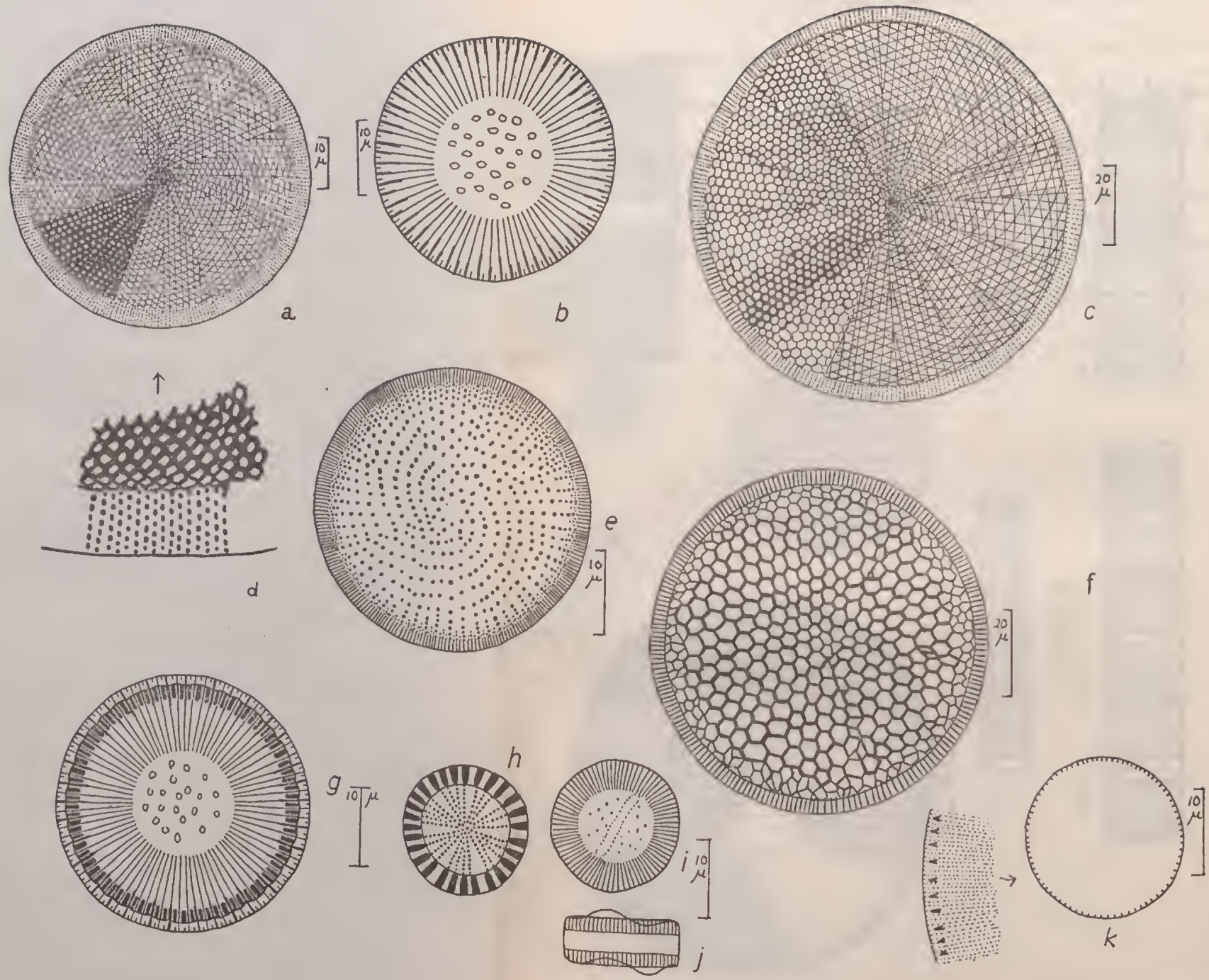


Plate II.

(*a* & *d*) *Coscinodiscus divisus* Grunow; (*b* & *g*) *Cyclotella striata* (Küetzing) Grunow; (*c*) *Coscinodiscus symmetricus* Kitton; (*e*) *Coscinodiscus griseus* Grev. var. *gallopagensis* Grunow; (*f*) *Coscinodiscus antiquus* (Grunow) A. Cleve; (*h*) *Cyclotella meneghiniana* (Küetzing); (*i* & *j*) *Cyclotella küetzingiana* Thwaites; (*k*) *Thalassiosira fluviatilis* Hustedt.

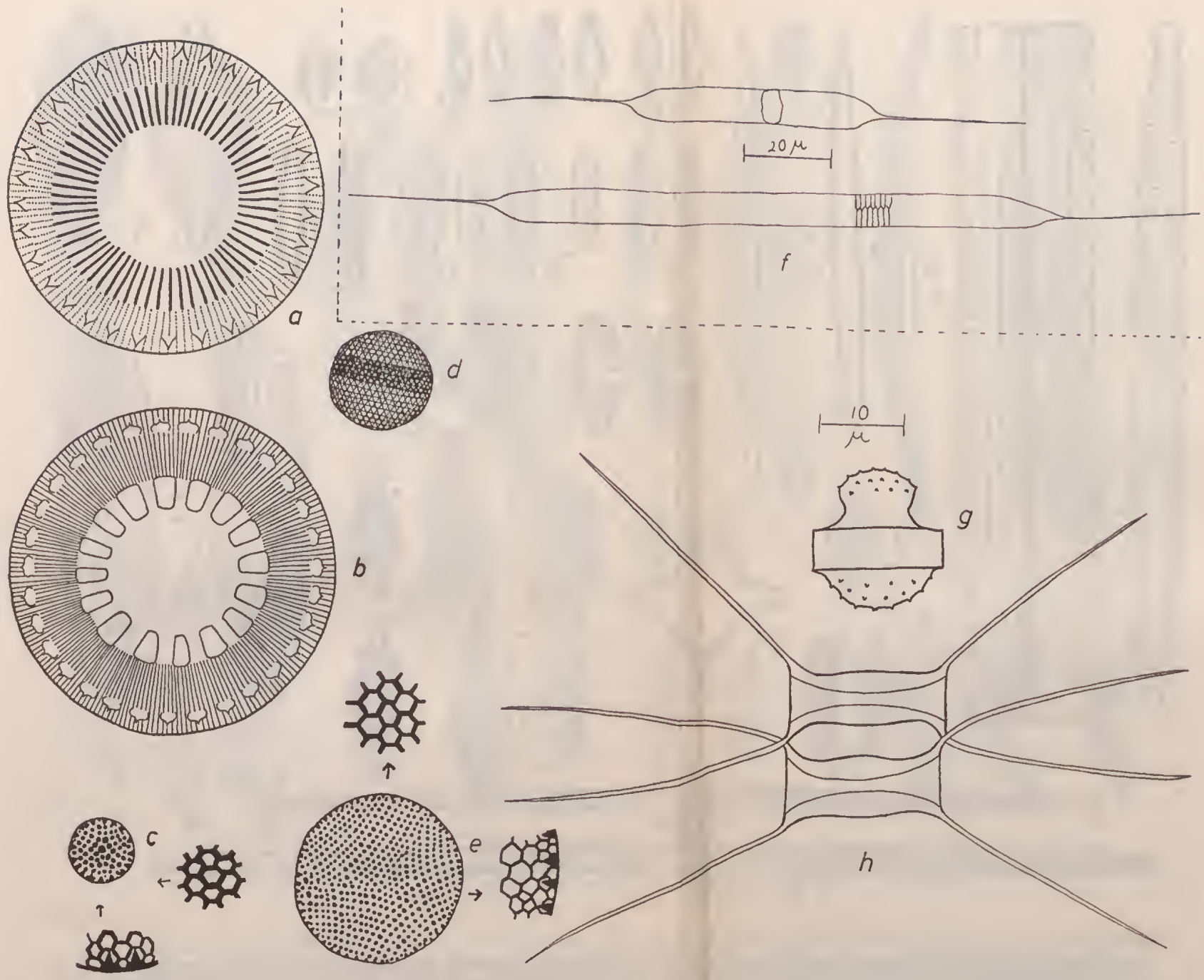


Plate III.

(*a*) *Stephanodiscus biserialis* Prowse *sp. nov.*; (*b*) *Stephanodiscus fenestralis* Prowse *sp. nov.*; (*c*) *Coscinodiscus decipiens* Grunow; (*d*) *Coscinodiscus lineatus* Ehrenberg var. *van heurckii* P. T. Cleve; (*e*) *Coscinodiscus excentricus* Ehrenberg; (*f*) *Rhizosolenia eriensis* H. L. Smith; (*g* & *h*) *Chaetoceros amanita* A. Cleve.

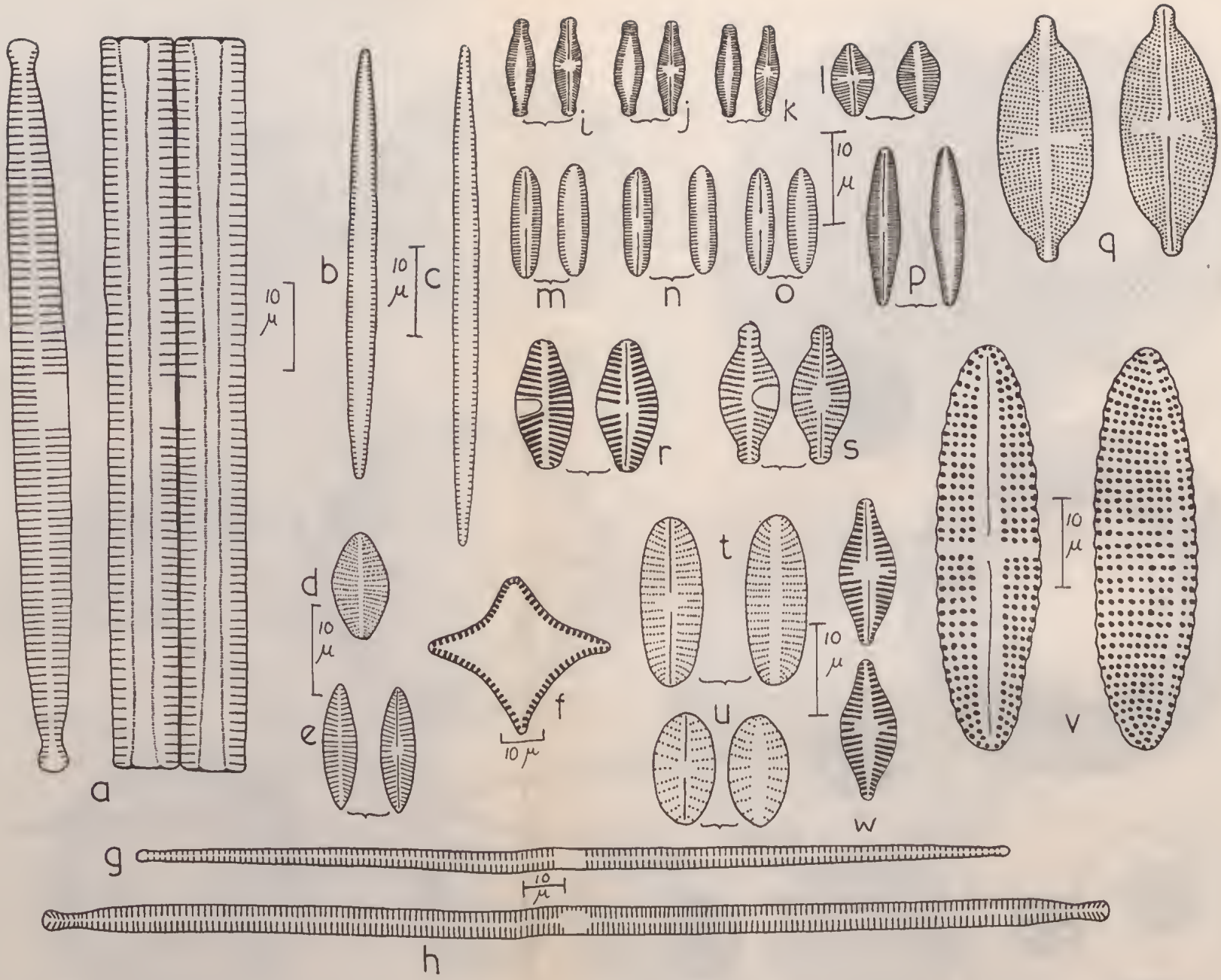


Plate IV.

(*a*) *Fragilaria vaucheriae* (Küetzing) Boye Petersen; (*b* & *c*) *Synedra tabulata* (C. A. Ag.) Küetzing var. *acuminata* (Grunow) Hustedt; (*d*) *Fragilaria virescens* Ralfs. var. *elliptica* Hustedt; (*e*) *Achnanthes subhudsonis* Hustedt; (*f*) *Fragilaria lapponica Grunow* var. *tetragonalis* Prowse *var. nov.*; (*g*) *Synedra ulna* (Nitzsch) Ehrenberg var. *danica* (Küetzing) Grunow; (*h*) *Synedra ulna* (Nitzsch) Ehrenberg var. *amphirhynchus* (Ehrenberg) Grunow; (*i*, *j* & *k*) *Achnanthes woltereckii* Hustedt; (*l*) *Achnanthes exigua* Grunow; (*m*, *n* & *o*) *Achnanthes tropica* Hustedt; (*p*) *Achnanthes tenuissima* Hustedt; (*q*) *Achnanthes stauroneiformis* Prowse *sp. nov.*; (*r*) *Achnanthes lanceolata* (Bréb.) Grunow; (*s*) *Achnanthes lanceolata* (Bréb.) Grunow var. *rostrata* Hustedt; (*t* & *u*) *Cocconeis thumensis* A. Mayer; (*v*) *Achnanthes crenulata* Grunow; (*w*) *Achnanthes hauckiana* Grunow var. *rostrata* Schulz.

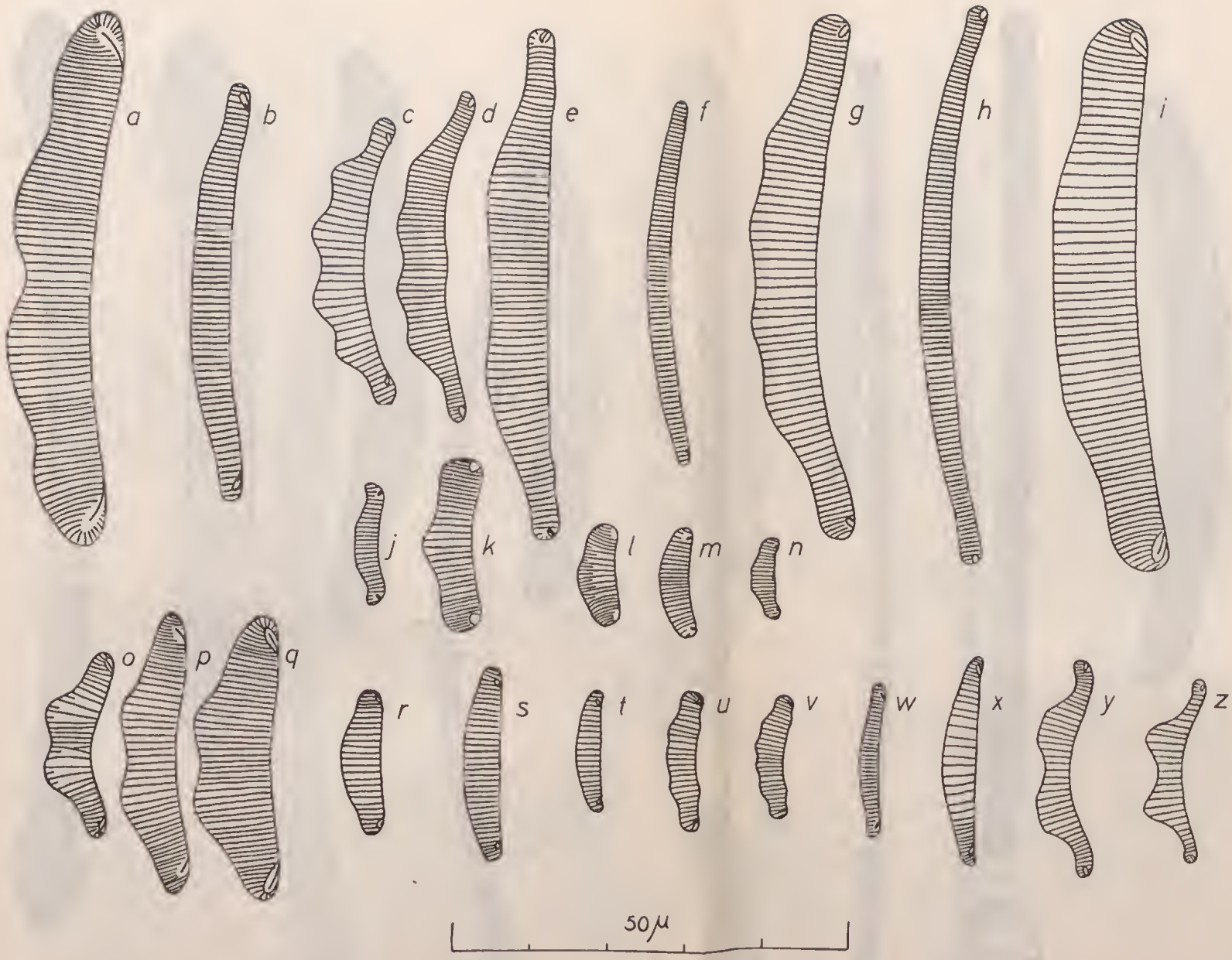


Plate V.

(*a*) *Eunotia monodon.* Ehrenberg var. *constricta* A. Cleve-Euler; (*b*) *Eunotia pectinalis* (Küetzing) Rabenhorst; (*c* & *d*) *Eunotia camelus* Ehrenberg var. *karveerensis* Gandhi; (*e*) *Eunotia grunowi* A. Berg var. *uplandica* A. Cleve f. *subundulata* A. Cleve; (*f*) *Eunotia lunaris* (Ehrenberg) Grunow; (*g*) *Eunotia monodon* Ehrenberg var. *undulata* A. Cleve-Euler; (*h*) *Eunotia lunaris* (Ehrenberg) Grunow var. *capitata* Grunow; (*i*) *Eunotia major* (W. Smith) Rabenhorst var. *indica* (Grunow) A. Berg; (*j*) *Eunotia exigua* (Brébisson) Grunow; (*k*) *Eunotia praemonas* A. Cleve-Euler var. *monodon* (Oestrup) A. Cleve-Euler; (*l* & *r*) *Eunotia praemonas* A. Cleve-Euler var. *inflata* (Grunow). A. Cleve-Euler; (*m*) *Eunotia faba* (Ehrenberg) Grunow var. *densestriata* Oestrup; (*n*) *Eunotia cancellata* A. Berg. var. *esseda* A. Berg; (*o*) *Eunotia sarekensis* A. Cleve-Euler var. *minor* A. Cleve-Euler; (*p* & *q*) *Eunotia diodon Ehrenberg* var. *minor* Grunow; (*s*) *Eunotia monodon Ehrenberg* var. *alpina* Küetzing; (*t* & *x*) *Eunotia sudetica* O. Müeller var. *incisa* (May.) A. Cleve-Euler; (*u* & *v*) *Eunotia polydentula* (Brun) A. Berg var. *perminuta* Grunow; (*w*) *Eunotia pectinalis* (Küetzing) Rabenhorst var. *minor* (Küetzing) Rabenhorst; (*y* & *z*) *Eunotia camelus* Ehrenberg.

Plate VI.

(*a, d* & *e*) *Eunotia robusta* Ralfs; (*b* & *c*) *Eunotia flexuosa* Küetzing; (*f*) *Eunotia major* (W. Smith) Rabenhorst var. *emarginata* A. Cleve; (*g* & *h*) *Eunotia formica* Ehrenberg; (*i*) *Eunotia praemonos* A. *Cleve-Euler* var. *tibetica* (Mereschk.) A. Cleve-Euler.

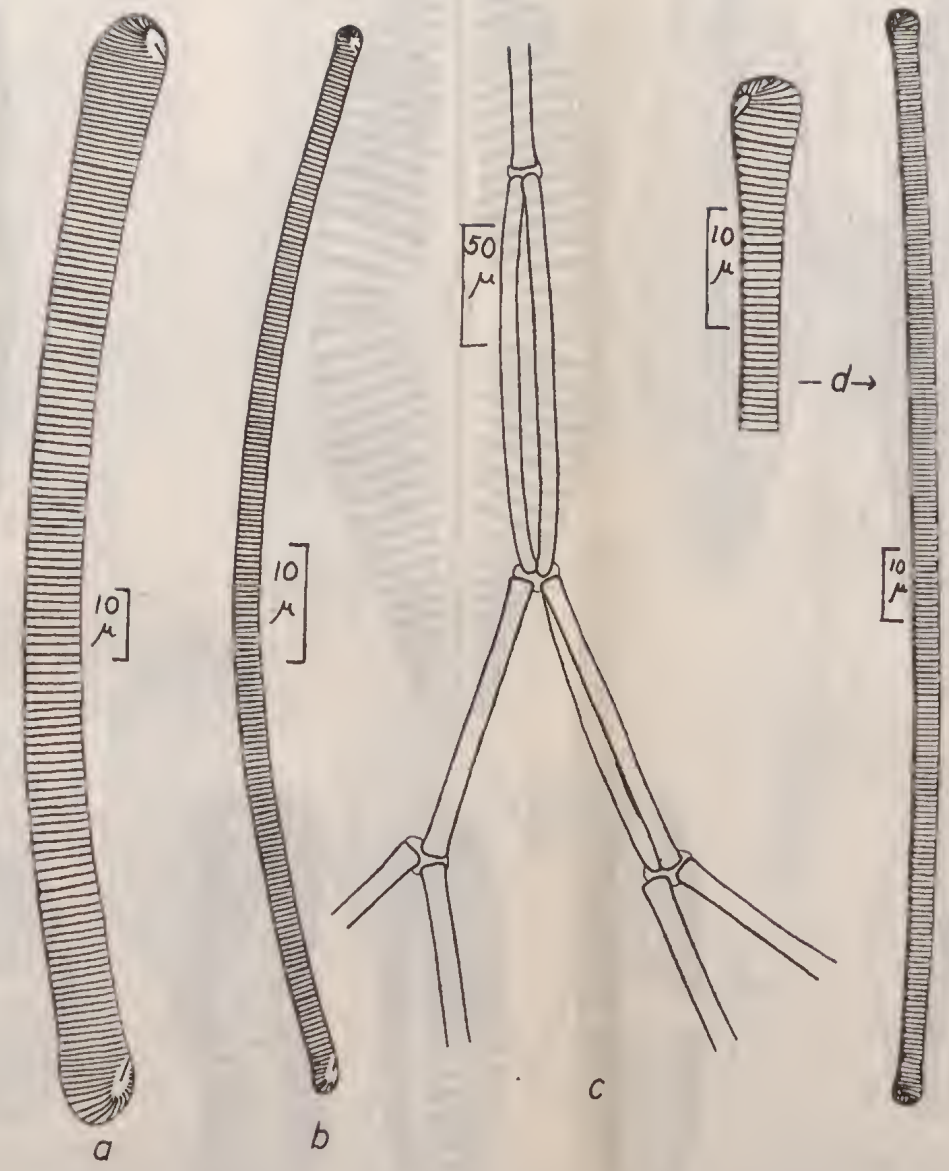


Plate VII.

(*a*) *Eunotia major* (W. Smith) Rabenhorst var. *linearis* A. Cleve; (*b*) *Eunotia gracilis* (Ehrenberg) Rabenhorst; (*c* & *d*) *Desmogonium rabenhorstianum* Grunow; (*c*) general habit of colony.

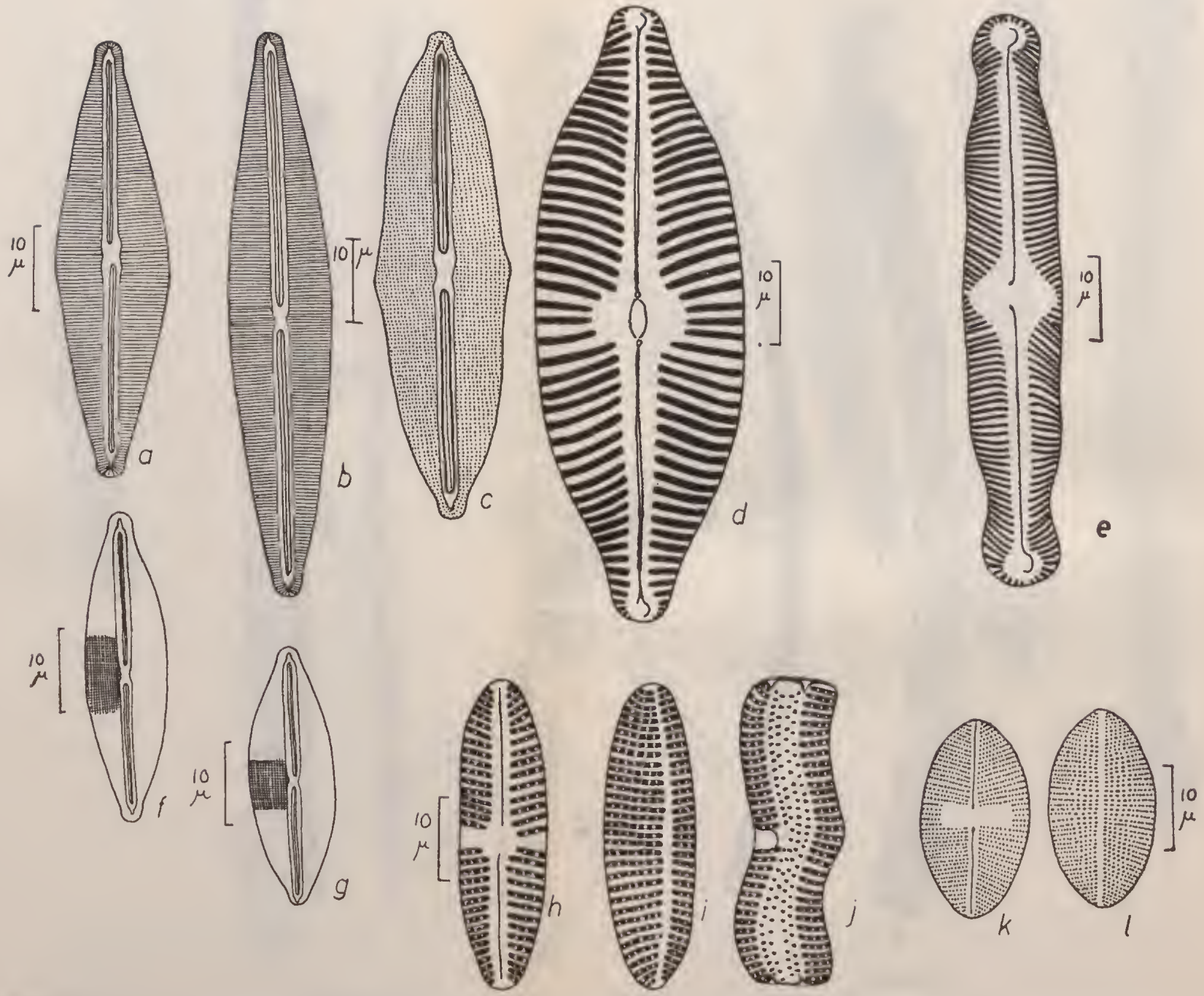


Plate VIII.

(*a* & *b*) *Frustulia rhomboides* (Ehrenberg) de Toni; (*c*) *Frustulia javanica* Hustedt; (*d*) *Navicula elegantoides* Hustedt; (*e*) *Pinnularia legumen* Ehrenberg; (*f* & *g*) *Frustulia saxonica* Rabenhorst; (*h*, *i* & *j*) *Achnanthes brevipes* C. A. Agardh var. *intermedia* Küetzing; (*k* & *l*) *Cocconeis feuerbornii* Hustedt.

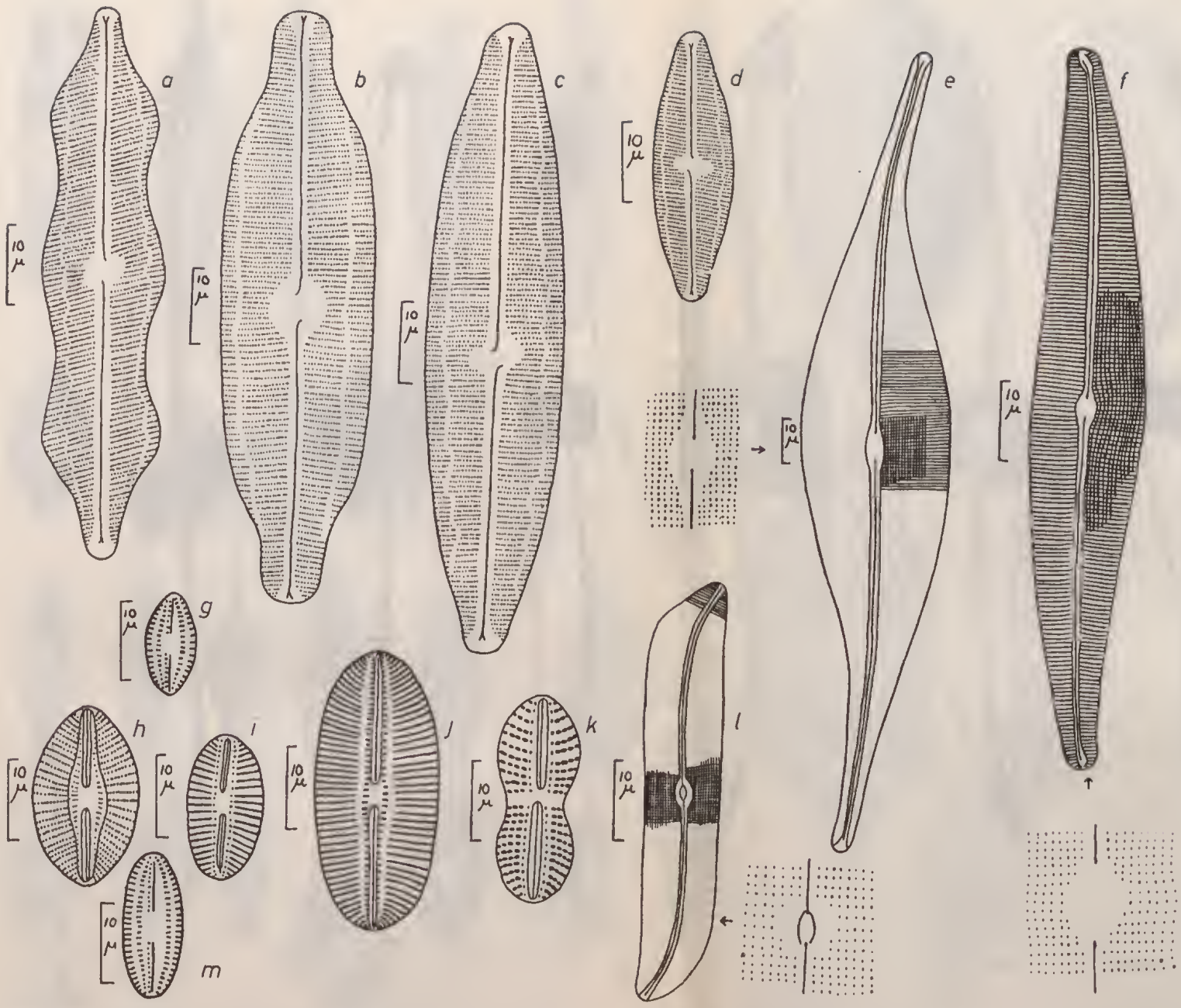


Plate IX.

(*a*) *Neidium hitchcockii* (Ehrenberg) P. T. Cleve; (*b*) *Neidium productum* (W. Smith) P. T. Cleve; (*c* & *d*) *Neidium iridis* (Ehrenberg) P. T. Cleve var. *ampliatum* (Ehrenberg) P. T. Cleve; (*e*) *Gyrosigma distortum* (W. Smith) P. T. Cleve var. *parkeri* (Harrison) P. T. Cleve; (*f*) *Gyrosigma spenceri* (W. Smith) P. T. Cleve var. *smithii* (Grunow) A. Cleve-Euler; (*g* & *m*) *Navicula tenera* Hustedt; (*h*) *Diploneis ovalis* (Hilse) P. T. Cleve; (*i*) *Diploneis decipiens* A. Cleve var. *parallela* A. Cleve; (*j*) *Diploneis oblongella* (Naegeli) P. T. Cleve var. *baltica* A. Cleve; (*k*) *Diploneis interrupta* (Küetzing) P. T. Cleve; (*l*) *Gyrosigma scalproides* (Rabenhorst) P. T. Cleve.

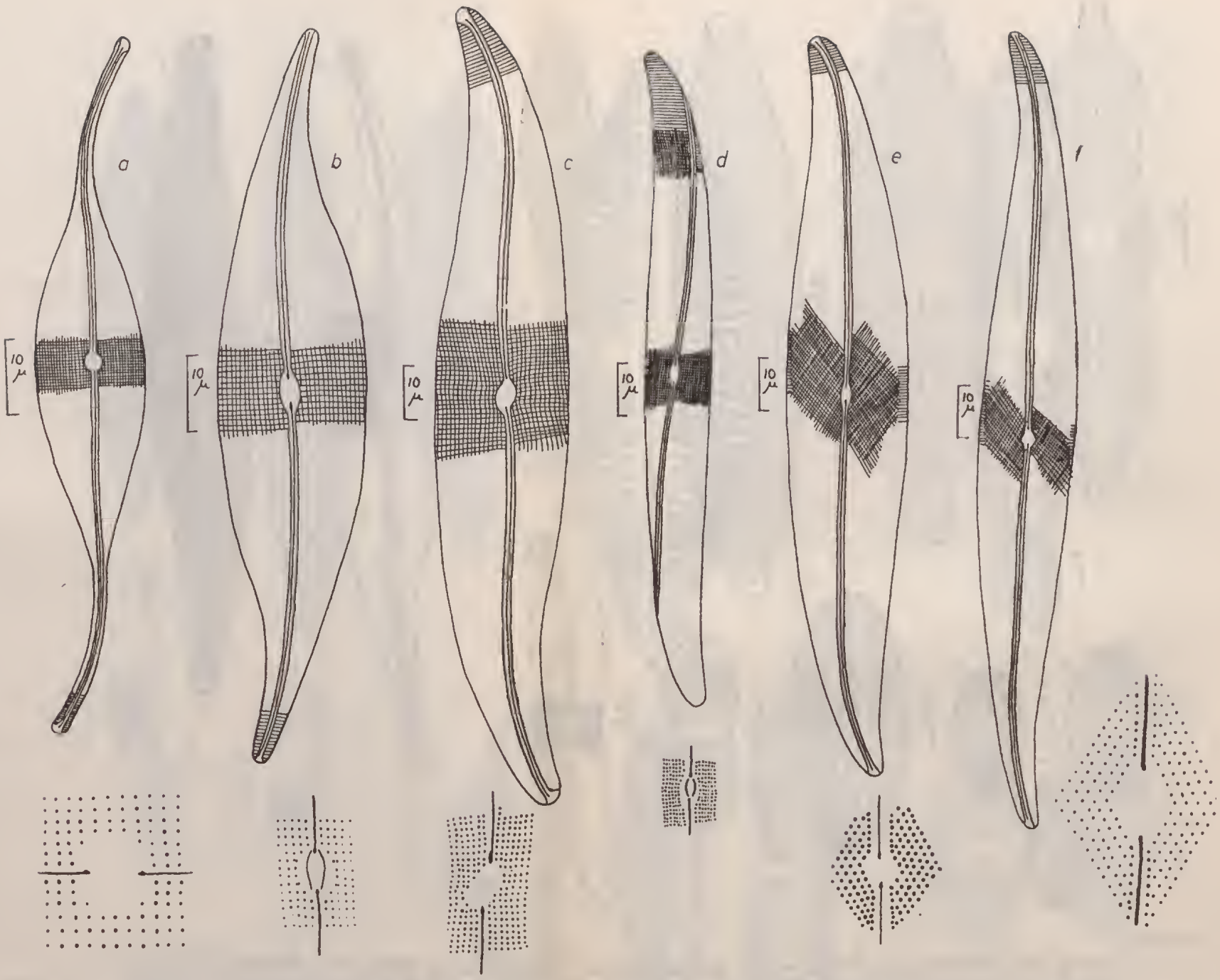


Plate X.

(*a*) *Gyrosigma fasciolum* (Ehrenberg) P. T. Cleve var. *arcuatum* (Donkin) P. T. Cleve; (*b*) *Gyrosigma distortum* (W. Smith) P. T. Cleve; (*c*) *Gyrosigma attenuatum* (Kuetzing) P. T. Cleve; (*d*) *Gyrosigma excentricum* Prowse *sp. nov.*; (*e*) *Pleurosigma salinarum* (Grunow) P. T. Cleve; (*f*) *Pleurosigma elongatum* W. Smith.

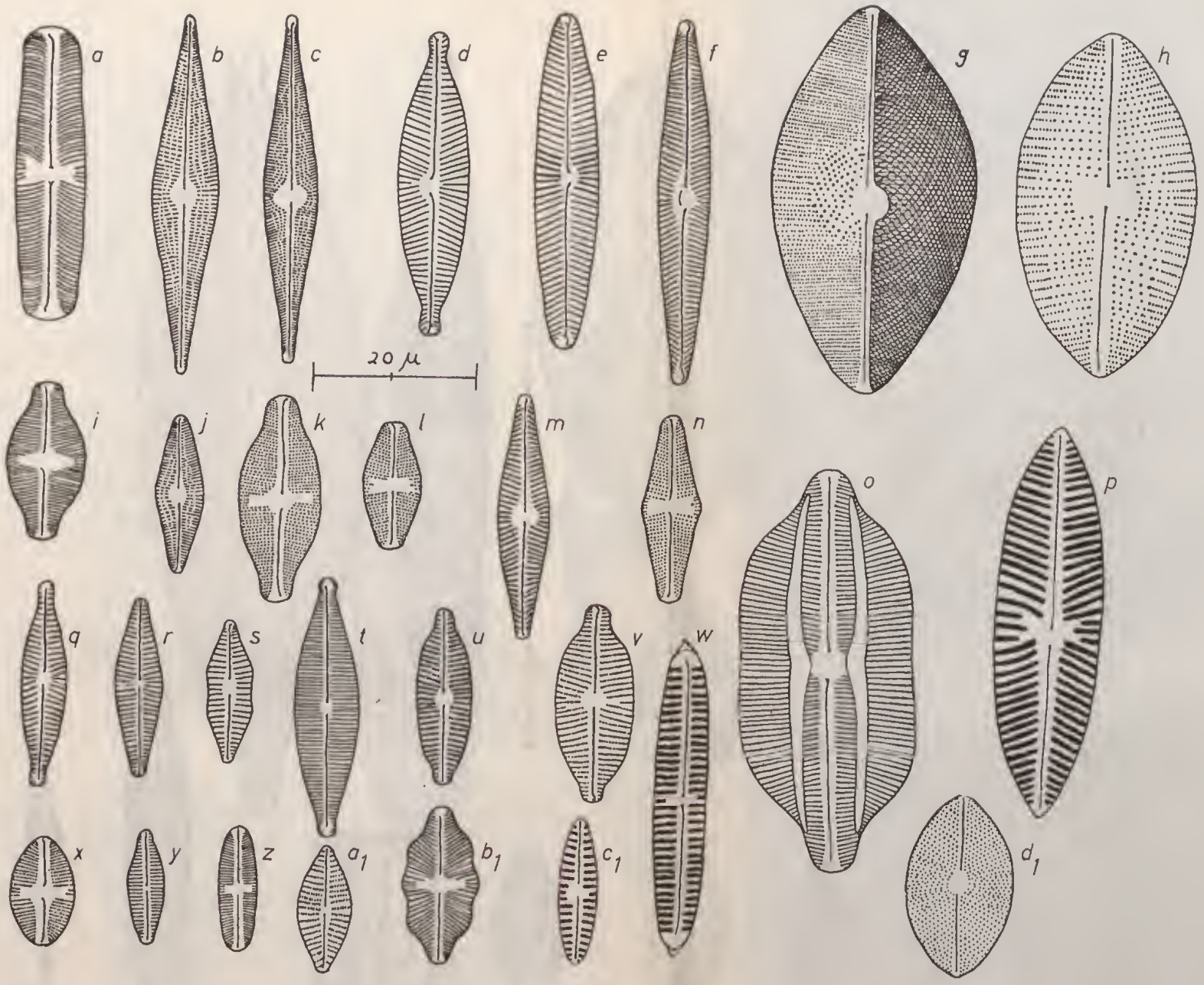


Plate XI.

(*a*) *Navicula pupula* Küetzing var. *capitata* Hustedt; (*b* & *c*) *Anomoeoneis serians* (Brébisson) P. T. Cleve var. *acuta* Hustedt; (*d* & *q*) *Navicula rhyncocephala* Küetzing; (*e*) *Navicula schroeteri* Meister; (*f*) *Navicula feuerborni* Hustedt; (*g*) *Navicula placenta* Ehrenberg var. *obtusa* Meister; (*h*) *Navicula glacialis* P. T. Cleve var. *septentrionalis* P. T. Cleve; (*i*) *Navicula platystoma* Ehrenberg; (*j*) *Anomoeoneis brachysira* (Brébisson) Grunow; (*k* & *l*) *forms of Navicula amphibola* P. T. Cleve; (*m*) *Navicula radiosa* Küetzing var. *minutissima* (Grunow) P. T. Cleve; (*n*) *Navicula lagerheimi* P. T. Cleve var. *intermedia* Hustedt; (*o*) *Navicula lyra* Ehrenberg var. *ehrenbergii* P. T. Cleve; (*p*) *Navicula crucifera* Grunow; (*r*) *Navicula cryptocephala* Küetzing var. *veneta* (Küetzing) Grunow; (*s*) *Navicula antiqua* A. Cleve; (*t*) *Navicula halophila* (Grunow) P. T. Cleve var. *subcapitata* Oestrup; (*u*) *Navicula anglica* Ralfs; (*v*) *Navicula gastrum* Ehrenberg; (*w*) *Navicula cancellata* Donkin var. *apiculata* Grunow; (*x*) *Navicula rotaeana* (Rabenhorst) Grunow; (*y*) *Navicula minuscula* Grunow; (*z*) *Navicula minima* Grunow; (a_1) *Navicula toornensis* P. T. Cleve; (b_1) *Navicula trituberculata* Prowse *sp. nov.*; (c_1) *Navicula hungarica* Grunow var. *lüneburgensis* Grunow; (d_1) *Navicula punctulata* W. Smith.

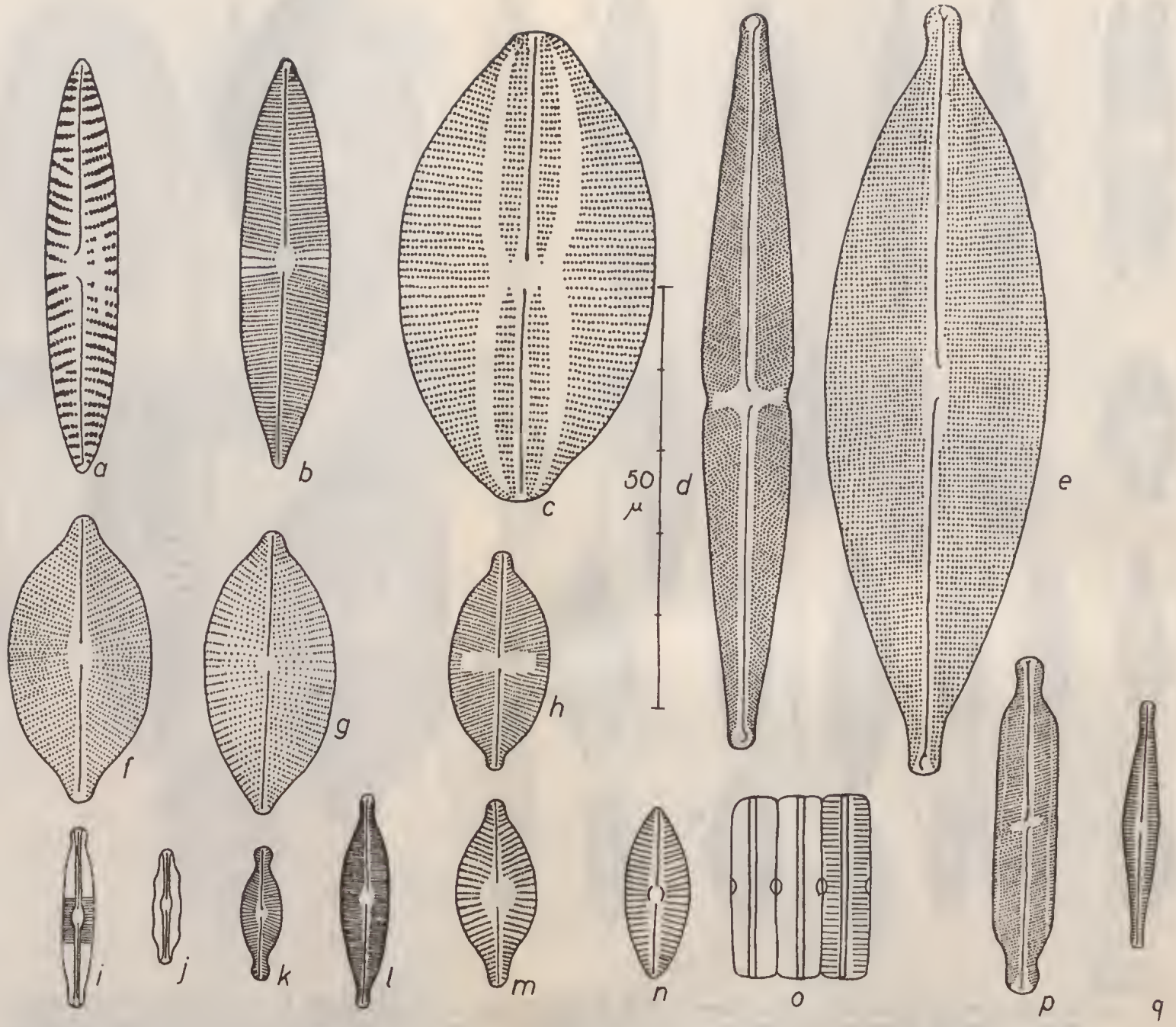


Plate XII.

(*a*) *Navicula arenaria* Donkin; (*b*) *Navicula grevillei* (C. A. Agardh) P. T. Cleve; (*c*) *Navicula lyra Ehrenberg* var. *dilatata* A. Schmidt; (*d*) *Stauroneis phoenicenteron* (Nitzsch) Ehrenberg var. *elegans* Prowse *var. now.;* (*e*) *Navicula cuspidata* Küetzing var. *ambigua* (Ehrenberg) P. T. Cleve; (*f*) *Navicula pusilla* W. Smith; (*g*) *Navicula brasiliensis* Grunow var. *minor* Prowse *var. nov.;* (*h*) *Navicula amphibola* P. T. Cleve; (*i*) *Navicula subtilissima* P. T. Cleve; (*j*) *Navicula tridentula* Krasske; (*k*) *Navicula hustedtii* Krasske; (*l*) *Navicula ostenfeldii* Öestrup; (*m*) *Navicula disparata* Hustedt; (*n* & *o*) *Navicula confervacea* Kuetzing; (*p*) *Neidium productum* (W. Smith) P. T. Cleve var. *minor* A. Cleve; (*q*) *Navicula microcephala* Grunow.

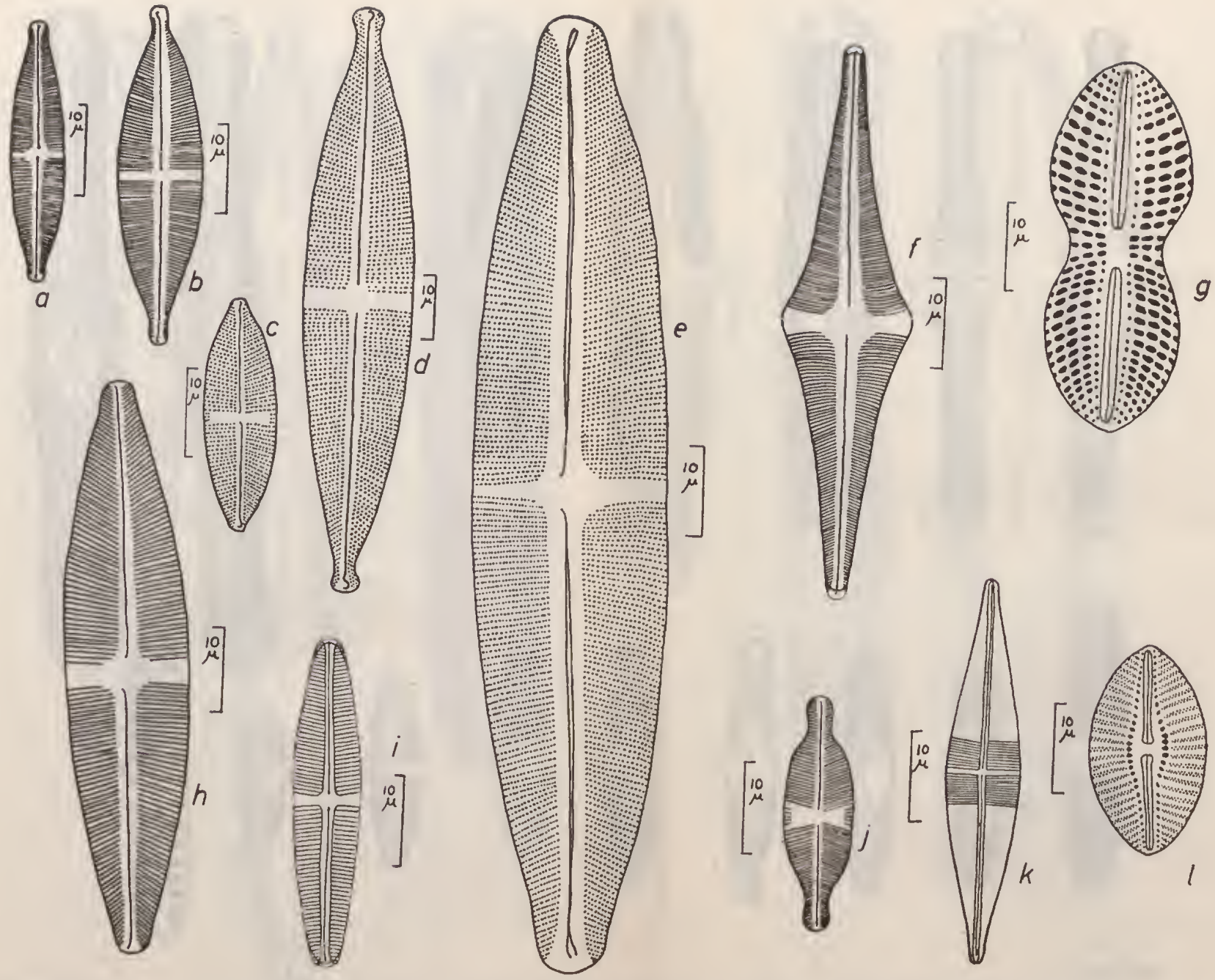


Plate XIII.

(*a* & *b*) *Stauroneis pusilla* A. Cleve var. *franconica* (May.) A. Cleve-Euler; (*c*) *Stauroneis phoenicenteron* (Nitzsch) Ehrenberg var. *halmei* Möelder f. *marginestriata* A. Cleve-Euler; (*d*) *Stauroneis anceps* Ehrenberg; (*e* & *h*) *Stauroneis phoenicenteron* (Nitzsch) Ehrenberg var. *intermedia* (Dipp.) A. Cleve-Euler; (*f*) *Stauroneis acuta* W. Smith; (*g*) *Diploneis bombus* Ehrenberg var. *minor* P. T. Cleve; (*i*) *Stauroneis obtusa* Lagerstedt; (*j*) *Stauroneis anceps* Ehrenberg var. *gothica* A. Cleve-Euler; (*k*) *Stauroneis anceps* var. *hyalina* Brun & Peragallo; (*l*) *Diploneis parma* P. T. Cleve.

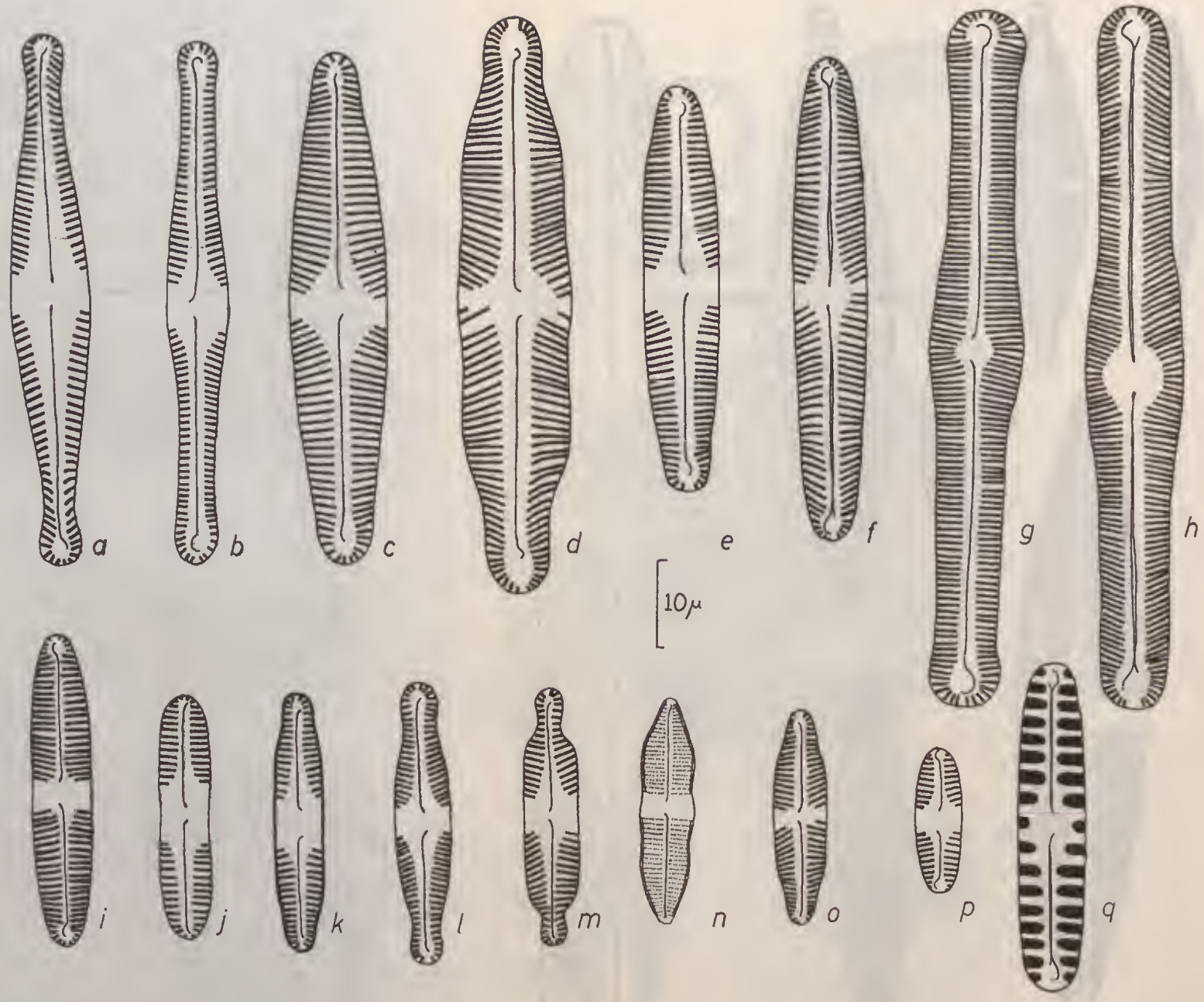


Plate XIV.

(*a*) *Pinnularia braunii* (Grunow) P. T. Cleve; (*b*) *Pinnularia gibba* W. Smith var. *interrupta* A. Cleve-Euler; (*c* & *e*) *Pinnularia microstauron* (Ehrenberg) P. T. Cleve; (*d*) *Pinnularia microstauron* var. *ambigua* Meister; (*f*) *Pinnularia microstauron* var. *brébissonii* (Kuetzing) Hustedt; (*g*) *Pinnularia tabellaria* Ehrenberg; (*h*) *Pinnularia bogotensis* (Grunow) P. T. Cleve var. *continua* A. Cleve; (*i*, *j* & *p*) *Pinnularia stricta* Hustedt; (*k*) *Pinnularia appendicula* (C. A. Agardh) P. T. Cleve var. *budensis* Grunow; (*l*) *Pinnularia braunii* (Grunow) P. T. Cleve. var. *amphicephala* (A. Mayer) Hustedt; (*m*) *Pinnularia biceps* Gregory var. *minor* (Boye Petersen) A. Cleve; (*n*) *Caloneis silicula* (Ehrenberg) P. T. Cleve var. *minuta* P. T. Cleve; (*o*) *Pinnularia brébissonii* (Küetzing) P. T. Cleve var. *hybrida* (Grunow) A. Cleve; (*q*) *Pinnularia borealis* Ehrenberg.

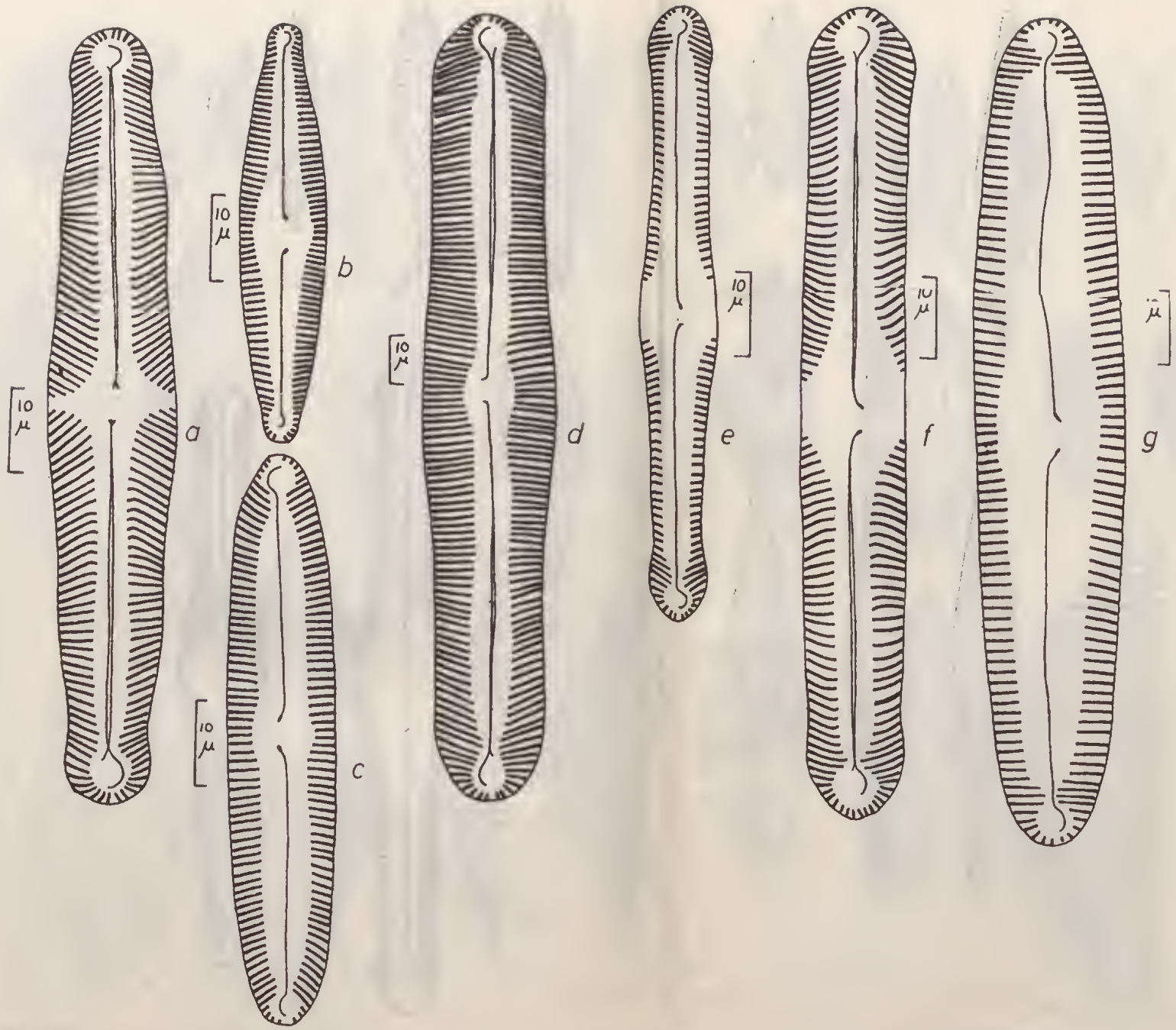


Plate XV.

(*a*) *Pinnularia stomatophoroides* Mayer var. *nuda* A. Cleve-Euler; (*b*) *Pinnularia parva* (Gregory) P. T. Cleve var. *parvula* (Ralfs.) A. Cleve-Euler; (*c*) *Pinnularia hemiptera* (Kuetzing) Rabenhorst; (*d*) *Pinnularia trigonocephala* P. T. Cleve; (*e*) *Pinnularia braunii* (Grunow) P. T. Cleve var. *amphicephala* (A. Mayer) Hustedt; (*f*) *Pinnularia stauroptera* (Grunow) P. T. Cleve var. *subparallela* Mayer; (*g*) *Pinnularia brevicostata* P. T. Cleve.

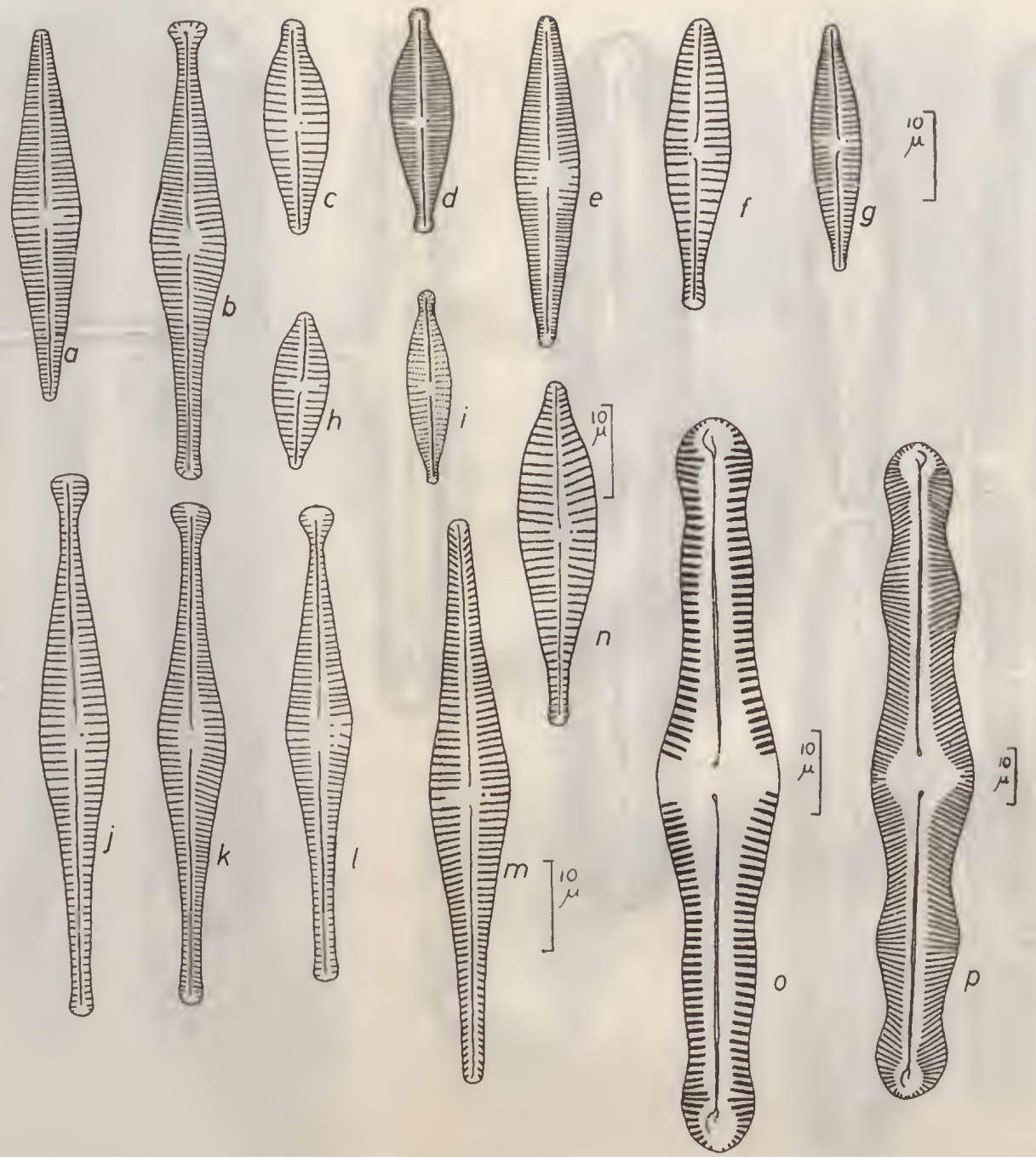


Plate XVI.

(*a* & *e*) *Gomphonema gracile* Ehrenberg; (*b*, *j*, *k* & *l*) *Gomphonema subtile* Ehrenberg; (*c*, *d*, *g*, *h*, & *i*) *Gomphonema parvulum* (Küetzing) van Heurck; (*f* & *n*) *Gomphonema subventricosum* Hustedt; (*m*) *Gomphonema longiceps* Ehrenberg var. *subclavata* Grunow f. *gracilis* Hustedt; (*o*) *Pinnularia polyonca* (Brebisson) P. T. Cleve; (*p*) *Pinnularia mesolepta* (Ehrenberg) W. Smith.

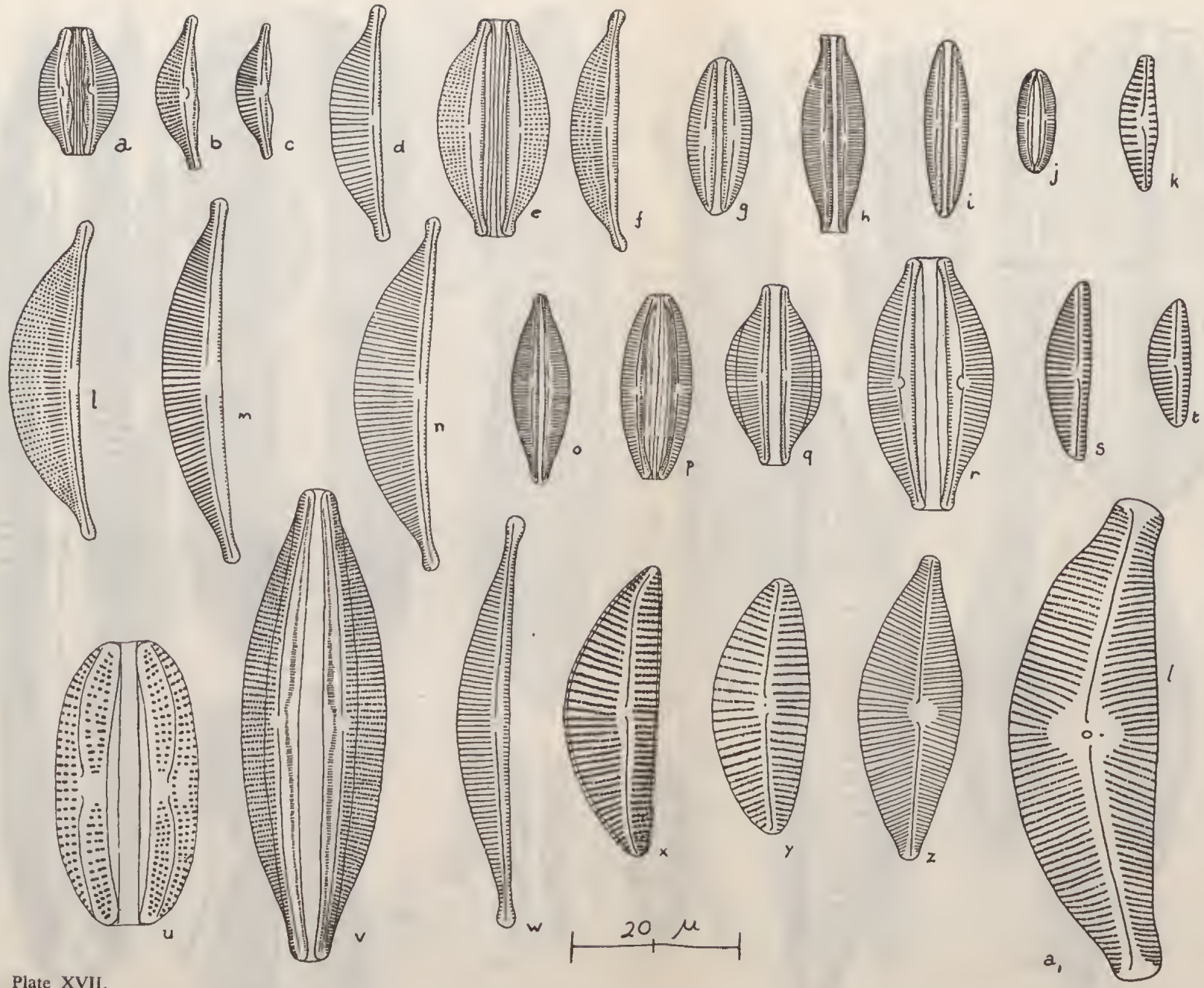


Plate XVII.

(*a, b* & *c*) *Amphora bitumida* Prowse *sp. nov.;* (*d*) *Amphora exigua* Gregory; (*e, f, n. q, v* & *w*) *Amphora acutiuscula* Kuetzing; (*g* & *i*) *Amphora angusta* (Gregory) P. T. Cleve; (*h* & *o*) *Amphora coffaeiformis* C. A. Agardh; (*j*) *Amphora perpusilla* Grunow; (*k*) *Cymbella javanica* Hustedt; (*l*) *Amphora holsatica* Hustedt var. *malayana* Prowse *var. nov.;* (*m*) *Amphora holsatica* Hustedt; (*p*) *Amphora libyca* Ehrenberg; (*r*) *Amphora normani* Rabenhorst; (*s* & *t*) *Cymbella ventricosa* Küetzing; (*u*) *Amphora proteus* Gregory; (*x*) *Cymbella turgida* Gregory; (*y*) *Cymbella kolbei* Hustedt; (*z*) *Cymbella cuspidata* Kuetzing; (*a*ı) *Cymbella tumida* (Brébisson) van Heurck.

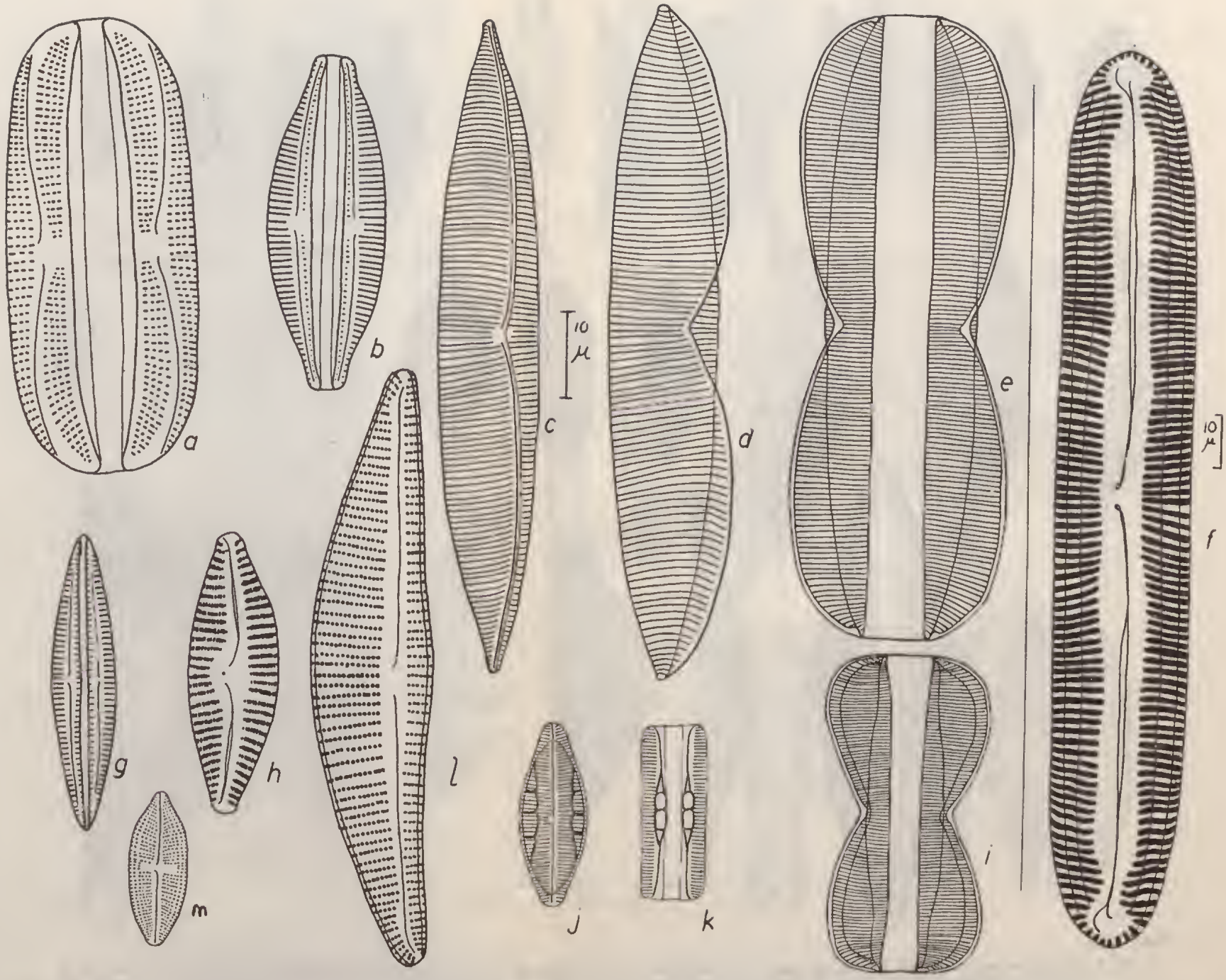


Plate XVIII.

(*a*) *Amphora proteus* Gregory; (*b*) *Amphora acutiuscula* Küetzing; (*c, d, e* & *i*) *Tropidoneis lepidoptera* (Gregory) P. T. Cleve; (*f*) *Pinnularia macilenta* (Ehrenberg) P. T. Cleve; (*g*) *Amphora angusta* (Gregory) P. T. Cleve; (*h*) *Cymbella sumatrensis* Hustedt; (*j* & *k*) *Mastogloia exigua* Lewis; (*l*) *Cymbella lanceolata* (Ehrenberg) van Heurck; (*m*) *Caloneis ladogensis* P. T. Cleve var. *cuneata* A. Cleve.

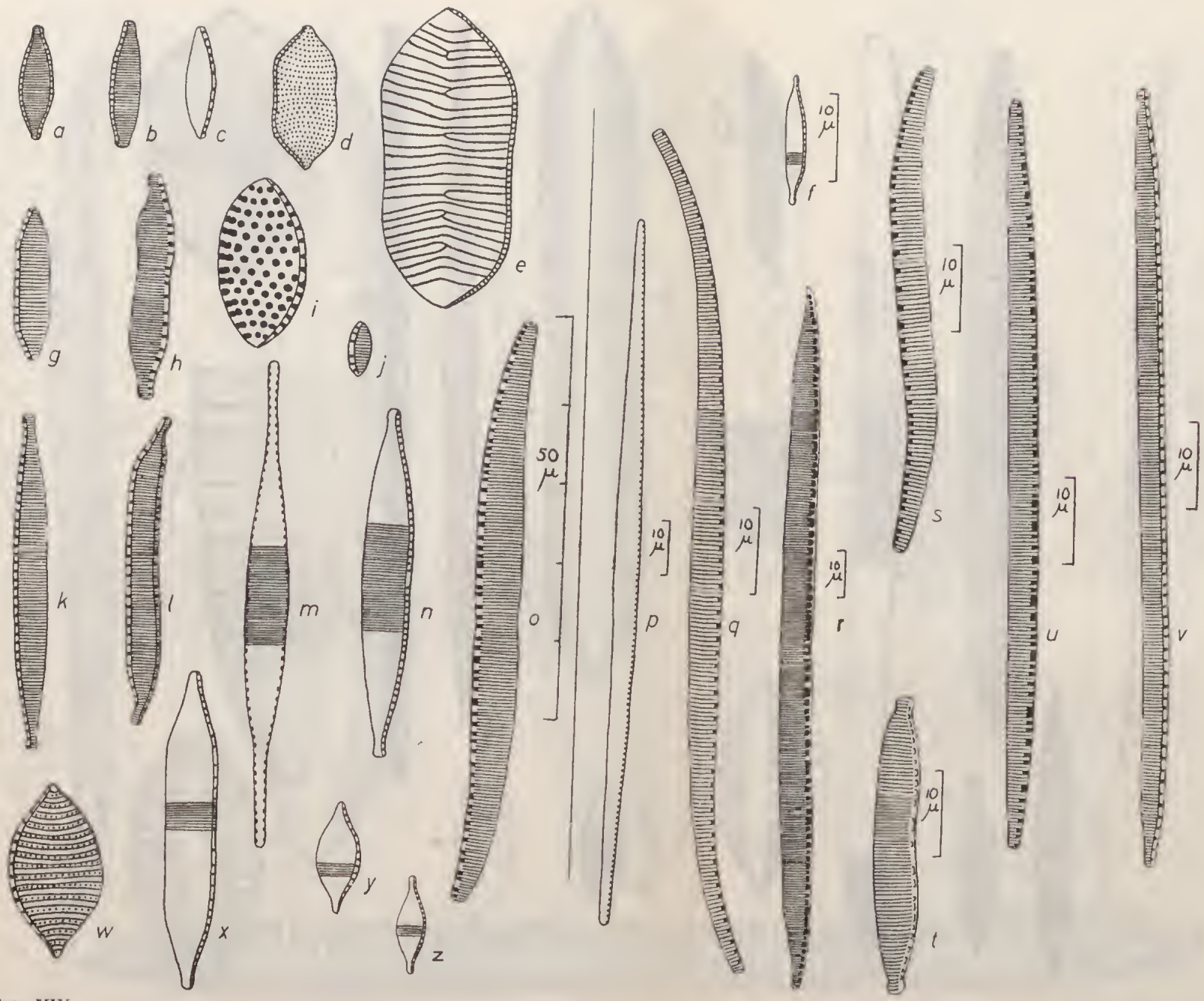


Plate XIX.

(*a, b* & *c*) *Nitzschia fonticola* Grunow; (*d*) *Nitzschia constricta* Gregory) Grunow; (*e*) *Nitzschia tryblionella* Hantzsch var. *victoriae* Grunow; (*f*) *Nitzschia microcephala* Grunow; (*g*) *Nitzschia amphibia* Grunow var. *acutiuscula* Grunow; (*h*) *Nitzschia parvula* Lewis; (*i*) *Nitzschia granulata* Grunow; (*j*) *Nitzschia communis* Rabenhorst var. *abbreviata* Grunow; (*k*) *Nitzschia palea* (Küetzing) W. Smith; (*l*) *Nitzschia sigma* (Küetzing) W. Smith var. *clausii* (Hantzsch) Grunow; (*m*) *Nitzschia acicularis* (Küetzing) W. Smith; (*n*) *Nitzschia stagnorum* Rabenhorst; (*o*) *Nitzschia obtusa* W. Smith var. *scalpelliformis* Grunow; (*p*) *Nitzschia subtilis* (Küetzing) Grunow; (*q*) *Nitzschia lorenziana* Grunow var. *subtilis* Grunow; (*r*) *Hantzschia amphioxys* (Ehrenberg Grunow var. *vivax* (Hantzsch) Grunow; (*s*) *Nitzschia ignorata* Krasske; (*t*) *Hantzschia amphioxys* (Ehrenberg) Grunow var. *capitata* O. Müeller; (*u*) *Nitzschia gandersheimiensis* Krasske; (*v*) *Nitzschia heufleuriana* Grunow; (*w*) *Nitzschia punctata* (W. Smith) Grunow var. *apiculata* A. Cleve-Euler; (*x*) *Nitzschia diducta* Hustedt; (*y* & *z*) *Nitzschia towutensis* Hustedt.

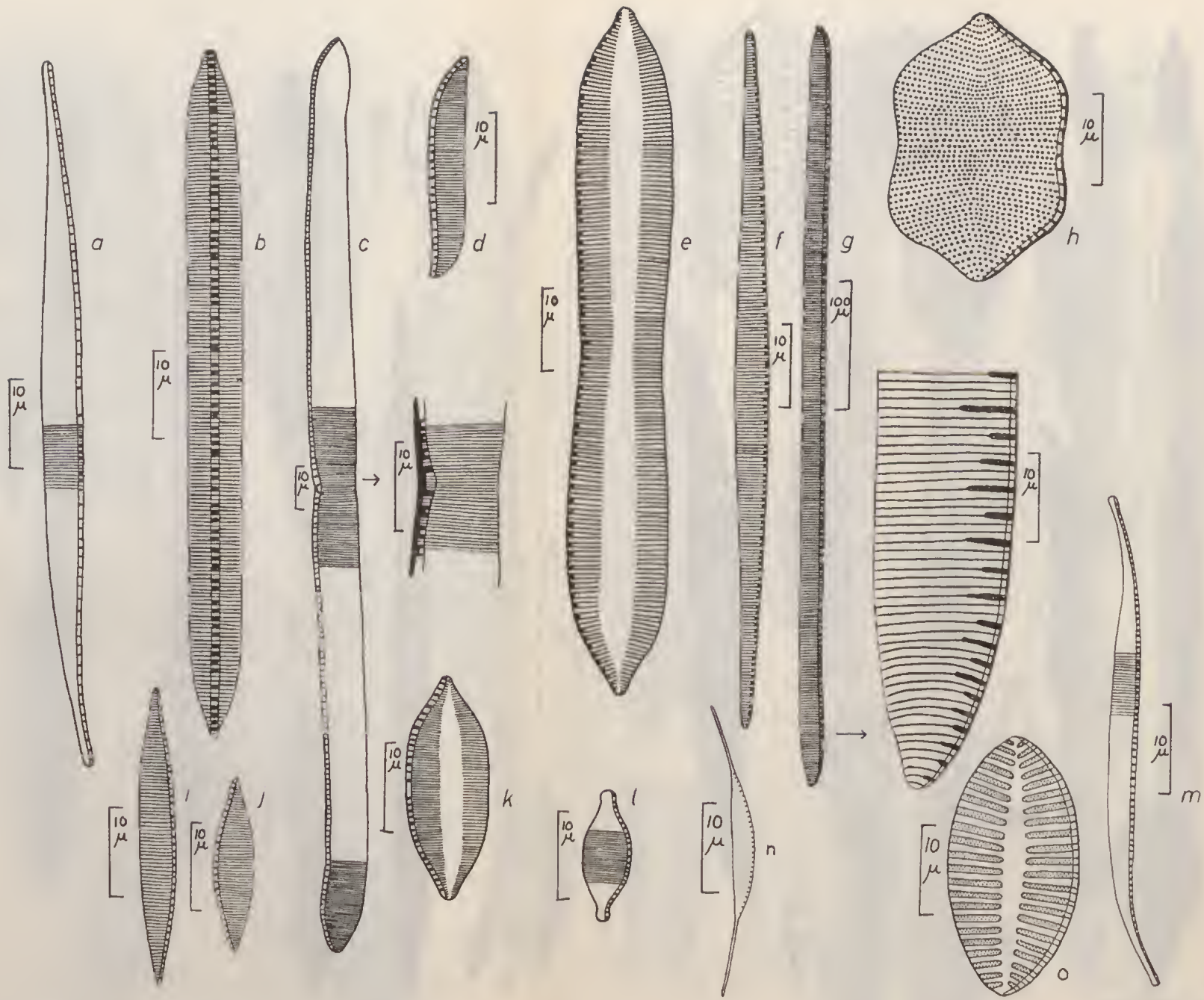


Plate XX.

(*a* & *m*) *Nitzschia sigma* (Küetzing) W. Smith; (*b*) *Nitzschia paradoxa* (Gmelin) Grunow; (*c*) *Nitzschia obtusa* W. Smith; (*d*) *Nitzschia obtusa* var. *scalpelliformis* Grunow; (*e*) *Nitzschia plana* W. Smith; (*f*) *Nitzschia subtilis* (Küetzing) Grunow; (*g*) *Nitzschia scalaris* (Ehrenberg) W. Smith; (*h*) *Nitzschia punctata* (W. Smith) Grunow var. *malayana* Prowse *var. nov.*; (*i* & *j*) *Nitzschia romana* Grunow; (*k*) *Nitzschia littoralis* Grunow var. *tergestina* Grunow; (*l*) *Nitzschia towutensis* Hustedt; (*n*) *Nitzschia closterium* (Ehrenberg) W. Smith; (*o*) *Nitzschia navicularis* (Brébisson) Grunow.

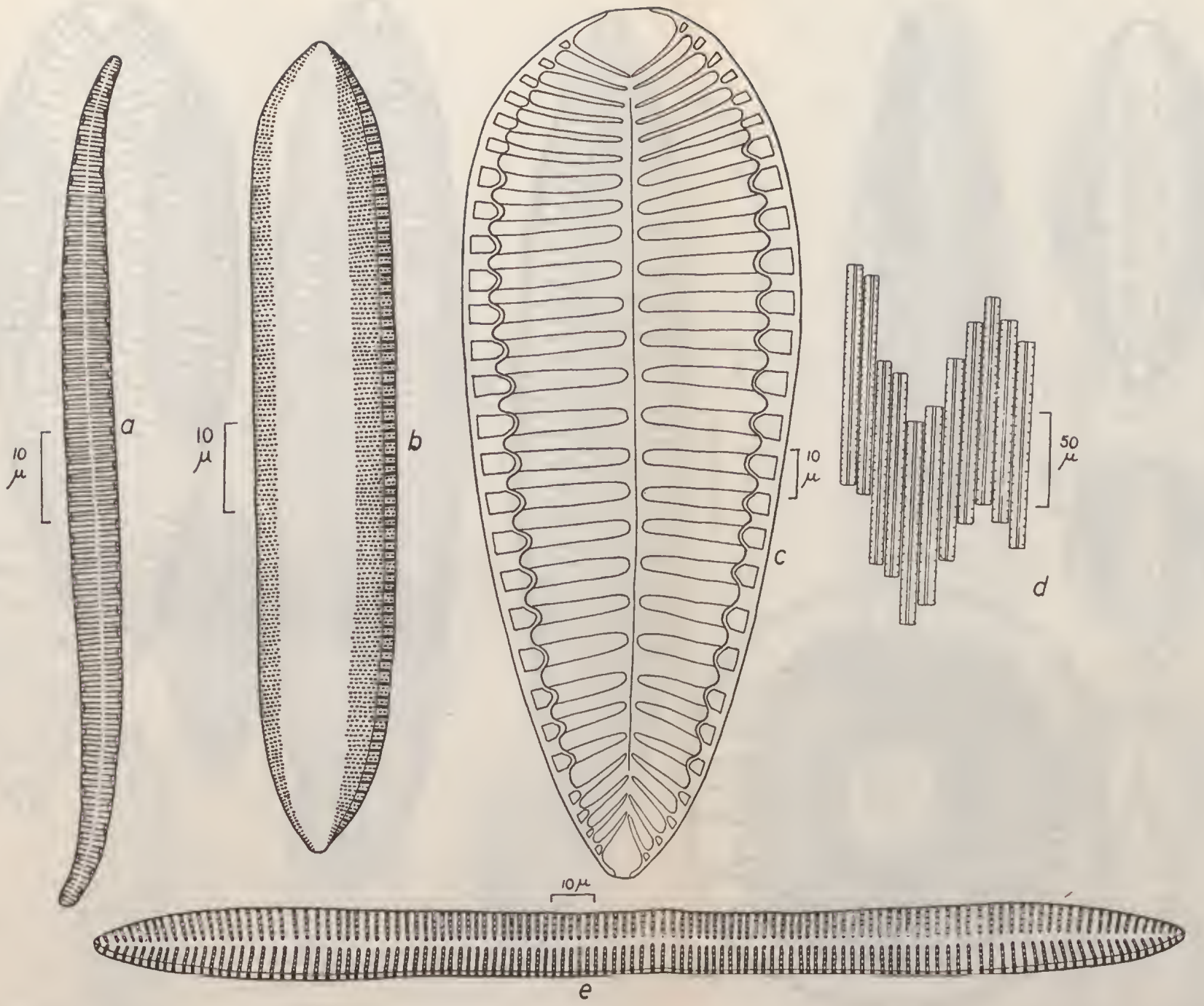


Plate XXI.

(*a*) *Stenopterobia intermedia* (Lewis) Fricke; (*b*) *Nitzschia marginulata* Grunow; (*c*) *Surirella robusta* Ehrenberg; (*d*) *Nitzschia paradoxa* (Gmelin) Grunow, habit of colony; (*e*) *Nitzschia surirelloidea* Prowse *sp. nov.*

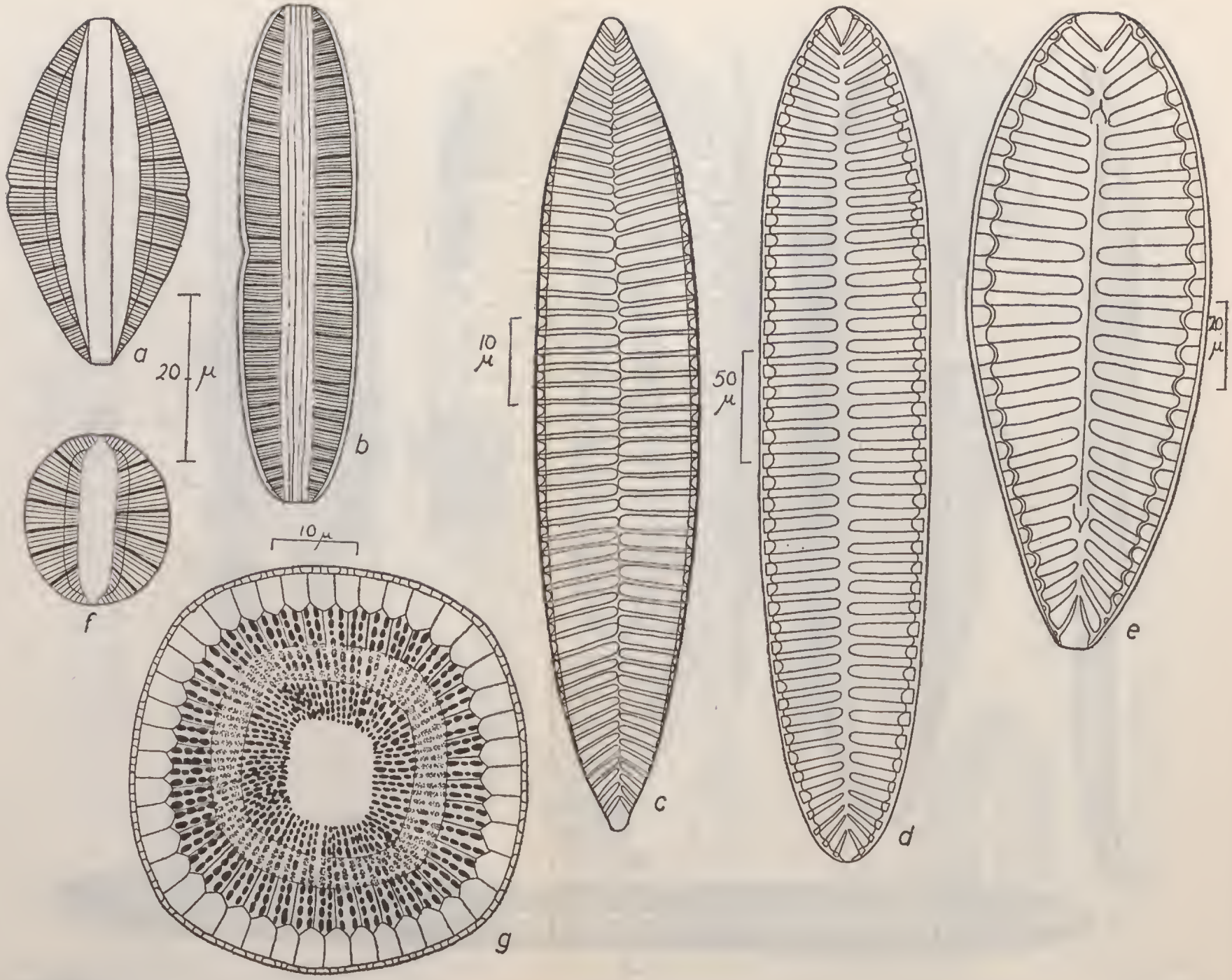


Plate XXII.

(*a*) *Rhopalodia gibberula* (Ehrenberg O. Müeller; (*b*) *Rhopalodia parallela* (Grunow) O. Müeller; (*c*) *Surirella lemmermanni* Hustedt; (*d*) *Surirella biseriata* Brébisson; (*e*) *Surirella capronii* Brébisson; (*f*) *Rhopalodia musculus* (Küetzing) O. Müeller; (*g*) *Campylodiscus clypeus* W. Smith.

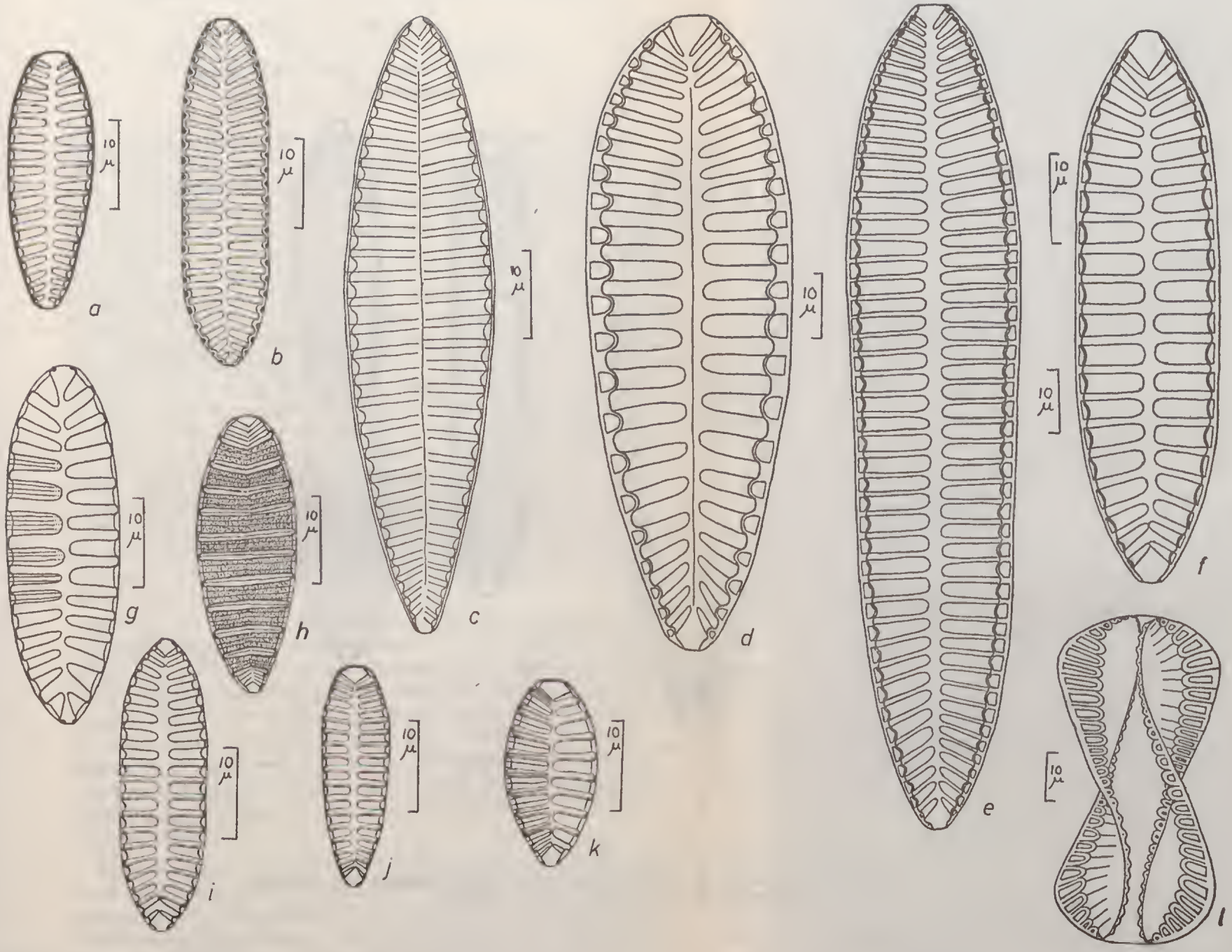


Plate XXIII.

(*a, h, j* & *k*) *Surirella tenuissima* Hustedt; (*b* & *i*) *Surirella angusta* Küetzing; (*c*) *Surirella angusticostata* Hustedt; (*d*) *Surirella robusta* Ehrenberg var. *splendida* (Ehrenberg) van Heurck; (*e*) *Surirella tenera* Gregory; (*f* & *g*) *Surirella linearis* W. Smith; (*l*) *Surirella spiralis* Küetzing.

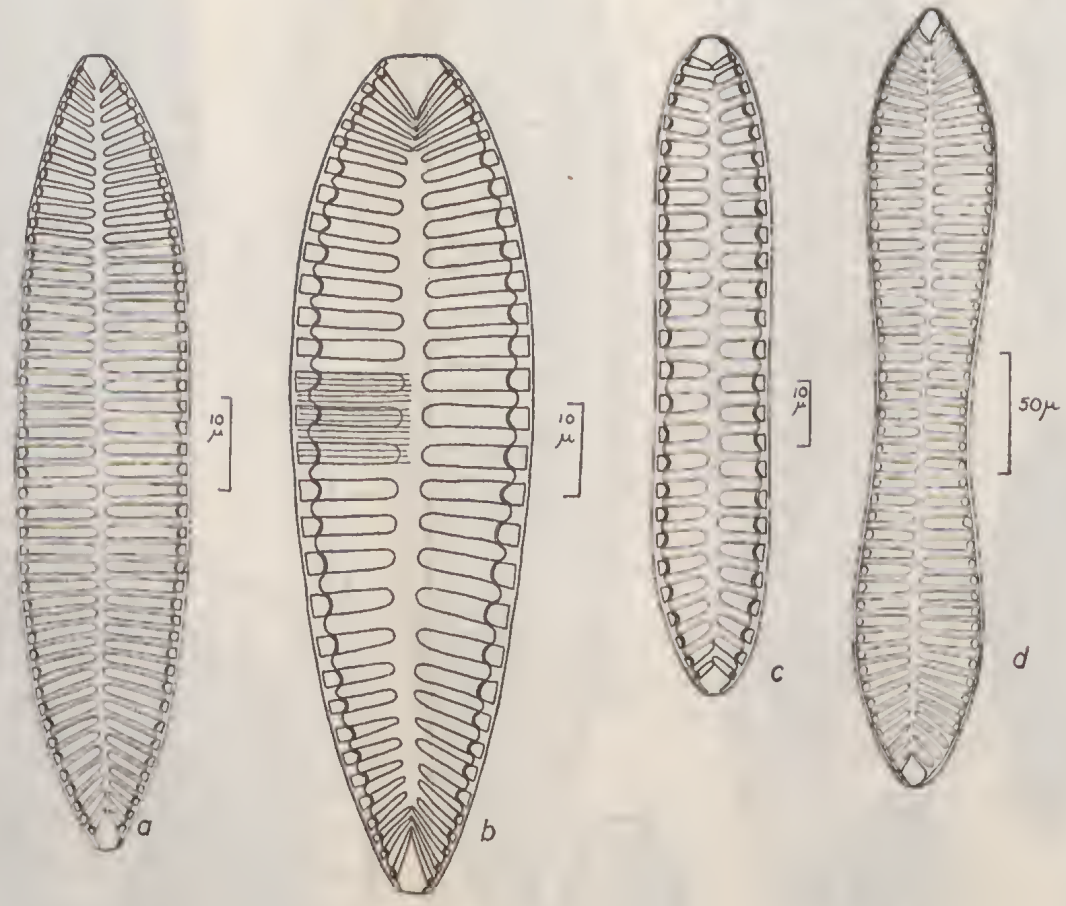


Plate XXIV.

(*a* & *c*) *Surirella linearis* W. Smith; (*b*) *Surirella robusta* Ehrenberg var. *splendida* (Ehrenberg) van Heurck; (*d*) *Surirella muelleri* Hustedt.

Further Malayan Freshwater Flagellata

By G. A. Prowse

Tropical Fish Culture Research Institute,
Batu Berendam, Malacca

Malaya has numerous rivers, swamps, paddy fields and ponds of various kinds, and one would naturally expect to find an abundance of Flagellata in these waters. Despite this, very little is known of the forms which occur in this area, largely because it has been only in recent years that attention has been turned to the freshwater microflora of Malaya. In addition, for accurate determination the Flagellata must be studied in the living state, or at least freshly killed with osmic acid vapour. Most fixatives, like Formalin or alcohol, cause such distortion of the organism that it is recognisable only with great difficulty. Thus, what knowledge we have of the Flagellata is confined to those forms collected from easily accessible places, and as more extensive areas are covered we may expect the number of described species to increase considerably. References to the Malayan freshwater flagellates are few and scanty in content, and with the exception of my own longer paper on the Euglenineae (Prowse 1958), have all been based on preserved specimens examined far from the native habitat. The present paper cannot be regarded as in any way complete, even in those groups discussed in it; the Volvocales, Xanthophyceae and the Dinophyceae are omitted and will be described in later papers.

Most of the material on which this paper is based has been examined immediately after collection, both living, and freshly killed with osmic acid vapour. In some cases, especially with those organisms inhabiting polluted waters, the material has been examined again after keeping it in the laboratory for several days. In a few cases the organisms have been studied in culture, although in no cases were the cultures absolutely free from other organisms. Drawings were all carried out with the aid of a camera lucida, using an Ortholux microscope; any inaccuracies are therefore my own.

Since this paper is not intended to be in any way complete, I have refrained from constructing keys beyond the level of genera. Species are listed alphabetically under the genus. The Euglenineae described here is additional to those mentioned in an earlier paper (Prowse 1958), and as only one genus, *Rhizaspis,* has been added to the earlier list, it has been felt not necessary to construct a new key.

The Flagellata are so called because of the presence of one or more protoplasmic threads, the flagella, by means of which the organism is propelled in the water. Originally the term was used to distinguish naked flagellate forms from those forms such as the Volvocales which possess a cell wall. This distinction is no longer valid, since in the Chlorophyceae there are a few naked flagellate members, particularly in the Polyblepharidaceae, whilst thalloid and filamentous development has also been found in other groups such as the Xanthophyceae, Chrysophyceae and even the Dinophyceae. As now used, the term Flagellata embraces a diverse assemblage of forms belonging to well-defined and differing classes, and includes as well a somewhat heterogeneous collection of colourless forms whose affinities are uncertain. Apart from this latter, which cannot be constituted a true class, each group includes holophytic pigmented forms, and also colourless forms amongst which the mode of nutrition may range from saprophytic to completely holozoic. There are even species containing chromatophores which can display holozoic nutrition (e.g. *Chrysamoeba*) and these often show amoeboid characters, as do several of the colourless forms. The distinguishing features of each group will be dealt with under the class headings, although the key will also include brief reference to them.

KEY TO THE FLAGELLATA

A. Cells with chromatophores ..... B.

A. Cells colourless, without chromatophores ..... G.

B. Chromatophores grass green ..... C.

B. Chromatophores yellowish green to bright green, not grass green ..... D.

B. Chromatophores yellowish to brownish ..... E.

B. Chromatophores variable in colour ..... F.

C. Cells usually with one chloroplast, rarely more; elaborate vacuolar apparatus "gullet", absent; flagella usually two or four equal in length; storage material starch; complex colonial forms occur .. VOLVOCALES (Chlorophyceae).

C. Cells usually with several chloroplasts; vacuolar system elaborate, forming a "gullet"; storage material paramylum EUGLENINEAE (I).

D. Cells bright green; chloroplasts numerous; elaborate vacuolar system or "gullet" present; trichocysts present in the cell; storage material fat ... CHLOROMONADINEAE (II).

D. Cells more yellowish green; elaborate vacuolar system or "gullet" absent; chloroplasts usually few; flagella usually two, unequal in length; storage material oil, never starch XANTHOPHYCEAE.

E. Chromatophores usually brownish in colour (but see F), usually two in a number; cells markedly dorsiventral with a groove or canal where the flagella are inserted; flagella usually two, unequal; storage products solid carbohydrates-starch and allied substances .. CRYPTOPHYCEAE (III).

E. Chromatophores brownish, usually numerous; membrane usually consisting of sculptured plates; flagella two, one tranverse and undulatory, often in a groove, the other projecting vertically and free; storage products starch and oil ..... DINOPHYCEAE.

E. Chromatophores golden yellow, usually 1–2 in number; flagella 1–3; cells often with an elaborate envelope; storage products leucosin; colonial forms frequent CHRYSOPHYCEAE (II).

F. Chromatophores blue, blue-green or red, usually two in number; cells markedly dorsiventral with a groove or canal where the flagella are inserted, flagella usually two, unequal; storage products solid carbohydrates-starch and allied substances .... CRYPTOPHYCEAE in part (III).

G. Cells colourless, with an elaborate vacuolar apparatus or "gullet"; storage product paramylum EUGLENINEAE (in part) (I).

G. Cells colourless, distinctly dorsiventral with a groove or canal where the flagella are attached, flagella usually two, unequal; storage product starch or allied carbohydrate CRYPTOPHYCEAE (in part) (III).

G. None of the above characters RESIDUAL COLOURLESS FLAGELLATA (IV).

EUGLENINEAE

One hundred and twenty-five species of Euglenineae from Malayan freshwaters have been described in an earlier paper (Prowse 1958), and the following are species or forms additional to that list. No key is provided here, but the genera are listed in the same order as in the previous paper.

The most characteristic features distinguishing the Euglenineae from the other classes, are the presence of a narrow canal or cytostome leading back into an enlarged vacuolar swelling or reservoir, and the fact that the storage product is paramylum, a polysaccharide allied to starch, but not staining with iodine or chlorzinc-iodide.

Euglenaceae

Possessing green chloroplasts, ranging from discoid to band-shaped with or without pyrenoids. The green colour may in some cases be obscured by the production of haematochrome. Colourless forms have appeared which are so obviously related to pigmented forms that there is no difficulty in identification.

EUGLENA Ehrenberg 1838

1. **Euglena agilis** Carter [syn. *Euglena pisciformis* Klebs]. CELLS elongate-ovoid, 18–20μ long $\times$ 9–11μ wide, bluntly rounded at the anterior end and tapered to a blunt point at the posterior end; PERIPLAST very faintly striated, the striations not easily visible. CHROMATOPHORES two parietal plates nearly filling the lining of the periplast, but with the division between them always visible; from the side they appear as elongated bands, but in freshly killed specimens lightly stained with Gentian violet the edges are seen to be lobed. PYRENOIDS one in each chromatophore, usually centrally placed and with a paramylum cup on each side; additional paramylum in the form of a few very short rods. EYESPOT faint, orange in colour. FLAGELLUM a little over body length. The organism swims rapidly, with a characteristic sideways flick of the tail end. (Pl. I figs. h, i).

   MALAYA: Malacca—fish-ponds.

   Worldwide in distribution.

2. **Euglena exilis** Gojdics. CELLS broadly fusiform 70–85μ long $\times$ 18–22μ wide, rounded at the anterior end, tapering gently to a point at the posterior end. PERIPLAST very prominently striated, the striae seen clearly to consist of rows of dots. The CYTOPLASM contains scattered spherical granules which stain with neutral red, but are otherwise not easily visible. CHROMATOPHORES usually four elongated parietal plates, lobed at the edges, the lobes best seen when the cell has swollen out and is lightly stained with gentian violet. PYRENOIDS one in the centre of each chromatophore, with a cup of paramylum on each side; additional paramylum in the form of small rectangular rods 2–3μ long. FLAGELLUM $\frac{1}{2}$–1 times body length. EYESPOT large, orange red. Cell distinctly metabolic, bulging in the middle and then narrowing down again. (Pl. I fig. k).

   MALAYA: Malacca—fish-ponds.

   Originally described from U.S.A.

Despite the larger size and fatter shape of the Malayan forms, I have felt it better to place them under Gojdics species (Gojdics measurements are 37–53μ $\times$ 8–10μ). They clearly agree in the striated pellicle, shape and number of the chromatophores, and in

the granules which stain neutral red. The flagellum in the Malayan form is admittedly longer than in the original species from U.S.A. There are distinct affinities with *Euglena polymorpha* Dangeard, which is of a similar size and shape, but that species has 12–20 smaller chromatophores.

3. **Euglena flava** Dangeard. CELLS broadly fusiform, 55–70μ long $\times$ 20–25μ wide, rounded at the anterior end and tapering to a blunt tail at the posterior end. PERIPLAST faintly striated, the striations difficult to see. CHROMATOPHORES 10–15 elongated discs with smooth edges, parietally placed parallel to the long axis and appearing as elongated bands in side view. PYRENOIDS one in each chromatophore with a cup of paramylum on each side, additional paramylum not seen. The cells are coloured red by numerous granules of haematochrome which are either clumped in the middle, or dispersed throughout the cell. FLAGELLUM about body length. EYESPOT a quite large, orange-red concave disc. The cell is distinctly metabolic stretching out and contracting to a round ball. (Pl. I fig. g).

MALAYA: Malacca—small experimental ponds at Batu Berendam.

This species formed orange-red scums in small ponds manured with buffalo manure. Why it should have occurred rather than *Euglena sanguinea* Ehrenberg, to be found in almost any padi field or carp pond, is hard to say. Perhaps the origin of the buffalo manure might have explained it, but there are no records of this. A bloom of *Euglena flava* Dangeard is quite different from the brick-red blooms of *Euglena sanguinea* Ehrenberg, being much more orange in colour. Chu (1946) has suggested that *Euglena flava* Dangeard is synonymous with *Euglena caudata* Huebner, which he found produced haematochrome in culture, but neither in Dangeard's original description, nor in the Malayan material of *Euglena flava* was there any sign of lobing in the chloroplast as in *Euglena caudata.*

4. **Euglena gracilis** Klebs. CELLS nearly cylindrical, 45–55μ long $\times$ 8–12μ wide, rounded at the anterior end and bluntly pointed at the posterior end, although the tail may round off under pressure from the cover slip. PERIPLAST with such faint striations as to be hardly visible, even under oil immersion. CHROMATOPHORES 7–10 parietal yellowish-green circular to ovoid discs, but the outlines may become irregular when they are closely packed together. PYRENOIDS one in each chromatophore, with a paramylum cup on each side; additional paramylum ovoid bodies which may become so abundant as to bulge out the periplast. FLAGELLUM half to body length, very

active. EYESPOT crimson, prominent. The cell is very active, swimming rapidly by a zig-zag motion which is characteristic, and it can be very metabolic. (Pl. I figs. e, f).

MALAYA: Malacca—fish-ponds.

Selangor—Sungai Gombak, Kuala Lumpur.

Negri Sembilan—standing pools, Port Dickson.

Worldwide in distribution.

This species is easily recognised by its clear yellow-green colour and its characteristic zig-zag swimming motion. It does not appear to be abundant in any sample of water collected, although it is probably wide-spread in distribution. Nevertheless it is probably the easiest species to culture, being tolerant of the acid conditions that often develop in cultures. Cultures of material from different sources often show slight differences in the physiology of the organism and in two cultures at Batu Berendam the cells have shown a tendency to secrete haematochrome, although never in the quantity to be found in the typical red species of *Euglena.*

5. **Euglena intermedia** (Klebs) Schmitz var. *klebsii* Lemmermann. CELLS cylindrical 100–130μ long $\times$ 15–18μ wide, only slight-narrowing to the blunt anterior end, and narrowing at the posterior end to a short blunt tail piece. PERIPLAST apparently unstriated, even under oil-immersion. The CYTOPLASM is granular and contains spherical bodies which stain with neutral red, scattered throughout the cell except at the ends, where they tend to be clumped. CHROMATOPHORES numerous, lenticular, 8–10μ long, without pyrenoids. PARAMYLUM in short rods 2 in length, each with a slight central depression. EYESPOT purplish red, conspicuous. FLAGELLUM rarely seen, less than one-sixth body length, the cell usually moving by means of a squirming motion. (Pl. I fig. a).

MALAYA: Selangor—Kuala Lumpur, a pond.

Negri Sembilan—Seremban and Port Dickson, stagnant water.

Malacca—stagnant water.

Johore—Muar and Yong Peng, stagnant water.

Singapore—stagnant pools.

A very characteristic species, particular with its squirming habit. The Malayan forms belong to the var. *klebsii* Lemmermann because of the small paramylum rods. The species and its varieties could be confused with *Euglena deses* Ehrenberg, and the type was originally referred to that species as var. *intermedia* Klebs. However *Euglena intermedia* and its forms, including the Malayan material here described, have no pyrenoids as in *Euglena deses.*

6. **Euglena mutabilis** Schmitz [Syn. *Euglena acus* Ehrenberg var. *mutabilis* Klebs.] CELLS cylindrical, 80–110μ long $\times$ 5–9μ wide, tapering very slightly to the blunt, often slightly oblique anterior end and tapering to a point at the posterior end. The PERIPLAST shows faint, steeply spiralling striae which are visible with difficulty. The CYTOPLASM contains numerous small spherical granules visible without staining and scattered throughout the cell. CHROMATOPHORES yellowish-green, usually four parietal plates, two on each side of the nucleus; they are so closely appressed to each other and stretch nearly round the cell that the division between them is difficult to see, but will show up in certain positions of the cell, particularly after staining. PYRENOIDS one in each chromatophore, usually central and showing up as a bulge in edge view. PARAMYLUM short rectangular bodies about 2μ long and often so abundant as to fill the cell. FLAGELLUM not seen in any of the Malayan material examined, the cell being only slightly metabolic and moving by a sideways lashing movement or looping from end to end; eyespot crimson, prominent. (Pl. I figs. b, c, d).

MALAYA: Negeri Sembilan—ditches at Seremban and Port Dickson.

Malacca—ditches at Batu Berendam and elsewhere.

Singapore—ditches near the Royal Island Club golf course and Peirce reservoir.

Distribution worldwide.

LEPOCINCLIS Perty 1852

7. **Lepocinclis fusiformis** (Carter) Lemmermann (emend Conrad) [syn. *Euglena fusiformis* Carter, *Lepocinclis fusiformis* Lemmermann, *Lepocinclis sphagnophila* Lemmermann partem]. CELLS broadly fusiform, 50–60μ long $\times$ 25–30μ wide, slightly truncate at the anterior end, rounded acute at the posterior end. PERIPLAST with distinct striations spiralling backwards from left to right. CHROMATOPHORES numerous, discoid, parietal, each with a simple pyrenoid. PARAMYLUM in the form of two large rings lying just inside the pellicle. FLAGELLUM about 1½ times body length. EYESPOT crimson, anterior. (Pl. I fig. 1).

MALAYA: Singapore in a stagnant pool.

Worldwide in distribution.

PHACUS Dujardin 1841

8. **Phacus meson** Pochmann [syn. ? *Phacus pleuronectes* (O. F. Mueller) Dujardin after Dangeard, *Phacus longicauda* (Ehrenberg) Dujardin var. *brevicaudata* Skvortzow, *Phacus longicauda* var. *indica* Skvortzow]. CELL oval, 75–80μ long without tail

× 50μ wide, rounded at the anterior end and tapering posteriorly to a short, stout, straight, pointed tailpiece about 30μ long. PERIPLAST distinctly striated longitudinally CHROMATOPHORES numerous, discoid. PARAMYLUM two large rings. FLAGELLUM about body length. EYESPOT crimson, small. (Pl. I. fig. n).

MALAYA: Fish-ponds in Malacca.

Reported from various parts of S.E. Asia and possibly from Europe.

This form resembles *Phacus longicauda* (Ehrenberg) Dujardin in some respects, but differs in the much shorter, stouter, straight tailpiece and the more oval shape of the body of the cell.

TRACHELOMONAS Ehrenberg 1833 emend Déflandre 1926

9. **Trachelomonas allia** Drezepolski forma. This form differs from the type in being distinctly broader at the posterior end, tapering gently to the rounded anterior end. As there are intermediate forms there is no reason to separate the present one as a distinct variety. (Pl. I fig. q).

MALAYA: Fish-ponds in Malacca.

10. **Trachelomonas intermedia** Dangeard. CELL subspherical to elliptic, 18–20μ long × 15–17μ wide. LORICA golden brown, finely but distinctly punctate. PORUS with a ring of thickening. CHROMATOPHORES several, discoid. EYESPOT crimson, clearly visible. FLAGELLUM 1½–2 times body length. (Pl. 1 fig. j).

MALAYA: A ditch in Malacca.

Widespread throughout the world.

11. **Trachelomonas volvocinopsis** Swirenko [syn. *Trachelomonas indica* Skvortzow]. CELL spherical, 15μ in diameter. LORICA smooth, brown without thickening to the porus. CHROMATOPHORES 8–10, discoid, without pyrenoids. EYESPOT red. FLAGELLUM 2–3 times body length. (Pl. I fig. o).

MALAYA: Selangor—standing water at Kuala Lumpur.

Negri Sembilan—standing water at Port Dickson and Seremban.

Malacca—fish-ponds and ditches.

Johore—standing water at Muar.

Singapore—standing water near the reservoirs and the Royal Island Club golf course.

This species might be confused with *Trachelomonas volvocina* Ehrenberg, from which it differs by having more than two chromatophores and by completely lacking pyrenoids.

STROMBOMONAS Déflandre 1930

12. **Strombomonas verrucosa** (Daday) Déflandre var. *chinensis* (Skvortzow) Déflandre [syn. *Trachelomonas chinensis* Skvortzow and vars. *ovata* Skvortzow and *assuriensis* Skvortzow, *Trachelomonas conspersa* Pascher emend. Gordon]. CELL ovoid, 28–30μ long $\times$ 22–25μ wide, truncate at the anterior end with a very short wide neck, subconical at the posterior end. LORICA brown, thick and irregularly granular or verrucose on the surface. CHROMATOPHORES numerous discoid. EYE-SPOT crimson, clearly visible. FLAGELLUM about 1½ times body length. (Pl. I fig. p).

MALAYA: Fish-ponds in Malacca.

Described from China and Russia.

Peranemaceae

Cells metabolic or rigid, often crawling, but also free-swimming, usually bilaterally asymmetrical, and dorsiventrally organised. Flagella 1–2 or sometimes absent. Vacuolar system as in *Euglena,* but usually with two rod-shaped bodies, or a tubular siphon the former closely associated with the reservoir. Storage material paramylum granules and sometimes fat. The cells are complete without a stigma or chloroplasts, although occasionally partly digested chloroplast material may be seen inside the cell. Nutrition usually holozoic.

PERANEMA Dujardin 1841

13. **Peranema inflexum** Skuja. CELL cylindrical fusiform, 30–40μ long $\times$ 9–12μ wide, narrowed at the anterior end, bluntly rounded at the posterior end, the whole cell usually slightly bent or curved laterally. PERIPLAST with distinct striations spiralling backwards from left to right. RESERVOIR and canal about ¼ body length with an associated rod-shaped organ ("staborgan"). PARAMYLUM as small oval bodies scattered throughout the cell. FLAGELLUM about body length. (Pl. 1 fig. m).

MALAYA: A swamp in Kuala Lumpur.

Described from Northern Europe.

Rhizaspidaceae Skuja

A single genus **Rhizaspis** Skuja

RHIZASPIS Skuja 1948

Cells without flagella, elliptic to ovate, slightly narrowed at the anterior end, rounded to sub-cuneate at the posterior end, markedly flattened dorsiventrally, dorsal side convex, the ventral side concave to slightly convex and often with a slight furrow in it. Periplast smooth, colourless, firm except at the anterior end where fine pseudopodia arise. Siphon or accessory rod-shaped organs ("stab-organs") absent, but there are several vacuoles at the anterior end. The cytoplasm is colourless, with numerous spherical granules of paramylum and sometimes 1–2 large refractive bodies which are probably composed of leucosin.

This is a curious genus, very animal like in nature and nutrition. On the other hand it shows distinct affinities with the Euglenineae in the storage of paramylum, the colourless cytoplasm and the firm periplast.

14. **Rhizaspis granulata** Skuja. CELLS broadly elliptic to ovate, 60–65μ long $\times$ 40–45μ wide $\times$ 18–20μ thick; at the narrowed anterior end it is slightly protruded to form a rounded lip-like structure, from which fine pseudopodia arise, at the posterior end it is broadly cuneate; in side view the cell is curved with a truncate anterior end and cuneate posterior end, the ventral side concave with a broad shallow longitudinal furrow, the dorsal side convex. PERIPLAST colourless, smooth and quite firm. CYTOPLASM colourless, with several vacuoles at the anterior end, numerous PARAMYLUM granules at the posterior end, several food granules, and sometimes 1 large refractive granule of leucosin, although this is not always present. NUCLEUS large, subcentral. The cell moves by crawling over the substratum by means of the pseudopodia, with the cell body erect, or more usually held at an oblique angle. (Pl. II figs. c, d).

MALAYA: Experimental fish-ponds in Malacca.

Described from Northern Europe.

There is no doubt about the identity of the Malayan specimens. They agree with Skuja's description except in the number of leucosin granules, for here they are often absent.

15. **Rhizaspis simplex** Skuja. CELLS oval, 50–55μ long $\times$ 30–35μ wide $\times$ 20–22μ thick, rounded at the posterior end, narrowed to the truncate anterior end, from which fine pseudopodia arise, but without a lip-like protrusion; in side view the cell convex on the dorsal side, less so on the ventral side; sometimes

there are two low broadly rounded ridges on the dorsal side, and a shallow furrow on the ventral side, but these are not always very visible since the cell is a little metabolic and can swell out its outlines. PERIPLAST colourless, smooth, firm but elastic. CYTOPLASM colourless with several vacuoles at the anterior end and numerous spherical granules of PARAMYLUM at the posterior end, and often several food granules. Leucosin appears to be absent. NUCLEUS large, sub-central. The cell crawls along by means of the pseudopodia, keeping the body erect, but occasionally this latter will shorten and fatten slightly. (Pl. II figs. a, b).

MALAYA: Experimental fish-ponds in Malacca.

Described from Northern Europe.

The truncate anterior end places the Malayan forms under this species, but they are a little fatter than the forms described by Skuja, and the ridges and furrows are not always so easy to see.

CHLOROMONADINEAE

A class of flagellates with only a few forms known, and of which the affinities are very uncertain. No coccoid or filamentous forms have been recorded, all known forms being motile unicells, usually oval or pyriform in shape. The cell is often dorsiventrally flattened, with a ventral furrow. There are two flagella, one usually trailing, and they are attached near the aperture of a complex vacuolar system recalling that in the Euglenineae. In the pigmented forms there are numerous discoid chloroplasts, bright green in colour, but containing an excess of xanthophyll—they give a blue colour with concentrated hydrochloric acid, and in this respect the group resembles the Xanthophyceae. Neither starch nor paramylum occur, food reserves being fats and oils. In many forms radially disposed trichocysts are found in the peripheral regions, often more crowded at the anterior end, and these may be discharged on stimulus. Reproduction, as far as is known, is by longitudinal fission. This class forms a somewhat isolated group, but resembles the Euglenineae in the vacuolar system, but differs in the nature of the pigments and food reserves, in which respect it shows closer resemblance to the Xanthophyceae.

Two genera recorded from Malaya:—

1. Cells green, with trichocysts. Flagella apically attached *Gonyostomum.*

2. Cells green, with trichocysts. Flagella laterally attached *Merotrichia.*

GONYOSTOMUM Diesing 1866

Cells motile, dorsiventrally flattened, obovate, to spherical in front view, slightly metabolic, often narrowed posteriorly. Dorsal surface convex, ventral surface flattened, with a shallow furrow leading from the opening of the vacuolar system ("pharynx") and running longitudinally. Vacuolar system a triangular "pharynx"—like structure. Chromatophores numerous, discoid, green. Eyespot absent. Nucleus central. Trichocysts radial, abundant, more closely packed at the anterior end. Flagella two, one trailing but both attached at the mouth of the "pharynx". Oil and fat droplets occur as the food reserve.

16. **Gonyostomum depressum** Lemmermann [syn. *Vacuolaria depressa* Lauterborn]. CELL round in face view, 30–40μ in diameter, broad elliptic in side view, about 25–30μ thick. CHROMATOPHORES numerous, green, discoid, lining the periphery of the cell. VACUOLAR SYSTEM a small triangular "pharynx". TRICHOCYSTS numerous, peripheral, radial, but crowded at the anterior end. FLAGELLA two, distinctly unequal in length. Storage material oil and fat droplets. (Pl. II fig. o).

    MALAYA: Malacca—in acid swamps.

    Described from Europe.

    This species resembles *Gonyostomum latum* Iwanoff, but differs in the unequal flagella.

17. **Gonyostomun semen** Diesing [syn. *Rhaphidomonas semen* Ehrenberg]. CELL elongate-obovate, 40–70μ long $\times$ 22–40μ wide, rounded at the anterior end and narrowed to a subcuneate posterior end, very much flattened dorsiventrally, about 10–15μ thick, and with a broad ventral furrow. CHROMATOPHORES numerous, green, discoid, lining the periphery of the cell. VACUOLAR SYSTEM a prominent apical, triangular "pharynx". TRICHOCYSTS numerous, peripheral, radial, but very crowded at the anterior end. FLAGELLA two, nearly equal, but one trailing, both about body length. Storage material fat and oil. (Pl. II fig. g).

    MALAYA: Malacca—in acid swamps.

    Worldwide in distribution.

MEROTRICHIA Mereschkowski 1877

Cells ellipsoidal to bean shaped, sometimes slightly metabolic, rounded at the anterior end, occasionally slightly narrowed towards the posterior end. Vacuolar system a rounded "pharynx" like structure, laterally placed towards the anterior end. Chromatophores numerous, green discoid. Eyespot absent. Nucleus central.

Trichocysts scattered except at the anterior end, where they are crowded. Flagella two (one only described for *Merotrichia bacillata* Mereschkowski, but a second one is probably present), unequal, attached laterally at the mouth of the pharynx. Food reserves consists of oil and fat droplets. One species reported in Malaya.

18. **Metrotrichia capitata** Skuja. CELLS oval to bean-shaped, 30–40μ long $\times$ 22–25 μ wide, rounded at the anterior end and narrowed towards the posterior end, but sometimes slightly metabolic; just below the anterior end is a lateral cleft indicating a pharynx and the cell is often curved towards that side. CHROMATOPHORES numerous, green, discoid, lining the periphery of the cell, VACUOLAR SYSTEM a laterally placed "pharynx" with a groove leading into it. TRICHOCYSTS crowded at the anterior end, few and scattered elsewhere. FLAGELLA two, the swimming one about $\frac{3}{4}$ body length and pointing forward, the other longer 1–1$\frac{1}{2}$ body length, trailing. Storage material fat and oil. (Pl. II. fig. h).

MALAYA: Malacca—in acid swamps.

Described from Northern Europe.

CRYPTOPHYCEAE

Cells usually motile by means of two apical or lateral flagella, although a few coccoid forms have been placed in this group. The cells are dorsiventrally flattened, oval, slipper-shaped or reniform, and possess a longitudinal furrow. In many forms a gullet extends inwards from the anterior end of the furrow. Chromatophores usually 2, occasionally many, sometimes one or absent, the pigments varying from golden-brown, red, to distinctly blue. Pyrenoids occur, apparently not embedded in the chromatophores, and occasionally they may be absent. Storage products starch or allied carbohydrates, and sometimes oil as well. In some forms trichocysts may occur closely surrounding the gullet. Reproduction is usually by longitudinal division, although palmelloid stages may be formed first.

Three genera have been found in Malaya:—

1. Cells pigmented, slipper shaped, with two flagella which are attached slightly to one side of the apex *Cryptomonas.*
2. Cells as above but without chromatophores *Chilomonas.*
3. Cells pigmented, reniform, with the two flagella attached at the middle of the concave margin . . . . . *Sennia.*

CRYPTOMONAS Ehrenberg 1838

Cells slipper-shaped, dorsiventrally flattened, convex on the dorsal surface, flat or concave ventrally, with a broad longitudinal furrow from which a gullet extends inwardly from the anterior end. Flagella two, attached at the opening of the gullet. Chromatophores 1 or 2, lateral and parietal. Storage products starch grains. Trichocysts often visible round the gullet. There are 1–3 contractile vacuoles. Stigma apparently absent.

19. **Cryptomonas erosa.** Ehrenberg var. *reflexa* Marsson. CELLS slipper-shaped, 20–30μ long $\times$ 10–15μ wide, obliquely truncate at the anterior end, narrowed posteriorly to a blunt point which is turned to one side, so that the whole cell is slightly sigmoid. CHROMATOPHORES two, lateral, golden brown to yellowish green in colour. PYRENOIDS absent. STORAGE PRODUCTS oval to polygonal starch grains lining the inner sides of the chromatophores. FLAGELLA two, slightly unequal, the longer being a little more than body length, the other a little less, both inserted at the mouth of the gullet in the middle of the oblique anterior end. (Pl. II. figs. k, l, n).

MALAYA: Malacca—in experimental fish-ponds.

Worldwide in distribution.

This is very similar to *Cryptomonas marssonii* Skuja, which has been separated off for reasons which are not very obvious, in particular the more sharply truncate anterior end and the more depressed mouth of the gullet.

20. **Cryptomonas ovata** Ehrenberg. CELLS almost ellipsoidal, 45–50μ long $\times$ 18–25μ wide, slightly obliquely truncate at the anterior end, rounded at the posterior end, the whole cell curved slightly to one side. CHROMATOPHORES two, lateral, large, nearly filling the periphery of the cell but with the division between them quite clear, golden brown to yellowish green in colour, often appearing netted where the closely packed starch grains press against them. PYRENOIDS absent. STORAGE PRODUCTS starch grains, usually oval but appearing polygonal when tightly packed, lining the inner sides of the chromatophores. GULLET prominent, stretching 1/3–½ length of the cell, and surrounded by trichocysts. FLAGELLA two, nearly equal, a little less than body length. (Pl. II fig. m).

MALAYA: Malacca—in small experimental fish-pond.

Worldwide in distribution.

21. **Cryptomonas phaseolus** Skuja. CELLS small, elliptic, 12–15μ long $\times$ 8–9μ wide, rounded at both ends and only very slightly oblique at the anterior end. CHROMATOPHORES two, lateral, brownish in colour. PYRENOIDS absent. STORAGE PRODUCTS several comparatively large oval starch granules lining

the inner side of the chromatophores; occasionally 1–2 central, oval refractive bodies. GULLET about 1/3–½ body length, with the opening at one side of the apex. FLAGELLA two slightly unequal in length, a little shorter than body length. (Pl. II figs. i, j).

MALAYA: Malacca—in experimental fish-pond.

Described from Northern Europe.

Skuja describes his specimens as violet brown and thiophile. The Malacca specimens are more golden brown to reddish brown, but they may well be thiophile, since the pond in which they were found had a slight smell of hydrogen sulphide.

CHILOMONAS Ehrenberg 1838

Cells resembling *Cryptomonas* but completely devoid of chromatophores and pyrenoids. Cells more or less slipper-shaped, dorsiventrally flattened, the opening of the gullet somewhat sunken so that the surrounding margin has a lip-like appearance. One lateral margin is distinctly more convex than the other, which may be flattened. Trichocysts often surrounded the gullet, and storage products are comparatively large starch granules. Flagella two, unequal, attached at the mouth of the gullet.

Usually found in polluted water, often in abundance.

22. **Chilomonas paramecium** Ehrenberg. CELLS slipper-shaped. 25–30μ long $\times$ 10–15μ wide, rounded at the posterior end, lip-like at the anterior end, with a lateral kink indicating the sunken opening of the gullet; lateral margin adjacent to the gullet only slightly convex or even flattened, the other margin distinctly convex. CHROMATOPHORES absent. PYRENOIDS absent. GULLET prominent, about half the length of the cell, surrounded by trichocysts. STORAGE PRODUCTS large round starch granules. FLAGELLA two, unequal, the longer being about body length. (Pl. II fig. f).

MALAYA: Selangor—polluted water from the Gombak river, Kuala Lumpur.

Worldwide in distribution.

SENNIA Pascher 1913 emend. Skuja 1948

Cells bean-shaped, dorsiventrally flattened and one lateral margin decidedly convex, the other slightly concave with an equatorial groove running from it. Gullet in the middle of the concave side, not very prominent. Trichocysts apparently absent. 1–2 contractile vacuoles occur near the gullet. Chromatophores 1–2, golden yellow to olive-green in colour. Pyrenoids present or absent. Eyespot present or absent. Flagella two, unequal in length, laterally attached at the opening of the gullet.

23. **Sennia parvula** Skuja. CELLS small, bean-shaped, 10μ long $\times$ 5μ wide, very convex on one lateral margin, flattened or slightly concave on the other. CHROMATOPHORE one, curving round the convex margin, olive-green in colour. STIGMA absent in the Malayan specimens. PYRENOIDS absent. GULLET small, in the middle of the concave margin, without trichocysts but with a single small contractile vacuole. FLAGELLA two, divergent, unequal in length, the longer about body length. (Pl. II fig. e).

MALAYA: Malacca—in an experimental fish-pond.

Reported from Northern Europe, America and Africa.

The Malayan specimens differ from the type only in the absence of the stigma, a varying feature in this genus anyway.

CHRYSOPHYCEAE

The Chrysophyceae are characterised by possessing chromatophores which are golden-yellow to brown in colour, although in waters rich in organic matter they may assume a greenish tint. The main pigment giving the golden-yellow colour is *phycochrysin,* but modified chlorophylls and xanthophylls may also occur. Storage products consist of oil and whitish, highly refractive, usually round lumps, leucosin, often forming a prominent mass in the posterior portion of the cell. Leucosin appears to be a carbohydrate, although some doubt has been thrown on this, and it is readily soluble in most reagents and dots not react with iodine. Starch is never formed.

All Chrysophyceae appear to be uninucleate and may range from simple motile flagellate cells, and motile colonies to branched palmelloid forms or even a few filamentous species. A characteristic feature of the class is the formation endogenously of cysts, the walls of which are impregnated with silica.

The Chrysophyceae are frequently grouped together with the Xanthophyceae and Bacillariophyceae in the phylum Chrysophyta. In addition to the absence of chlorophyll b in all three classes, and the absence of starch, there are certain other structural similarities. In both the Xanthophyceae and Chrysophyceae endogenously formed cysts have been reported. These are frequently impregnated with silica, an obvious comparison with the Bacillariophyceae. The cell envelope of some Chrysophyceae (*Hyalobryon*) is laminated, recalling similar conditions in the Xanthophyceae (*Ophiocytium*) and even the intercalary bands in the Diatoms. Leucosin has been reported in certain Diatoms.

KEY TO THE ORDERS OF THE CHRYSOPHYCEAE

1. Cells normally motile and flagellate, sometimes amoeboid. Colonial forms motile ..... CHRYSOMONADALES.

2. Cells normally amoeboid, holozoic, flagellate stages rare or absent ..... [RHIZOCHRYSIDALES].

3. Cells in palmelloid colonies, often elaborately branched [CHRYSOCAPSIDALES].

4. Cells coccoid, flagellate stages rare or absent [CHRYSOPHAERALES].

5. Plants filamentous ..... [CHRYSOTRICHALES].

KEY TO THE CHRYSOMONADALES

1. Cells with 1 flagellum ..... CHROMULINEAE.

2. Cells with 2 equal flagella ..... ISOCHRYSIDEAE.

3. Cells with 2 unequal flagella ..... OCHROMONADEAE.

4. Cells with 3 flagella, one short and two long [PRYMNESEAE].

CHROMULINEAE

(i) Cells naked ..... (ii).

(i) Cells not naked, possessing a wall or envelope ..... (iii).

(ii) Cells only rarely amoeboid, usually flagellate .. *Chromulina*.

(ii) Cells markedly amoeboid, with prominent pseudopodia *Chrysamoeba*.

(iii) Cells with small lens-shaped siliceous scales embedded in the wall, without regular arrangement and devoid of spines (*Microglena*).

(iii) Cells with much larger siliceous scales, regularly arranged and frequently bearing long spines ..... *Mallomonas*.

(iii) Cells with siliceous material in complete transverse bands (*Conradiella*).

(iii) Cells enclosed in a stalked envelope ..... *Chrysopyxis*.

(iii) Cells in spherical colonies, set with long needles (*Chrysosphaerella*).

CHROMULINA Cienkowsky 1870

Cells naked, ovoid pyriform, elliptic or spherical unicells, often very metabolic and each bearing a single apical flagellum. Periplast of the cell often granular or set with small wart-like excrescences. Chromatophores 1–2, clearly differentiated, curved plate or rings, sometimes nearly filling the periphery of the cell, in most cases without pyrenoids. In many species there is a stigma. At the anterior end there are 1–2, sometimes more, contractile vacuoles. Storage products leucosin, often as a large single sphere at the posterior end of the cell, and oil droplets. The cysts are formed endogenously, with the wall impregnated with silica and are spherical with a symmetrically placed mouth, which may or may not bear a prominent neck.

24. **Chromulina sphaerica** Bachman. CELLS spherical, 12–15μ in diameter. PERIPLAST smooth, not granular nor with excrescences. CHROMATOPHORE a single larged curved plate lying against the periplast but varying in position, without a pyrenoid. STIGMA present, small crimson but conspicuous. FLAGELLUM 1–1½ body length. (Pl. V fig. g).

MALAYA: Malacca—in fish-ponds.

Described from Europe.

Bachman describes his species with the chromatophore in the middle, whereas here it lines the periphery. It is therefore possible that the Malayan forms should be regarded as a separate species, although it is difficult to decide how much importance should be given to the position of the chromatophore. In all other respects the Malayan forms agree with Bachman's description.

CHRYSAMOEBA Klebs. 1893

Cells motile with a single apical flagellum, often bearing fine pseudopodia whilst still flagellate, occasionally losing the flagellum. Chromatophores 1–2 curved plates or bands, central or parietal. Stigma present or absent. Pyrenoids present or absent. Cysts, where known, spherical with a centrally placed orifice. Leucosin granule often present as storage material.

25. **Chrysamoeba radians** Klebs. FLAGELLATE STAGE ovoid, 15–25μ long $\times$ 8–12μ wide, often narrowed at the posterior end. CHROMATOPHORE usually 1, bandshaped curving round the cell even in amoeboid stages, occasionally two, without PYRENOIDS. STIGMA absent. FLAGELLUM 1–1½ body length rarely shorter. CYST spherical, 20–22μ in diameter, with a short tapering neck. (Pl. V fig. i, j, k, l).

MALAYA: Malacca—in fish-ponds.

Worldwide in distribution.

The Malayan forms are larger than most records for this species, and the chromatophore is appreciably larger and curves just inside the periplast rather than being central. For this reason they might be regarded as a separate species. On the other hand they were collected from very fertile ponds in a region of high light intensity. It is possible that in less fertile waters and with lower light intensities the chromatophores may be smaller and contract to the middle of the cell.

MALLOMONAS Perty 1852

Cells solitary, motile by means of a single flagellum, ovoid, ellipsoid, cylindrical, spherical or pyriform in shape; periplast with numerous circular, discoid or angular silicified imbricating scales; scales usually regularly arranged, often in spirals, rarely truely irregular, often bearing long siliceous spines or setae which may be toothed, occasionally shorter ones or completely lacking; chromatophores golden-yellow, 2, lateral and parietal; contractile vacuoles present at the anterior end of the cell; eyespot often lacking; nucleus ellipsoid, often large and distinct; storage material leucosin, as large spherical granules at the posterior end.

26. **Mallomonas acaroides** Perty. CELLS ovoid to ellipsoid, 30–50μ long $\times$ 15–22 μ wide, rounded posteriorly and often slightly narrowed at the anterior end. SCALES oval to elliptic, arranged in spiral rows. SETAE long, somewhat curved, one to each scale so that the whole cell is covered by spines. CHROMATOPHORES 2, large, lateral and parietal, golden-yellow in colour. FLAGELLUM about body length. (Pl. III figs. e, f, l).

MALAYA: Malacca—in experimental fish-ponds.

Distribution worldwide.

This is a characteristic if somewhat variable species. The Malayan forms are larger than most of those recorded from elsewhere, but, not sufficiently so to warrant any separation as a variety.

27. **Mallomonas curta** (Playfair) Conrad. [syn. *Mallomonas litomesa* Stokes var. *curta*. Playfair]. CELLS elliptic 18–30μ long $\times$ 11–15μ wide, with a very short broad papillum at the anterior end, rounded at the posterior end. SCALES circular, arranged in shallow spirals. SETAE six only, about $\frac{3}{4}$ body length, attached at the papillum and curving backwards. FLAGELLUM about body length. STIGMA small, crimson but often lacking. (Pl. III figs. g, i).

MALAYA: Malacca—in swamp.

Described from Australia and reported from Europe.

28. **Mallomonas playfairii** Conrad var. **opisthiodonta** Prowse. **var. nov.** CELLS ellipsoid, 19–20μ × 14–15μ wide, broadly rounded at both ends, but terminating anteriorly in a very short neck. SCALES rhombic, spirally arranged at an angle 45°, without spines except in the four rearmost scales, which each bear a single short spine. CHROMATOPHORES two, large, parietal. FLAGELLUM nearly body length. (Pl. III fig. j).

MALAYA: Malacca—fish-ponds. (Type locality).

HOLOTYPE: Prowse 398 deposited at Tropical Fish Culture Research Institute, Malacca.

Cellulae ellipsoideae, 19–20μ longae, 14–15μ latae, utrinque late-rotundatae, unaquaeque antice in collum brevissimum terminata. *Squamae* rhombicae, ad angulum 45° spiraliter disposatae, spiris longissimis carentes, sed quattuor squamae postremae tantum brevissime unispinosae. *Flagellum* corpori paene aequilongum aequilongum. *Chromatophora* duo, magna, parietalia.

MALAYA: Malacca—in stagnis piscosis. (Holotypus).

29. **Mallomonas spherica** Prowse **sp. nov.** CELLS spherical, 8–9μ in diameter. SCALES elliptic, arranged spirally at a slight angle, only the anterior-most scales being spiny; SETAE 9–10 in all, 2–2½ times longer than the body, strongly reflexed. CHROMATOPHORES 2, discoid, parietal. FLAGELLUM nearly as long as the body. (Pl. III fig. m).

MALAYA: Malacca—in fish-ponds. (Type locality).

HOLOTYPE: Prowse 395 deposited at Tropical Fish Culture Research Institute, Malacca.

Cellulae sphericae, 8–9μ in diam. *Squamae* ellipticae, ad angulum paululum spiraliter dispositae, eae antice sitae tantum spinasae; spinis 9–10, quam corpus 2–2½-plo longioribus, valide reflexis. *Flagellum* corpori paene aequilongum. Chromatophora duo, discoidea, parietalia.

MALAYA: Malacca—in stagnis piscosis. (Holotypus).

30. **Mallomonas splendens** (G. S. West) Playfair [syn. *Lagerheimia splendens* G. S. West]. CELLS cylindrical, 30–50μ long × 15–17μ wide, slightly narrowed at each end to the rounded poles. SCALES nearly rhombic, finely punctate and spirally arranged. SETAE confined to the poles, 4 at each end, about ¾ body length, divergent. CHROMATOPHORE one, large, lining one side. FLAGELLUM about ½ body length. (Pl. III fig. c).

MALAYA: Selangor—acid swamp in Kuala Lumpur.

Negri Sembilan—acid swamps at Port Dickson and Seremban.

Malacca—acid swamps in various areas.

Singapore—swampy pools near the Royal Island Club golf course and Peirce reservoir.

Worldwide in distribution, including Indonesia.

A very characteristic species.

31. **Mallomonas teilingioides** Prowse **sp. nov.** CELLS elongate-elliptic, 50–55μ long, 18–20μ wide, equally rounded at both ends, or slightly narrower at the anterior end. SCALES distinctly quadrate, spirally arranged, only the ones near the poles bearing setae, the others apparently smooth 5–9 in the largest spirals (median ones). SETAE slender, simple, 15–20 at each end of the cell, 30–32μ long. CHROMATOPHORES two, large, parietal, golden yellow. STIGMA prominent, crimson, at the anterior end. FLAGELLUM ½ body length. LEUCOSIN a large single grain at the posterior end. (Pl. III figs. d, k).

Superficially resembling *Mallomonas teilingii* (Teiling) Conrad, from which it differs in scales being quadrate (not discoid) and in having slightly more numerous setae.

MALAYA: Malacca—in fish-ponds. (Type locality).

HOLOTYPE: Prowse 414a deposited at Tropical Fish Culture Research Institute, Malacca.

Superficialiter *Mallomonas teilingii* (Teiling) Conrad similis, a qua squamis quadratis, non discoideis, et setis paulo numerosioribus differt.

Cellulae elongato-ellipticae, 50–55μ longae, 18–20μ latae, utrinque pariter rotundatae vel apice anteriori angustiusculae. *Squamae* conspicue quadratae, spiraliter dispositae, apicales tantum setosae, alterae apparenter leves, in singulis spiris maximis 5–9. *Setae* graciles simplices, utraque cellulae apice 15–20 sitae, 30–32μ longae. Flagellum longitudine semi-cellulare. Chromatophora dua, magna, parietalia, fulva; ocellum prominens, coccineum, prope apicem anteriorem situm. Leucosin unigranulare, magnum ad extremitatem posteriorem situm.

MALAYA: Malacca—in fossis piscicolis. (Holotypus).

Philipose (1953) has described a species which shows some resemblances to the present one, but he was not able to determine the exact nature of the scales. He suggests that they were discoid and circular, and this fact and his report of fewer setae at the anterior end, suggests that he was dealing with a different species.

32. **Mallomonas tonsurata** Teiling var. **alpina** (Pascher) Krieger. [syn. *Mallomonas alpina* Pascher, *Mallomonas tonsurata* var. *megalepis* Schiller]. CELLS small, ovoid, 15–20μ long $\times$ 10–12μ wide, rounded at the posterior end, narrowing at the anterior end. SCALES small, elliptic, with a V-shaped mark on the

base of each, and arranged in very shallow spirals. SETAE confined to the anterior end, usually in three rows of six, comparatively stout, toothed, longer than body length. CHROMATOPHORES 2, lateral and parietal, golden-yellow. STIGMA small, crimson, situated at the anterior end. FLAGELLUM about body length. (Pl. III figs. a, b).

MALAYA: Malacca—in fish-ponds.

Described from Europe, but reported also from Java.

This variety differs from the type mainly in its smaller size and the toothed setae.

33. **Mallomonas tonsurata** Teiling var. **dorsidentata** Prowse **var. nov.** Cells elongate-ovoid, 23–25μ long $\times$ 8–9μ wide, slightly narrowed at the anterior end. SCALES small, elliptic, arranged at a slightly acute angle, the rearmost scales very shortly unidentate. SETAE very long, 20–30 in number, confined to the anterior half of the cell, the apical ones 15μ long, shorter than the infra-apical ones which are 20μ long. CHROMATOPHORES two large, discoid, parietal. FLAGELLUM nearly body length. (Pl. III fig. h).

MALAYA: Malacca—in fish-ponds. (Type locality).

HOLOTYPE: Prowse 406 deposited at Tropical Fish Culture Research Institute, Malacca.

Cellulae elongato-ovoideae, apice antico paulo angustiores, 23–25μ longae, 8–9μ latae. *Squamae* parvae, ellipticae, ad angulum acutiusculum dispositae; squamae postremae brevissime unidentatae. *Setae* longissimae in dimidia cellulae antica circumscriptae, 20–30, eae apicales 15μ longae breviores quam infra-apicales 20μ longae. *Flagellum* corpori fere aequilongum. *Chromatophora* duo, magna, discoidea, parietalia.

MALAYA: Malacca—in stagnis piscosis. (Holotypus).

CHRYSOPYXIS Stein 1878

Cells each enclosed in a cellulose envelope which is flask-shaped in face view, with a slender thread like attachment extension at the base; in side view the base is saddle-shaped, sitting on an algal filament, with a thread like attachment extension each side, which may completely surround the filament from one side to the other. Chromatophores one or two, golden yellow, usually parietal. Flagellum one, but often replaced by a slender protoplasmic extension (rhizopodium) which may or may not be slightly branched, in both cases protruding from the orifice of the envelope. Contractile vacuoles occur, apical when a flagellum is present, apparently basal when a rhizopodium is present; in the latter case it seems likely that the cell has inverted within the envelope, so that the rhizopodium arises from the morphologically posterior end of the cell.

34. **Chrysopyxis sp.** ENVELOPE flask-shaped, 10–12μ high $\times$ 6–8μ wide, sharply drawn out basally to a fine peduncle, apically tapering to a narrow neck. CELL round, three quarters filling the envelope. CHROMATOPHORES two, parietal, or possibly one, divided deeply into two lobes. 'FLAGELLUM' long, twice body length, probably rhizopodial in nature since it does not arise from the anterior end of the cell, but sometimes from the side and sometimes from the morphological posterior end, the cell lying at all angles in the envelope and may even be inverted. CONTRACTILE VACUOLES variable in position. (Pl. IV fig. e).

MALAYA: Malacca—in fish-ponds.

This shows very great resemblances to *Chrysopyxis iwanoffi* Lauterborn, but differs in that the rhizopodium is unbranched and closely resembles a flagellum.

35. **Chrysopyxis sp.** ENVELOPE ovoid, 18–20μ long $\times$ 8–10μ wide, narrowing apically to a widish neck, tapering basally to a short peduncle. CELL round, two thirds filling the envelope, slightly flattened anteriorly. CHROMATOPHERE one, large, parietal, curving transversely round the cell. FLAGELLUM one, arising from the anterior end of the cell, 1½ body length. CONTRACTILE VACUOLES two, apical. (Pl. IV fig. f).

MALAYA: Malacca—in fish-ponds.

This species resembles *Chrysopyxis urna* Korshikov in the envelope, but differs in retaining the flagellum and in the apical contractile vacuoles.

ISOCHRYSIDEAE

2 equal flagella

1. Cells apparently naked, long stalked, epiphytic (*Stylochrysallis*).

2. Cells within an envelope . . . . . ii.

ii. Envelope with a prominent orifice, no siliceous scales . . . . iii.

ii. Envelope with siliceous scales, completely surrounding the protoplast . . . . . v.

iii. Envelope long stalked . . . . . (*Stylotheca*).

iii. Envelope very shortly stalked or sessile . . . . . (*Derepyxis*).

iv. Cells in pairs, never more, with broad bases attached to each other . . . . . *Chrysodidymus*.

iv. Cells in spherical colonies, attached bases tapering . . *Synura*.

iv. Cells in bands usually of two rows, basal attachments broad (*Catenochrysis*) = (*Chlorodesmus*).

CHRYSODIDYMUS Prowse gen. nov.

Somewhat similar to *Synura,* this genus is readily distinguished by its colonies being always of two cells, wider posteriorly. The motion is forward and backwards in a straight line, occasionally making a turn of 180° and moving on as before, never effecting its movement as in *Synura* by rolling in complete revolutions. *Cells* trapezoidal in shape, united directly and firmly at the posterior ends to form bicellular colonies, the anterior end free and narrower than the posterior ones. *Involucre* similar to that in *Synura,* with siliceous, shortly spinose scales. *Flagella* two to each cell, apical, apparently equal in length, in motion one pointing forward, the other trailing behind. *Chromatophores* two, large, discoid and parietal.

Synurae aliquatenus simile sed coloniis nunquam non bicellularibus, protinus vel retrorsum recte progredientibus interdum per 180° vertentibus et dein ut supra moventibus, nunquam ut in *Synura* per gyrationes vel circumvolutiones proficientibus, cellulis postice lateoribus hoc genus facile distinguendum.

Cellulae ambitu trapezoideae, apicibus posticis extemplo firmiterque in colonias bicellulares unitae; apicibus anticibus liberis quam postices angustioribus; involucrum eo *Synurae* simile, squamis siliceis, spinulosis praeditum. *Flagella* per cellulam singulam bina, apicalia, simulate aequilonga, in motu unum porrectum, alterum a tergo trahens. *Chromatophora* bina, magna, discoidea, parietalia. Species holotypica: *Chrysodidymus synuroideus* Prowse.

36. **Chrysodidymus synuroideus** Prowse **sp. nov.** CELLS 14–15μ long, posterior end 10–11μ wide, anterior end 7–8μ wide, trapezoid in shape. CHROMATOPHORES, two large, parietal golden yellow. FLAGELLA body length or slightly longer, apparently equal in length. (Pl. IV fig. n.).

MALAYA: Malacca—in acid swamps. (Type locality).

HOLOTYPE: Prowse 248a deposited at Tropical Fish Culture Research Institute, Malacca.

Cellulae ambitu trapezoideae, 14–15μ longae, apicibus posterioribus 10–11μ latis, apicibus anterioribus 7–8μ latis. Chromatophora dua, magna, parietalia, fulva. *Flagella* corpori aequilonga vel paululo longiora, inter se aequilonga ut videtur.

MALAYA: Malacca—in locis paludosis acidis (Holotypus).

37. **Chrysodidymus gracilis** Prowse **sp. nov.** CELLS longer and narrower than those in the preceding species 22–24μ long, posterior end 8.5–9μ wide, anterior end 6–6.5 μwide. FLAGELLA nearly body length. (Pl. IV fig. m).

MALAYA: Malacca—in acid swamps.

HOLOTYPE: Prowse 248b deposited at Tropical Fish Culture Research Institute, Malacca.

Cellulae eis prioris speciei longiores angustioresque, 22–24μ longae, apicibus posterioribus 8.5–9μ latis, apicibus anterioribus 6–6.5μ latis. *Flagella* corpori fere aequilonga.

MALAYA: Malacca in locis paludosis acidis. (Holotypus).

SYNURA Ehrenberg 1838

Cells ovoid, pyriform or clavate, united in spherical to sausage-shaped colonies, with the cells attached to each other by the attenuated posterior ends, even in two-celled colonies, thus differing markedly from *Chrysodidymus* and *Catenochrysis*. Cell membrane bearing siliceous scales which are frequently shortly spinose, one spine to each scale. Chromatophores two, large, parietal, golden yellow in colour. Flagella two to each cell, apparently equal in length, but one projects forwards, the other trailing sideways; the forward projecting flagellum is of the "tinsel" type, with a row of very short cilia, the trailing flagellum being smooth. The colony moves by rolling over and over, revolving through 360° continuously in one direction.

38. **Synura uvella** Ehrenberg. CELLS elongate-ovoid to pyriform, 20–25μ long $\times$ 12–15μ wide, broadly rounded at the anterior end, narrowing markedly at the posterior end, often to a thread-like attachment organ. CHROMATOPHORES two, large, parietal, golden yellow. FLAGELLA two, apical, apparently equal, more than body length. COLONIES of few to many cells, spherical to sausage shaped. (Pl. IV figs. d, k, l).

MALAYA: Selangor—in acid swamps near Kuala Lumpur.

Negri Sembilan—in various acid swamps.

Malacca—in acid swamps.

Singapore—in acid swamps near the Royal Island Club golf course.

Probably to be found in all parts of Malaya.

Worldwide in distribution.

OCHROMONADEAE

2 unequal flagella

(i) Cells without cellulose envelopes, naked ..... ii.

(i) Cells with cellulose envelopes ..... iii.

(ii) Cells solitary ..... *Ochromonas.*

(ii) Cells colonial, usually in spherical colonies .... (*Uroglena, Volvochrysis, Synochromonas, Synuropsis*).

(iii) Cells in dendroid colonies, or epiphytic and solitary. Protoplasts stalked inside envelope ..... iv.

(iii) Cells solitary. Protoplasts not stalked inside envelope (*Pseudokephyrion, Kephyriopsis, Bitricha, Styloceras*).

(iv) Envelope markedly laminate, with ends of lamina projecting *Hyalobryon.*

(iv) Envelope not laminate or if lamina present visible with difficulty and not projecting ..... *Dinobryon.*

OCHROMONAS Wyssotzki 1887

Cells usually solitary, naked, free swimming or occasionally attached by a posterior threadlike extension. Shape very variable, occasionally amoeboid. Periplast usually fine and smooth, rarely thick and verrucose. Chromatophores 1–2, golden-yellow, often very much reduced. Flagella two, unequal, the longer one pointing forwards in swimming, the shorter trailing sideways. Palmelloid stages often found.

39. **Ochromonas hinterzartensis** Doflein. CELL elongated ovoid, 14–15μ long $\times$ 7–8 μ wide, rounded at the posterior end, slightly narrower anteriorly. PERIPLAST beset with peripheral granules, but not verrucose. CHROMATOPHORE single, band-shaped, curving round lower half of cell, golden yellow in colour. STIGMA absent. FLAGELLA two, unequal, the longer body length, the shorter about 1/3 body length. LEUCOSIN as four large oval granules. (Pl. V fig. h).

MALAYA: Malacca—in fish-ponds.

Described from Northern Europe.

This Malayan form seems to fit best into this species, especially with its peripheral granules and several large leucosin granules. The shorter flagellum is a little longer than that in the holotype as described from Germany, but it is difficult to be accurate in estimates of the lengths of flagella.

DINOBRYON Ehrenberg 1835

(includes **Epipyxis** (Ehrenberg) Lauterborn and **Dinobryopsis** Lemmermann).

Cells free-floating, sessile or epiphytic, solitary or in colonies, each cell enclosed in a conical, campanulate or cylindric cellulose envelope, which is open at the top, pointed at the base, and may have smooth or undulate sides, colonies dendroid, divergent or compact. Protoplast oval to fusiform, attached to the base or side of the envelope by a stalk. Chromatophores 1–2, elongate, parietal, golden yellow in colour. Eyespot crimson, apical. Spherical siliceous cysts are quite common in some species.

40. **Dinobryon bavaricum** Imhof. [syn. *Dinobryon stipitatum* Stein, *D. stipitatum* var. *bavaricum* (Imhof) Zacharias, *D. stipitatum* var. *undulatum* Lemmermann, *D. stipitatum* subspec. *eustipitatum* Pascher, *D. stipitatum* subspec. *bavaricum* Pascher, *D. stipitatum* var. *affine* (Lemmermann) Pascher, *Dinobryon elongatum* Imhof, *D. elongatum* var. *undulatum* Lemmermann, *D. elongatum* var. *affine* Lemmermann, *Dinobryon bavaricum* Imhor. var. *affine* Lemmermann, *Dinobryon sociale* Ehrenberg var. *bavaricum* (Imhof.) Bachman, *Dinobryon cylindricum* Imhof var. *ceylonicum* Lemmermann]. CELLS in rather narrow dendroid colonies. ENVELOPE (*lorica*) 40–60μ long $\times$ 8–10μ wide, cylindric in the upper part with undulate walls, and drawn out to a long pointed conical basal region. CHROMATOPHORES two, parietal, golden yellow. FLAGELLA two, very unequal, the longer 1½ length of cell protoplast. (Pl. IV fig. a).

MALAYA: Malacca—in unlimed experimental fish-ponds and acid swamps.

Distribution generally in colder waters in various parts of the world.

The occurrence of this very striking species in fish ponds is surprising, since it has generally been regarded as a cold-water form. Even in India it has only been reported from high mountain waters, whereas in Malacca it was quite frequent in unlimed fish-ponds with temperatures up to 31° C. It is probable that temperature is not a determining factor for its occurrence, and some chemical factor is of greater importance, particularly pH.

41. **Dinobryon sertularia** Ehrenberg [syn. *Dinobryon thyrsoideum* Chodat, *Dinobryon sertularia* var. *thyrsoideum* (Chodat) Lemmermann]. COLONIES dendroid, often large and thick and rather bushy. ENVELOPE 25–30μ long $\times$ 8–10μ wide, cylindric to slightly campanulate, swollen in the central portion, flaring at the mouth, and tapering to a short bluntly pointed basal portion. CHROMATOPHORES two, parietal, golden yellow. FLAGELLA two, unequal, the longer about body length. CYSTS quite common, spherical, with a curved apical neck to the pore, the whole enclosed in a gelatinous envelope at the mouth of the lorica. (Pl. IV figs. b, c).

MALAYA: Penang—acid swamps.
Perak—acid swamps near Ipoh.
Pahang—acid swamps near Kuantan.
Negri Sembilan—acid swamps near Seremban and Port Dickson.
Malacca—acid fish-ponds and acid swamps.
Johore—acid swamps near Muar and Yong Peng.
Singapore—acid swamps near the Royal Island Club golf course.

Worldwide in distribution.

42. **Dinobryon inflatum** Lemmermann. CELLS solitary, epiphytic. ENVELOPE broadly oval, 30–35μ long $\times$ 15–20μ wide, tapering to a short stalk basally and narrowing to a short but distinct cylindrical neck apically. PROTOPLAST round to fusiform, attached near the base of the envelope by a fine stalk. CHROMATOPHORE one, apparently near the base, golden yellow in colour. FLAGELLA two, unequal, the longer the length of the protoplast, the other about ¼ this length. (Pl. IV fig. g).

MALAYA: Malacca—in acid swamp epiphytic on *Mougeotia.*

Originally described from Northern Europe.

I have tentatively placed the Malayan material under this species, by virtue of the general shape of the envelope and the distinct neck apically, but details of the original description are somewhat lacking.

HYALOBRYON Lauterborn 1896

Cells epiphytic, usually solitary but occasionally forming dendroid colonies, each cell in a cellulose envelope which is distinctly laminate, formed of overlapping thimble-like segments. Envelope (*lorica*) usually cylindric, sometimes narrower towards the anterior end, occasionally spreading at the mouth, tapering at the posterior end to the attachment point or even a stalk. Protoplast oval to spindle-shaped with usually 2 unequal chromatophores, sometimes apparently only one; chromatophores golden yellow in colour. Flagella two, unequal. Cysts where known ellipsoid with a distinct porus and plug.

43. **Hyalobryon lauterbornii** Lemmermann. CELLS solitary, epiphytic. ENVELOPE cylindric, 35–40μ long $\times$ 8–10μ wide, tapering to a pointed conical base, hardly flaring at the mouth; laminations of the wall close together, starting from the base and hardly projecting, most easily seen in empty envelopes. PROTOPLAST ovoid, stalked, attached near base of the envelope. CHROMATOPHORE apparently one, golden yellow in colour. FLAGELLA two, unequal, the longer about body length, the shorter ¼–1/3 as long. (Pl. IV figs. h, i & j).

MALAYA: Malacca—in experimental fish-ponds, epiphytic on filamentous algae.

Worldwide in distribution. This is the commonest of the species and is very variable.

The Colourless Flagellata

This is a heterogenous assemblage of genera and species with divers affinities, which in many cases are somewhat obscure. They all have in common the complete absence of a chromatophore

and the method of nutrition may range from saprobic to completely holozoic, some forms displaying distinctly animal-like tendencies. The colourless Euglenineae, Volvocales and Dinoflagellata, all of which show well marked affinities to pigmented forms, are excluded from the account.

There are numerous ways of classifying the colourless flagellates, but since the number to be described below is small, the simplest way is to separate them on the basis of flagellation.

KEY TO THE COLOURLESS FLAGELLATA

(i) Cells with flagella attached apically ..... ii.

(i) Cells with flagella attached to each lateral margin ..... v.

(ii) Cells with a single flagellum ..... iii.

(ii) Cells with two unequal flagella ..... iv.

(iii) Cells in stalked campanulate envelopes (lorica) arranged in a dendroid fashion ..... *Poteriodendron.*

(iii) Cells arranged in a granular gelatinous sheaths *Phalansterium.*

(iii) Cells with a flaring collar and enclosed in a thin lorica, usually solitary ..... *Salpingoeca.*

(iv) Cells naked, colonial, at end of granular stalk .. *Anthophysa.*

(v) One flagellum at each margin ..... *Turbomonas.*

(v) Four flagella at each margin, two long and two short *Trepomonas.*

POTERIODENDRON Stein 1878

Cells enclosed in campanulate, stalked cellulose lorica which are arranged in a dendroid fashion, with each lorica attached by means of its stalk to the inside of the lorica below. The protoplasts are usually single in a lorica, uniflagellate, the flagellum attached slightly subapically with a prominent lip on one side of the apex; this lip is retractile and can be withdrawn. A contractile vacuole is present in the basal part of the protoplast. One species is known.

44. **Poteriodendron petiolatum** Stein. LORICA campanulate, 20–25μ long $\times$ 8–10μ wide, slightly widened at the mouth, with thickened walls basally and with an internal basal knob, each lorica attached inside a lower one by a thin stalk 15–30μ long, the lowest lorica with a long stalk 60–70μ long, with a slight basal holdfast. PROTOPLAST one in each lorica attached by

a short stalk to the base, ovoid, 8–10μ long $\times$ 4–5μ wide, with a distinct apical lip which can be retracted. FLAGELLUM single, apical, slightly longer than body length. (Pl. V. fig. a).

MALAYA: Malacca—in a ditch both attached and as free-swimming colonies.

Distribution world-wide.

PHALANSTERIUM Lienkowski 1865

Cells enclosed in a granular gelatinous mass, impregnated with iron; the mass may be spherical (*P. consociatum* (Fresenius) Cienkowski) with the cells peripheral, or dendroid (*P. digitatum* Stein) with the cells at the ends of the branches. Each cell is uniflagellate with the long flagellum protruding through the surface of the gelatinous mass, and the individual protoplasts each have a long narrow apical collar. One or two contractile occur at the posterior end.

45. **Phallansterium digitatum** Stein. SHEATH dendroid, with rounded very slightly concave ends, apparently hollow in the greater part, terminal branches about 10μ wide. CELL ovoid, 6–8μ long $\times$ 3–4μ wide, with a long apical colour, not easily visible and through which the flagellum protrudes; cell often appearing slightly beaked sub-apically on living material. FLAGELLUM single, 10μ or more long, protruding through the ends of the gelationous sheath. (Pl. V fig. f).

MALAYA: Malacca—in acid swamps.

Worldwide in distribution.

The Malayan material shows a number of differences from the type description, being somewhat smaller. The narrow apical collars are often difficult to see in the Malayan material, and the cells often show a slightly beaked appearance not mentioned in the original. This beaked appearance may be due to contraction of the cell longitudinally, as often happens with cells under coverslips under conditions of decreased aeration. The whole organism, despite its smaller size, so closely resembles *Phalansterium digitatum* Stein that it seems logical to include it under that species, at least until further investigation proves otherwise.

SALPINGOECA J. Clark 1867

Cells enclosed in a thin envelope or lorica, which is usually constricted at the neck or mouth, and is basally attached, either sessile or stalked. The protoplast may occupy part or nearly all of the lorica, being attached to it by a thin stalk which may be long to extremely short. A characteristic feature of the protoplast is the slightly flaring funnel-like collar just below the apex and protruding beyond the mouth of the lorica. There is a single apical flagellum, and a single contractile vacuole.

46. **Salpingoeca frequentissima** (Zacharias) Lemmermann [syn. *Diplosiga frequentissima* Zacharias, *Diplosigopsis frequentissima* (Zacharias) Lemmermann]. LORICA very thin, vase shaped, 10μ long $\times$ 5 wide, constricted at the neck and widely flaring at the mouth, sharply pointed to very shortly stalked at the base. Protoplast nearly filling the lorica, with a flaring collar 3–5μ long $\times$ 3–5μ wide projecting beyond the mouth of the lorica. FLAGELLUM single, apical, about body length or slightly longer. CONTRACTILE vacuole single, nearly central. (Pl. V. fig. b).

MALAYA: Malacca—in a fish pond, attached to *Mougeotia* and to phytoplankton.

Worldwide in distribution.

This is very common on planktonic diatoms in temperate waters, but in Malaya is more frequent on filamentous algae, where it can be very abundant indeed.

STOMATOCHONE Pascher 1942

Cells single, epiphytic on other algae, attached by a short stalk, and obliquely truncate; deeply incurved at the apex so as to form a rim or lip. Flagella two, distinctly unequal in length. There is a single basal contractile vacuole.

There are reasons for thinking that these are colourless members of the Chrysophyceae (Bourelly 1957), but in the absence of a cyst such an affinity still remains uncertain. The organisms are often as dense clusters on planktonic algae.

47. **Stomatochone infundibuliformis** Pascher. CELLS single, small, 5–7μ long $\times$ 4–5μ wide, with an obliquely truncated apex, rounding posteriorly and then narrowing to a very short stalk by which it is attached. FLAGELLA two, very unequal, the longer 1½ body length, the shorter about ¼ body length, both arising from a prominent apical depression. CONTRACTILE vacuole basal, NUCLEUS median. (Pl. V fig. d).

MALAYA: Malacca—in an acid experimental fish-pond, and in acid swamps, abundant as an epiphyte on *Pleurotaenium kayei.*

Worldwide in distribution.

The Malayan specimens seem much smaller than the size usually given for this species, but it is doubtful if such size differences are of real taxonomic significance.

ANTHOPHYSA Bory de St. Vincent 1822

Cells colonial, forming dense clumps at the ends of a prominent branched, brownish, somewhat granular, rigid gelatinous stalk. Individual cells roughly conical, with two unequal apical flagella. Stigma present or absent.

48. **Anthophysa vegetans** (O. F. Mueller) Stein. [syn. *Volvox vegetans* O. F. Mueller]. CELLS conical, 10–12μ long $\times$ 5–6 wide, obliquely truncate at the anterior end with a slight central depression, tapering posteriorly to a blunt, narrow, attachment end. FLAGELLA two, apical, unequal, the longer 1½ body length, the shorter ¼ to ½ body length. STIGMA absent in the Malayan material. CONTRACTILE VACUOLE sub-apical. STALK variable in length, rigid, gelatinous, thickly impregnated with iron, sparsely branched. (Pl. V. fig. e).

MALAYA: Malacca—in experimental fish-ponds, often attaehed to decaying debris.

Worldwide in distribution.

TURBOMONAS Prowse **gen. nov.**

Cells small, hyaline, flattened, obovate or sub-cordate, spirally twisted lengthwise. Flagella two, each attached midway on each lateral margin. Motion forward, swiftly gyrational in nature, the flagella whirling at right-angles to the longitudinal axis. Nucleus one, central.

Cellulae parvae, hyalinae, applanatae, obovatae vel subcordatae, longitudinaliter obtortae. *Flagella* bina, unumquodque in margine utriusque lateris medio insertum. *Motus* cellulae porro ex natura gyrationis, flagellis ad axin longitudinalem per angulum rectum gyrantibus effectus. Nuclea uno, centrali.

Species holotypica: T. *gyrans* Prowse.

49. **Turbomonas gyrans** Prowse **sp. nov.** CELLS 12–13μ long, 7–9μ wide, 3–3.5μ thick, narrowed at the anterior end, wider and almost flattened posteriorly, twisted lengthwise through 90°, propelled forward both by the gyrations of the body and the whirling of the flagella. EYESPOT absent. FLAGELLA nearly as long as the body, pointing in opposite directions. CYTOPLASM hyaline, with a few refractive granules. (Pl. V fig. c).

MALAYA: Selangor—Sg. Gombak, Kuala Lumpur Holotype Prowse 388).

And occurring elsewhere in water containing putrid material.

Holotype is deposited at Tropical Fish Culture Research Institute, Malacca.

Cellulae 12–13μ longae, 7–9μ latae, 3–3.5 μ crassae, antice angustatae, postice latiores et fere applanatae, per 90° longitudinaliter obtortae, gyrationibus corporis flagello-rumque conjunctim propulsae; ocellis nullis. *Flagella* corpori paene aequilonga, opposite directa. *Cytoplasma* hyalinum, cum paucis granulis refractivis.

MALAYA: Selangor, Sg. Gombak, Kuala Lumpur (Holotypus).

In regionibus diversis: in aqua cum materiis putridis inquinata.

This organism is reminiscent of the Distomataceae in the way it rotates with the flagella whirling out at right angles, but it differs in having a single central nucleus. Staining with Gentian Violet suggests that although the flagella appear to be lateral in attachment, they are actually apical in origin, having fused with the margin of the cell until midway. This species should be compared with the next species, *Trepomonas rotans,* in which there are two lateral nuclei and the flagella are truly laterally attached.

TREPOMONAS Dujardin 1841

Cells mainly broadly oval, flattened in cross-section, slightly twisted, with two posterior lobe-like inflations. Nuclei two, one near each margin. Flagella two long and two short on each margin, opposite the nuclei, near the anterior end of each lobe. Cells swim by sweeping the flagella at right angles to the long axis, the body rotating and moving forward, all with a rather deliberate motion.

50. **Trepomonas rotans** *Klebs.* CELLS broadly oval, 18–20μ long $\times$ 11–12μ wide, rounded at the anterior end, the main body of the cell narrowing to the posterior end, but the lobes widening posteriorly and projecting slightly beyond the end of the main body, so that the posterior end of the cell is truncate and slightly concave. FLAGELLA 2 long, more than body length, 2 short about 1/3 body length, on each margin opposite each nucleus which is about 1/3 from the anterior end. VACUOLES fairly large and numerous. (Pl. V. fig. m).

MALAYA: Johore—stagnant water from Kota Tinggi.

Worldwide in distribution.

The slower deliberate rotating of the cell is very different from the fast whirling of *Turbomonas gyrans.*

I am grateful to the Colonial Office and the Tropical Fish culture Research Institute, Malacca for facilities to carry out these studies. I am also very grateful to all those people who have kindly collected material for me, among them Mr. H. M. Burkill, Director of the Botanic Gardens, Dr. D. S. Johnson of the Department of Zoology, University of Malaya in Singapore, Dr. Anne Johnson of the Department of Botany in the same University, Miss Joan Floyd (now Mrs. Charlton) late of Victoria Institution, Kuala Lumpur, and Mr. S. F. Owen, P.W.D. Headquarters in Kuala Lumpur. I am deeply grateful for all the encouragement I have been given by the Department of Botany, University of Malaya, and by the Botanic Gardens, Singapore. I am equally grateful to all those generous people, too numerous to name, who have sent me reprints, which have so greatly assisted this work. To the Director of the Botanic Gardens I am especially grateful for permission to publish in the Gardens Bulletin. Finally I owe a deep sense of gratitude to Dr. Furtado of the Botanic Gardens, Singapore, for the Latin translations.

BIBLIOGRAPHY

ALLEGRE, C. & T. L. Jahn (1943). A survey of the genus *Phacus* Dujardin (Protozoa). Euglenoidinae. Trans. Amer. Micr. Soc. 62: 233–244, pls. 1–3.

ASMUND, B. & D. K. Hilliard (1961). Studies on Chrysophyceae from some ponds and lakes in Alaska I. Hydrobiologia 17: 237–258.

BEHRE, K. (1956). Die Susswasseralgen der Wallacea.Expedition. Arch. f. Hydrobiol. Suppl. 23: 1–104.

BERNARD, C. (1908). Protococcacées et desmidiés d'eau donce recoltéés à Java.Dept. l'Agric. Indes Néerlandaise: 1–230, plo. 1–16.

BERNARD, C. (1909). Sur quelques algues unicellulaires recoltées dans le domaine Malais. Dept. l'Agric. Indes Néerlandaise: 1–94 plo. 1–VI.

BOURELLY, P. (1957). Recherches sur les Chrysophycées Revue Algol. Mem. Hors. Serie 1. : 1–412.

CONRAD, W. (1935). Étude systematique du genre *Lepocinclis* Perty. Mem. Mus. Roy. d'Hist. Nat. Belg. 1: 1–85.

CONRAD, W. (1938). Flagellates des Iles de la Sonde (Euglenacées). Bull. Mus. Roy. d'Hist Nat. Belg. XIV No. 8: 1–20.

CONRAD, W. (1938). Notes protistologiques V. Observations sur *Uroglena soniaca* n. sp. et remarques sur le genre *Uroglena* Ehr. Bull. Mus. Roy. d'Hist Nat. Belg. XIV No. 42: 1–27.

CONRAD, W. & L. van Meel (1951). Materiaux pour une monographie de *Trachelomonas* Ehrenberg 1834, *Strombomonas* Deflandre 1930, et *Euglena* Ehrenberg 1832, genres d'Euglenacées. Mem. Inst. Roy. Sc. Nat. Belg. 124: 1–124, plo. 1–19.

DEFLANDRE, G. (1926). Monographie du genre *Trachelomonas* Nemours.

DEFLANDRE, G. (1928). Algue d'eau douce du Venezuala (Flagellés et Chlorophycées). Rev. Algol. 3: 213–214.

DEFLANDRE, G. (1930). *Strombomonas* nouveau genre d'Euglenacées (*Trachelomonas* Ehr. pro. parte). Arch. Protistenk. 69: 551–614.

DEFLANDRE, G. (1932). Contributions à la connaissance de flagellés librés I. Ann. Protist. 3: 219–239, plo. 21–23.

ETTL, H. & J. Perman (1958). Několik novych nebo málo známych zástupcu oddělení Chrysophyceae. Preslia 30: 69–75.

FOTT, B. (1957). Taxonomic drobnohledné flory nasich vod. Preslia 29: 278–319.

FOTT, B. (1959). Algenkunde Jena. 481 pp.

FOTT, B. (1959). Zur Frage de Sexualität bei den Chrysomonaden Nova Hedwigia 1 (4): 115–121, pls. 22–23.

FOTT, B. (1960). Taxonomische Übertragungen und Namensänderungen unter den Algen. Preslia 32: 142–154.

FOTT, B. & J. KOMAREK (1960). Das Phytoplankton der Teiche im Teschner Schlesien. Preslia 32: 113–141, pls. 7–9.

FRITSCH, F. E. (1935). The structure and reproduction of the Algae I. Cambridge.

GOJDICS, M. (1953). The genus Euglena. Wisconsin.

HÜBER-PESTALOZZI, G. (1936). Phytoplankton aus seen und sumpfen Javas gesammelt von Prof. C. Schroeter. Ber. Schweiz. Bot. Ges. 46: 131–168.

HÜBER-PESTALOZZI, G. (1941). Des Phytoplankton des Süsswassers 2 (1) —Chrysophyceen. in Die Binnengewasser (Thienemann) Stuttgart.

HÜBER-PESTALOZZI, G. (1955). Das Phytoplankton des Süsswassers 4— Euglenophyceen. in Die Binnengewasser (Thienemann) Stuttgart.

LEEDALE, G. F. (1959). Amitosis in three species of Euglena. Cytologia 24 (2); 213–219.

LEFÈVRE, M. (1933). Contribution a la connaissance des flagellés d'Indochine. Ann. Crypt. Exot. 6: 258–264.

LUND, J. W. G. (1949). New or rare British Chrysophyceae 1. New Phyt. 48 (3): 453–460.

LUND, J. W. G. (1952). On *Dinobryon suecicum* Lemm. var. *longispinum* Lemm. Naturalist 1952 (Oct.–Dec.): 163–166.

LUND, J. W. G. (1955). Contributions to our knowledge of British Algae XIV—Three new species from the English Lake District. Hydrobiologia 7 (3): 219–229.

LUND, J. W. G. (1960). Some new or rare Chrysophyceae from the English Lake District. Hydrobiologia 16: 97–108.

NYAGAARD, G. (1932). Contributions to our knowledge of the freshwater algae of Africa 9—Freshwater algae and phytoplankton from Transvaal. Trans. Roy. Soc. S. Africa 25: 18, fig. 19.

OYE, P. van (1925). Flagellates du Congo Belge. Bull. Soc. Roy. Bot. de Belge. 58 (1): 11–19.

PASCHER, A. (1925). Neue oder wenig bekannte Protisten XV. Arch. Protist. 50: 486–510.

PASCHER, A. (1925). Neue order wenig bekannte Protisten XVII. Arch. Protist. 51: 549–577.

PASCHER, A. (1926). Neue oder wenig bekannte Protisten XIX Arch. Protist. 53: 459–476.

PASCHER, A. & E. LEMMERMANN (1914). Flagellatae in Die Süsswasserflora Deutschlands, Oesterreich und der Schweiz Heft. I. G. Fischer, Jena.

PASCHER, A. & W. VLK. (1942). Zur Kenntnis der Chrysophycen des sabzhaltigen Flachmoores Hrabanow bei Lissa E. Lotos 88: 163–177.

PHILIPOSE, M. T. (1953). Contributions to our knowledge of Indian Algae 1.—Chrysophyceae. Proc. Indian Acad. Sc. 37: 232–248.

PHILIPOSE, M. T. (1956). On some new or little known Chrysophyceae. New Phytol. 55: 289–388.

PLAYFAIR, G. I. (1921). Australian freshwater flagellates. Proc. Linn. Soc. N.S.W.: 99–146, pls. 1–9.

POCHMANN, A. (1942). Synopsis der gättung *Phacus* Arch. Protistenk 95 (2): 8–252, figs. 1–170.

POCHMANN, A. (1953). Struktur, Wachstum und Teilung der Korperhulle bei den Euglenineen. Planta 42: 478–548.

POCHMANN, A. (1955). *Helikotropis okteres* n. gen. n. spec. (Peranemataceae) und die Frage de Aetologie der Kielbildungen bei farblosen Euglenineen. Oesterr. Bot. Zeitsch. 102 (1): 1–17.

POCHMANN, A. (1957). Über die Kerbangen des Zellrandes bei Phacus und eine ahnliche bei einer Chrysomonade beobachtete Erscheinung. Arch. Protist. 102: 44–83.

POCHMANN, A. (1957). Zur Frage der ontogenetischen Gestaltentwicklung der Eugleninezelle. Deutsch. Bot. Ges. 70 (7): 291–296.

POCHMANN, A. (1958). Zweiter Beitrag zur Kenntnis der Struktur Entwicklung und Zerteilung der Paramylonkorner. Oesterr. Bot. Zeitsch. 104: 321–341.

POCHMANN, A. (1959). Über dic Tatigkcit der nichtkontraktilen Importvakuole und den Modus der Osmoregulation bei dem Salzflagellaten *Choanogaster* ncbst Bemcrkungen uber die Funktion der Pusulcn. Deutsch. Bot. Ges. 72 (2): 99–108.

POCHMANN, A. (1959). Über Choanogaster einen neuen farblosen Salzflagellaten vom Urmia-See. Arch. Protist. 103: 507–530, pls. 21–22.

PRESCOTT, G. W. (1951). Algae of the Western Great Lakes Area. Michigan. Cranbrook Inst. of Science.

PRESCOTT, G. W. (1957). The Machras Brazilian Expcdition. Chlorophyta, Euglenophyta. Contr. Sci. Los Angeles Country Mus. 11: 1–29.

PRINGSHEIM, E. G. (1942). Contributions to our knowledge of Saprophytic algae and flagellata III—*Astasia*, *Distigma*, *Menoidium* and *Rhabdomonas*. New Phytol 41: 171–205.

PRINGSHEIM, E. G. (1948). Taxonomic problems in the Euglenineae. Biol. Rev. Camb. Phil. Soc. 23: 46–61.

PRINGSHEIM, E. G. (1956). Contributions towards a Monography of the genus *Euglena*. Nova Acta Leopold. 18 (25): 5–168.

PROWSE, G. A. (1958). The Euglenineae of Malaya. Gardens Bull. Singapore 16: 136–204.

ROSENBERG, M. (1944). On a bluc-grecn Cryptomonad, *Chroomonas nordstedtii* Hansg. Ann. Bot. 8: 315–322.

SKUJA, H. (1949). Zur Süsswasscralgenflora Burmas. Nova. Acta. Reginae Soc. Scientiarum Upsalicnsis 14 (5); 1–188. pls. 1–39.

SKVORTZOW, B. V. (1927). Dic Euglenaceengattung Phaeus Dujardin. Ber. Deutsch. Bot. Ges. 46: 105–125.

SKVORTZOW, B. V. (1937). Contributions to our knowledge of the Freshwater algae of Rangoon, Burma, India 1—Euglenaceen from Rangoon. Arch. Protistenk. 90. 69–87, pls. 9–12.

SKVORTZOW, B. V. (?). Species novae et minus cognitae Algarum, Flagellatarum et Phycomycetarum Asiae, Africae, Americae et Japoniae ncc non Ccylon anno 1931—45 descripte et illustrato per tab. 1–18. Zapiski 2: 1–34, pls. 1–18.

SUXENA, M. R. (1955). Freshwater Euglcninae from Hyderabad. India I. Jour. Indian Bot. Soc. 34 (4): 429–450.

TIFFANY, L. H. & M. E. BRITTON (1952). The Algac of Illinios Chicago 407 pp.

WANG, C. & D. NIE (1934). Notes on *Trachelomonas* in Nanking. Sinensis 5: 122–146.

WARD, H. B. & G. C. WHIPPLE edit. W. T. EDMONSON (1959). Freshwater Biology 2nd Edition. New York; 117–170 & 190–231.

Plate I.

(*a*) *Euglena intermedia* (Klebs.) Schmitz var. *klebsii* Lemmermann; (*b, c, d*) *Euglena mutabilis* Schmitz; (*e, f*) *Euglena gracilis* Klebs; (*g*) *Euglena flava* Dangeard; (*h, i*) *Euglena agilis* Carter; (*j*) *Trachelomonas intermedia* Dangeard; (*k*) *Euglena exilis* Gojdics; (*l*) *Lepocinclis fusiformis* (Carter) Lemmermann; (*m*) *Peranema inflexum* Skuja; (*n*) *Phacus meson* Pochmann; (*o*) *Trachelomonas volvocinopsis* Swirenko; (*p*) *Strombomonas verrucosa* (Daday) Déflandre var. *chinensis* (Skvortzow) Déflandre; (*q*) *Trachelomonas allia* Drezepolski fa.

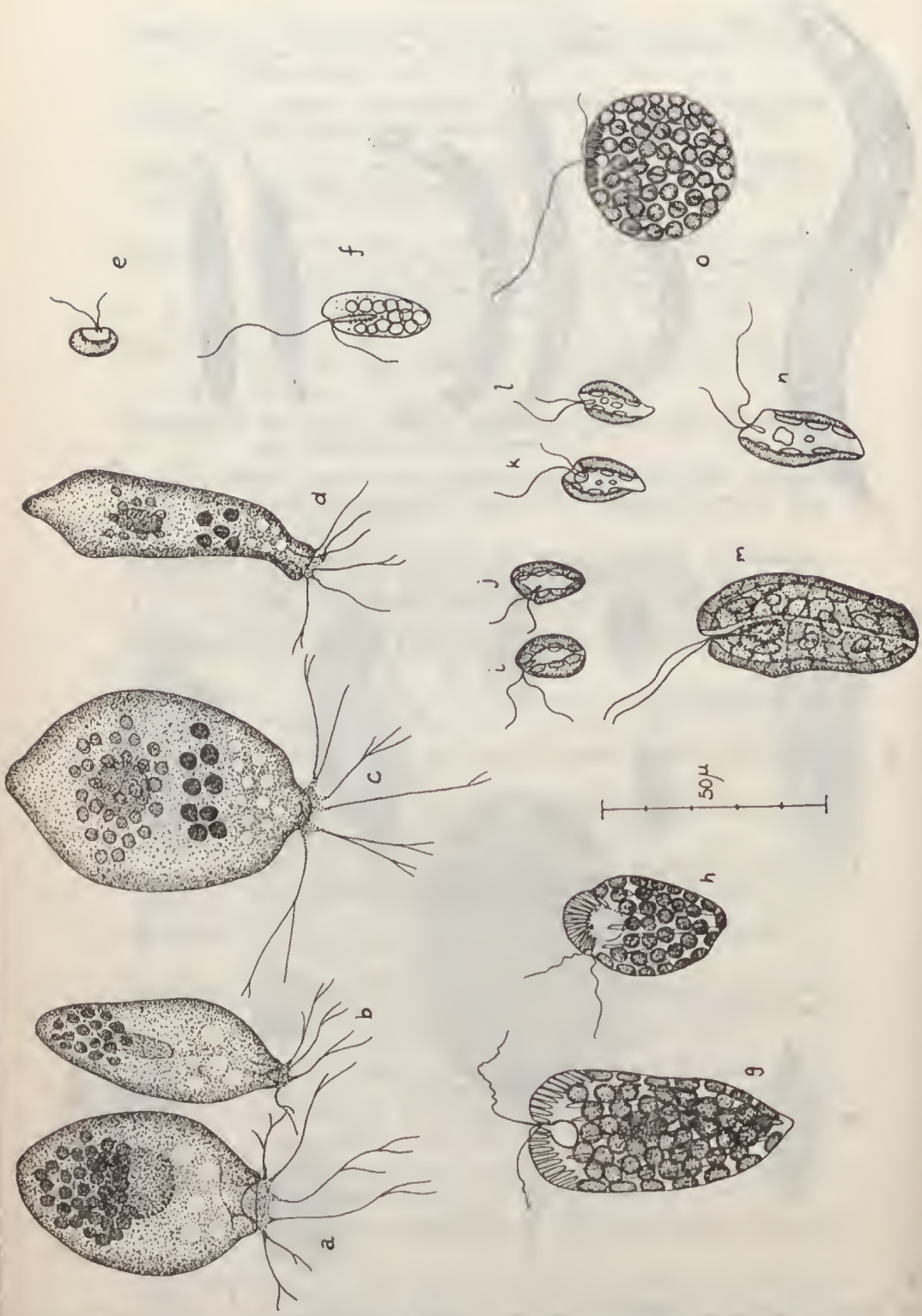


Plate II.
(a, b) Rhizaspis simplex Skuja; (c, d) Rhizaspis granulata Skuja; (e) Sennia parvula Skuja; (f) Chilomonas paramecium Ehrenberg; (g) Gonyostomum semen Diesing; (h) Merotrichia capitata Skuja; (i, j) Cryptomonas phaseolus Skuja; (k, l, n) Cryptomonas

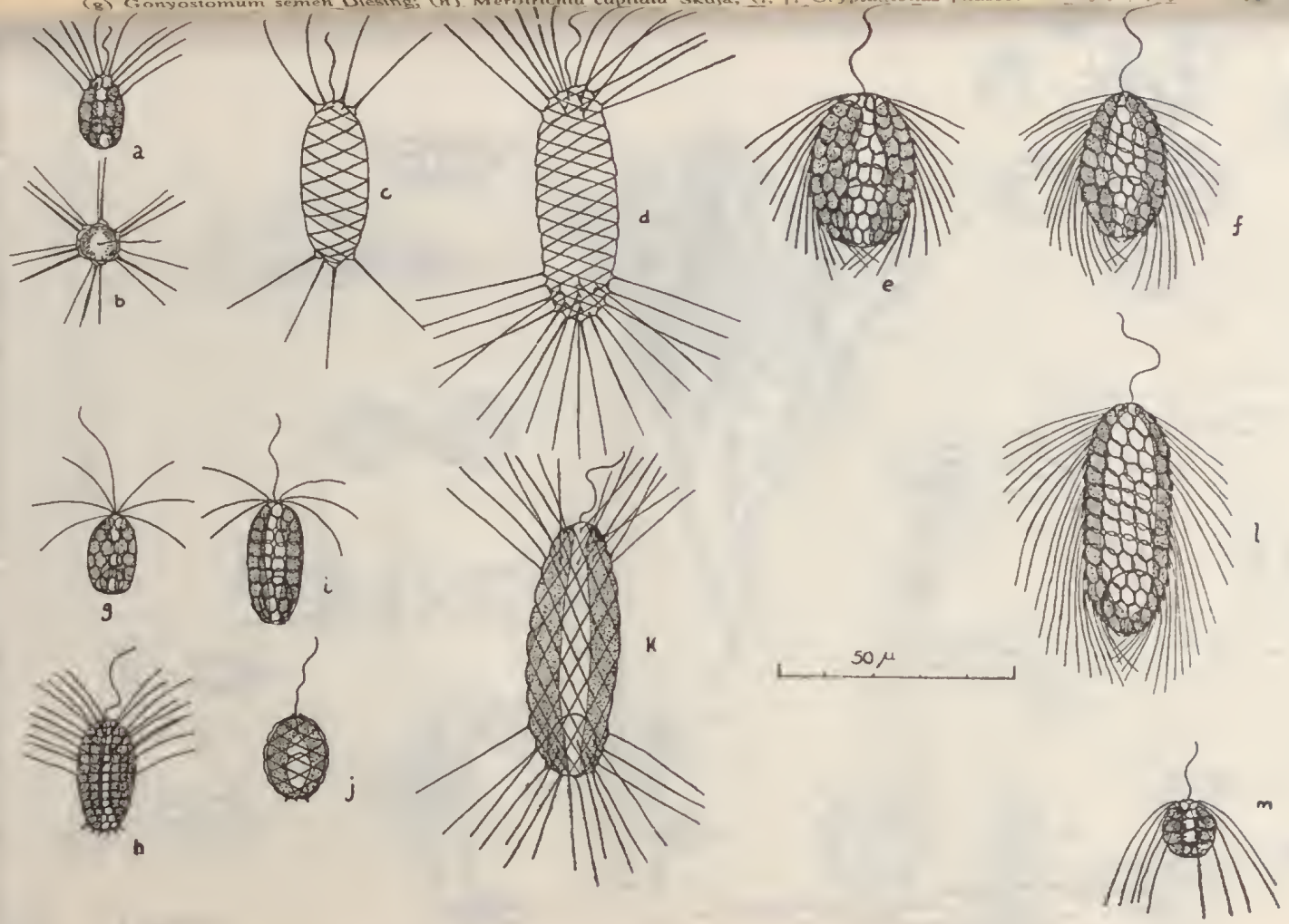


Plate III.

(*a, b*) *Mallomonas tonsurata* Teiling var. *alpina* (Pascher) Krieger; (*c*) *Mallomonas splendens* (G. S. West) Playfair; (*d, k*) *Mallomonas teilingioides* Prowse *sp. nov.*; (*e, f, l*) *Mallomonas acaroides* Perty; (*g, i*) *Mallomonas curta* (Playfair) Conrad; (*h*) *Mallomonas tonsurata* var. *dorsidentata* Prowse *var. nov.*; (*j*) *Mallomonas playfairii* Conrad var. *opisthiodonta* Prowse *var. nov.*; (*m*) *Mallomonas spherica* Prowse *sp. nov.*

Plate IV.

(*a*) *Dinobryon bavaricum* Imhof; (*b, c*) *Dinobryon sertularia* Ehrenberg; (*d, k*) *Synura uvella* Ehrenberg; (*e*) *Chrysopxis* sp.; (*f*) *Chrysopxis* sp.; (*g*) *Dinobryon inflatum* Lemmermann; (*h, i, j*) *Hyalobryon lauterbornii* Lemmermann; (*l*) *Synura uvella* Ehrenberg, two-celled colony; (*m*) *Chrysodidymus gracilis* Prowse *sp. nov.*; (*n*) *Chrysodidymus synuroides* Prowse *sp. nov.*

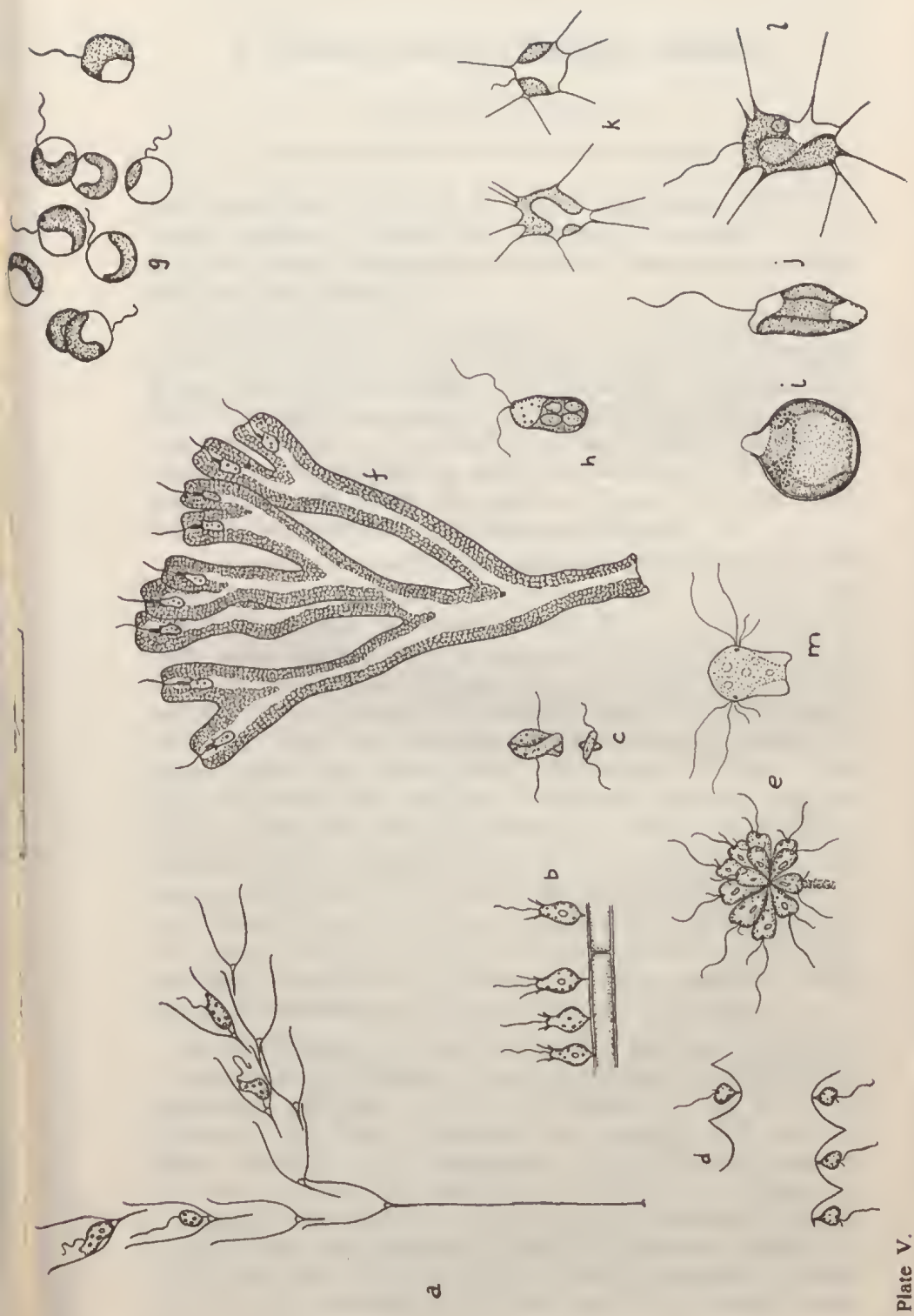


Plate V.

(*a*) *Poteriodendron petiolatum* Stein; (*b*) *Salpingoeca frequentissima* (Zacharias) Lemmermann; (*c*) *Turbomonas gyrans* Prowse *sp. nov.*; (*d*) *Stomatochone* sp.; (*e*) *Anthophysa vegetans* (O. F. Muller) Stein; (*f*) *Phalansterium digitatum* Stein; (*g*) *Chromulina sphaerica* Bachman; (*h*) *Ochromonas hinterzartensis* Doflein; (*i–l*) *Chrysamoeba radians* Klebs; (*m*) *Trepomonas rotans* Klebs.

A Check List of Malayan Grasses

By H. B. GILLILAND

Department of Botany, University of Singapore

THE PUBLICATION of Dr. N. L. Bor's "The Grasses of Burma, Ceylon, India and Pakistan" in 1960 makes it possible to draw up a check list of the grasses of the Malay Peninsula with reasonably up to date names.

In point of time, the first synthesis of our knowledge of the grasses of the Malay Peninsula was prepared by Sir Joseph Hooker in his "Flora of British India" Vol. VII which was published in 1897. That great graminologist, Dr. Otto Stapf, had just recently joined the staff of the Kew Herbarium and assisted with this account. Since Burma and the Malay Peninsula were at that time administered from India, the plants of Burma and the Malay Peninsula were included in that monumental work.

Simultaneously an independent synthesis of plant records for the Malay Peninsula was begun by Dr. King—then Curator of the Calcutta Herbarium in association with Mr. J. S. Gamble and many other botanists. This is commonly referred to as King & Gamble's "Materials for a Flora of the Malay Peninsula", and was published in the Journal of the Asiatic Society of Bengal between 1889 and 1908. This, however, did not include the Monocotyledons which were specially dealt with by H. N. Ridley, then Director of the Botanic Gardens of Singapore and the Straits Settlements, under the title of "Materials for a Flora of the Malay Peninsula—Monocotyledons" in 1907/1908. Volume III of his work, published in 1907, contains the first complete account of the grasses of Malaya. On retirement Mr. Ridley devoted his time to a further study of the flora of Malaya at Kew, and in 1925 published Volume V of "The Flora of the Malay Peninsula" which carried our knowledge of Malayan grasses a stage further.

Mr. I. H. Burkill, who from 1912 to 1925 had succeeded Ridley as Director of the Botanic Gardens of Singapore and the Straits Settlements, published in 1935 a "Dictionary of the Economic Products of the Malay Peninsula" in 2 volumes. This contains further references to and discussions of many Malayan grasses. The first work to merit discussion thereafter was a paper by P. Jansen, a botanist on the staff of the Flora Malesiana Foundation at Leyden, who published "Notes on Malaysian Grasses" in Reinwardtia, Vol. II, part 2, in 1953. Many references to herbaceous grasses of the Malay Peninsula occur in this paper. Meantime M. R. Henderson, by now Director of the Botanic Gardens,

Singapore, produced the volume entitled "Malayan Wild Flowers —Monocotyledons" published by the Malayan Nature Society in Kuala Lumpur in 1954. This contains a useful account of the commoner Malayan herbaceous grasses.

It will be noted that the last two works referred to have discussed the grasses without reference to the aborescent bamboos. However, Dr. R. E. Holttum, former Director of the Botanic Gardens, Singapore and first Professor of Botany at the University of Malaya, had been making a study of the bamboos and was able to bring our knowledge of this interesting and important group in Malaya up to date in a paper published in 1958 in the *Gardens' Bulletin,* Singapore. Actually, Professor Holttum had prepared a manuscript account of the grasses of the Malay Peninsula which he very kindly passed on to the present writer and which has been of great help in preparing the present list. Comments on the significance of the geographical distribution of the present records will appear elsewhere.

1. **Acroceras munroanum** (Balansa) Henr. Blumea *3*, 445, 1940; Bor, Grasses Burma, Ceylon, India & Pakistan, 275, 1960.

   Panicum munroanum Balansa in Morot, J. de Bot. 4, 140; 1890.

   Acroceras crassi-apiculatum (Merr.) Alston in Trimen Handb. Fl. Ceyl. 6 Suppl. 324, 1931; Burkill Kew Bull. 317, 1935; Dict. Econ. Prod. Mal. Pen. 1, 39, 1935.

   Panicum ridleyi Hack. nom. nud. ex Ridl. in Trans. Linn. Soc. ser. 2, 3, 400, 1893.

   Acroceras ridleyi (Hack.) Stapf ex Ridley, Flor. Mal. 5, 229, 1925.

   A creeping grass of coastal sands.

2. **Acroceras zizanioides** (H.B.K.) Dandy, J. Bot. *69*, 54, 1931; Bor, l.c. 275, 1960.

   Panicum zizanioides H.B.K. Nov. Gen. & Sp. 1, 110, 1816.

   Acroceras sparsum Stapf. ex Ridl. Flor. Mal. 5, 229, 1925; Burkill, l.c. 1, 39, 1935.

   Common in disturbed places with good light.

3. **Alloteropsis cimicina** (Linn.) Stapf, Flor. Trop. Afr. *9*, 487. 1919; Ridl. Flor. Mal. *5*, 223, 1925; Burkill, l.c. *1*, 105, 1935; Bor, l.c. 276, 1960.

   Milium cimicinum Linn. Mant. Alt. 184, 1771.

   A ruderal probably introduced through disturbance.

4. **Apluda mutica** Linn. Sp. Pl. 82, 1753; Bor, l.c. 93, 1960.

   Apluda varia var. intermedia Ridl. Mat. 3, 164, 1907; Flor. Mal. 5, 207, 1925; Burkill, l.c. 1, 193, 1935.

   A ruderal found only in the northern States.

5. **Aristida culionensis** Pilg. in Perk. Fragm. Fl. Philip *1*, 145, 1904.

   Has been recorded from Perlis.

6. **Aristida setacea** Retz. Obs. Bot. *4*, 22, 1786; Jansen in Reinwardtia *2*, 230, 1953; Bor, l.c. 412, 1960.

   Aristida adscensionis Ridl. non Linn. Flor. Mal. 5, 242, 1925.

   Rare in the northwest.

7. **Arthraxon lanceolatus** (Roxb.) Hochst. in Flora *39*, 188, 1856; Bor, l.c. 100, 1960.

   Andropogon lanceolatus Roxb. Flor. Ind. 1, 257, 1820.

   Rare on limestone in Kedah.

8. **Arthraxon nudus** (Nees) Hochst. in Flora *39*, 188, 1856; Bor, l.c. 101, 1960.

   Batratherum nudum Nees ex Steud. Syn. Pl. Glum. 383, 1853.

   Lankawi islands, rare.

9. **Arundinella setosa** Trin. Gram. Panic. 63, 1826; Ridl. Flor. Mal. *5*, 239, 1925; Burkill, l.c. *1*, 259, 1935; Bor, l.c. 424, 1960.

   Occurs only in the northwest.

10. **Arundo donax** Linn. Sp. Pl. 81, 1753; Agric. Bull. Straits & F.M.S. *10*, 260, 1911; Burkill, l.c. *1*, 260, 1953; Bor, l.c. 41, 1960.

    "Teberau gading" Introduced.

11. **Axonopus affinis** Chase, J. Wash. Acad. Sci. *29*, 180, 1938; Bor, l.c. 227, 1960.

    A. compressus var. affinis Henderson, Malay, Wild Fls. Monocots. 339, 1954.

12. **Axonopus compressus** (Sw.) P. Beauv. Ess. Agrost. 12, 154, 167, 1812; Ridl. Flor. Mal. *5*, 216, 1925; Burkill, l.c. *1*, 276, 1953; Jagoe, Gard. Bull. S.S. 109, 1940; Henderson, l.c. 337, 1954; Gilliland, Comm. Mal. Plts. 26, 1958; Bor, l.c. 278, 1960.

    Milium compressus Swartz Prodr. Veg. Ind. Occ. 24, 1788.

    Paspalum platicaulon Poir. in Lamk. Encycl. Meth. Bot. 5, 34, 1804.

    P. "platycaule" of Ridl. Mat. 3, 125, 1907.

    Introduced "carpet grass" now abundant in lawns, etc.

13. **Bambusa arundinacea** (Retz.) Willd. Sp. Pl. *2*, 245, 1799; Holttum, Gard. Bull. Sing. *16*, 59, 1958.

    Bambos arundinacea Retz. Obs. Bot. 5, 24, 1789; Holttum in Taxon, 5, 65, 1956.

    Planted in Singapore and Penang.

14. **Bambusa blumeana** Schult. Syst. Veg. *7*, 1343; Ridl. Flor. Mal. *5*, 256; 1925; Burkill, l.c. *1*, 298, 1935; Holttum, l.c. 57, 1958.

Bambusa spinosa Blume non Roxb. ex Nees. in Bot. Zeit. 580, 1825; Ridl. Mat. 3, 183, 1907.

The "buloh duri" is probably introduced.

15. **Bambusa burmanica** Gamble in Ann. R. Bot. Gard. Calcutta *7*, 35, pl. 33, 1896; Holttum, l.c. 62, 1958.

Known only from northern Kedah.

16. **Bambusa glaucescens** (Willd.) Sieb. ex Munro Trans. Linn. Soc. *26*, 89, 1868; Holttum, Kew Bull. *2*, 207, 1956; l.c. 67, 1958; Gilliland, Comm. Mal. Plts. 29, 1958.

Ludolfia glaucescens Willd. in Ges. Nat. Freund. Berl. Mag. 2, 320, 1808.

Bambusa multiplex Raeusch. non Louv. ex Burkill, l.c. 1, 299, 1935.

Bambusa nana Roxb. ex Munro l.c. 89, 1868; Ridl. Mat. 3, 184, 1907; Flor. Mal. 5, 258, 1925.

The "buloh pagar" makes an excellent hedge. Not native in Malaya.

17. **Bambusa heterostachya** (Munro) Holttum in Jour. Arn. Arb. *27*, 341, 1946; l.c. 65, 1958.

Gigantochloa heterostachya Munro in Trans. Linn. Soc. 26, 125, 1868; Ridl. Mat. 3, 188, 1907; Flor. Mal. 5, 262, 1925; Burkill, l.c. 1, 1069, 1935.

Gigantochloa latispiculata Gamble in Ann. R. Bot. Gard. Calcutta 7, 67, pl. 59, 1896; Ridl. Mat. 3, 189, 1907; Flor. Mal. 5, 263, 1935; Burkill, l.c. 1069, 1935.

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

Type from Malacca; also recorded Negri Sembilan, Johore, Singapore & Perak.

18. **Bambusa magica** Ridl. J.S.B.R.A. Soc. *44*, 208, 1904; Mat. *3*, 184, 1907; Flor. Mal. *5*, 258, 1952; Burkill, l.c. *1*, 299, 1935; Holttum, l.c. 75, 1958.

Bambusa elegans Ridl. J.S.B.R.A. Soc. 44, 208, 1904; Mat. 3, 185, 1907; Flor. Mal. 5, 258, 1925.

The "buloh perindu" is endemic on the higher more exposed ridges of the Main Range.

19. **Bambusa montana** (Ridl.) Holttum Kew Bull. *2*, 206, 1956; l.c. 77, 1958.

Dinochloa montana Ridl. J.S.B.R.A. Soc. 44, 210, 1905; Mat. 3, 193, 1907; Flor. Mal. 5, 267, 1925.

Endemic to Penang Hill.

20. **Bambusa pauciflora** Ridl. Flor. Mal. *5*, 529, 1925; Burkill, l.c. *1*, 299, 1935; Holttum, l.c. 76, 1958.

"Buloh padi" is a rare endemic only known from Fraser's Hill.

21. **Bambusa ridleyi** Gamble, Ann. R. Bot. Gard. Calc. *7*, 34, pl. 32, 1896; Ridl. Mat. *3*, 184, 1907; Flor. Mal. *5*, 257, f. 225, 1925; Holttum, l.c. 71, 1958.

Endemic from forest in Singapore and Pahang.

22. **Bambusa vulgaris** Schrad. in Wendl. Coll. Pl. *2*, 26, t. 47, 1810; Ridl. Mat. *3*, 185, 1907; Flor. Mal. *5*, 256, 1952; Burkill, l.c. *1*, 300, 1935; Holttum l.c. 63, 1958.

"Buloh minyak" is the commonest cultivated bamboo of Malaya.

23. **Bambusa wrayi** Stapf; Kew Bull. 14, 1893; Ridl. Mat. *3*, 183, 1907; Flor. Mal. *5*, 259, 1925; Burkill, l.c. *1*, 301, 1935; Holttum, l.c. 72, 1958.

The "buloh bersumpitan" is an endemic species from the mountains in Perak.

24. **Bothriochloa intermedia** (R. Br.) A. Camus, Ann. Soc. Linn. Lyon. N.S. 76, 164, 1931; Bor. l.c. 108, 1960.

Andropogon intermedius R. Br. Fl. N. Holl. 202, 1810; Ridl. Mat. 3, 166, 1907; Henderson, l.c. 346, 1956.

Amphilophis glabra var. paupera Stapf in Ridl. Flor. Mal. 5, 209, 1925.

A rare roadside weed north of Johore.

25. **Bothriochloa pertusa** (Linn.) A. Camus l.c. 1931; Bor, l.c. 109, 1960.

Holcus pertusus Linn. Mant. Alt. 301, 1771.

Amphilophis pertusus (Linn.) Stapf in Flor. Trop. Afr. 9, 175, 1917; Flor. Mal. 5, 209, 1925.

Rare, recorded from Malacca.

26. **Brachiaria distachya** (Linn.) Stapf in Flor. Trop. Afr. 9, 565, 1919; Ridl. Flor. Mal. *5*, 219, 1925; Burkill, l.c. *1*, 356, 1935; Jansen, l.c. 238, 1953; Henderson, l.c. 342, 1954; Bor, l.c. 281, 1960.

Panicum distachyum Linn. Mant. 1, 138, 1767; Ridl. Mat. 3, 133, 1907.

Rather rare from Malacca & Port Swettenham.

27. **Brachiaria holotricha** Ohwi in Bull. Tokyo Sci. Mus. *18*, 4, 1947; Jansen l.c. 238, 1953.

Rare, recorded from Penang.

28. **Brachiaria mutica** (Forsk.) Stapf l.c. 526, 1919; Ridl. Flor. Mal. *5*, 219, 1952; Burkill, l.c. *1*, 356, 1935.

Panicum muticum Forsk. Flor. Aegypt.Arab. 20, 1775; Ridl. Mat. 3, 133, 1907.

A stoloniferous prolific grass introduced in Malaya.

29. **Brachiaria paspaloides** (Presl.) Hubb. in Hk. Ic. Pl. T3363, 1938; Henderson, l.c. 342, 1954; Bor, l.c. 284, 1960.

Urochloa paspaloides Presl. Rel. Haenk. 1, 318, 1830.

A weed of cultivated and waste land.

30. **Brachiaria reptans** (Linn.) Gardn. & Hubb., Hk. Ic. Pl. sub t.3363, 1938; Bor, l.c. 285, 1960.

Panicum reptans Linn. Syst. Nat. ed. 10, 2, 870, 1759.

Urochloa reptans (Linn.) Stapf. l.c. 601, 1920; Ridl. Flor. Mal. 5, 220, 1925; Burkill, l.c. 2, 2211, 1935.

A creeping perennial introduced at Port Swettenham.

31. **Briza minor** Linn. Sp. Pl. 70, 1753; Bor, l.c. 528, 1960.

A European weed now established on hill stations.

32. **Capillipedium parviflorum** (R. Br.) Stapf l.c. 169, 1917; Bor, l.c. 112, 1960.

A swamp grass in Malaya.

33. **Centotheca lappacea** (Linn.) Desv. Nuov. Bull. Soc. Phil. Paris *2*, 189, 1810; Ridl. Mat. *3*, 181, 1907; Flor. Mal. *5*, 253, 1952; Burkill, l.c. *1*, 508, 1935; Henderson, l.c. 309, 1954; Bor, l.c. 459, 1960.

Cenchrus lappaceus Linn. Sp. Pl. ed. 2, 2, 1488, 1763.

Centotheca latifolia (Osbeck) Trin. Fund-Agrost. 141, 1820; Jansen, l.c. *253, 1953.*

"Rumput lilit kain" is common associated with forest paths, clearings, etc.

34. **Centotheca longilamina** Ohwi, Bull. Tokyo Sci. Mus. *18*, 10, 1947; Jansen, l.c. 253, 1953.

C. lappacea var. longilamina (Ohwi) Bor, l.c. 459, 1960.

Also a forest grass.

35. **Chloris barbata** Sw. Fl. Ind. Occ. *1*, 200, 1797; Ridl. Mat. *3*, 173, 1907; Flor. Mal. *5*, 250, 1925; Burkill, l.c. *1*, 529, 1935; Henderson, l.c. 315, 1954; Bor, l.c. 465, 1960.

An introduced ruderal now well established.

36. **Chloris dolichostachya** Lagasca Gen. et Spec. Pl. 5, 1816; Bor, l.c. 466, 1960.

Known only from the Lankawi islands in Malaya.

37. **Chrysopogon aciculatus** (Retz.) Trin. Fund. Agrost. 188, 1820; Ridl. Flor. Mal. *5*, 207, 1925; Burkill, l.c. *1*, 535, 1935; Henderson, l.c. 344, 1954; Gilliland, Comm. Mal. Plts. 50, 1958; Bor, l.c. 115, 1960.

    Andropogon aciculatus Retz. Obs. Bot. 5, 22, 1789; Ridl. Mat. 3, 169, 1907.

    The "Love-grass" of Malayan lawns and all inhabited land.

38. **Chrysopogon collinus** Ridl. Flor. Mal. *5*, 208, 1925.

    Jansen in Reinwardtia 2, 254, 1953 suggests that this may turn out to be a form of C. montanus Trin. which Bor. l.c. 116, 1960 equates to C. fulvus (Spreng.) Chiov.

    A rare grass of the northwest.

39. **Chrysopogon orientalis** (Desv.) A. Camus, Fl. Gen. Indoch. *7*, 332, 1922.

    Raphis orientalis Desv. Opusc. 69, 1831.

    Andropogon wightianus Steud. Syn. Pl. Glum. 1, 395, 1854; Ridl. Mat. 3, 167, 1907.

    Chrysopogon wightianus (Steud.) Thw. Enum. Pl. Zeyl. 366, 1864; Ridl. Flor. Mal. 5, 208, 1925.

    Pahang, Kelantan & Trengganu and the northwest.

40. **Coelachne simpliciuscula** (Wight & Arn.) Munro ex Benth. in J. Linn. Soc. Bot. *19*, 93, 1881; Bor, l.c. 576, 1960.

    Panicum simpliciusculum Wight & Arn. ex Steud. Syn. Pl. Glum. 1, 96, 1854.

    A swamp grass from Kedah.

41. **Coelorachis foveolata** (Holtt.) Jansen l.c. 256, 1953.

    Rottboellia foveolata Holttum, Gard. Bull. Sing. 9, 247, 1947.

    Rare recorded only from the northwest.

42. **Coelorachis glandulosa** (Trin.) Stapf ex Ridl. Flor. Mal. *5*, 204, 1925; Burkill, l.c. *1*, 618, 1935; Jansen, l.c. 255, 1953; Henderson, l.c. 347, 1954; Bor, l.c. 120, 1960.

    Rottboellia glandulosa Trin. Mem. Acad. Petersb. ser. 6, 2, 250, 1833; Ridl. Mat. 3, 161, 1907.

    A coarse grass of river banks widely distributed in Malaya.

43. **Coelorachis helferi** (Hk. f.) Henr. Blumea *4*, 518, 1941; Jansen, l.c. 256, 1953; Bor, l.c. 120, 1960.

    Rottboellia helferi Hk. f. Flor. Brit. Ind. 7, 158, 1896.

    Mnesithea rupincola Ridl. J.S.B.R.A. Soc. 57, 116, 1910; Flor. Mal. 5, 206, 1925.

    Rare on riverbed rocks in Perak.

44. **Coix gigantea** Koenig ex Roxb. Fl. Ind. ed. 2, *3*, 570, 1832; Ridl. Flor. Mal. *5*, 191, 1925; Bor, l.c. 264, 1960.

Coix lachryma-jobi var. gigantea (Roxb.) of Ridl. Mat. 3, 151, 1907.

From the Kinta river in Perak.

45. **Coix lachryma-jobi** Linn. Sp. Pl. 972, 1753; Ridl. Mat. *3*, 151, 1907; Flor. Mal. *5*, 191, 1925; Burkill, l.c. *1*, 629, 1935; Henderson, l.c. 6, 354, 1954; Bor, l.c. 264, 1960.

Cultivated and wild races of "Job's Tears" or "Jelai" are found.

46. **Cymbopogon calcicola** C. E. Hubb. Kew Bull. 24, 1941; Henderson, l.c. 354, 1954.

On limestone in Lankawi, Kedah and Pahang.

47. **Cymbopogon flexuosus** (Nees) Wats. in Atkins, Gaz. N.W. Prov. Ind. 392, 1882; Bor. l.c. 127, 1960.

Andropogon flexuosus Nees ex Steud. Syn. Pl. Glum. 1, 388, 1854. This is probably Ridley's "C. citratus Stapf" (A. citratus DC) of the Flor. Mal. 5, 211, 1925; Burkill, l.c. 1, 724, 1935; Henderson, l.c. 354, 1954.

"Lemon Grass."

48. **Cymbopogon nardus** (Linn.) Rendle, Cat. Welw. Afr. Pl. *2*, 155, 1899; Ridl. Flor. Mal. *5*, 211, 1925; Burkill, l.c. *1*, 727, 1935; Henderson, l.c. 353, 1954; Bor, l.c. 130, 1960.

Andropogon nardus Linn. Sp. Pl. 1046, 1753; Ridl. Mat. 3, 168, 1907.

"Citronella grass."

49. **Cynodon arcuatus** Presl. Rel. Haenk. *1*, 290, 1830; Bor, l.c. 469, 1960.

Cynodon dactylon Ridl. non Pers. Mat. 3, 173, 1907; Flor. Mal. 5, 249, 1925; Burkill, l.c. 1, 729, 1935; Henderson, l.c. 314, 1954.

A stoloniferous but not rhizomatous species, widespread, flowering only in dry spells.

50. **Cyrtococcum accrescens** (Trin.) Stapf in Hook. Ic. Pl. t3096, 1922; Ridl. Flor. Mal. *5*, 234, 1925; Burkill, l.c. *1*, 744, 1935; Jansen, l.c. 257, 1953; Bor, l.c. 291, 1960.

Panicum accrescens Trin. Sp. Gram. Ic. 1, pl. 88, 1827.

Panicum patens Ridl. non Linn. Mat. 3, 142, 1907.

A grass tolerant of some shade, widely distributed.

51. **Cyrtococcum oxyphyllum** (Steud.) Stapf in Hk. Ic. Pl. t3096, 1922; Ridl. Flor. Mal. *5*, 233, 1925; Bor, l.c. 291, 1960.

Panicum oxyphyllum Steud. Syn. Pl. Glum. 1, 68, 1854.

Panicum pilipes Nees et Arn. ex Buese in Miq. Pl. Junghn. 3, 376, 1854; Ridl. Mat. 3, 141, 1907; Henderson, l.c. 331, 1954.

Panicum trigonum Ridl. non Retz. J.S.B.R.A. Soc. 23, 21, 1891.

A creeping grass of shady places, widespread.

52. **Cyrtococcum patens** (Linn.) A. Camus, Bull. Mus. Nat. Hist. Paris 27, 118, 1921; Bor, l.c. 292, 1960.

Panicum patens Linn. Sp. Pl. 58, 1753.

Cyrtococcum carinatum (Presl.) Stapf in Ridl. Flor. Mal. 5, 233, 1925.

Cyrtococcum trigonum (Retz.) A. Camus, Burkill, l.c. 1, 744, 1935.

Panicum trigonum Henderson l.c. 330, 1954.

From Malacca, Negri Sembilan & Selangor.

53. **Dactyloctenium aegyptium** (Linn.) Beauv. Ess. Agrost. Expl. Pl. 15, 159, 1812; Henderson, l.c. 316, 1954; Bor. l.c. 489, 1960.

Cynosurus aegyptius Linn. Sp. Pl. 72, 1753.

Dactyloctenium aegyptiacum Willd. Enum. Hort. Berol. 1029, 1809; Ridl. Flor. Mal. 5, 251, 1925; Burkill, l.c. 1, 747, 1953.

Eleusine aegyptiaca Ridl. non Desf. Mat. 3, 174, 1907.

An introduced weed of sandy places.

54. **Dendrocalamus asper** (Schult.) Backer ex Heyne Nutt. Pl. Ned. Ind. ed. 2, *1*, 301, 1927; Burkill, l.c. *1*, 781, 1935; Holttum Gard. Bull. Sing. *16*, 100, 1958.

Bambusa aspera Schult. Syst. Nat. 7, 1352, 1830.

Dendrocalamus flagellifer Munro Trans. Linn. Soc. 26, 150, 1866; Ridl. Flor. Mal. 5, 265, 1925.

The "buloh betong" or "Rebong China" is a favourite "bamboo shoot". Widespread.

55. **Dendrocalamus dumosus** (Ridl.) Holttum, Gard. Bull. Sing. *11*, 296, 1947 & l.c. 96, 1958.

Schizostachym dumosum Ridl. J.S.B.R.A. Soc. 61, 64, 1912; Flor. Mal. 5, 271, 1925.

A rare bamboo from limestone in Kedah and the Lankawi islands.

56. **Dendrocalamus elegans** (Ridl.) Holttum, Gard. Bull. Sing. *11*, 296, 1947 & l.c. 95, 1958.

Schizostachyum elegans Ridl. J.S.B.R.A. Soc. 73, 146, 1916; Flor. Mal. 5, 271, 1925.

Another rare bamboo from limestone in the Lankawi islands.

57. **Dendrocalamus giganteus** Munro, Trans. Linn. Soc. *26*, 150, 1868; Ridl. Mat. *3*, 191, 1907; Flor. Mal. *5*, 265, 1925; Burkill, l.c. *1*, 781, 1935; Holttum, l.c. 103, 1958.

"Buloh semiliang" is sporadic probably introduced.

58. **Dendrocalamus hirtellus** Ridl. J.S.B.R.A. Soc. *73*, 146, 1916; Flor. Mal. *5*, 266, 1925; Holttum, l.c. 93, 1958.

"Buloh kapor" is recorded from open places in forest in Johore, Kedah & Kelantan.

59. **Dendrocalamus pendulus** Ridl. J.S.B.R.A. Soc *44*, 210, 1905; Mat. *3*, 192, 1907; Flor. Mal. *5*, 266, 1925; Burkill, l.c. 1, 782, 1935; Holttum, l.c. 90, 1958.

Cephalostachyum malayanum Ridl. J.S.B.R.A. Soc. 57, 118, 1910; Flor. Mal. 5, 267, 1925.

Schizostachym subcordatum Ridl. J.S.B.R.A. Soc. 82, 204, 1920; Flor. Mal. 5, 269, 1925.

"Buloh akar" is abundant in the valleys of the Main Range.

60. **Dendrocalamus sinuatus** (Gamble) Holttum, l.c *11*, 296, 1947; *16*, 97, 1958.

Oxytenanthera sinuata Gamble, Ann. R. Bot. Gard. Calc. 7, 71, pl. 62, 1896; Ridl. Flor. Mal. 5, 264, 1925; Burkill, l.c. 2, 1617; 1935.

This "buloh akar", whose locus classicus is Seremban, Negri Sembilan, is uncommon.

61. **Dendrocalamus strictus** (Roxb.) Nees, Linnaea *9*, 476, 1834; Burkill, l.c. *1*, 782, 1935; Holttum, l.c. 98, 1958.

Bambo stricta Roxb. Corom. Pl. 1, 58, t80, 1798.

The "male bamboo" of India is known in cultivation in Penang, Kuala Lumpur & Singapore.

62. **Dichanthium annulatum** (Forsk.) Stapf, Flor. Trop. Afr. *9*, 178, 1917; Bor, l.c. 133, 1960.

Andropogon annulatus Forsk, Fl. Aeg.-Arab. 173, 1795.

This and the next species are hay grasses which do best in the north.

63. **Dichanthium caricosum** (Linn.) A. Camus, Bull. Mus. Nat. Hist. Paris *27*, 549, 1921; Ridl. Flor. Mal. *5*, 210, 1925; Burkill, l.c. *1*, 802, 1935; Bor, l.c. 134, 1960.

Andropogon caricosus Linn. Sp. Pl. ed. 2, 1480, 1763.

Recorded from Kedah.

64. **Digitaria adscendens** (H.B.K:) Henr., Blumea, *1*, 92, 1934; Bor, l.c. 298, 1960

Panicum adscendens H.B.K. Nov. Gen. et Sp. Pl. 1, 97, 1816.

Digitaria marginata Link., Hort. Berol. 1, 229, 1821; Ridl. Flor. Mal. 5, 214, 1925; Burkill, & c. 1, 808, 1935; Henderson, l.c. 340, 1954.

Digitaria chinensis Hornem. Suppl. Hort. Bot. Hafn. 8, 1819; Ridl. Flor. Mal. 5, 215, 1925.

65. **Digitaria bicornis** (Lamk.) Roem. & Schultz ex Lond. Hort. Brit. 24, n. 1578, 1830; Bor, l.c. 299, 1960.

Paspalum bicorne Lamk. Tab. Encycl. Meth. Bot. 1, 176, 1791.

Paspalum heteranthum Hk. f. non Link. nec Nees et Mayen Flor. Brit. Ind. 7, 16, 1896; Ridl. Mat. 3, 126, 1907.

Digitaria barbata Willd. Enum. Hort. Berol. 91, 1809; Ridl. Flor. Mal. 5, 215, 1925.

Recorded from the eastern coastal areas.

66. **Digitaria didactyla Willd.** Enum. Pl. Hort. Berol. 91, 1809; Burkill, l.c. *1*, 809, 1935; Gilliland, Comm. Mal. Plts. 80, 1958; Bor, l.c. 300, 1960.

"Serangoon grass" is widely used for lawns but is not native.

67. **Digitaria longiflora** (Retz.) Pers. Syn. 1, 85, 1805; Ridl. Flor. Mal. *5*, 214, 1925; Burkill, l.c. *1*, 808, 1935; Henderson, l.c. 342, 1954; Bor, l.c. 302, 1960.

Paspalum longiflorum Retz. Obs. 4, 15, 1786; Ridl. Mat. 3, 126,

A roadside ruderal widespread in Malaya.

68. **Digitaria pertenuis** Buse in Miq. Pl. Junghn. 381, 1854; Ridl. Flor. Mal. *5*, 214, 1925.

A garden weed from Penang and Singapore.

69. **Digitaria pusilla** Ridl. Flor. Mal. 5, 215, 1925.

A rare grass recorded from N. Kedah.

70. **Dimeria ciliata** Merr. Philip. J. Sci. 9, 262, 1914; Jansen, l.c. 267, 1953.

Dimeria fuscescens var. barbata Ridl. Flor. Mal. 5, 191, 1925.

Rare in the far north.

71. **Dimeria glabra** Ridl. Flor. Mal. 5, 192, 1925.

Dimeria ornithopoda var. glabra (Ridl.) Jansen, l.c. 266, 1953.

A rare grass of drying swamps.

72. **Dimeria kurzii** Hk. f. Fl. Brit. Ind. *7*, 103, 1897; Ridl. Flor. Mal. *5*, 192, 1925; Bor, l.c. 142, 1960.

Rare in the far north.

73. **Dimeria leptorachis** Hack. Monogr. Androp. 89, 1889; Jansen, l.c. 267, 1953.

Once recorded from Kedah.

74. **Dimeria ornithopoda** Trin. Fund. Agrost. 167, t14, 1820; Ridl. Mat. *3*, 151, 1907; Flor. Mal. *5*, 192, 1925; Burkill, l.c. *1*, 810, 1935; Jansen, l.c. 265, 1953; Henderson, l.c. 346, 1954; Bor, l.c. 142, 1960.

A grass of lawns & dry grassy spots.

75. **Dinebra retroflexa** (Vahl.) Panz., Denkschr. Acad. Moench. 274, t12, 1814; Bor, l.c. 491, 1960.

Cynosurus retroflexus Vahl. Symb. Bot. 2, 20, 1791.

Dinebra arabica Jacq. Fragm. 77, t121, 1809; Ridl. Flor. Mal. 5, 249, 1925.

Seems to have come and gone from Malaya at Port Swettenham.

76. **Dinochloa scandens** (Bl.) O. Ktze. Rev. Gen. Pl. 773, 1891; Merrill, J.S.B.R.A. Soc. *86*, 53, 1921; Holttum, Gard. Bull. Sing. *16*, 84, 1958.

Bambusa scandens Bl. ex Nees in Flora 7, 291, 1824.

Dinochloa tjankorreh Buse ex Miq. Pl. Jungh. 388, 1854; Ridl. Mat. 3, 192, 1907; Flor. Mal. 5, 267, 1925.

A "buloh akar" from the Dindings & Perak.

77. **Dinochloa** sp. Holttum, Gard. Bull. Sing. *16*, 85, 1958.

From Gunong Panti & G. Pulai in Johore.

78. **Diplachne fusca** (Linn.) P. Beauv. Agrost. 80, 163, 1812; Burkill, l.c. *1*, 834, 1935; Bor, l.c. 492, 1960.

Festuca fusca Linn. Sp. Pl. ed. 2, 109, 1762.

Widespread in the north.

79. **Diplachne malayana** C. E. Hubb., Kew Bull. 106, 1934.

Recorded from North Kedah.

80. **Echinochloa colonum** (Linn.) Link. Hort. Berol. 209, 1827; Ridl. Flor. Mal. *5*, 222, 1925; Burkill, l.c. *1*, 888, 1935; Henderson, l.c. 336, 1954; Gilliland, Comm. Mal. Plts. 89, 1958; Bor, l.c. 308, 1960.

Panicum colonum Linn. Syst. Nat. ed. 10, 2, 870, 1759; Ridl. Mat. 3, 132, 1907.

"Padi burong" is associated with padi as a weed of cultivation.

81. **Echinochloa crus-galli** (Linn.) Beauv. Ess. Agrost. 53, 161, 1812; Ridl. Flor. Mal. *5*, 222, 1925; Burkill, l.c. *1*, 889, 1935; Henderson, l.c. 337, 1954; Bor, l.c. 310, 1960.

Panicum crus-galli Linn. Sp. Pl. 56, 1753; Ridl. Mat. 3, 132, 1907.

A sporadic weed like the last and also called "padi burong".

82. **Echinochloa frumentacea** Link. Hort. Berol. *1*, 214, 1827; Bor, l.c. 311, 1960.

Echinochloa crus-galli var. frumentacea Ridl. Flor. Mal. 5, 223, 1925.

Panicum crus-galli var. frumentaceum Ridl. Mat. 3, 132, 133, 1907.

Occasionally cultivated.

83. **Echinochloa stagnina** (Retz.) P. Beauv. Ess. Agrost. 53, 161, 171, 1812; Burkill, l.c. *1*, 888, 1935; Bor, l.c. 311, 1960.

Panicum crus-galli var. stagninum Ridl. Mat. 3, 132, 1907.

Occasional escape from cultivation.

84. **Eleusine corocana** (Linn.) Gaertn. Fruct. & Sem. *1*, 8, t.l.fll, 1788; Ridl. Mat. *3*, 174, 1907; Burkill, l.c. *1*, 916, 1935; Bor, l.c. 492, 1960.

Cynosurus corocanus Linn. Syst. Nat. ed. 10, 2, 875, 1759.

A cultivated plant sometimes found in Malaya, "Ragi".

85. **Eleusine indica** (Linn.) Gaertn. Frust. & Sem. *1*, 8, 1789; Ridl. Mat. *3*, 173, 1907; Flor. Mal. *5*, 250, 1925; Burkill, l.c. *1*, 917, 1935; Bor, l.c. 493, 1960.

Cynosurus indicus Linn. Sp. Pl. 72, 1753.

"Rumput sambau" is a weed of waste land throughout Malaya.

86. **Eragrostis atrovirens** (Desf.) Trin. ex Steud. Nom. Bot. ed. 2, *1*, 562, 1840; Bor, l.c. 503, 1960.

Poa atrovirens Desf. Fl. Atlant. 1, 73, t14, 1798.

Eragrostis elegantula (Kunth) Nees in Steud. Syn. Pl. Glum. 1, 271, 1854 non E. elegantula Nees 1851; Ridl. Mat. 3, 179, 1907; Flor. Mal. 5, 248, 1925; Burkill, l.c. 1, 933, 1935.

Eragrostis chariis Auct. non (Schult.) Hitchc.; Hubb. in Kew Bull. 345, 1949; Jansen, l.c. 269, 1953.

A glaucous perennial which survives periodic inundation.

87. **Eragrostis japonica** (Thunb.) Trin., Mem. Acad. Petersb. ser. 6, *1*, 405, 1831; Bor, l.c. 509, 1960.

Poa japonica Thunb. Flor. Jap. 51, 1784.

Diandrochloa japonica (Thunb.) de Winter in Bothalia 7, 2, 388, 1960.

Eragrostis interrupta Ridl. Mat. 3, 178, 1907; Flor. Mal. 5, 246, 1925; Burkill, l.c. 1, 934, 1935.

A tall grass rare in the north of Malaya.

88. **Eragrostis malayana** Stapf in Hk. f. Flor. Brit. Ind. 7, 317, 1897; Ridl. Mat. *3*, 178, 1907; Flor. Mal. *5*, 247, 1925; Jansen, l.c. 272, 1953; Bor, l.c. 510, 1960.

Resembling E. unioloides but with more numerous florets, widespread in sandy sites.

89. **Eragrostis pilosa** (Linn.) Beauv. Ess. Agrost. 71, 162, 175, 1812; Ridl. Mat. *3*, 179, 1917; Flor. Mal. *5*, 247, 1925; Burkill, l.c. *1*, 934, 1935; Bor, l.c. 512, 1960.

Poa pilosa Linn. Sp. Pl. 68, 1753.

A sporadic ruderal of cultivation.

90. **Eragrostis tenella** (Linn.) Beauv. ex Roem. & Schult. Syst. Veg. *2*, 576, 1817; Ridl. Mat. *3*, 177, 1907; Flor. Mal. *5*, 245; Jansen, l.c. 274, 1953; Bor, l.c. 513, 1960.

Poa tenella Linn. Sp. Pl. 69, 1753.

Eragrostis amabilis Kuntze of Burkill, l.c. 1, 933, 1935.

A common weed throughout Malaya.

91. **Eragrostis unioloides** (Retz.) Nees in Steud. Syn. Pl. Glum. *1*, 264, 1854; Burkill, l.c. *1*, 934, 1935; Bor, l.c. 515, 1960.

Eragrostis amabilis Ridl., non W. & A. in Mat. 3, 178, 1907; Flor. Mal. 5, 246, 1925.

"Rumput kolam padang" is widespread as a weed.

92. **Eremochloa ciliaris** (Linn.) Merr. Philip. J. Sci. *1*, Suppl. *5*, 331, 1906; Bor, l.c. 146, 1960.

Nardus ciliaris Linn. Sp. Pl. 53, 1753.

Eremochloa malayana Ridl. Mat. 3, 155, 1907; Flor. Mal. 5, 196, 1925; Burkill, l.c. 1, 935, 1935.

A rare grass of the north of Malaya.

93. **Eriachne pallescens** R. Br. Prodr. Fl. Nov. Holl. 184, 1810; Ridl. Mat. *3*, 172, 1907; Flor. Mal. *5*, 240, 1925; Burkill, l.c. *1*, 936, 1935; Henderson, l.c. 316, 1954; Bor, l.c. 479, 1960.

Common in dry exposed places.

94. **Eriochloa procera** (Retz.) Hubb., Kew Bull. 256, 1930; Jansen, l.c. 276, 1953; Bor, l.c. 312, 1960.

Agrostis procera Retz. Obs. Bot. 4, 19, 1786.

Eriochloa polystachya Ridl. non H.B.K. in Mat. 3, 127, 1907.

Eriochloa annulata (Fluegge) Kunth, Rev. Gram. 1, 30, 1829; Ridl. Flor. Mal. 5, 223, 1925; Henderson, l.c. 325, 1954.

Eriochloa ramosa (Retz.) Ktze; Burkill, l.c. 1, 938, 1935.

Waste ground throughout Malaya.

95. **Eulalia leschenaultiana** (Dcne) Ohwi, Bull. Tokyo Sci. Mus. *18*, 2, 1947; Jansen, l.c. 277, 1953; Bor, l.c. 155, 1960.

Andropogon leschenaultianus Dcne, Herb. Timor. Descr. 29, 1835.

Recorded from the Peninsula fide Jansen.

96. **Eulalia milsumi** Ridl. Flor. Mal. *5*, 196, t222, 1925; Jansen, l.c. 277, 1953.

Local from Klang Gates, Selangor.

97. **Eulalia ridleyi** (Hack.) Stapf. ex Ridl. Flor. Mal. *5*, 197, 1925; Jansen, l.c. 277, 1953.

Pollinia ridleyi Hack. Oestr. Bot. Zeitsch. 40, 1, 7, 1891; Ridl. Mat. 3, 155, 1907.

Sand dunes of the East Coast of Malaya.

98. **Eulalia speciosa** (Debeaux) O. Ktze. Rev. Gen. Pl. *2*, 775, 1891; Bor, l.c. 157, 1960.

Erianthus speciosus Debeaux, Act. Soc. Linn. Bordeaux 32, 53, 1878.

Eulalia lanipes Ridl. J. F.M.S. Mus. 7, 56, 1916; Flor. Mal. 5, 196, 1925; Jansen, l.c. 277, 1953.

Recorded from Kedah Peak.

99. **Eustachys tenera** (Presl.) C. E. Hubb. Kew Bull. 25, 1941.

Cynodon tener Presl. Rel. Haenk. 1, 291, 1830.

Chloris ridleyi Hack. Oestr. Bot. Zeitsch. 52, 237, 1902.

Penang, Kelantan, Pahang, Singapore.

100. **Garnotia stricta** Brogn. in Duperrey, Voy. Coq. Bot. 133, t21, 1831; Ridl. Flor. Mal. *5*, 242, 1925; Burkill, l.c. *1*, 1061, 1935; Bor, l.c. 569, 1960.

Usually at high altitudes in the mountains.

101. **Gigantochloa apus** (Schult.) Kurz, Tijds. Ned. Ind. 27, 226, 1864; Holttum, Gard. Bull. Sing. *16*, 112, 1958.

Bambusa apus Schult. Syst. Veg. 7, 1353, 1830.

Cultivated in Singapore and at Serdang, Selangor.

102. **Gigantochloa hasskarliana** (Kurz.) Backer ex Heyne Nutt. Plant. Ned. Ind. ed. 2, *1*, 299, 1927; Holttum, l.c. 118, 1958.

Schizostachyum hasskarlianum Kurz, Indian Forester 1, 353, 1876.

Oxytenanthera nigrociliata Munro non Buse, Trans. Linn. Soc. 26, 128, 1868; Ridl. Mat. 3, 189, 1917; Flor. Mal. 5, 263, 1925; Burkill, l.c. 2, 1617, 1935.

Cultivated for tall hedges in Singapore and Penang.

103. **Gigantochloa latifolia** Ridl. Flor. Mal. *5*, 262, 1925; Holttum, l.c. 132, 1958.

Oxytenanthera auriculata Prain ex Ridl. Flor. Mal. 5, 264, 1925.

var. alba Holttum, l.c. 133, 1958.

var. efimbriata Holttum, l.c. 133, 1958.

Recorded from Kedah & Pahang & cultivated in Singapore.

104. **Gigantochloa levis** (Blanco) Merr. Am. J. Bot. *3*, 1916; Holttum, l.c. 119, 1958.

Bambusa levis Blanco, Flor. Filip. ed. 1, 272, 1837.

Gigantochloa verticillata Munro non Willd. ex Ridl. Mat. 3, 186, 1907; Flor. Mal. 5, 260, 1925. p.p.; Burkill, l.c. 1, 1019, 1935.

Bamboo shoots are prepared from this widely cultivated species.

105. **Gigantochloa ligulata** Gamble, Ann. R. Bot. Gard. Calc. *7*, 67, pl. 58, 1896; Ridl. Mat. *3*, 188, 1907; Flor. Mal. *5*, 262, 1925; Burkill, l.c. *1*, 1069, 1935; Holttum, l.c. 129, 1958.

A species with many forms from the northern States of Malaya.

106. **Gigantochloa maxima** Kurz, Ind. Flor. 1, 343, 1876; Holttum, 114, 1958.

Gigantochloa verticillata Munro non Willd. in Ridl. Mat. 3, 1907; Flor. Mal. 5, 260, 1925. p.p.; Burkill, l.c. 1, 1069, 1935.

var. minor Holttum, l.c. 116, 1958.

var. viridis Holttum, l.c. 115, 1958.

A bamboo valued for its strength as a structural material.

107. **Gigantochloa ridleyi** Holttum, Gard. Bull. Sing. *15*, 275, 1956; l.c. 127, 1958.

Cultivated in Province Wellesley and Singapore.

108. **Gigantochloa scortechinii** Gamble, Ann. R. Bot. Gard. Calc. *7*, 62, pl. 53, 1896; Ridl. Mat. *3*, 186, 1907; Flor. Mal. *5*, 261, 1925; Burkill, l.c. *1*, 1069, 1935; Holttum, l.c. 122, 1958.

var. albovestita Holttum l.c. 124, 1958.

The "buloh aur" grows in the north and along the Main Range.

109. **Gigantochloa wrayi** Gamble, l.c. 64, pl. 55, 1896; Ridl. Mat. *3*, 187, 1907; Flor. Mal. *5*, 261, 1925; Burkill, l.c. *1*, 1070, 1935; Holttum, l.c. 124, 1958.

Gigantochloa kurzii Gamble, l.c. 65, 1896; Ridl. Mat. 3, 187, 1907; Flor. Mal. 5, 261, 1925 quoad spec. malay.

"Buloh beti" is native to the northern States.

110. **Haekelochloa granularis** (Linn.) O. Ktze Rev. Gen. Pl. *2*, 776, 1891; Bor, l.c. 159, 1960.

Cenchrus granularis Linn. Mant. 2, 575, 1771.

Manisuris granularis (Linn.) Linn. f. Nov. Gram. Gen. 40, 1779; Ridl. Mat. 3, 163, 1907; Flor. Mal. 5, 205, 1925; Burkill, l.c. 2, 1422, 1935.

A rare weed of sandy places.

111. **Hemarthria vaginata** Buse in Miq. Plant. Jungh. 354, 1854.

Rottboellia protensa Ridl. non Hack, Mat. 3, 163, 1907.

Hemarthria protensa Ridl. non Steud., Flor. Mal. 5, 205, 1925.

A rare grass recorded in Kedah and Kelantan.

112. **Heteropogon contortus** (Linn.) Beauv. ex Roem. & Schult. Syst. Veg. *2*, 836, 1817; Ridl. Flor. Mal. *5*, 213, 1925; Burkill, l.c. *1*, 1143, 1935; Bor, l.c. 163, 1960.

Andropogon contortus Linn. Sp. Pl. 1045, 1753; Ridl. Mat. 3, 167, 1907.

Open sandy places of coastal areas.

113. **Hymenachne aurita** (Presl.) Backer in Heyne, Nutt. Pl. Ned. Ind. ed. 2, *1*, 197, 1922.

Panicum auritum Presl. ex Nees Agrost. Bras. 116, 1829; Ridl. Mat. 3, 135, 1907; Flor. Mal. 5, 226, 1925; Burkill, l.c. 2, 1655, 1935; Henderson, l.c. 382, 1954.

A tall grass of riverbanks.

114. **Hymenachne pseudointerrupta** C. Muell., Bot. Zeit. *19*, 333, 1861; Bor, l.c. 313, 1960.

Panicum amplexicaule Henderson, l.c. 529, 1954.

Panicum myuros Ridl. non H.B.K., Mat. 3, 135, 1907.

Hymenachne myuros Ridl. non Beauv., Flor. Mal. 5, 230, 1925; Burkill, l.c. 1, 1214, 1935.

"Rumput kumpai" is a widespread grass of open swamps.

115. **Ichnanthus vicinus** (F. M. Bailey) Merr. Enum. Philip. *1*, 70, 1923; Burkill, l.c. *2*, 1221, 1935; Bor, l.c. 314, 1960.

Panicum vicinum F. M. Bailey, Syn. Queens. Pl. Suppl. 3, 82, 1890.

Ichnanthus pallens Munro non Sw. in Ridl. Mat. 3, 142, 1907; Flor. Mal. 5, 231, 1925.

A widespread forest grass.

116. **Imperata cylindrica** (Linn.) Beauv. Ess. Agrost. 165, 1812; Burkill, l.c. *2*, 1228, 1935; Henderson, l.c. 34, 1954; Gilliland, Comm. Mal. Plts. 121, 1958; Bor, l.c. 169, 1960.

Lagurus cylindricus Linn. Syst. Nat. ed. 10, 878, 1759.

Imperata arundinacea Cyrillo, Pl. Rar. Neap, 2, 27, 1788; Ridl. Mat. 3, 152, 1907; Flor. Mal. 5, 193, 1925.

Lalang occurs wherever Man misuses land. Its valuable role in holding soil against erosion should not be overlooked however.

117. **Imperata conferta** (J. S. Presl.) Ohwi, Bot. Mag. Tokyo, *55*, 549, 1941; Bor, l.c. 169, 1960.

Saccharum confertum J.S. Presl. ex C.B. Presl. Rel. Haenk 1, 346, 1830.

Imperata exaltata Ridl. non Brogn. Mat. 3, 152, 1907; Flor. Mal. 5, 193, 1925.

Imperata contracta Hitchc.; Burkill, l.c. 2, 1228, 1935; Henderson, l.c. 343, 1954.

Larger than Lalang and not so common.

118. **Isachne albens** Trin. Sp. Gram. *1* t. 85, 1826; Ridl. Mat. *3*, 128, 1907; Flor. Mal. *5*, 237, 1925; Burkill, l.c. *2*, 1252, 1935; Henderson, l.c. 326, 1954; Jansen, l.c. 280, 1953; Bor, l.c. 579, 1960.

A grass of the mountains & hill stations.

119. **Isachne confusa** Ohwi, Bull. Tokyo Sci., Mus. 18, 14, 1947; Jansen, l.c. 282, 1953; Bor, l.c. 578, 1960.

Isachne rigida Nees, Ridl. Flor. Mal. 5, 238, 1925; Burkill, l.c. 2, 1253, 1935; Henderson, l.c. 326, 1954.

Occurs in the northern States.

120. **Isachne globosa** (Thunb.) O. Ktze Rev. Gen. Pl. *2*, 778, 1891; Burkill, l.c. *2*, 1252, 1935; Jansen, l.c. 282, 1953; Bor, l.c. 580, 1960.

Milium globosum Thunb. Flor. Jap. 49, 1784.

Isachne australis R. Br. Prodr. Fl. N. Holl. 196, 1810; Ridl. Mat. 3, 129, 1907; Flor. Mal. 5, 239, 1925.

Widespread on the margins of swamps.

121. **Isachne kinabaluensis** Merr. J.S.B.R.A. Soc. 76, 1917; Jansen, l.c. 283, 1953.

Isachne javana Ridl. non Nees, Mat. 3, 128, 1907; Flor. Mal. 5, 238, 1925.

A mountain species from Gunong Ledang in Johore northwards.

122. **Isachne kunthiana** (Wight & Arn. ex Steud.) Miq. Fl. Ind. Bot. *3*, 460, 1857; Jansen, l.c. 285, 1953; Bor, l.c. 581, 1960.

Panicum kunthianum Wight & Arn. ex Steud., Syn. Pl. Glum. 1, 96, 1854.

Isachne semitalis Ridl. Flor. Mal. 5, 237, 1925.

From Singapore northwards.

123. **Isachne lankawiensis** Jansen, Reinwardtia *2*, 284, 1953.
From limestone in the Lankawi islands.

124. **Isachne miliacea** Roth. Nov. Sp. Pl. 58, 1821; Ridl. Mat. *3*, 129, 1907; Flor. Mal. *5*, 239, 1925; Burkill, l.c. *2*, 1253, 1935; Jansen, l.c. 285, 1953; Bor, l.c. 522, 1960.
From Singapore northwards.

125. **Isachne saxicola** Ridl. Flor. Mal. *5*, 237, 1925; Jansen, l.c. 288, 1953.
Isachne javana var. saxicola Ridl. J. F.M.S. Mus. 6, 196, 1915.
var. *denticulata* Ridl. Flor. Mal. *5*, 237, 1925.
Recorded from Gunong Tahan.

126. **Isachne sylvestris** Ridl. J.S.B.R.A. Soc. *44*, 206, 1905; Mat. *3*, 129, 1907; Flor. Mal. *5*, 238, 1925.
Isachne albens var. sylvestris (Ridl.) Jansen, l.c. 280, 1953.
Rare, recorded from the Dindings.

127. **Ischaemum apricum** Ridl. Flor. Mal. *5*, 203, 1925; Jansen, l.c. 292, 1953.
Recorded from Penang.

128. **Ischaemum fieldingianum** Rendle. J. Bot. *22*, 101, 1894; Ridl. Mat. *3*, 159, 1907; Flor. Mal. *5*, 202, 1925; Jansen, l.c. 298, 1953.
Ischaemum commelynifolium Stapf ex Ridl. Flor. Mal. 5, 202, 1925.
Ischaemum maculatum Stapf ex Ridl. l.c. 202, 1925.
Widespread from Johore swamps to Kedah Peak.

129. **Ischaemum fluviatile** Ridl. Flor. Mal. *5*, 202, 1925.
Recorded from Kelantan.

130. **Ischaemum goebelii** Hack., Oest. Bot. Zeit. *51*, 149, 1901; Bor, l.c. 179, 1960.
Ischaemum imbricatum (Munro) Stapf ex Ridl. Flor. Mal. 5, 200, 1925.
Ischaemum barbatum var. imbricatum (Munro) Jansen, l.c. 294, 1953.
Kedah & Perlis & recorded as a weed in Singapore.

131. **Ischaemum indicum** (Houtt.) Merr., J. Arn. Arb. *19*, 320, 1938; Bor, l.c. 180, 1960.
Phleum indicum Houtt. Nat. Hist. 11, 13, 198, t.90 f.2, 1782.
Ischaemum ciliare Retz. Obs. Bot. 6, 36, 1791; Ridl. Mat. 3, 160, 1907.

Ischaemum aristatum Ridl. non Linn. Flor. Mal. 5, 203, 1925; Burkill, l.c. 2, 1253; Henderson, l.c. 351, 1954.

Ischaemum barbatum Retz. Obs. Bot. 6, 35, 1791; Ohwi, Act. Phyt. Geobot. 11, 175, 1942; Jansen, l.c. 293, 1953.

Common, especially in the north.

132. **Ischaemum laeve** Ridl. J.S.B.R.A. Soc. *14*, 217, 1905; Mat. *3*, 158, 1907; Flor. Mal. *5*, 201, 1925.

Recorded from Singapore.

133. **Ischaemum macrurum** Stapf ex Ridl. Flor. Mal. *5*, 203, 1925; Jansen, l.c. 298, 1953.

Singapore and Negri Sembilan.

134. **Ischaemum magnum** Rendle, J. Bot. *32*, 102, 1894; Ridl. Mat. *3*, 158, 1907; Flor. Mal. *5*, 200, 1925; Jansen, l.c. 299, 1953; Bor, l.c. 182, 1960.

The locus classicus is Singapore and it belongs to the south.

135. **Ischaemum muticum** Linn. Sp. Pl. 1049, 1753; Ridl. Mat. *3*, 159, 1907; Flor. Mal. *5*, 201, 1925; Henderson, l.c. 350, 1954; Bor, l.c. 183, 1960.

Common throughout Malaya especially near the sea.

136. **Ischaemum polystachyum** Presl. Rel. Haenk. 1, 328, 1830; Jansen, l.c. 300, 1953.

Ischaemum plumosulum Stapf ex Ridl. Flor. Mal. 5, 201, 1925.

Pollinia rupestris Ridl. J.S.B.R.A. Soc. 44, 208, 1905; Mat. 3, 156, 1907; Flor. Mal. 5, 199, 1925.

Recorded from Penang & Johore west coast.

137. **Ischaemum rugosum** Salisb. lc. Stirp. Rar. 1, t. 1, 1791; Ridl. Mat. *3*, 157, 1907; Flor. Mal. *5*, 200, 1925; Henderson, l.c. 350, 1954; Bor, l.c. 184, 1960.

From Singapore northwards.

138. **Ischaemum trimorense** Kunth. Rev. Gram. 369, t.98, 1829; Ridl; Mat. *3*, 160, 1907; Flor. Mal. *5*, 203, 1925; Burkill, l.c. *2*, 1253, 1935; Jansen, l.c. 301, 1953; Henderson, l.c. 351, 1954; Bor, l.c. 185, 1960.

Common in open places.

139. **Leersia hexandra** Swartz, Prod. Veg. Ind. Occ. 21, 1778, Ridl. Mat. *3*, 148, 1907; Flor. Mal. *5*, 253, 1925; Burkill, l.c. *2*, 1327, 1935; Henderson, l.c. 320, 1954; Bor, l.c. 599, 1960.

Rice-grass occurs in swamps everywhere.

140. **Leptaspis urceolata** (Roxb.) R. Br., Benn. Pl. Jav. Rar. 23, t.6, 1838; Ridl. Mat. *3*, 150, 1907; Flor. Mal. *5*, 255, 1925; Burkill, l.c. *2*, 1333, 1935; Jansen, l.c. 304, 1953; Henderson, l.c. 307, 1954; Bor, l.c. 617, 1960.

Pharus urceolatus Roxb. Fl. Ind. ed. 2, 3, 611, 1832.

A widespread forest grass.

141. **Leptochloa chinensis** (Linn.) Nees, Syll. Ratisb. *1*, 4, 1828; Ridl. Mat. *3*, 175, 1907; Flor. Mal. *5*, 249, 1925; Burkill, l.c. *2*, 1333, 1935; Bor, l.c. 516, 1960.

Poa chinensis Linn. Sp. Pl. 69, 1753.

A weed of cultivation throughout Malaya.

142. **Leptochloa panicea** (Retz.) Ohwi, Bot. Mag. Tokyo, 55, 311, 1941; Bor, l.c. 517, 1960.

Poa panicea Retz. Obs. Bot. 11, 1783.

Leptochloa polystachya Ridl. non Kunth, Flor. Mal. 5, 248, 1925; Burkill, l.c. 2, 1333, 1935.

A weed of rice fields in the north.

143. **Lepturus repens** (G. Forst.) R. Br. Prodr. Fl. N. Holl. 207, 1810; Ridl. Mat. *3*, 182, 1907; Flor. Mal. *5*, 254, 1925; Bor, l.c. 585, 1960.

Rottboellia repens G. Forst. Prodr. 9, 1786.

Recorded from the east coast.

144. **Lophatherum gracile** Brongn. in Duperr. Bot. Voy. Coq. 50, t.8, 1831; Ridl. Mat. *3*, 181, 1907; Flor. Mal. *5*, 253, 1925; Burkill, l.c. *2*, 1364, 1935; Bor, l.c. 460, 1960.

A forest grass common throughout.

145. **Massia triseta** (Nees) Balansa in Morot, J. Bot. Paris, *4*, 165, 1890, Bor, l.c. 479, 1960.

Eriachne triseta Nees ex Steud. Syn. Pl. Gl. 237, 1854; Ridl. Mat. 3, 172, 1907; Flor. Mal. 5, 240, 1925; Henderson, l.c. 316, 1954.

A wiry perennial from Malacca to Pahang and north.

146. **Microstegium ciliatum** (Trin.) A. Camus, Ann. Soc. Linn. Lyon, *68*, 201, 1921; Jansen, l.c. 305, 1953; Bor, l.c. 193, 1960.

Pollinia ciliata Trin. Mem. Acad. Petersb. ser. 6, 2, 306, 1833; Ridl. Mat. 3, 156, 1907.

P. ciliata var. glabrata Ridl. Flor. Mal. 5, 198, 1925.

Pollinia gracilis Ridl. Mat. 3, 156, 1907.

Forest margins from Selangor northwards.

147. **Microstegium geniculatum** (Hayata) Honda, Mon. Poac. Japon. 410, 1930; Jansen, l.c. 306, 1953.

Pollinia geniculata Hayata, Ic. Pl. Formos. 7, 73, 1918.

Pollinia hendersonii C. E. Hubb., Kew Bull. 79, 1927.

Microstegium hendersonii C. E. Hubb. in Hutchins, Fam. Fl. Pl. 2, 227, 1934; Burkill, l.c. 2, 1786, 1935.

A rare mountain species.

148. **Microstegium nudum** (Trin.) A. Camus Ann. Soc. Linn. Lyon, *68*, 201, 1921; Bor, l.c. 194, 1960.

Once collected from Fraser's Hill, Pahang.

149. **Microstegium vagans** (Nees ex Steud.) A. Camus l.c. 200, 1921; Bor, l.c. 195, 1960.

Pollinia vagans Nees ex Steud. Syn. Pl. Glum. 1, 410, 1855.

Pollinia grata (Nees et Meyen) Hack. Monog. Phan. 6, 175, 1889; Ridl. Mat. 3, 156, 1907; Flor. Mal. 5, 198, 1925; Burkill, l.c. 2, 1786, 1935.

Ephebopogon gratus Nees et Meyen ex Steud. Nom. ed. 2, 1, 556, 1840.

Recorded from Penang and to the north.

150. **Miscanthus sinensis** Anderss. Oefvers. Kon. Vet-Akad. Förh. 165, 1855.

Miscanthus japonicus Ridl. non Anderss., Flor. Mal. 5, 194, 1925; Burkill, l.c. 2, 1479, 1935.

Recorded only from Perak.

151. **Mnesithea cancellata** Ridl. Flor. Mal. *5*, 206, 1925.

Rottboellia cancellata Ridl. J.S.B.R.A. Soc. 59, 288, 1920.

Rare in the far north of Malaya.

152. **Mnesithea geminata** (Hack.) Ridl. Mat. 3, 163, 1907; Flor. Mal. *5*, 206, 1925; Jansen, l.c. 309, 1953.

Rottboellia geminata Hack. Oesterr. Bot. Zeitschr. 41, 48, 1891.

Sandy places on the east coast.

153. **Mnesithea mollicoma** (Hance) A. Camus, Bull. Mus. Hist. Nat. Paris, *25*, 57, 1919; Jansen, l.c. 308, 1953.

Rottboellia mollicoma Hance, J. Bot. 9, 134, 1871.

Mnesithea pubescens Ridl. J.S.B.R.A. Soc. 44, 207, 1905; Mat. 3, 163, 1907; Flor. Mal. 5, 206, 1925; Burkill, l.c. 2, 1484, 1935.

Recorded from Johore.

154. **Myriostachya wightiana** (Nees) Hk. f. Flor. Brit. Ind. 7, 327, 1897; Burkill, l.c. 2, 1521, 1935; Jansen, l.c. 310, 1953; Bor, l.c. 518, 1960.

Leptochloa wightiana Nees ex Steud. Syn. Pl. Glum. 1, 209, 1854.

Myriostachya wightiana var. longispicula Hk. f. l.c. 328, 1897; Ridl. Mat. 3, 180, 1907; Flor. Mal. 5, 245, 1925.

A grass of estuarine muds from Penang northwards.

155. **Neyraudia reynaudiana** (Kunth) Keng ex Hitchc. Am. J. Bot. *21*, 131, 1934; Bor, l.c. 518, 1960.

Arundo reynaudiana Kunth. Rev. Gram. 2, 275, t49, 1830.

Neyraudia madagascariensis (Kunth.) Hk. f., Ridl. Mat. 3, 176, 1907.

Triraphis madagascariensis Stapf ex Ridl. Flor. Mal. 5, 251, 1925; Burkill, l.c. 2, 2186, 1935; Henderson, l.c. 310, 1954.

A reed recorded as far south as Seremban & Malacca.

156. **Oplismenus burmannii** (Retz.) Beauv. Ess. Agrost. 54, 168, 169, 1812; Ridl. Mat. *3*, 145, 1907; Flor. Mal. *5*, 221, 1925; Burkill, l.c. *2*, 1585, 1935; Jansen, l.c. 312, 1953; Henderson, l.c. 336, 1954; Bor, l.c. 317, 1960.

Recorded from Penang and Kedah.

157. **Oplismenus compositus** (Linn.) Beauv. Ess. Agrost. 54, 168, 169, 1812; Ridl. Mat. *3*, 145, 1907; Flor. Mal. *5*, 221, 1925; Burkill, l.c. *2*, 1586, 1935; Jansen, l.c. 311, 1953; Henderson, l.c. 335, 1954; Bor, l.c. 318, 1960.

Panicum compositum Linn. Sp. Pl. 57, 1753.

A grass of dry rocky spots in shade, widespread in Malaya.

158. **Oryza granulata** Nees et Arn. ex Hk. f. Flor. Brit. Ind. *7*, 93, 1896; Bor, l.c. 604, 1960.

Recorded from a river bank in northern Perak.

159. **Oryza minuta** Presl. Rel. Haenk. *1*, 208, 1830; Burkill, l.c. *2*, 1593, 1935; Henderson, l.c. 321, 1954; Bor, l.c. 605, 1960.

Oryza latifolia Ridl. non Desv. Mat. 3, 148, 1907; Flor. Mal. 5, 252, 1925.

"Padi burong" or wild rice.

160. **Oryza rufipogon** Griff. Notul. *3*, 5, 1851; Bor, l.c. 605, 1960.

Oryza fatua var. longe-aristata Ridl. Flor. Mal. 5, 1925.

Oryza fatua of Burkill, l.c. 2, 1593, 1935.

Also "Padi burong."

161. **Oryza ridleyi** Hk. f. Flor. Brit. Ind. 7, 93, 1897; Ridl. Mat. *3*, 148, 1907; Flor. Mal. *5*, 252, 1925; Burkill, l.c. *2*, 1593, 1935; Jansen, l.c. 312, 1953; Henderson, l.c. 321, 1954; Bor, l.c. 605, 1960.

On riverbanks throughout Malaya.

162. **Ottochloa nodosa** (Kunth) Dandy, J. Bot. *69*, 55, 1931; Bor, l.c. 318, 1960.

Panicum nodosum Kunth, Rev. Gram. 1, 97, 1833; Henderson, l.c. 332, 1954.

Hemigymnia multinodis Stapf, Ridl. Flor. Mal. 5, 228, 1925; Burkill, 1, 1138, 1935.

Hemigymnia fusca Ridl. Flor. Mal. 5, 228, 1925; Burkill, l.c.

A perennial grass of swamps.

163. **Panicum austro-asiaticum** Ohwi, Act. Phytotax. Geobot. *2*, 45, 1942; Jansen, l.c. 314, 1953; Bor, l.c. 324, 1960.

Panicum humile Nees ex Steud. non Thunb., in Syn. Pl. Glum. 84, 1854; Ridl. Mat. 3, 135, 1907; Flor. Mal. 5, 224, 1925; Burkill, l.c. 2, 1655, 1935.

A grass of northern Malaya.

164. **Panicum brevifolium** Linn. Sp. Pl. 59, 1753; Burkill, l.c. *2*, 1655, 1935; Jansen, l.c. 315, 1953; Henderson, l.c. 329, 1954, Bor, l.c. 324, 1960.

Panicum ovalifolium Poir in Lamk. Encyl. Bot. Suppl. 4, 279, 1816; Ridl. Mat. 3, 141, 1907; Flor. Mal. 5, 227, 1925.

Common throughout Malaya.

var. *hirtifolium* (Ridl.) Jansen, l.c. 315, 1953.

Panicum hirtifolium Ridl. Mat. 3, 141, 1907; Flor. Mal. 5, 228, 1925.

Rare in Selangor.

165. **Panicum cambogiense** Balansa in Morot, J. de Bot. *4*, 142, 1890; Bor, l.c. 325, 1960.

Panicum luzonense Ridl. non Presl. Mat. 3, 136, 1907.

Panicum caesium Ridl. non Nees, Flor. Mal. 5, 225, 1925.

Panicum tuberculatum Burkill non Presl. l.c. 2, 1658, 1935.

Widespread in Malaya.

166. **Panicum elegantissimum** Hk. f. Flor. Brit. Ind. *7*, 52, 1897; Ridl. Mat. *3*, 139, 1907; Flor. Mal. *5*, 226, 1925; Bor, l.c. 325, 1960.

A rare grass from Perak.

167. **Panicum maximum** Jacq. Coll. Bot. *1*, 76, 1786; Ridl. Mat. *3*, 140, 1907; Flor. Mal. *5*, 1925; Burkill, l.c. *2*, 1656, 1935; Bor, l.c. 327, 1960.

Guinea grass is widely cultivated as fodder.

168. **Panicum montanum** Roxb. Fl. Ind. *1*, 313, 1820; Ridl. Mat. *3*, 139, 1907; Flor. Mal. *5*, 227, 1925; Burkill, l.c. *2*, 1657, 1935; Jansen, l.c. 306, 1953; Bor, l.c. 329, 1960.

Recorded from Selangor and northwards.

169. **Panicum paludosum** Roxb. Flor. Ind. *1*, 310, 1820; Bor, l.c. 329, 1960.

Panicum proliferum Ridl. non Lam., Mat. 3, 139, 1907; Flor. Mal. 5, 225, 1925; Burkill, l.c. 2, 1657, 1935.

A floating grass of pools & swamps, rare.

170. **Panicum perakense** (Hk. f.) Merr. Philip. J. Sci. *11C*, 52, 1916; Ridl. Flor. Mal. *5*, 226, 1925; Jansen, l.c. 317, 1953.

Panicum humidorum var.? perakense Hk. f. Fl. Br. Ind. 7, 54, 1897; Ridl. Mat. 3, 137, 1907.

A rare grass recorded from Johore northwards.

171. **Panicum repens** Linn. Sp. Pl. ed. 2, 87, 1762; Ridl. Mat *3*, 139, 1907; Flor. Mal. *5*, 225, 1925; Burkill, l.c. *2*, 1657, 1935; Henderson, l.c. 329, 1954; Bor. l.c. 330, 1960.

Widespread in Malaya.

172. **Panicum sarmentosum** Roxb. Fl. Ind. *1*, 308, 1820; Ridl. Mat. *3*, 140, 1907; Flor. Mal. *5*, 227, 1925; Henderson, l.c. 332, 1954; Bor, l.c. 330, 1960.

"Rumput jangut Ali" is widespread throughout Malaya.

173. **Paspalidium punctatum** (Burm.) A. Camus, Fl. Gen. Indochin. *7*, 419, 1922; Ridl. Flor. Mal. *5*, 218, 1925; Burkill, l.c. *2*,1672, 1935; Jansen, l.c. 318, 1953; Bor, l.c. 333, 1960.

Panicum punctatum Burm. Fl. Ind. 26, 1768; Ridl. Mat. 3, 132, 1907.

Rare, recorded from Johore.

174. **Paspalum cartilagineum** Presl. Rel. Haenk. *1*, 216, 1830; Jansen, l.c. 320, 1953; Bor, l.c. 335, 1960.

Recorded from Pahang.

175. **Paspalum commersonii** Lam. Ill. *1*, 175, t43, 1791; Ridl. Flor. Mal. *5*, 218, 1925; Jansen, l.c. 319, 1953; Bor, l.c. 335, 1960.

Paspalum scrobiculatum Ridl. non Linn. Mat. 3, 213, 1907; Burkill, l.c. 2, 1674, 1935; Henderson, l.c. 340, 1954.

Paspalum orbiculare Ridl. non Forst., Flor. Mal. 5, 217, 1925.

P. commersonii var. hirsutum Jansen, l.c. 319, 1953.

A weed widespread in Malaya.

176. **Paspalum conjugatum** Berg. Act. Helvet. Phys. Math. *7*, 129, t8, 1762; Ridl. Mat. *3*, 124, 1907; Flor. Mal. *5*, 218, 1925; Burkill, l.c. *2*, 1673, 1935; Henderson, l.c. 339, 1954; Bor, l.c. 336, 1960.

"Rumput kerbau" is widespread in Malaya.

177. **Paspalum longifolium** Roxb. Flor. Ind. *1*, 280, 1820; Ridl. Flor. Mal. *5*, 217, 1925; Bor, l.c. 339, 1960.

Paspalum platycoleum Ridl. Flor. Mal. 5, 217, 1925.

Widespread in Malaya.

178. **Paspalum vaginatum** Sw. Prodr. Fl. Ind. Occ. 21, 1788; Burkill, l.c. *2*, 1675, 1935; (cf. Jansen l.c. 321, 1953); Henderson, l.c. 339, 1954; Bor, l.c. 341, 1960.

Paspalum distichum Ridl. non Linn. Mat. 3, 124, 1907; Mal. 5, 218, 1925.

A grass of saline mud around the coasts.

179. **Pennisetum purpureum** Schum. Beskr. Guin. Pl. 44, 1827; Burkill, l.c. *2*, 1688, 1935; Henderson, l.c. 325, 1954; Bor, l.c. 348, 1960.

"Napier fodder" is well established in many places in Malaya.

180. **Pennisetum clandestinum** Hochst. ex Chiov. Ann. Ist. Bot. Roma *8*, 41, t5 f2, 1903; Burkill, l.c. *2*, 1687, 1935; Henderson, l.c. 325, 1954; Bor, l.c. 344, 1960.

Kikuyu grass is now established on hill stations in Malaya.

181. **Perotis indica** (Linn.) O. Ktze. Rev. Gen. Pl. 787, 1891; Burkill, l.c. *2*, 1696, 1935; Henderson, l.c. 319, 1954; Bor, l.c. 611, 1960.

Anthoxanthum indicum Linn. Sp. Pl. 28, 1753.

Perotis latifolia Ait. Hort. Kew 1, 85, 1789; Ridl. Mat. 3, 149, 1907; Flor. Mal. 5, 243, 1925.

"Rumput ekor kuching" is a common grass of maritime sandy areas.

182. **Phragmites karka** (Retz.) Trin. ex Steud. Nom. Bot. ed. 2, *2*, 324, 1841; Ridl. Mat. *3*, 175, 1907; Bor, l.c. 416, 1960.

Arundo karka Retz. Obs. Bot. 4, 21, 1786.

Phragmites communis Ridl. non Trin. Flor. Mal. 5, 240, 1925; Burkill, l.c. 2, 1715, 1935, Henderson, l.c. 309, 1954.

"Tebu salah" is the common reed of rivers & tin tailings.

183. **Poa annua** Linn. Sp. Pl. 68, 1753, Ridl. Flor. Mal. *5*, 254, 1925; Jansen, l.c. 322, 1953; Henderson, l.c. 311, 1954; Bor, l.c. 555, 1960.

A European weed now established at hill stations.

184. **Pogonatherum paniceum** (Lam.) Hack. Allg. Bot. Zeit. *12*, 178, 1906; Jansen, l.c. 333, 1953; Bor, l.c. 202, 1960.

Saccharum paniceum Lamk. Encycl. Meth. Bot. 1, 595, 1785.

Pogonatherum saccharoideum var. monandra Hack. Monog. Androp. 193, 1889; Ridl. Mat. 3, 154, 1907; Flor. Mal. 5, 195, 1925; Henderson, l.c. 348, 1954.

Pogonatherum crinitum Trin. of Burkill, l.c. 2, 1780, 1935.

From Johore northwards "Bamboo grass" occurs in mountain streams.

185. **Polytrias amaura** (Buse) O. Ktze. Rev. Gen. Pl. 788, 1891; Henderson, l.c. 348, 1954; Bor, l.c. 202, 1960.

Andropogon amaurus Buse in Miq. Pl. Junghn. 360, 1854.

Pollinia praemorsa (Nees) Hack. Monog. Androp, 189, 1889; Ridl. Mat. 3, 164, 1907.

Eulalia praemorsa (Nees) Stapf ex Ridl. Flor. Mal. 5, 197, 1925; Burkill, l.c. 1, 975, 1935.

Recorded from Singapore, Malacca, Kuala Lumpur and Penang.

186. **Pseudechinolaena polystachya** (H.B.K.) Stapf. Flor. Trop. Agr. *9*, 495, 1919; Ridl. Flor. Mal. *5*, 221, 1925; Burkill, l.c. *2*, 1812, 1935; Bor, l.c. 352, 1960.

Echinolaena polystachya H.B.K. Nov. Gen. & Sp. 1, 119, 1816.

Rare in the mountains in Northern Malaya.

187. **Pseudoraphis spinescens** (R. Br.) Vickery, Proc. R. S. Queensl. *62*, 7, 69, 1952; Bor; l.c. 353, 1960.

Panicum spinescens R.Br. Prodr. 193, 1810.

Andropogon squarrosus Linn. f. Suppl. 433, 1781; Ridl. Mat. 3, 168, 1907.

Recorded from the Expt. Station, Telok Chengai, Kedah.

188. **Racemobambos setifera** Holttum, Gard. Bull. Sing. *15*, 271, 1956; l.c. 16, 134, 1958.

A rare scrambling bamboo of Johore.

189. **Rhynchelytrum repens** (Willd.) C. E. Hubb. Kew Bull. 110, 1934; Bor, l.c. 355, 1960.

Tricholaena rosea Nees Ind. sem. Hort. Vratisl. 1835; Ridl. Flor. Mal. 5, 235, 1925; Burkill, l.c. 2, 2177, 1935; Henderson, l.c. 325, 1954.

"Red-top" is now well established in many parts of Malaya.

190. **Saccharum arundinaceum** Retz. Obs. Bot. *4*, 14, 1786; Ridl. Mat. *3*, 153, 1907; Flor. Mal. *5*, 193, 1925; Burkill, l.c. *2*, 1924, 1935; Henderson, l.c. 344, 1954; Bor, l.c. 211, 1960.

"Teberau" is a wild sugarcane of sandy river banks in Malaya.

191. **Saccharum spontaneum** Linn. Mant. *2*, 183, 1771; Henderson, l.c. 344, 1954; Bor, l.c. 214, 1960.

The reputed wild parent of sugar cane.

Burkill, l.c. *2*, 1926, 1935, discusses the hybridisation of *S. spontaneum* with the sugarcane *S. officinarum* Linn.

192. **Sacciolepis indica** (Linn.) Chase, Proc. Biol. Soc. Wash. *21*, 8, 1908; Ridl. Flor. Mal. *5*, 232; 1925; Burkill, l.c. *2*, 1940, 1935; Henderson, l.c. 334, 1954; Bor, l.c. 357, 1960.

Aira indica Linn. Sp. Pl. 1753 in "errata".

Panicum indicum Linn. non Mill., Mant. Pl. 2, 184, 1771; Ridl. Mat. 3, 134, 1907.

Sacciolepis angusta Ridl. non Stapf, Flor. Mal. 5, 232, 1925; Burkill, l.c. 2, 1940, 1935.

Sacciolepis turgida Ridl. Flor. Mal. 5, 231, 1925; Burkill, l.c. 2, 1941, 1935.

Widespread in Malaya.

193. **Sacciolepis interrupta** (Willd.) Stapf, Flor. Trop. Afr. *9*, 757, 1920; Bor, l.c. 358, 1960.

Panicum interruptum Willd. Sp. Pl. 1, 341, 1797.

Lankawi islands in padi fields.

194. **Sacciolepis myosuroides** (R. Br.) A. Camus Fl. Gen. Indochin. *7*, 460, 1922; Ridl. Flor. Mal. *5*, 232, 1925; Henderson, l.c. 335, 1954; Bor, l.c. 358, 1960.

Panicum myosuroides R.Br. Prodr. Fl. N. Holl. 189, 1810; Ridl. Mat. 3, 134, 1907.

Throughout Malaya in swampy sites.

195. **Schizachyrium brevifolium** (Sw.) Nees. Agrost. Bras. 332, 1829; Ridl. Flor. Mal. *5*, 210, 1925; Burkill, l.c. *2*, 1975, 1935; Jansen, l.c. 336, 1953; Bor, l.c. 215, 1960.

Andropogon brevifolius Sw. Prodr. Veg. Ind. Occ. 26, 1788; Ridl. Mat. *3*, *165*, *1907*; Henderson, l.c. *346*, *1954*.

Sporadic north of Johore.

196. **Schizachyrium sanguineum** (Retz.) Alst. Suppl. Fl. Ceyl. 334, 1931; Bor, l.c. 216, 1960.

Rottboellia sanguinea Retz. Obs. Bot. 3, 25, 1783.

Schizachyrium semiberbe Nees Agrost. Bras. 336, 1829; Ridl. Flor. Mal. 5, 210, 1925; Burkill, l.c. 2, 1975, 1935.

Rare in the south.

197. **Schizostachyum aciculare** Gamble, Ann. Bot. Gard. Calc. *7*, 117, pl. 104, 1896; Ridl. Mat. *3*, 196, 1907; Flor. Mal. *5*, 270, 1925; Burkill, l.c. *2*, 1976, 1935; Holttum Gard. Bull. Sing. *16*, 39, 1958.

"Buloh padi" is known from Malacca, Negri Sembilan & Selangor.

198. **Schizostachyum brachycladum** Kurz. J. As. Soc. Bengal. *39*, 89 pl. 6, f.2, 1870; Burkill, l.c. *2*, 1977, 1935; Holttum, l.c. 45, 1958; Gilliland, Comm. Mal. Plts. 194, 1958.

Schizostachyum chilianthum Ridl. non Kurz. p.p., Mat. 3, 194, 1907; Flor. Mal. 5, 269, 1925; Burkill, l.c. 2, 1977, 1935.

"Buloh nipis" is widely cultivated in Malaya.

var. auriculatum Holttum, l.c. 47, 1958.

Cultivated in Singapore.

199. **Schizostachyum gracile** (Munro) Holttum, Kew Bull. 206, 1956; l.c. 37, 1958.

Melocanna gracilis Munro, Trans. Linn. Soc. 26, 133, 1868.

Schizostachyum tenue Gamble, Ann. Bot. Gard. Calc. 7, 114, pl. 100, 1896; Ridl. Mat. 3, 194, 1907; Flor. Mal. 5, 268, 1925; Burkill, l.c. 2, 1977, 1935.

Schizostachyum chilianthum Ridl. non Kurz. p.p.

"Buloh rappen" is wild & cultivated in Malaya.

var. erectum Holttum, l.c. 38, 1958.

Malacca and Negri Sembilan.

200. **Schizostachyum grande** Ridl. J.S.B.R.A. Soc. *82*, 204, 1920; Flor. Mal. *5*, 271, 1925; Burkill, l.c. *2*, 1977, 1935; Holttum, l.c. 49, 1958.

"Buloh semeliang" is common in the foothills of the Main Range.

201. **Schizostachyum jaculans** Holttum Kew Bull. 494, 1953; Gard. Bull. Sing. *16*, 40, 1958.

Schizostachyum blumei Gamble non Nees, Ann. Bot. Gard. Calc. 7, 116, pl. 112, 1896; Ridl. Mat. 3, 195, 1907; Flor. Mal. 5, 272, 1925; Burkill, l.c. 2, 1976, 1935.

"Buloh sumpitan" is both wild and cultivated in Malaya.

202. **Schizostachyum longispiculatum** Kurz, J. As. Soc. Bengal, *39*, 89, pl. 6, f.1, 1870; Ridl. Flor. Mal. *5*, 270, 1925; Burkill, l.c. *2*, 1977, 1935; Holttum; l.c. 48, 1958.

Schizostachyum latifolium Gamble, Ann. R. Bot. Gard. Calc. 7, 117, 1896; Ridl. Mat. 3, 196, 1907; Flor. Mal. 5, 270, 1925; Burkill, l.c. 2, 1977, 1935.

Ochlandra ridleyi Gamble, l.c. 127, 1896; Ridl. Mat. 3, 197, 1907; Flor. Mal. 5, 197, 1925; Burkill, l.c. 2, 1569, 1935.

Schizostachyum ridleyi (Gamble) Holttum, Gard. Bull. Sing. 11, 296, 1947.

This bamboo is widespread in Malaya at the edge of forest on river banks.

203. **Schizostachyum terminale** Holttum Gard. Bull. Sing. *15*, 274, 1956; *16*, 51, 1958.

Rare known only from one locality in Kedah.

204. **Schizostachyum zollingeri** Steud. Syn. Pl. Glum. 332, 1854; Ridl. Mat. *3*, 195, 1907; Flor. Mal. *5*, 269, 1925; Burkill, l.c. *2*, 1978, 1935; Holttum, l.c. 42, 1958.

Schizostachyum chilianthum Gamble non Buse p.p. Ann. Bot. Gard. Calc. 7, 115, pl. 101, 1896; Ridl. Mat. 3, 194, 1907; Flor. Mal. 5, 269, 1925; Burkill, l.c. 2, 1977, 1935.

Melocanna zollingeri (Steud.) Munro, Trans. Linn. Soc. 26, 134, 1868.

"Buloh telor" is common north from Selangor.

205. **Sphaerocaryum malaccense** (Trin.) Pilg., Fedde Rep. Sp. Nov. *45*, 2, 1938; Henderson, l.c. 317, 1956; Bor, l.c. 583, 1960.

Panicum malaccense Trin. Gram. Panic. 204, 1826.

Sphaerocaryum elegans Nees ex Steud.; Ridl. Mat. 3, 170, 1907; Flor. Mal. 5, 241, 1925.

A forest path grass from the lowlands of Malaya.

206. **Sclerostachya ridleyi** (Hack.) A. Camus, Ann. Soc. Linn. Lyon. N.S. *71*, 104, 1915; Burkill, l.c. *2*, 1983, 1935.

Saccharum ridleyi Hack. Oestr. Bot. Zeitschr., 41, 6, 1891; Ridl. Mat. 3, 153, 1907.

Sclerostachyum ridleyi Stapf mss. of Ridl. Flor. Mal. 5, 194, 1925.

A local river reed in Pahang.

207. **Setaria italica** (Linn.) Beauv. Ess. Agrost. 51, 170, 178, 1812; Ridl. Mat. *3*, 144, 1907; Flor. Mal. *5*, 234, 1925; Burkill, l.c. *2*, 1999, 1935; Henderson, l.c. 323, 1954; Bor, l.c. 362, 1960.

Panicum italicum Linn. Sp. Pl. 56, 1753.

"Sekoi" is cultivated by nomadic aboriginal tribes.

208. **Setaria pallide-fusca** (Schum.) Stapf & Hubb. Kew Bull. 259, 1930; Jansen, l.c. 339, 1953; Bor, l.c. 363, 1960.

Panicum pallide-fuscum Schum. Beskr. Guin. Pl. 58, 1827.

Setaria glauca Hack., Ridl. J.S.B.R.A. Soc. 23, 23, 1891; Mat. 3, 144, 1907.

Setaria rubiginosa (Steud.) Miq., Ridl. Flor. Mal. 5, 234, 1925.

Setaria geniculata Burkill, non Beauv. l.c. 2, 1999, 1935; Henderson, l.c. 323, 1956.

Common weed of waste ground.

209. **Setaria palmifolia** (Willd.) Stapf, J. Linn. Soc. Bot. *42*, 186, 1914; Burkill, l.c. *2*, 1999, 1935; Henderson, l.c. 324, 1954; Bor, l.c. 363, 1960.

Panicum palmifolium Willd. ex Poir. in Lam. Encycl. Suppl. 4, 282, 1816.

Setaria plicata Cooke, Ridl. Flor. Mal. 5, 235, 1925.

Widespread from N. Johore and northwards.

210. **Sorghum propinquum** (Kunth.) Hitchc. Lingn. Sci. J. *7*, 249, 1931; Bor, l.c. 223, 1960.

Sorghum affine (Presl.) A. Camus. "Stapf mss." of Ridl. Flor. Mal. 5, 195, 1925; Burkill, l.c. 2, 2055,1935.

Riverbanks in the north, a reedlike grass.

211. **Spinifex littoreus** (Burm.) Merr. Philip. J. Sci. *7C*, 229, 1912; Burkill, l.c. *2*, 2066, 1935; Henderson, l.c. 323, 1954; Bor, l.c. 366, 1960.

Stipa littorea Burm. f. Fl. Ind. 29, 1768.

Spinifex squarrosus Linn. Mant. 2, 163, 1771; Ridl. Mat. 3, 147, 1907; Flor. Mal. 5, 236, 1925.

Sandy seashores of the east coast of Malaya.

212. **Spodiopogon velutinus** (Jansen) Holttum Gard. Bull. Sing. *11*, 297, 1947.

Recorded only from Cameron Highlands.

213. **Sporobolus diander** (Retz.) Beauv. Ess. Agrost. 26, 147, 1812; Ridl. Mat. *3*, 170, 1907; Flor. Mal. *5*, 244, 1925; Burkill, l.c. *2*, 2069, 1935; Henderson, l.c. 318, 1954; Bor, l.c. 629, 1960.

Agrostis diandra Retz. Obs. Bot. 5, 19, 1789.

A weed of open sunny dry places in Malaya.

214. **Sporobolus indicus** auctt. non (Linn.) R.Br. ef Bor, l.c. 630, 1960.

Sporobolus indicus Ridl. Mat. 3, 171, 1907; Flor. Mal. 5, 244, 1925; Henderson, l.c. 318, 1954.

Sporobolus berteroanus Hitchc. & Chase; Burkill, l.c. 2, 2069, 1935.

A widespread weed of drier sunnier places in Malaya.

215. **Sporobolus piliferus** (Trin,) Kunth, Enum. Pl. *1*, 211, 1833; Ridl. Mat. *3*, 171, 1907; Flor. Mal. *5*, 244, 1925; Bor, l.c. 632, 1960.

Once recorded from Malacca.

216. **Sporobolus virginicus** (Linn.) Kunth. Rev. Gram. *1*, 67, 1829; Bor, l.c. 634, 1960.

Agrostis virginica Linn. Sp. Pl. 63, 1753.

Recorded from Singapore and Lankawi islands.

217. **Stenotaphrum helferi** Munro ex Hk. f. Flor. Brit. Ind. *7*, 91, 1897; Ridl. Mat. *3*, 146, 1907; Flor. Mal. *5*, 220, 1925; Burkill, l.c. *2*, 2075, 1935; Henderson, l.c. 337, 1954; Bor, l.c. 368, 1960.

Usually associated with limestone hills in the northern States.

218. **Themeda arguens** (Linn.) Hack. in D.C. Monog. Phan. *6*, 657, 1889; Ridl. Flor. Mal. *5*, 212, 1925; Burkill, l.c. *2*, 2146, 1935; Henderson, l.c. 351, 1954; Bor, l.c. 250, 1960.

Stipa arguens Linn. Sp. Pl. ed. 2, 117, 1762.

Anthistiria arguens (Linn.) Willd. Sp. Pl. 4, 901, 1806; Ridl. Mat. 3, 168, 1907.

"Rumput misai adam" is recorded throughout Malaya.

219. **Themeda arundinacea** (Roxb.) Ridl. Trans. Linn. Soc. *3*, 401, 1893; Bor, l.c. 250, 1960.

Anthistiria arundinacea Roxb. Fl. Ind. 1, 256, 1820.

Anthistiria gigantea var. arundinacea Hack. in DC Monog. Phan. 6, 674, 1889; Ridl. Mat. 3, 169, 1907.

(Themeda subsericans Ridl. Flor. Mal. 5, 212, 1925 is assumed to be a hybrid between Th. arundinacea × Th. villosa cf. Bor, l.c. 252.

Rare recorded from Pahang.

220. **Themeda villosa** (Poir.) A. Camus in Lecomte Fl. Gen. Indo-Chine *9*, 364, 1922; Ridl. Flor. Mal. *5*, 212, 1925; Burkill, l.c. *2*, 2147, 1935; Henderson, l.c. 352, 1954; Bor, l.c. 252, 1960.

"Rumput riong" is widespread in Malaya.

221. **Thuarea involuta** (Forst.) R. Br. ex R.&.S. Syst. Veg. *2*, 808, 1817; Bor, l.c. 368, 1960.

Ischaemum involutum G.Forst. Fl. Ins. Austr. Prodr. 73, 1786.

Thuarea sarmentosa Pers. Syn. Pl. 1, 110, 1805; Ridl. Mat. 3, 146, 1907; Flor. Mal. 5, 236, 1925; Burkill, l.c. 2, 2157, 1935; Henderson, l.c. 335, 1954.

On sandy coasts throughout just above high tide level.

222. **Thyrsostachys siamensis** Gamble, Ann. R. Bot. Gard. Calc. *7*, 59, pl. 51, 1896; Holttum, l.c. 80, 1958.

Cultivated bamboo of Singapore & Penang.

223. **Thysanolaena maxima** (Roxb.) O. Ktze. Rev. Gen. Pl. 794, 1891; Burkill, l.c. *2*, 2160, 1935; Henderson, l.c. 321, 1954; Bor, l.c. 650, 1960.

Agrostis maxima Roxb. Fl. Ind. 1, 319, 1820.

Thysanolaena agrostis (Roxb.) Nees, Edin. New Phil. J. 18, 180, 1835; Ridl. Mat. 3, 143, 1907; Flor. Mal. 5, 241, 1925.

"Buloh teberau" is also the name for this hillside reed from Negri Sembilan northwards.

224. **Vetiveria zizanioides** (Linn.) Nash in Small, Fl. Southeast U.S. 67, 1903; Stapf, Kew Bull. 346, 1906; Burkill, l.c. *2*, 2228, 1935; Henderson, l.c. 446, 1954; Bor, l.c. 258, 1960.

Phalaris zizanioides Linn. Mant. 2, 183, 1771.

Vetiveria odorata Virey, J. Pharm. 13, 501, 1827; Ridl. Flor. Mal. 5, 208, 1925.

The "Kuskus" or "Vetiver" cultivated in gardens.

225. **Zoysia matrella** (Linn.) Merr., Philip. J. Sci. *7C*, 230, 1912; Burkill, l.c. *2*, 2308, 1935; Henderson, l.c. 318, 1954; Gilliland, Comm. Mal. Plts. 222, 1958; Bor, l.c. 684, 1960.

Agrostis matrella Linn. Mant. 2, 185, 1771.

Zoysia pungens Willd. Ges. Nat. Fr. Berlin. N.S. 3, 441, 1801; Ridl. Mat. 3, 149, 1907; Flor. Mal. 5, 243, 1925.

Common as a maritime grass on sandy places.

The lawn *Zoysia* is a different species imported from the Philippines.

The Species of Brackenridgea in the Singapore Herbarium

By C. X. Furtado

Singapore

While comparing some recent collections, I noticed a great deal of confusion in the Singapore herbarium in the determinations of the specimens belonging to Brackenridgea. In Ridley's *Flora of the Malay Peninsula I* (1922), this material is referred to *Gomphia hookeri* and *G. corymbosa,* but since the main distinction is made on the colour of the flowers, whether they are red or white, many errors have crept in the naming of the species. Further *G. hookeri* was established on a Penang specimen which had a red fruiting calyx. Some authors mistook this to mean that the species produced red flowers. Actually the flowers are white, the red being developed in the pedicel, calyx and disc after the flowers have been fertilised and the petals shed. As a result all our recent material from Penang has been referred to *G. corymbosa*—a white flowered shrub which does not seem to develop the red pigment in the flowers after their being fertilised. Ridley overlooked the important paper by van Tieghem (Ann. Sci. Nat. VIII, 1902 pp. 393–399) where three new species were added to the genus *Brackenridgea,* besides the two mentioned by Ridley under *Gomphia.* Two of these, *B. rubescens* and *B. kingii* are reduced to *B. palustris,* described originally from Borneo; the third *B. perakensis* has been reduced here as a synonym of *B. hookeri.* In addition Singapore has been credited with a new species, **B. denticulata.** I mention here two extra Malayan species, one, *B. serrulata,* because it has leaves with spiny margins as in *B. denticulata,* and second, *B. foxworthyi* (Elm.) comb. nov. because it is an addition to the genus; it has also spinulose leaf margins.

Sections

Van Tieghem (l.c.) divided the genus into two sections: *Capitatae* and *Spiciformes.* In the former the inflorescence is a compound globose head, consisting of an abbreviated axis bearing short branches that produce flower-bearing stalks. The scales are arranged spirally on the main axis and distichously on the lateral branches. It is very difficult to detect the branches when the flowers are young, though they become obvious in the fruiting stage and later. The axis in the second section may be short or long, but is always simple and bears its scales usually distichously. Sometimes the older parts of the axis tend to produce branches bearing a separate set of flowers, so that this branching cannot be confused with the branching in the first section where all the flowers appear to form one head, the main axis itself rarely producing flowers.

The Species

A. Sectio *Capitatae* van Tiegh. op. cit. (1902) 397.

1. **Brackenridgea hookeri** (Pl.) A. Gray, New Gen. Pl. (1853) 6 (fide cit. seq.); C. Muell, in Walp., Ann. Bot. Syst. IV (1857) 421; Gray in Proc. Ann. Acad. III (1857) 51; Gilg in Engl. u. Prantl., Pflanzenf. III, 6 (1893) 143; v. Tiegh. in Ann. Sci. Nat. VIII (1902) 395.

G. perakensis v. Tiegh. in op. cit. VIII (1902) 396 **Syn. nov.**

Gomphia hookeri Planch. in Hook, Lond. Journ. Bot. VI (1847) 3; Walp., Ann. Bot. Syst. I (1848) 182; Bennett in Hook. f., Pl. Brit. Ind. I (1875) 525; King, Mat. Fl. Mal. Pen. II (1893) 474; Ridl., Fl. Mal. Pen. I (1922) 366 p.p.: **basionym.**

G. corymbosa Ridl. op. cit. 1 (1922) 367 *p.p.*

Ouratea hookeri (Pl.) Burkill in Kew Bull. (1935) 318: **isonym.**

Corner notes in his field label: Tree 60 ft. tall. Petals white. Sepals filaments, ovary and style greenish white. The petals drop off and the sepals, pedunele, ovary, carpel and disc become deep rose-red. Kunstler's field notes are as follows: Tree 40–60 ft. high. Flower white with an yellow centre. Flower with young fruits deep red, yellow inside. Md. Shah states that the tree is 25 ft. tall and that the inflorescence is cream coloured when young, turning red when fruiting.

MALAYA: **Penang,** Government Hill, alt. 2,500 ft. (Curtis 2,154, = 2,154, and 1,147); Moniot's Road, alt. 1,500 ft. (Haniff 2,409). **Perak,** Larut, alt. 1,500–2,000 ft. (Kunstler 7,310, isoholotype of *B. perakensis*). **Malacca,** Sungei Udang (Derry 935). **Negri Sembilan,** Gunong Tampin, alt. 1,800 ft. (Burkill 3,167). **Johore,** Mawai-Jemaluang Road (Corner 28,993); Gunong Pulai (Henderson s.n.).

BORNEO: **Sarawak,** Semengoh (Mead SAR 10); Bako National Park at Bukit Gondol, alt. 700 ft. (Md. Shah P. 5,649).

The type of the species was a specimen collected by Phillips in Penang, and characterised, as pointed out by van Tieghem, by its peculiarly compound and globose inflorescence and entire leaves. In the type of *B. perakensis* the flowers are young and so the compound character of its inflorescence is not easily seen; but in the isotype specimens where the flowers are older, its true character is recognized. Planchon had a specimen which had shed all its flowers and had one fruiting pedicel. Hence he described the calyx as reddish. Apparently this character has led Ridley to confuse this species with the other which produces red flowers and to place all the specimens with white flowers under *G. corymbosa* Ridl., leaving under *G. hookeri* none of the recent collections from Penang. The collector's field notes are given above to show that the flowers are white at first and only later, when the petals have dropped off, the sepals and other parts become red.

2. **Brackenridgea denticulata** Furtado **spec. nov.**

Gomphia corymbosa Ridl. in Fl. Mal. Pen. I (1922) 367 p.p.

A *B. hookerii,* cui affinissima, haec species foliis denticulato-spinosis recedit. A *B. serrulata* conjus folia serrulata spinulosa sunt, haec species inflorescentis capitato-compositis ut in *B. hookeri,* haud simplicibus, facile distinguitur.

MALAYA: **Singapore,** Bukit Timah (Ridley 10,738, holotypus in SING.; Hullett 436 & 910; Sinclair 39,573, sterilis); loc. incert. (Cantley's collection).

The flowers are crowded on a compound axis as in *B. hookeri,* but the leaves are spinulose in the margins. Without these spines, the specimens would be easily confused with *B. hookeri.* Ridley notes that it is a small tree and that its flowers are white. Hullett (No. 910) notes that the fruit bearing calyx is red.

B. Sectio *Spiciformes* v. Tiegh. op. cit. VIII (1902) 397.

3. **Brackenridgea corymbosa** (King) v. Tiegh. in Ann. Sci. Nat. VIII (1902) 395 & 397.

Gomphia hookeri Pl. var. *corymbosa* King, Mater. Fl. Mal. Pen. II (1893) 475: **basionym.**

G. corymbosa (King) Ridl. Fl. Mal. Pen. I (1922) 367 pro parte basionymica.

A shrub 6–9 ft. tall, producing bifarous white flowers in corymbs having a simple axis. The flowers are congested at the apex of a longish inflorescence axis, but below them the axis show the stalks of fallen flowers and the scales. Sometimes branches are produced from this lower part of the axis, each bearing bifarous flowers at its apex. The young fruit is described as pale green.

MALAYA: **Perak,** Gopeng, alt. 500–1,000 ft. (Kunstler 4,673, isoholotype in SING.).

4. **Brackenridgea palustris** Bartell, in Malpighia XV (1901) 165. t.10; v. Tiegh. in Ann. Sci. Nat. VIII (1902) 395 & 397.

B. kingii v. Tiegh. op. cit. VIII (1902) 395: **Syn. nov.**

B. rubescens v. Tiegh. op. cit. VIII (1902) 395: **Syn. nov.**

Gomphia hookeri Pl. sensu Ridl., Fl. Mal. Pen. I (1902) 366 p.p.

Tree 15–60 ft. tall. Corymbs terminal, very short, with leaves immediately below the rachis and without any long scaly rachis below the flowers. Flowers red, bifarously arranged. Leaves variable in size, broadly or narrowly ovate or ovate-lanceolate, usually brownish, 5–10 cm. long, 2–5 cm. wide. Fruit red.

MALAYA: **Kedah,** Kedah Peak, alt. 3,000 ft. (Robinson & Kloss 5899); alt. 3,600 ft. (Cheang & Chang 656 & 663, red fruit and flowers without petals red); Gunong Jerai (Mustafa CF. 20,734).

Perak, Larut (Kunstler 6,396, holotype of *B. kingii* in K, flowers (=fruiting calyx) dark red). **Pahang,** Praman (Ridley 1192, disc red, berris black); Kuantan at Baloh (Yeop CF. 835). **Malacca,** (Alvins 876 as *Pokoh Pendarak* & *Pokoh Chenarahan*). **Singapore,** Tanjong Gol (Goodenough 1,957); Changi (Goodenough 2,072, isotype of *B. rubescens*); Tampenis Road (Ridley 4,807); Tampenis river Ridley s.n., flowers deep red); Chan Chu Kang (Ridley 5,896).

SUMATRA: **Siberut** (Boden-Kloss 14,530, fruit red).

BORNEO: **Sarawak,** Kuching Haviland 2,224 sepals and pedicels pink).

This species was described from a specimen collected by Beccari in Borneo (P.B. No. 3,472) by the lake of Kapuas.

The species show a good deal of variation in the size and shape of the leaves, especially in the mountain collections. Cheang & Chang 663 has rather longish leaves with a long tapering apex.

6. **Brackenridgea serrulata** Bartell. in Malpighia XV (1901) 163 t.9; v. Tiegh. in Ann. Sci. Nat. VIII (1902) 395 & 397.

Tree or shrub. Inflorescence simple with bifarous flowers which are white at first, but become red later. Fruit bright red when ripe. Leaves serrulate.

BORNEO: **Sarawak,** Matang (Brooke 9,715, small tree, flowers pale pink or white; fruit black; calyx crimson; Haviland 1,021, timber tree); Bako National Park at Telok Asam, 400 ft. (Purseglove 4,919, shrub 8 ft. tall, fruits bright red).

This has serrulate leaves and white flowers as in *B. denticulata*, but the inflorescence is simple, with bifarously arranged flowers.

7. **Brackenridgea foxworthyi** (Elm.) Furtado **comb. nov.**

Ochna foxworthyi Elm., Philipp. Leafl. Bot. V (1913) 1823; Merr. Enum. Philipp. Pl. III (1923) 68. **basionym.**

PHILIPPINES: **Palawan,** Victoria Mts. at Panacan (Sulit 12,425); Bacungan, at Puerto Princesa (Edano 177).

The leaves are dentate or sometimes very obscurely so.

Name Changes in Bornean Araliads

By C. X. Furtado
Botanic Gardens, Singapore

1. **Schefflera furfuracea** Merr. MS.

Sch. borneensis Merr. in Journ. Str. Br. Roy. Asiat. Soc. 79 (1918) 27 basionym, non *S. borneensis* Merr. in Philipp. Journ. Sei: Bot. 13 (1918) 100.

Owing to an error this speeies was published under a name that had already been given by Merrill himself a few months earlier to another plant having 5-foliolate leaves, much larger leaflets, shorter and lightly pubeseent infloreseence and shorter-stalked umbels.

He referred to this earlier species in the introduction of a new set of *Shefflera* spp. published in his second paper, and identified with it a "specimen probably eollected by Haviland" (p. 27) from the Singapore herbarium. Yet in this seeond paper he used *S. borneensis* a second time for a different speeies which he obviously intended to call *Schefflera furfuracea* Merr., a name written by Merrill himself on the holotype in the Singapore herbarium. Its leaves are deseribed as 8–10 foliolate and is stated to have "greatly elongated primary branches of the inflorescence which are conspicuously brown-furfuraceous throughout and about 40 cm. in length."

Though these two species are manifestly distinct, unfortunately Merrill failed to detect his error in preparing *"A Bibliographic Enumeration of Bornean Plants"* (1921), so that here he united the two speeies as one.

2. **Schefflera petiolosa** (Miq.) Harms.

Sch. racemosa Merr. in Journ. Str. Br. Roy. Asiat. Soc. 79 (1918) 30, non *S. racemosa* (Wight) Harms (1898). *syn. nov.*

Merrill's binomial is a later homonym and so cannot be used. Fortunately the species does not differ materially from *S. petiolosa* (Miq.) Harms.

3. **Arthrophyllum merrillianum** Furtado **nom. nov.**

A. borneense Merr. in Univ. Calif. Publ. Bot. XV (1929) 231, basionym, non *A. borneense* Baker (1896).

THE

GARDENS' BULLETIN

SINGAPORE

Vol. XIX, Part II 31st October, 1962

CONTENTS

To be purchased at the Botanic Gardens, Singapore
Price: $12

Published by Authority

PRINTED BY LIM BIAN HAN, ACTING GOVERNMENT PRINTER, SINGAPORE

1962

The Classification of Moraceæ

E. J. H. Corner

Botany School, University of Cambridge

New subgenera:—*Trophis* P. Br. subgen. *Prototrophis* Corner.

New sections:—*Broussonetia* L'Herit. sect. *Allaeanthus* (Thw.) Corner; *Maclura* Nutt. sect. *Cardiogyne* (Bur.) Corner, sect. *Cudrania* (Tréc.) Corner; *Streblus* Lour. sect. *Bleekrodea* (Bl.) Corner, sect. *Paratrophis* (Bl.) Corner, sect. *Phyllochlamys* (Bur.) Corner, sect. *Pseudostreblus* (Bur.) Corner, sect. *Pseudotrophis* (Warb.) Corner, sect. *Sloetia* (Teysm. et Binn.) Corner, sect. *Taxotrophis* (Bl.) Corner; *Trophis* P. Br. sect. sect. *Calpidochlamys* (Diels) Corner, sect. *Maillardia* (Frapp. et Duch.) Corner.

New series:—*Maclura* Nutt. sect. *Cudrania* (Tréc.) Corner ser. *Connatae* Corner, ser. *Liberae* Corner.

New species:—*Streblus perakensis* Corner. *S. solomonensis* Corner.

New varieties:—*Antiaris toxicaria* Lesch. var. *macrophylla* (R. Br.) Corner, v. *welwitschii* (Engl.) Corner; *Broussonetia luzonica* (Blanco) Bur. v. *glabra* (Warb.) Corner; *Maclura amboinensis* Bl. v. *paucinervia* Corner; *Streblus glaber* (Merr.) Corner v. *australianus* Corner, *S. urophyllus* Diels v. *salicifolius* Corner, *S. asper* Lour. v. *monoica* (Gagnep.) Corner.

New specific combinations:—*Broussonetia kurzii* (Hook. f.) Corner, *B. zeylanica* (Thw.) Corner; *Maclura africana* (Bur.) Corner, *M. cochinchinensis* (Lour.) Corner and var. *pubescens* (Tréc.) Corner, *M. fruticosa* (Roxb.) Corner, *M. greveana* (Baill.) Corner, *M. humberti* (Léandri) Corner, *M. regia* (A. Chev.) Corner, *M. thorelii* Gagnep.) Corner; *Streblus anthropophagorum* (Seem.) Corner, *S. crenatus* (Gagnep.) Corner, *S. elongatus* (Miq.) Corner, *S. glaber* (Merr.) Corner, *S. ilicifolius* (Vid.) Corner, *S. indicus* (Bur.) Corner, *S. insignis* (Bl.) Corner, *S. laxiflorus* (Hutch.) Corner, *S. madagascariensis* (Bl.) Corner, *S. smithii* (Cheeseman) Corner, *S. spinosus* (Bl.) Corner, *S. tahitensis* (Nadeaud) Corner, *S. tonkinensis* (Stapf) Corner; *Trophis branderhorstii* (Diels) Corner, *T. drupacea* (Diels) Corner, *T. philippinensis* (Bur.) Corner.

Genera fully reviewed:—*Antiaris* Lesch., *Broussonetia* L'Herit., *Maclura* Nutt., *Plecospermum* Tréc., *Streblus* Lour.

Introduction—Distinction from Urticaceae—Subdivision of Moraceae (filaments; extrorse, introrse anthers; plicate leaves; perianth; pistillode; ovary; fruit; seed; embryo; number of floral parts; microscopic characters; inflorescence; spines)—Proto-Moraceae—Affinity of Urticales—Geographical table of Moraceous genera and species—Definition of Moraceae—Key to the tribes of Moraceae —Moreae—Artocarpeae—Olmedieae—Brosimeae—Dorstenieae—Ficeae—Genera excludenda—References.

Introduction

No family has such small standardised flowers, yet such an astonishing array of infructescences. Acquaintance with *Morus* leads to the supposition that these tropical accomplishments are recent developments of little significance to scientific theory. Acquaintance with the tropical plants shows, in contrast, that *Morus* is one of the more derived and reduced genera conforming with temperate simplicity. By denying itself so much in this way that is tropical, botany loses its grip. *Ficus* and *Artocarpus* are two vivid lights, but no student of the phylogeny of flowering plants has seen them. As morphology shifts to the tropics, the family will be appreciated. It holds many fascinating problems of vestigal features, transference of function, and parallel evolution. My contribution now is merely an interim development of the static classification into which the family has subsided. Much has still to be learnt of the American genera, not only from the herbarium, but from the forests in which they survive. There is, for instance, the unique *Palmolmedia* described by Ducke in 1939.

Distinction from Urticaceae

This is a problem. In the diagnosis of *Moraceae* on p. 209 the main differences are italicised. Chief are the orthotropous ovule and the lack of latex in the Urticaceae. On the ovular test Conocephaloideae must be transferred to Urticaceae and, this done, the genera in each family hold together. Latex-tubes are said to occur in the bark, at least the primary bark, of all Conocephaloideae (*Cecropia, Coussapoa, Musanga, Myrianthus, Poikilospermum,* and *Pourouma*), but not in the leaves or inflorescences and infructescences. This tribe may seem, therefore, intermediate between the two families, but other features as the shape of the stigma, the small seed, and the small embryo ally them with Urticaceous, not Moraceous, genera. Trifling as these two distinctions may seem, they delimit two large families, and the seeming triviality arises from lack of appreciation of the two characters. *Fatoua* is not an Urticaceous herb, but a Moraceous parallel. *Cecropia* is not a Moraceous tree, but an Urticaceous parallel.

The function of latex is unknown, yet it permeates as a capillary system giant Moraceous trees from root-tip to stem-tip, and it is initiated in the embryo. The function of ovular shape is also unknown, but it relates to angiospermous ancestry. The evidence, anatomical and taxonomical, suggests not that the direct orthotropous ovule is primitive, but that it is derived from the anatropous ovule transferred to the base of the ovary and straightened in conformity with its improved position for food-supply. In anatomical evidence, Bechter (1921) described the flexure of the ovular vascular bundle in *Boehmeria* and *Laportea,* which first ascends in the ovary-wall as if to an apical position, and then descends to the basal attachment. Certain tropical genera as

Stenochasma and, indeed, *Pourouma* have sub-basal and even laterally placed ovules which turn abruptly into the long orthotropous body. In this respect they appear intermediate with Moraceae, but details of flower and fruit again refer them unquestionably among Urticaceae.

Urticaceae are derivatives of Proto-Moraceae which lost the latex and in which the ovule was transferred from the lateral (appendicular) position to the axile. Conocephaloideae are the Urticaceous group with traces of Proto-Moraceous ancestry. Actually there is no difficulty whatever in separating most Moraceae, as *Artocarpus* or *Ficus,* from Urticaceae; the trouble arises in the very derived and simplified genera as *Dorstenia, Morus,* and *Streblus,* convergent with Urticaceous derivatives.

Lack of latex distinguishes also the Ulmaceae, the flowers of which are generally functionally bisexual. The combination of Ulmeae with Celtideae in one family introduces several of the difficulties met in the subdivision of the Moraceae, especially the two subfamilies Moroideae and Artocarpoideae. As I will show, these two subfamilies cannot be maintained, at least in their present light, because the nature of the stamen, inflexed or straight in bud, though useful enough in the material on which taxonomists have to rely, has not the phyletic significance which practice would attribute. The same solutions will probably fit Ulmaceae and, then, the position of the Cannabiaceae will be ascertained.

Subdivision of Moraceae

To the student of *Ficus* the classification and, therefore, the comprehension of Moraceae is confused with excessive genera. The fig (syconium) is so characteristic that no one is willing to make *Ficus a* tribe or family and raise its subdivisions to generic or tribal rank. Further, there is a continuum through *Ficus* linking the first with the last. It is a genus which preserves a great deal of its evolution, and its products may still be strung together. But, suppose no other Moraceae existed and that most modern *Ficus* had disappeared, then *Ficus* would be a family with several distinct genera. In this light other Moraceae must be considered; they are fragments only from a greater past.

An exception was Miquel. Where others have seen in *Ficus* merely specific variety, and have failed, only too often, even to dissect the flowers, Miquel studied deeply and was so impressed with the great range of floral variation in the genus that he proposed many genera in place of the one. His prowess defeated him; he was overwhelmed with sterile material for identification and had to forgo his principle. Yet, if the flowers were on the outside of the head, instead of inside the fig, many would have seen without difficulty and have followed him and argued that a colossal monoecious banyan with unistaminate flowers and simple stigma could not be congeneric with a slender dioecious creeper with

bistaminate flowers and bifid stigma. The enormous bracteate fig of *Dammaropsis* differs as much from that of *F. carica* as the Olmedieae do from the Artocarpeae, yet *Dammaropsis* is also sunk in *Ficus*. The point is not that there is so much variation in this genus but that the extremes are linked by intermediates. For instance, the group of *F. hirta* (2 stamens, peculiar seed, no cystoliths, palmate-leafed trees) is very distinct from that of *F. subulata* (1 stamen, gall-ovary in the male flower, simple seed, cystoliths, simple-leafed epiphyte), but the remainder of their sections *Ficus* and *Sycidium* link these extremes together.

I take *Ficus* as demonstrative, and where monoecism or dioecism, staminal number, perianth-construction, stigmatic and seed-details, ovary-position, microscopic differences in cystoliths, gland-hairs, hypodermis, etc., and differences in habit and leaf are the chief distinctions between genera, I treat them with suspicion. Caution is needed, nevertheless, in recombining the fragments of other Moraceae. There has been much parallel evolution, even *Sparattosyce* simulating *Ficus*, so that similar effects need meticulous care in separation, and endless tables of comparison must be prepared to sort out the details. Endless because it is always found that much critical information is lacking and cannot be obtained from the bits of the plants in herbaria; too often the American and African plants are in default. Yet, the pieces of the puzzle are so strange, so splendidly different from the banalities of many other families, that the monography of the Moraceae is one of the most exciting chapters in angiosperm taxonomy. To relate a mulberry and a bread-fruit, one superficially the aggrandisement of the other, and add the little *Fatoua* calls for a working hypothesis of flowering-tree evolution. A concept of Proto-Moraceae is essential.

Filaments. The form of the filament in the flower-bud has been taken as a primary means of distinguishing subfamilies or tribes. The filament may be short and lengthen directly to project the anther or it may be inflexed under tension until the flower opens and the filament straightens and flicks the pollen from the anther. Such is the Urticaceous stamen, and the difference between subfam. Moroideae (inflexed filament) and subfam. Artocarpoideae (straight filament). Certain facts discredit this criterion.

Because of their orthotropous ovule and general affinity in other respects, the subfam. Conocephaloideae must be transferred to the Urticaceae. This at once introduces the straight stamen (*Musanga, Myrianthus, Cecropia, Coussapoa, Pourouma*) into the Urticaceae. *Poikilospermum* has always been placed in the Urticaceae because of its inflexed filament. This character holds only for one part of the genus; the other part (*Conocephalus* Bl.) has the straight stamen and has always been referred to the Moraceae. It is acknowledged now that these two subgenera are congeneric; some species, indeed, have such slightly inflexed filaments that it is not clear on this point alone to which subgenus they should be

referred. Then, *Cudrania,* placed in Artocarpoideae, has straight filaments but, as I will show, is merely a section of *Maclura* (Moroideae) with inflexed filaments; there is the reputed hybrid *Macludrania* (*M. pomifera* × *C. tricuspidata*), but its filament has not been described. Again, for the same reason *Sorocea* and *Clarisia* are placed in Artocarpoideae where their racemose or spicate inflorescences and non-syncarpous fruits are entirely anomalous; in fact, they are nearer to *Trophis* (Moroideae) with inflexed filaments. *Craterogyne* (inflexed filaments) has been placed in Dorstenieae and *Trymatococcus* (straight filaments) in Brosimeae, yet other differences are so slight that I would refer them to one genus of Brosimeae. Lastly, so far as I have been able to find out, subinflexed filaments are described by Woodson (1960) in *Batocarpus* (Artocarpeae).

The inflexed filament has a small anther, often reniform or bilobed. The flower has at least two stamens (*Craterogyne, Dorstenia*), generally 3–5, and it has a pistillode against which the anthers are pressed immovably in the bud. The filaments are at first short and straight; in lengthening they are forced to curve outwards against the bulging concave tepals and so they become, as it were, inflexed; they never inflex. The inflexed filament, therefore, in this as in other cases, such as the Caesalpinioideae, is related with the immovability of the anther in bud. In some genera, nevertheless, the pistillode is minute or even absent, and one must suppose that the connivent anthers caused the so-called inflection.

The straight filament commonly bears a rather large anther, often mucronate, typical of the normal angiosperm stamen. Its flower is often unistaminate, but may be 2–5 merous, and there may be 7–8 stamens (*Antiaris, Ficus*). It rarely has a pistillode (present in *Ficus* pr. p., *Antiaropsis, Sparattosyce*). In development the anther fills most of the bud-cavity, and not until the flower begins to open does the filament elongate. Extended anther-growth and retarded filament-growth distinguish this flower from that with inflexed filament. Now which may be ancestral?

The straight filament is generally associated with the advanced, capitate or condensed, inflorescence, as in Artocarpeae, Brosimeae, Olmedieae, and Ficeae. The inflexed filament is associated with the less advanced spicate, racemose, cymose, and paniculate inflorescences, an exception being the Dorstenieae. The straight filament is more suited to the compacting of flowers because it does not need the elbow-room for the explosive stamen. For this reason the inflexed filament seems the more primitive. It is the straight filament, however, which has the less specialised anther. The minute anther of *Artocarpus* is clearly as derived as it is diminished from the large anther shown by *Parartocarpus*. The best developed anthers, strongly mucronate, occur in *Ficus* sect. *Rhizocladus* (climbers). Likewise the small anther of the inflexed filament must be derived. Possibly therefore the inflexed filament

is derived from the stamen with small anther, in turn derived from the stamen with large anther and straight filament, and one suits one kind of inflorescence, the other another. It may be recalled that in all flowering plants the anther develops before the filament which is an intercalary growth. The ability of the anther to fill the bud-cavity determines the form of the filament. So the large anther and necessarily short filament seems the primitive condition, and it brings the Moraceous stamen into line with the theory of Parkin (1951).

It follows that the inflexed filament has been evolved in parallel in different Moraceous and, even Urticaceous and Ulmaceous, groups or genera. That such parallel evolution may well have taken place is shown by the parallel occurrence of the extraordinary turbinate anther with transverse equatorial dehiscence found in *Ficus sterrocarpa* Diels, *Brosimum alicastrum* Sw., and *Craterogyne kameruniana* (Engl.) Lanjouw (Fig. 1, L, N).

I conclude that the form of the filament is not useful for primary distinctions and that it leads to artifical grading. Further, I conclude that the presence of the straight stamen in Moraceous groups with condensed inflorescences shows that they are variously derived from states with expanded inflorescences, and that any attempt to relate them directly is short-sighted, because they are the survivors of as varied Proto-Moraceae which have given rise at any stage of inflorescence-evolution to forms with inflexed filaments.

Extrorse, introrse anthers. Ficus, Antiaropsis, and *Antiaris* have introrse anthers. Other genera, so far as I can determine, have extrorse anthers. In those with inflexed filaments, the anthers are often described as introrse, but in bud they are extrorse and only after they have been pulled out and rotated on the filaments do they become introrse. The distinction is important because the introrse anther would not be so effective in the wide-spread explosive stamen-mechanism.

Plicate leaves. Engler used this character to define subfam. Moroideae in contrast to the inrolled or convolute leaf in subfam. Artocarpoideae. However, all the smaller elliptic leaves of Moroideae are convolute as in *Maclura* and *Streblus,* and all the larger palmate, pinnate, or cordate leaves of Artocarpoideae are plicate, as *F. carica,* and *Artocarpus incisa.* Large leaves, plicate in bud, seem to be the pachycaulous character, small leaves convolute in bud the leptocaulous as in other families and, indeed, genera.

Fig. 1. Stamens of Moraceae, × 10. A, *Ficus sphaeroidea* Corner. B, *F. robusta* Corner. C, *F. subulata* Bl. v. *gracillima* (Diels) Corner. D, *Antiaropsis decipiens* K. Schum. E, *Artocarpus kemando* Miq. F, Diagrams of the introrse anthers of *F. robusta* and the extrorse anthers of *Parartocarpus*. G, *Parartocarpus venenosus* Zoll. et Mor. H, Diagrams of extrorse anthers as in Moreae, and introrse anthers of *Antiaropsis*. I, *Ficus obliqua* Forst. f., with oblique crescentic dehiscence. J, *Maclura* (*Cudrania*) *fruticosa* (Roxb.) Corner, with flanged and ridged filament curved at the tip. K, Stamen with incurved filament, as in Moreae. L, Diagram of the stamen of *Ficus sterrocarpa* Diels. M, Diagram of the stamen of *F. hesperidiiformis* King. N, *F. sterrocarpa*. O, *F. hesperidiiformis*.

Perianth. The more or less free tepals of many genera contrast with the gamophyllous or utriculate perianth of others, and both with the state without perianth. All states occur in *Ficus*. To attempt to use them as primary distinctions leads to confusion. Thus *Artocarpus* subgen. *Pseudojaca, Hullettia,* and *Trymatococcus* are not to be classed together because they have practically no perianth, any more than *Streblus* sect. *Bleekrodea, Malaisia,* and *Ficus* sect. *Sycocarpus* are to be classed together because of their utriculate perianth. These peculiarities have also been evolved in parallel.

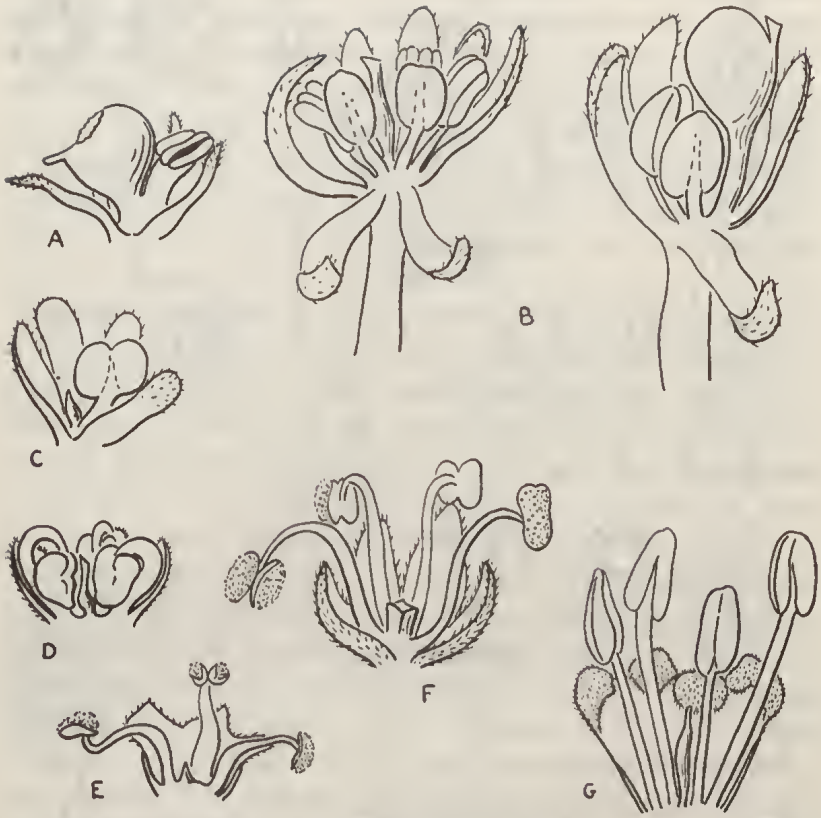


Fig. 2. Male flowers of Moraceae to show the pistillodes, × 10. A, *Ficus obscura Bl.* B, *F. henryi* Diels, two flowers. C, *F. wassa* Roxb. D, *Plecospermum spinosum* Tréc. E, *Streblus elongatus* (Miq.) Corner. F, *Morus macroura* Miq. G, *Maclura thorelii* (Gagnep.) Corner.

Pistillode. This diminutive sterile structure of the male flower, apparently indicative of the bisexual origin of the Urticalean flower, poses several problems. It is best developed as a short quadrate-columnar structure in Moreae and Urticaceae: against it press the four anthers with inflexed filaments. In contrast it is a minute, but very persistent, spike in *Fatoua, Streblus* (sect. *Bleekrodea, Pseudostreblus, Sloetia*), *Sloetiopsis,* and *Neosloetiopsis.* It is absent from *Clarisia* and *Sorocea.* To separate these sections of *Streblus* and classify them with *Fatoua* on this ground is unreasonable in the face of their overwhelming resemblance in other respects with the rest of *Streblus.* A similar pistillode occurs in *Antiaropsis* and *Sparattosyce* in the Olmedieae and, sometimes, as the merest vestige, in *Parartocarpus* and *Treculia* in the Artocarpeae, and *Trymatococcus* in the Brosimeae. In other Artocarpeae, as *Broussonetia, Maclura,* and *Plecospermum,* the pistillode is better developed as a small ligulate ovary with a minute style and, even, stigmatic arms. In *Helianthostylis,* generally placed in Artocarpeae but problematic, it is long, filiform, and exsert from the flower. Finally, in *Ficus,* it varies from a vestigial, but clearly

recognisable, ovary to a minute spike, or it is absent. In two cases, however, namely *Ficus henryi* Diels and sect. *Sycidium* subsect. *Palaeomorphe*, the pistillode functions as a gall-ovary with insect. These are the nearest approach to the functionally bisexual flower in the family. Of all the taxonomic characters in the family, the pistillode is the most demonstrative of the value of vestigal inheritance.

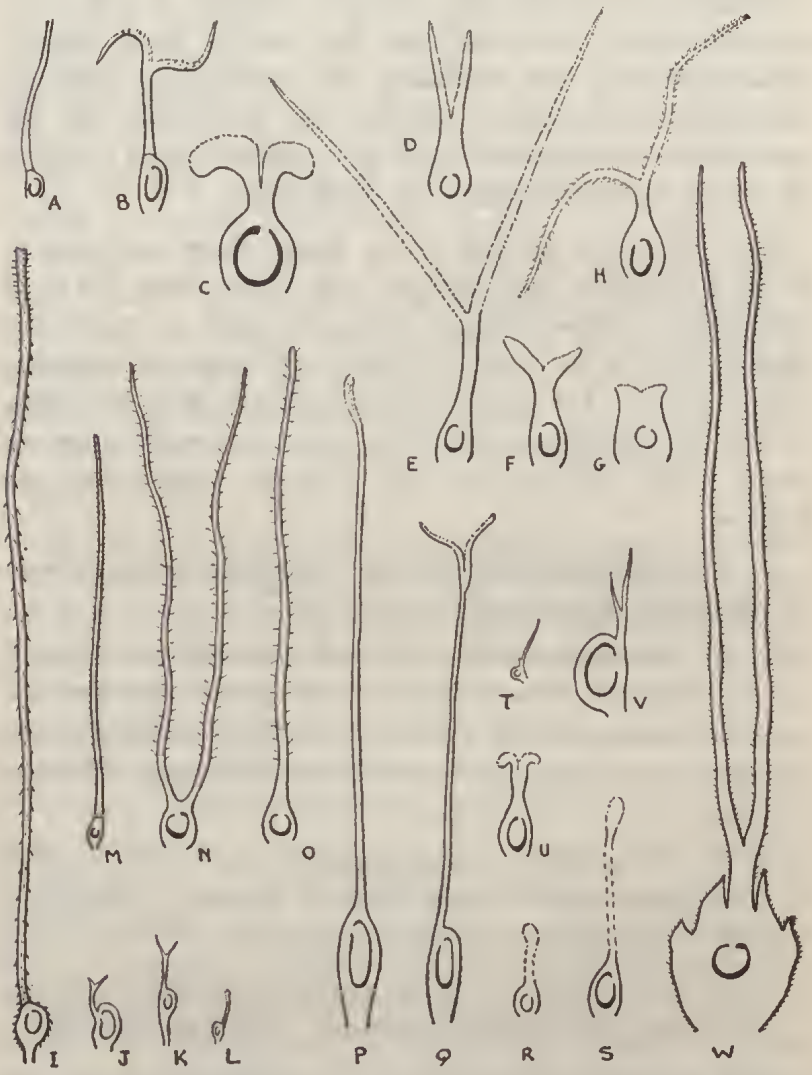


Fig. 3. Ovaries of Moraceae, × 7. A, *Maclura cochinchinensis* (Lour.) Corner. B, *M. thorelii* (Gagnep.) Corner. C, *M. fruticosa* (Roxb.) Corner. D, *Streblus glaber* (Merr.) Corner. E, *S. asper* Lour. F, *S. macrophyllus* Bl. G, *S. solomonensis* Corner. H, *Malaisia*. I, *Ficus macrostyla* Corner. J, *F. deltoidea* Jack. K, *F. aurantiaca* Griff. L, *F. fistulosa* Reinw. M, *Broussonetia papyrifera* (L.) Vent. N, O, *Plecospermum andamanicum* King. P, *Artocarpus hirsutus* Lam. Q, *A. lanceifolius* Roxb. R, *A. vrieseanus* Miq. S, *Parartocarpus venenosus* Zoll. et Mor. T, *Fatoua*. U, *Prainea frutescens* Becc. V, *Antiaropsis*. W, *Antiaris toxicaria* Lesch., the I-flowered female inflorescence with inferior ovary.

Ovary. There are three states. Firstly, the ovary is superficial. Secondly, it is sunk in loculi or sockets of the receptacle with the perianth free from the walls of the loculus (*Artocarpus* subgen. *Artocarpus, Craterogyne, Plecospermum*), or there is no perianth (*Artocarpus* subgen. *Pseudojaca, Hullettia, Parartocarpus*). Thirdly, the ovary is truly inferior and only the ovule is free in the loculus of the receptacle (*Antiaris, Castilloa, Trophis,* and many Brosimeae); in several cases the ovary is partly inferior, (*Sorocea, Maclura* sect. *Cudrania*). The semi-inferior ovary occurs also in *Ficus* subgen. *Urostigma* sect. *Malvanthera* and this shows that ovary-displacement has also suffered parallel evolution and is not a primary criterion for classification.

Fruit. The ovary develops into a drupe. There are traces in *Morus* of two loculi, each with an ovule, in the drupe, but in all other genera, whether there are one or two styles, or one or two stigmatic arms to the single style, ovary and drupe are unilocular and uni-ovulate. The largest drupes with best developed pulpy exocarp and woody endocarp occur, so far as known, in the advanced genera *Parartocarpus* and *Treculia.* Modifications are these:—

1. The drupe diminishes to a drupelet (*Fatoua, Ficus, Dorstenia, Broussonetia*).

2. The drupe develops a strongly thickened parenchymatous base and dehisces over the thin apex to eject the seed (in endocarp) forcibly (*Streblus* sect. *Phyllochlamys, Sloetia, Taxotrophis,* and possibly *Bleekrodea; Ficus* spp., *Dorstenia* spp.).

3. The perianth (always persistent) becomes fleshy, often at the expense of the exocarp (*Morus, Ampalis, Pachytrophe, Maclura, Artocarpus* subgen. *Artocarpus*).

4. The receptacle becomes pulpy to form the fleshy syncarp (most Artocarpeae, Brosimeae, Olmedieae, and *Ficus*).

These modifications have occurred in parallel evolution. The second is highly peculiar because it re-instates dehiscence by a transverse, not longitudinal, rupture in the indehiscent drupe. It is a problem whether this is the original fruit-form in *Streblus* or a subgeneric product. In some species of *Ficus,* without systematic significance, and in *Dorstenia* the crustaceous endocarp is squeezed out of the pulpy drupelet.

Seed. By seed I imply not only the correct botanical usage but the practical. I intend the endocarp and its enclosed true seed: strictly it is a pyrene, not an achene, but everyone calls these bodies the seeds. There are small seeds 0.5–3 mm. long, and large seeds 4–20 mm. long. The one genus with both kinds is *Ficus;* its seeds are mostly 1–2 mm. long, but seeds 3–5 mm. long occur in *F. deltoidea* and its immediate allies. According to my durian-theory (Corner, 1954) the large seed is primitive. This conclusion agrees in general with the primitive state of the straight filament, for most genera with this character are tropical forest-plants with large seeds. Small seeds preponderate in genera, including Urticaceae, with inflexed filaments, both tropical and extra-tropical (*Broussonetia, Morus*), and also herbaceous (*Dorstenia, Fatoua*). The exception is *Ficus* which is the small-seeded derivative with straight stamens, adaptable in consequence to secondary vegetation and the epiphytic habit. The conclusion emphasizes again the retention of primitive features in Artocarpeae, Brosimeae, and Olmedieae with advanced inflorescence.

Embryo. There is such diversity in embryo-characters that it would seem that they should be of prime importance in classification. From this standpoint I have retired after much trial. There can be no doubt from the impossibility of fitting embryo-characters into a satisfactory scheme of classification that they represent also parallel evolution. Small seeds have small simple embryos with relatively long radicle and flat, thin cotyledons (*Broussonetia, Dorstenia, Fatoua, Ficus, Morus*); they are not primitive but neotenic, derived from the complicated embryos of the large seeds. The variety is shown in Fig. 4, 5. There is every gradation from curved embryos with plicate-conduplicate cotyledons to straight embryos with two thick, flat cotyledons and those with such very unequal cotyledons as to be functionally monocotyledonous. *Streblus* and *Maclura,* even *Ampalis* and *Pachytrophe,* reveal what has happened, for they show the range from rather thin, plicate-conduplicate cotyledons, which most resemble the foliage leaf with plicate vernation (otherwise lost in these genera), to the simple state with incumbent radicle (*Streblus*) or accumbent (*Ampalis, Maclura*). The trend is roughly parallel with the diminution of seed-size. Then comes thickening of the cotyledons, leading to the hypogeal, non-photosynthetic state, accompanied by loss of folding and by unequal development of the two. There are considerable differences depending on the exact shape of the

ovule, whether anatropus or campylotropous, the unequal development of the ovary or ovule after fertilisation, and the orientation of the embryo about the sagittal plane of the ovule. These are intricate points which require copious material for elucidation, together with seedling-studies. They have been worked out in some species of *Artocarpus, Parartocarpus,* and *Prainea* by Jarrett (1959, 1960). The conclusion must be that the small and simple embryos of *Broussonetia, Ficus,* and *Morus* are parallel with those of Urticaceae; that the fleshy cotyledons specialise as hypogeal food-stores for the plumule; and that the primitive state with the cotyledons resembling the foliage leaf is as rare as in most other families. Similar argument will apply to the Ulmaceae.

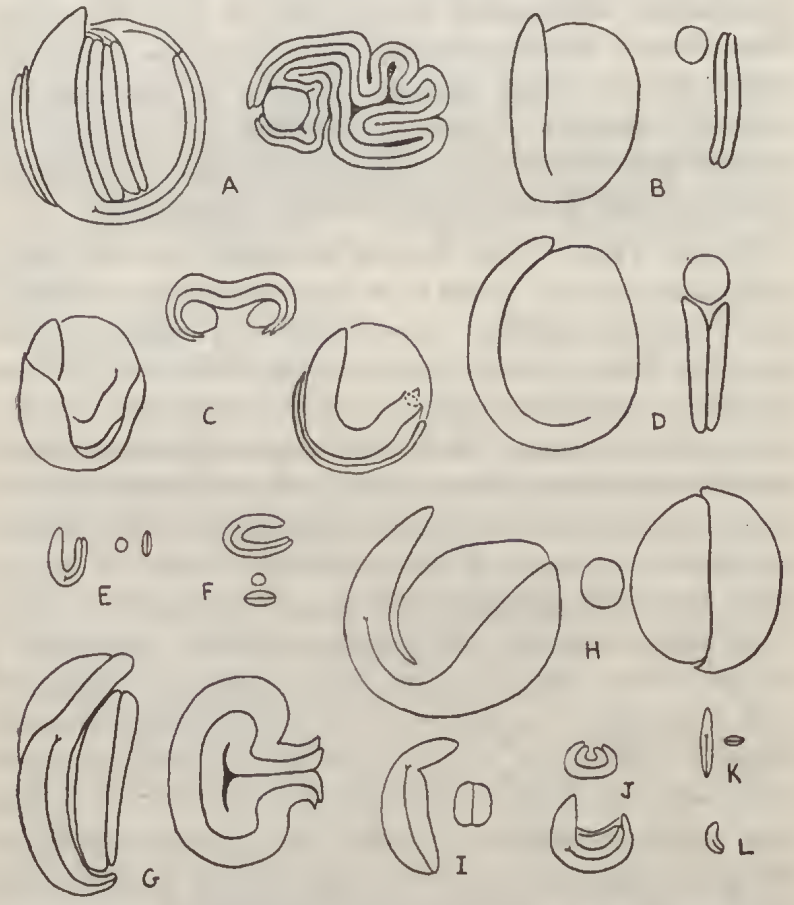


Fig. 4. Moraceous embryos, × 5. A, *Maclura africana* (Bur.) Corner. B, *M. pomifera* (Raf.) Schneid. C, *M. cochinchinensis* (Lour.) Corner. D, *M. thorelii* (Gagnep.) Corner. E, *Broussonetia papyrifera* (L.) Vent. F, *Morus macroura* Miq. G, *Antiaropsis decipiens* K. Schum. H, *Trophis branderhorstii* (Diels) Corner. I, *Ficus deltoidea* Jack. J, *F. hesperidiiformis* King. K, *F. rhizophoriphylla* King. L, *F. grossularioides* Burm. f.

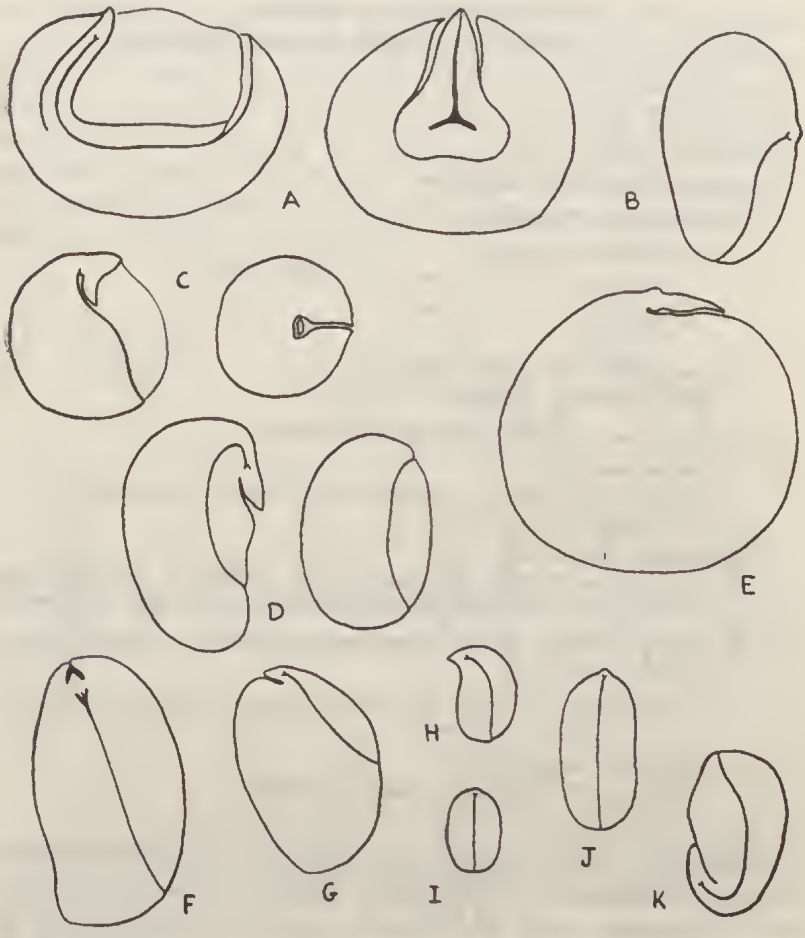


Fig. 5. Moraceous embryos, × 5: those of *Artocarpus* and *Parartocarpus*, × 1. A, *Plecospermum spinosum* Trécc. B, *Streblus insignis* (Bl.) Corner. C, *S. asper* Lour. D, *S. indicus* (Bur.) Corner. E, *S. elongatus* (Miq.) Corner. F, *Artocarpus integer* Linn. f. G, *A. heterophyllus* Lam. H, *A. elasticus* Reinw. I, *A. glaucus* Bl. J, *A. anisophyllus* Miq. K, *Parartocarpus venenosus* Zoll. et Mor.

The embryos may be classified as follows:—

A. Cotyledons rather thin.

1. Cotyledons conduplicate, plicate; radicle long.
   Broussonetia kurzii; Maclura sect. *Cardiogyne*, sect. *Cudrania* pr.p.; *Pachytrophe, Sparattosyce, Streblus* sect. *Paratrophis* pr.p.

2. Cotyledons conduplicate, not plicate.
   Ficus pr.p.

3. Cotyledons flat or curved, not folded.

   a. Radicle incumbent.

      i. Embryo longitudinal in fruit.
         Broussonetia, Streblus sect. *Paratrophis* pr.p.

      ii. Embryo transverse in fruit.
         Dorstenia, Fatoua, Ficus pr.p., *Morus.*

b. Radicle obliquely incumbent to accumbent.
Ampalis, Maclura sect. *Maclura* and sect. *Cudrania* pr.p.

c. Embryo straight.
Ficus pr.p.

B. Cotyledons thick, fleshy.

1. Radicle long, often incumbent.

a. Cotyledons conduplicate.

i. Cotyledons subequal.
Antiaropsis, Streblus sect. *Paratrophis* pr.p.

ii. Cotyledons very unequal.
Treculia.

b. Cotyledons not folded, equal.
Parartocarpus, Trophis.

2. Radicle short, curved: cotyledons not folded.

a. Cotyledons equal.
Artocarpus subgen. *Artocarpus* pr.p. (radicle incumbent or accumbent.).

b. Cotyledons unequal.
Artocarpus subgen. *Artocarpus* pr.p., *Malaisia, Plecospermum, Sorocea; Streblus* sect. *Pseudostreblus, Streblus* and *Taxotrophis.*

3. Radicle very short, almost none; embryo straight or slightly curved.

a. Cotyledons equal.
Anonocarpus, Antiaris, Artocarpus subgen. *Pseudojaca, Castilloa, Hulletia, Noyera, Prainea.*

b. Cotyledons unequal.
Streblus sect. *Bleekrodea* and sect. *Sloetia.*

Number of Floral Parts. In *Ficus* there are many differences in number of stamens (1–8) and tepals (0–8); the style may have one or two stigmatic arms, and the gall-stigma may differ. These numerical points have been exaggerated into generic characters in other tribes, chiefly because their species are more relictual and the trivialities appear profound. In the light of *Ficus,* the pentamery of *Pseudostreblus* and the trimery of *Sloetia* are not generic differences from the tetramerous *Streblus.*

Microscopic characters. The striking taxonomic differences in the occurrence of cystoliths, hypodermis, crystals, resin-cells, gland-hairs, papillate hairs, and so on, in the leaf were first explained by Renner (1907). Their value is shown also by *Ficus,* where they have variously subgeneric, sectional, and specific rank. The temptation is to believe that they may be generic characters in the fragmentary tribes. A detail worth pursuing is the nature of the resin-cells which occur in the mesophyll of *Artocarpus, Maclura* sens. lat., *Malaisia,* and *Prainea.* These cells are known to be absent from *Broussonetia, Plecospermum,* and *Parartocarpus,* all of which I classify in the Artocarpeae, but there are still many genera in which they have not yet been studied. In *Prainea* and *Artocarpus* subgen. *Artocarpus,* yellow resin-cells are scattered in the mesophyll. In *Artocarpus altilis* (Miq.) J.J.Sm. they

are aggregated into compact glands (masses of yellow resin-cells) in the leaf-teeth. In *Maclura* they are aggregated into 2–7 yellow glands immersed in the mesophyll of the bracts and/or the tepals. In *Malaisia* they form a glandular cylinder, or ring in transverse section, in the mesophyll of the pericarp. In *Prainea,* further, they form small masses in the mesophyll of the perianth. Yet, from *Artocarpus* subgen. *Pseudojaca,* with the exception of *A. altilis,* the resin-cells are absent.

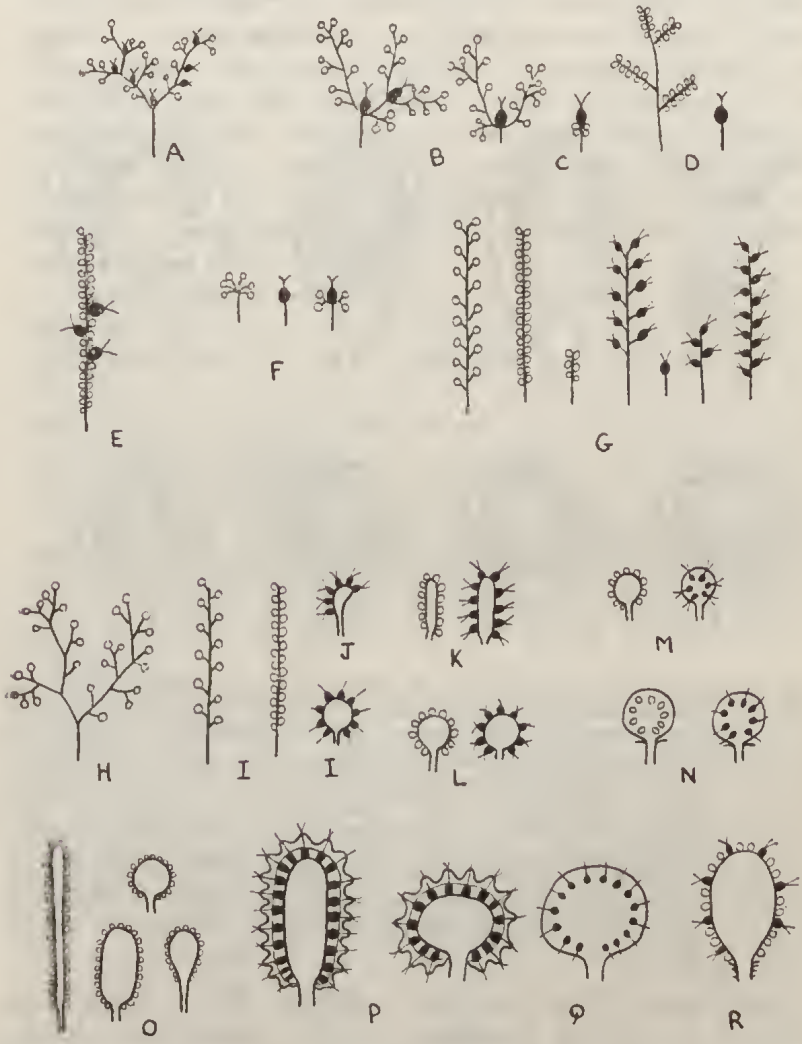


Fig. 6. Diagrams of the inflorescences of Moreae (A-G) and Artocarpeae (H-R). A, *Fatoua.* B, *Streblus* (*Bleekrodea*) *insignis* (Bl.) Corner. C, *S. madagascariensis* (Bl.) Corner. D, *S.* (*Pseudostreblus*) *indicus* (Bur.) Corner. E, *S.* (*Sloetia*) *elongatus* (Miq.) Corner. F, *S.* (*Streblus*) *asper* Lour. G, *Streblus* sect. *Pseudotrophis* and *Taxotrophis* (pedicellate flowers) and sect. *Paratrophis* (sessile flowers). H, *Maclura* sect. *Maclura.* I, *Broussonetia.* J, *Malaisia.* K, *Maclura* sect. *Chloroxylon.* L, *Maclura* sect. *Cudrania.* M, *Plecospermum.* N, *Parartocarpus.* O, *Artocarpus,* male. P, subgen. *Artocarpus.* Q, *Artocarpus* subgen. *Pseudojaca.* R, *Treculia.*

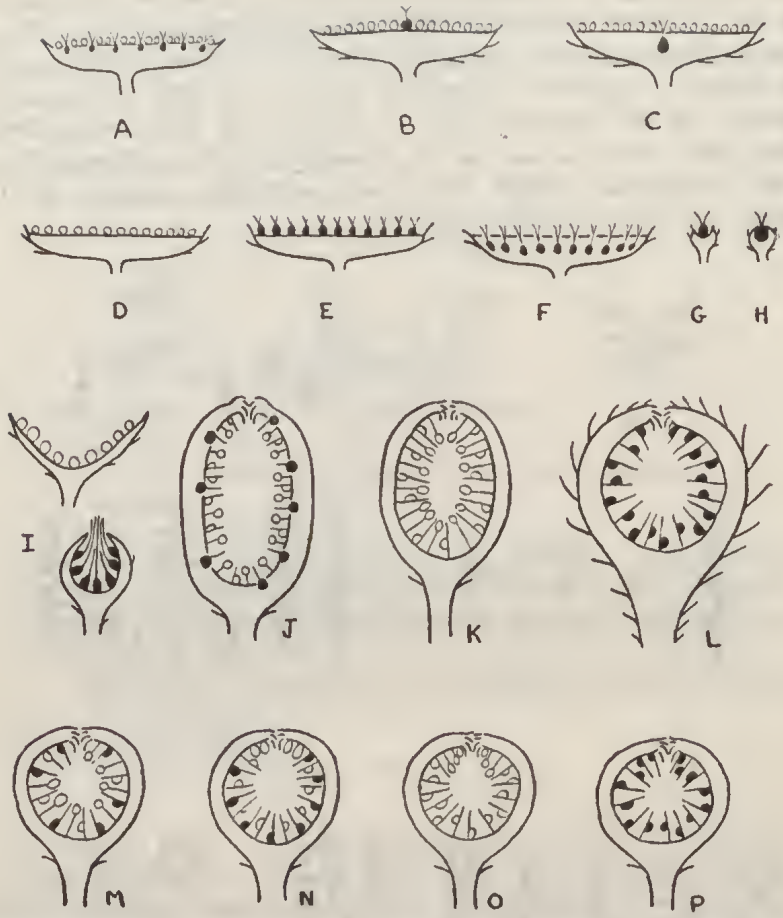


Fig. 7. Diagrams of inflorescences of Dorstenieae (A), Brosimeae (B, C), Olmedieae (D-I), and Ficus (J-P). G, H, 1-flowered female inflorescences of *Olmedia* and *Antiaris* respectively. I, Male and female inflorescences of *Sparattosyce*. J, *Ficus* subgen. *Urostigma* sect. *Malvanthera*, the ovaries immersed in the fig-wall. K, gall-fig of *Ficus* subgen. *Ficus* sect. *Kalosyce*, with disperse pedicellate male flowers. L, multibracteate seed-fig of *Ficus* subgen. *Ficus* sect. *Sycocarpus*. M, *Ficus* subgen. *Urostigma*, male, gall-, and seed-flowers disperse in the same fig. N, *Ficus* subgen. *Sycomorus*, with male flowers ostiolar and sessile. O, P, *Ficus* subgen. *Ficus*, gall-fig with ostiolar male flowers and seed-fig, dioecious.

Inflorescence. The shape and structure of the inflorescence seems to be the only satisfactory basis for primary classification. *Ficus* is one example, Brosimeae another, because they are conspicuous. Far less obvious is the unity of the relatively unspecialised panicles, racemes, spikes, and heads of Moreae. Because the advanced inflorescences resulting in syncarps must have been derived from less advanced inflorescences, as shown by the Moreae, the tendency is to regard this tribe as primitive. Its genera, however, are all advanced in many respects, and much more can be learnt about Proto-Moraceae from the other tribes.

When defined broadly, these tribes stand by themselves and point as variously back to Proto-Moraceae. The splitting of genera and tribes in a confusion of floral detail has obstructed a clear view of the family. Indeed, so far as clarification is now needed, the question must be considered whether there is not just one genus for each tribe, comparable with *Ficus*. The point, as already explained, is that *Ficus*, as the most recent ebullition of the family, still shows a fairly continuous spectrum of evolution. The other tribes have merely fragments of their spectra. It is the lack of detailed knowledge to bridge these gaps which makes the putting together of these genera at present highly dubious. I have joined several genera into *Streblus* and have felt inclined to join all into one genus *Morus* for the Moreae. I have joined three or four genera in *Maclura*, and united *Allaeanthus* with *Broussonetia*. Compare, then, the small genera *Malaisia*, *Prainea*, and *Plecospermum*, and it will be seen how difficult it is to place them with satisfaction. *Artocarpus*, *Parartocarpus*, and *Treculia* introduce another set of differential details.

A peculiar point about the spicate inflorescences of Moreae and some Artocarpeae is the presence of a sterile longitudinal strip on one side, to which Baillon first drew attention. It needs investigation. It does not occur in the racemose or paniculate inflorescences with pedicellate flowers, and it is absent from the capitate inflorescences, though vestigial in the subcapitate female inflorescence of *Malaisia*.

I have united Broussonetieae with Artocarpeae because I can find no sharp separation. Perhaps this sterile groove is significant. It occurs in the spicate male inflorescences of *Broussonetia*, *Maclura*, and *Malaisia*, but not in the spicate inflorescences of *Artocarpus*.

Spines. Short shoots ending in a spine (stem-tip) distinguish *Streblus* sect. *Phyllochlamys*, sect. *Pseudotrophis* (excluding *S. macrophyllus* Bl.), and sect. *Taxotrophis*, and also *Maclura* (except for the African trees of sect. *Chlorophora*). In *M. africana* (*Cardiogyne*) the spines end short leafy shoots: in the others the spines are leafless, or nearly so. It seems that the feature has developed in parallel in these two genera, just as the spinous leaf-edge of *Streblus ilicifolius* parallels that of *Sorocea*. It is remarkable that the habit has not developed in any other genus, though in *Ficus* there is the solitary example of a spinous leaf-edge in *F. macilenta* King var. *ilicifolia* Corner.

Proto-Moraceae

To present an archetype is often considered mere speculation. Then, what is it that systematists imply when they put into genera and tribes the remnants of ancient groups? Must they be blind to the pictures this sort of pattern will show? Every taxon implies, unless one disbelieves evolutionary theory, an antecedent.

The more numerous the taxa, the clearer should become the antecedent. Taxonomy which denies itself this duty to speculate grows more and more minute and is well-labelled microtaxonomy. Without a hypothesis of origins, the taxonomist cannot appreciate what he is doing. I often think that taxonomy is a larder of notions awaiting thought.

The following is my view on the ancestors of Moraceae, supported by reasons.

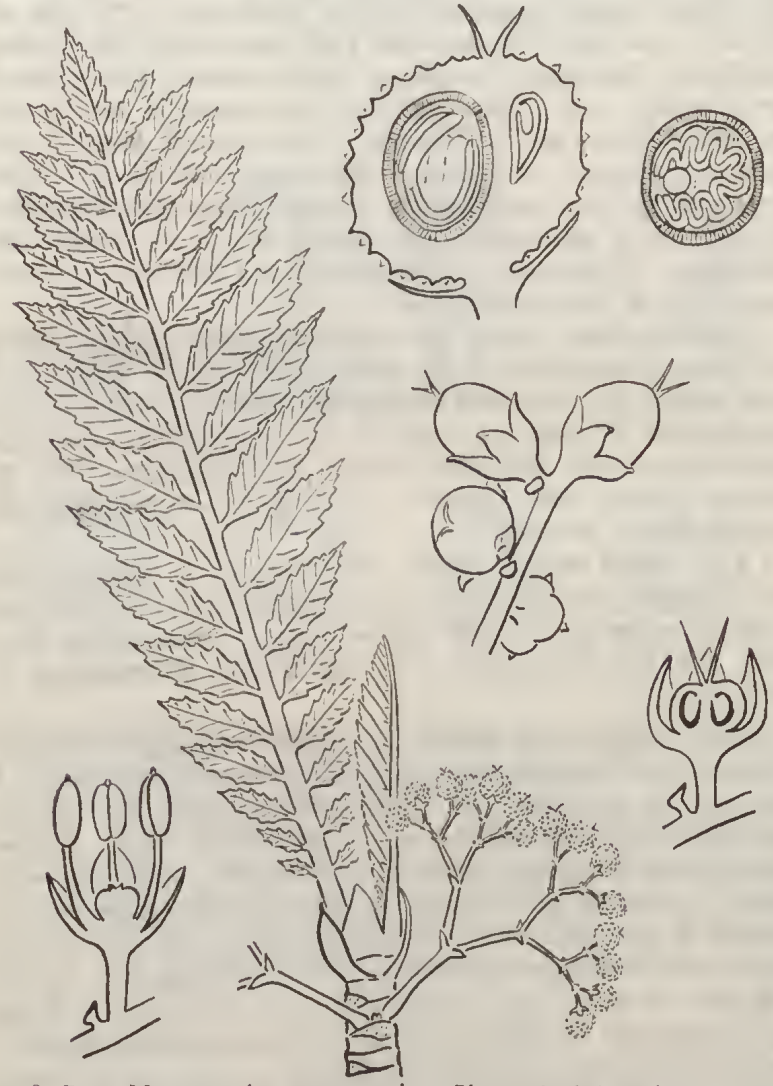


Fig. 8. Proto-Moraceae in reconstruction. Pinnate-leafed pachycaul stem, × 1/6. Male and female flowers, × 3. Fruits, one with echinulate drupe, the other with smooth drupe and spinous perianth-segments, × 1. Seed (endocarp) in section, × 1.

Characters of Proto-Moraceae.—Monoecious, pachycaul, pinnate-leafed; stipules foliaceous, amplexicaul; latex present. Inflorescences cymose-paniculate; flowers unisexual, pedicellate, apetalous, male and female in the same inflorescence; perianth with

5–8 imbricate tepals. Male flowers with the stamens opposite the tepals; anthers large, mucronate; filaments straight in bud; pistillode as a sterile ovary. Female flowers (?with abortive stamens); ovary superior, with 2 loculi or one; styles 2, long, or one with two long stigmatic arms; ovule one in each loculus, subapical, anatropous. Drupe large, with woody endocarp, surrounded at the base by the persistent spicate tepals. Seed with membranous testa, enclosed in the endocarp, with little endosperm. Embryo curved; radicle long, incumbent; cotyledons foliaceous, plicate-conduplicate; germination epigeal. Leaf with cystoliths on both sides; hypodermis ? none; stomata superficial on the lower side; microscopic gland-hairs multicellular, ? subglobose or peltate; hairs papillate.

Monoecious. This state is indicated as the primitive in *Ficus* subgen. *Urostigma, Pharmacosycea,* and *Sycomorus,* and there is clear evidence of the derivation of the male and female inflorescences, leading ultimately to dioecism, in *Streblus* sect. *Bleekrodea* and sect. *Streblus,* in *Treculia* and in *Parartocarpus.*

Pachycaul, megaphyllous, with foliose stipules. This ancestral state is shown by *Ficus* sect. *Sycidium, Sycocarpus,* and *Adenosperma,* perhaps also by sect. *Galoglychia* (subgen. *Urostigma*). It is shown for Olmedieae in *Palmolmedia.* Except for the foliaceous stipules it is the state of *Artocarpus anisophyllus* and *A. incisus.* It is indicated in *Bagassa,* allied with *Maclura,* in *Broussonetia,* and in *Dorstenia.* Specialisation in all these genera displaying pachycaul origin leads to the leptocaul and the willow-leafed habit in their more derived species. The point is important because it means that the family Moraceae and its tribes arose as short pachycaul trees and that such genera as *Ficus, Artocarpus, Maclura. Broussonetia,* and *Antiaris* have been independantly evolved into large trees, as some of them have been evolved into climbers. Comparative anatomy must learn from the anatomy of pachycaul plants, knowledge and, indeed, appreciation of which is still so deficient. The communities of banyans, which assemble on the ruins of civilisations, are not primitive fig-forests, the nature of which is to be seen rather in the secondary vegetation of pachycaul figs in Borneo, New Britain, and Bougainville Island.

Inflorescence. When traced from their inception, the flowers even of *Ficus* and *Dorstenia* are found to arise in a cymose pattern (Bernbeck, 1932). Intercalation of internodes into capitate inflorescences leads back to the racemose-cymose state, and this leads, by branching, to the paniculate. The cymose monoecious remnants as *Streblus* sect. *Bleekrodea,* Brosimeae, and Dorstenieae indicate that there was a central female flower, terminal and surrounded by male flowers as in Euphorbiaceous inflorescences. Conversely, condensation of such an inflorescence with or without dioecism leads to the variety of the Moraceae. The strong protogyny in bisexual Moraceous inflorescences also indicates the cymose construction with terminal female flower.

Flower-structure. The conclusions, argued on preceding pages, agree with those of Bechtel, based on vascular anatomy. Problematic is the antitepalous position of the stamens. It suggests missing petals of which there is no external sign in the Urticales. In *Ulmus americana,* Bechtel found abortive vascular bundles between and alternating with those of the tepals and stamens, as internal vestiges of petals; also, in this flower of floral formula P(8)/A8, there were six abortive vascular bundles internal to and alternating with the staminal; the ovary has four vascular bundles. Thus, the Ulmaceous flower gives evidence of $\frac{3}{8}$ phyllotaxis in perianth and androecium, descending to $\frac{1}{2}$ in the gynoecium. In most Moraceae this has become $\frac{1}{2}$ phyllotaxis throughout the flower, as P 2+2 A2+2 G1, with two styles or stigmatic branches. Such falling phyllotaxis is proof that the Proto-Moraceous flower is descended from one of massive construction with many parts.

Fruit. Of an antecedent drupe there can be no doubt, but the Proto-Moraceae must be considered along with other flowering plants. The syncarps of *Artocarpus* subgen. *Artocarpus,* of *Parartocarpus,* and of *Treculia* strongly resemble the fruit of the durian (*Durio zibethinus*). The spines of the durian are outgrowths of the ovary located beneath peltate scales; the pulp of the durian-seed is a true aril, its testa the outer integument. The spines of the Moraceous syncarps are thickened perianths, tepals or bracts; the peltate scales are bracts with peltate tops; the seed is a pyrene, the endocarp of which forms a false testa; the pulp is the outer part of the ovary-wall or the perianth. Transfer, then, the testa-lignification of *Durio* from the outer integument to the endocarp, the aril-pulpiness to the exocarp, the spinous character to the tepals and bracts, and there is the transformation into *Parartocarpus* or *Treculia.* In *Artocarpus* subgen. *Artocarpus* the perianth is divided into two parts, a proximal and a distal, both free from their neighbours but fused together with them laterally by a middle layer; the proximal part becomes the pulpy false aril and the distal part becomes the spine. A simple transfer of function, or gene-action, by one or two tissue-layers away from the ovule occurs and the durian-fruit is converted into the Moraceous syncarp. This false fruit is a syncarp not of carpels but of syncarpous ovaries; it is a second-order fruit, and thus every durian-feature is displaced outwards from its primary position to a secondary. That is, the stem-apex forms not floral primordia to become large flowers, but floral primordia so reduced and neotenic that they become, as it were, single uni-ovulate carpels which function as arillate seeds, and the reduced tepals are converted into spines. It requires the crowding of primordia on an embryonic condensed inflorescence for such displacement of differentiation. Thus it is the elaborate syncarp of Artocarpeae, not the simple drupe of Moreae, which has the primitive characters.

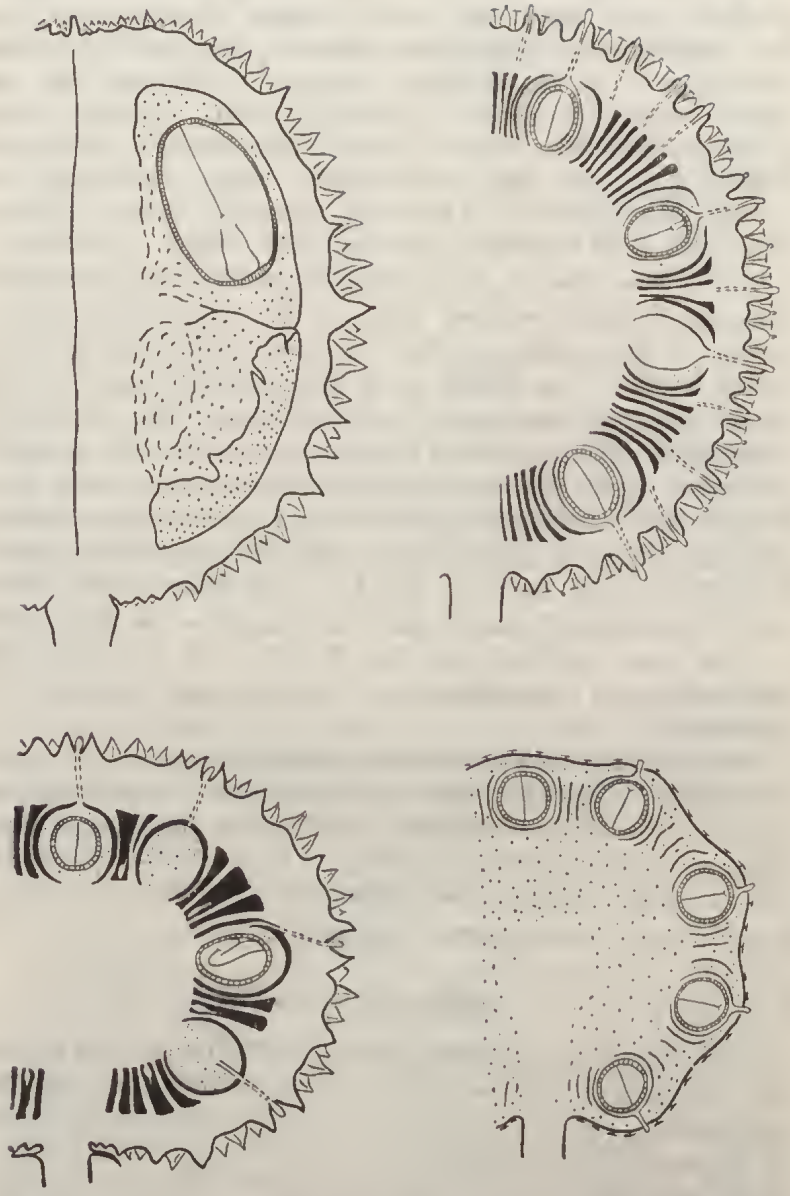


Fig. 9. Fruit of *Durio* (upper left) and syncarps of *Artocarpus* subgen. *Artocarpus* (upper right), subgen. *Pseudojaca* (lower right), and *Parartocarpus* (lower left), diagrammatic, × ½. The pulpy part of each fruit is dotted, namely aril (*Durio*), pericarp (*Parartocarpus*), perianth (subgen. *Artocarpus*), and the whole syncarp-tissue (subgen. *Pseudojaca*). Note, in subgen. *Artocarpus*, the utricular perianths (perforated by the style) are fused in their middle part, the strands between the fertile flowers being sterile perianths; in *Parartocarpus* and subgen. *Pseudojaca*, the ovaries are inferior in sockets of the receptacle and the strands between the fruiting ovaries are receptacular tissue. In *Artocarpus* the peltate interfloral bracts are shown.

It is necessary to argue this way because the durian-theory (Corner, 1954) shows that, for the modern flowering plant (not for a hypothetical pteridosperm ancestor), the arillate seed and spinous pericarp are primitive features. To suppose that the simple drupe of Moraceae is primitive and the syncarp a novel durian-anologue is to beg the question; this reasoning implies that Moreae never had the durian-features while *Artocarpus* discovered them anew only to lose them again in its subgen. *Pseudojaca* which in all respects is advanced upon subgen. *Artocarpus*.

Sapindaceae show the derivation of spineless drupes from spiny pericarps (*Nephelium*), and what are the sublamellate excrescences on the indehiscent fruit of *Planera* (Ulmaceae) if not durian-vestiges? That spines are a morphological entity, as vasculated epidermal outgrowths, the durian shows. That spines have biochemical precursors in the genotype is shown by the action of gall-insects which provoke durian-like galls in plants which seem to have lost the ability to produce spines, e.g. *Artocarpus canarana* Miq. which is galled *Hopea wightiana* (Dipterocarpaceae). Recently in North Borneo I found a small shrub (sterile) which bore a terminal pedunculate gall resembling a small durian-fruit 4–5 cm. long, but filled with flies. The day will come when the biochemistry of durianology is revealed and genetics will apprehend.

The lost history of Moraceae now begins to appear. It is not in the advanced leptocaul states of Moreae but in the pachycaul states of Artocarpeae, Olmedieae, Dorstenieae, and Ficeae. These tribes are not derived from Moreae, but all from Proto-Moraceae. *Morus* can be likened to sect. *Ficus;* behind *Morus* lies as much lost history as there is present evidence in *Ficus*.

Affinity of Urticales

Several botanists as Weddell, Hallier (1905), Bessey, and Bechtel have favoured affinity with Malvales. The Proto-Moraceous reconstruction, Fig. 8, is a remarkable parallel with Euphorbiaceae of the same alliance. Critical would be the microscopic structure of the seed-coat, but all Moraceous and Urticaceous seeds seem to be enclosed in endocarp (? transferred testa), and do not develop typical testa-structure. Then Hallier (1912), Tippo (1939), and Hutchinson (1959) refer Urticales to the affinity of Hamamelidales, which may lead back to a similar pachycaulous ancestor. It is necessary to consider pachycaulous ancestry because, as Moraceae show, family-characters, even tribal and generic, of flower and fruit must have been evolved in this state of flowering plant evolution. The pachycaulous is, in fact, the chief phase of flowering plant evolution which, as would be expected from its primitiveness, is widely missing.

GEOGRAPHICAL TABLE OF MORACEOUS GENERA AND SPECIES

Gen./Spp.	America	Africa	Asia and Australasia	Tribes
10/68	4/19	6/13	4/36	Moreae
15/95	8/20	2/7	7/68	Artocarpeae
18/69	13/58	2/5	4/6	Olmedieae
8/44	1/6	7/38	..	Brosimeae
1/120	1/80?	1/40?	1/1	Dorstenieae
1/1000?	1/150?	1/250?	1/600?	Ficeae
53/1397	27/333	18/353	17/711	Total Moraceae

Australasia has been included with Asia in this Table because it has only one peculiar genus, namely *Sparattosyce* with two species in New Caledonia; it has also six species of *Streblus* along with a few wide-spread species of *Artocarpus, Antiaris, Fatoua,* and *Malaisia.*

Excluding *Ficus* and *Dorstenia,* as satisfactory genera, the ratio of genera to species in America is 1/4, in Africa 1/3.7, and in Asia 1/7.3. The number of genera in America and Africa may well be halved, but these low ratios indicate that, excepting *Dorstenia* and *Ficus,* the genera are relics.

Moraceae Lindl.

Veg. Kingd. (1847) 266; Bureau, DC. Prodr. 17 (1873) 211; Engl. Nat. Pflanzenf. 3, 1 (1894) 66; Veg. Erde IX, vol. 3, 1 (1915) 17; Dalle Torre et Harms Gen. Siph. (1900) 120; Lemée, Dict. Phan. 7 (1939) 184; 8b (1943) 8, 14, 17.—*Artocarpaceae* Bur. DC. Prodr. 17 (1873) 280.—subfam. *Artocarpoideae* A.Br. ex Aschers. Fl. Prov. Brandenb. 1 (1864) 57; Engl., l.c. 80; D. Torre et Harms, l.c. 121.—subfam. *Moroideae* Engl. l.c. 70; D. Torre et Harms, l.c. 120.

Trees, shrubs, climbers, or herbaceous (*Dorstenia, Fatoua*). *Latex present,* generally milky. Leaves pinnate, palmate, incised, or simple, stipulate. Inflorescences axillary, typically paired, unisexual or bisexual, monoecious or dioecious, paniculate, racemose, spicate, capitate, or urceolate. Flowers small, unisexual, apetalous; tepals 8–0, generally 4, free or gamophyllous, imbricate or valvate, persistent; stamens isomerous and antitepalous, or reduced to 3, 2, or 1; filaments straight, free or connate, or inflexed; anthers large, mucronate, to small, bilobate and non-mucronate, varying crescentic to turbinate (with transverse. equatorial dehiscence); pistillode present in male flower or not; ovary 1–, rarely 2–, locular, superior to inferior, or immersed in sockets in the

inflorescence-axis; styles 2 or 1 with two stigmatic arms, or one stigmatic arm; *stigma not capitate or peltate; ovule* 1, *anatropous* or *campylotropous,* apical or subapical. *Fruits* drupaceous, *discrete or more or less connate in large fleshy syncarps. Seeds large or small,* invested in endocarp; testa membranous or disintegrated. *Embryos various,* curved or straight; radicle long or short, incumbent or accumbent; cotyledons plicate, conduplicate, or plane, foliaceous or thickened, equal to very unequal. Lamina with or without cystoliths. Chromosome haploid numbers 12, 13, 14, with intrageneric polyploidy. Gen. 53, pantropic, few temperate; species c. 1400 (Ficus c. 1000 spp.).

Key to the Tribes of Moraceae

1. Flowers inside urceolate receptacles (syconia), numerous; styles not extruded from the receptacles. Blastophagous with sterile insect-inhabited female flowers. Stamens, when 2 or more, with introrse anthers; filaments straight in bud. Female flowers stalked or sessile *Ficeae.*

1. Flowers not so enclosed or, if so, the styles exserted from the receptacle, not blastophagous. Stamens mostly extrorse. Female flowers mostly sessile.

   2. Inflorescences bisexual, discoid or compressed-elongate, globose or urceolate. Not spinous.

      3. Female flowers numerous in each receptacle, each surrounded by many sessile male flowers; stamens 1–3, mostly 2, the filaments inflexed in bud; ovaries immersed in sockets. Receptacles flattened, discoid to variously elongate, bracteate round the margin, forming syncarps. Seeds small. Herbs or suffrutescent *Dorstenieae.*

      3. Female flower solitary in the centre of each receptacle, surrounded by many sessile male flowers; stamens 1–4, the filaments straight in the bud or, rarely, inflexed; ovaries free or immersed. Receptacles discoid, globose, or urceolate, not elongate, forming syncarps. Seeds rather large. Trees, shrubs ..... *Brosimeae.*

   2. Inflorescences unisexual or, if bisexual, not discoid. Trees, shrubs, climbers, rarely herbs.

      4. Female inflorescence racemose or spicate with slender axis or 1-flowered, or the inflorescence bisexual (cymose or spicate), neither capitate nor discoid; ovaries mostly free, if inferior then not in sockets. Male inflorescence paniculate, racemose, spicate or capitate, often with a sterile groove; stamens 5–1, filaments mostly inflexed in bud, in some cases straight; pistillode generally present. Spinous or not ..... *Moreae.*

      4. Female inflorescence capitate or thickly spicate, mostly syncarpous: ovaries often immersed in sockets of the receptacle or connate with it. Male flowers mostly without pistillode.

         5. Male and female inflorescences discoid, obconic, or urceolate, with an involucre of 1-several bracts; female inflorescences varying 1-flowered. Syncarpous or not. Stamens 8–1, the filaments straight in bud. Not spinous ..... *Olmedieae.*

         5. Male and female inflorescences of different shape, involucrate or not. Female inflorescence thickly spicate to capitate-globose, never 1-flowered, syncarpous. Male inflorescence paniculate, racemose, spicate, or capitate; stamens 4–1, the filaments straight or inflexed in bud. Spinous or not .... *Artocarpeae.*

Tribe Moreae Gaud.

Voy. Freyc. (1826); Endl. Prodr. Fl. Norf. (1833) 40; Gen. Pl. (1841) 277; Suppl. 1, 1375; Suppl. 4 (1842) 33; Miq. Mart. Fl. Bras. 4, 1 (1852) 154; Bur. DC Prodr. 17 (1873) 234; Baill. Hist. Pl. 6 (1875) 167; Benth et Hook. Gen. Pl. 3 (1880) 343 (sub Urticaceae); Engl. Nat. Pflanzenf. 3, 1 (1894) 72; Veg. Erde IX, 3, pt. 1 (1915); Dalle Torre et Harms, Gen. Siph. (1900) 120.—*Soroceae* Miq. Mart. Fl. Bras. 4, 1 (1852) 111 (subtrib.); Bur. DC Prodr. 17 (1873) 288.—*Strebleae* Bur. id. 215; Benth. et Hook. l.c. 344 (ut subtribus); Dalle Torre et Harms l.c. 120.—*Fatoueae* Benth. et Hook. l.c. 344 (ut subtribus); Engl. Nat. Pflanzenf. 3, 1 (1894) 71; Dalle Torre et Harms, l.c. 120.—*Eumoreae* Benth. et Hook. l.c. 345.

Inflorescence paniculate, cymose, racemose, spicate, or (male) capitate, (the axis not expanded into a discoid, urceolate, globose, or stoutly spicate receptacle), bisexual or mostly unisexual. Female inflorescence cymose, racemose, spicate, or 1-flowered, never capitate. Filaments incurved or (*Sorocea, Clarisia*) straight in bud; anthers extrorse; pistillode commonly present. Ovary generally superior, inferior in a few genera. Fruit drupaceous, never in syncarps. Trees, shrubs, or (*Fatoua*) herbs, spinous or not, monoecious or dioecious. Gen. c. 10, species c. 68, pantropical or (*Morus*) temperate.

Key to the Genera of Moreae

1. Seeds small, 1–2 mm. wide, somewhat compressed; endocarp crustaceous. Embryo with long, incumbent, transverse radicle; cotyledons flat. Male flowers with pistillode; filaments 4, inflexed in bud.
   2. Herb. Inflorescence cymose, bisexual or unisexual. Madagascar, Asia. Australasia ..... *Fatoua.*
   2. Trees. Inflorescence racemose or spicate, unbranched, unisexual. Dioecious or monoecious. Asia, North America ..... *Morus.*
1. Seeds 4–12 mm. wide, rounded. Radical not transversely elongate; cotyledons often folded or much thickened, often unequal. Leaves distichous. Spinous or not.
   3. Male flower without pistillode. Filaments straight in bud. Female perianth utricular, 4-dentate. Ovary (drupe) inferior. Unarmed or with spinous-dentate leaf. America.
      4. Stamens 4, Male inflorescence racemose, spicate or (*Paraclarisia*) capitate ..... *Sorocea.*
      4. Stamen 1. Male inflorescence spicate ..... *Clarisia.*
   3. Male flower with pistillode. Filaments (3–5, mostly 4) inflexed in bud.
      5. Fruiting perianth fleshy as in *Morus*. Madagascar *Ampalis, Pachytrophe.*
      5. Fruiting perianth not fleshy, but the drupe thinly fleshy or with thickly fleshy base.
         6. Ovary (drupe) inferior. Unarmed. America, Malaysia, Madagascar ..... *Trophis.*
         6. Ovary (drupe) superior. Spinous or not. Asia, Australasia. (Africa ?) ..... *Streblus.* (Africa, *Neosloetiopsis, Sloetiopsis*).

Too many genera on insufficient and invalid grounds trouble this small tribe. I have reduced eleven to sections, or synonyms, of *Streblus,* and I have considered reducing *Streblus* to *Trophis,* and all genera to *Morus.* The variety in the tribe is certainly much less than that of *Ficus,* but insufficient knowledge and the difficulty in assessing relic plants such as *Fatoua, Morus, Ampalis,* and *Pachytrophe* render wholesale reduction at this stage unwise.

The tribe represents the relics of that part of the family in which the female inflorescence, though sometimes reduced to the one-flowered state, is not specialised in form through thickening of the axis.

Sexuality. The bisexual inflorescence of *Fatoua* and *Streblus* sect. *Bleekrodea* has been used to separate these two genera into a tribe Fatoueae. The Madagascan species of *Fatoua*, however, has unisexual inflorescences and sect. *Bleekrodea* merges through *Streblus tonkinensis* (*Teonongia* Stapf) with *S. asper*. The inflorescences of *S. tonkinensis* vary from the condition of sect. *Bleekrodea* with the female flower surrounded by males to the condition in *S. asper*, though monoecious, but Gagnepain has described var. *monoica* of *S. asper* as having a female flower in the male cluster. Then, because of its bisexual spike, *Sloetia* has been placed in Dorstenieae, where it is entirely out of place. In flower, fruit, seed, and leaf-structure *Sloetia* and *Bleekrodea* are closely allied and both, by analogy with *Ficus*, are merely sections of *Streblus*.

Sterile groove in male spike. As already noted, this feature occurs in all spicate inflorescences of Moreae and in *Broussonetia*, *Maclura*, and *Malaisia* of Artocarpeae. It has yet to be explained morphologically. It would seem to be a sign of affinity, yet the racemose and paniculate inflorescence of *Streblus* sens. lat., *Trophis*, and *Maclura* lack the sterile groove. In spite of its peculiarity it is difficult to give it a primary value in classification.

Capitate male inflorescence. The inflorescence of shortly pedicellate male flowers in *S. asper* seems a good generic character until it is realised that the insertion of a female flower into the centre of it, as may happen in *S. asper* var. *monoica*, turns it into the bisexual cyme of *Streblus* sect. *Bleekrodea*, with *S. tonkinensis* as the bridge. *Streblus* sect. *Phyllochlamys* has also a capitate male inflorescence, but the fruit-characters ally the single species with sect. *Taxotrophis* and indicate that the capitate male inflorescence is here a condensed raceme. *S. crenatus* (sect. *Pseudotrophis*) and *S. perakensis* (sect. *Paratrophis*) have almost capitate male inflorescences, but they have the sterile groove which indicates that they are derived from condensed spikes. It must be concluded that the condensation of the male inflorescence has occured independently in several lines of the genus.

Female inflorescence. Unlike the male, the female inflorescence never condenses into a head; that is the character of Artocarpeae. Instead, reduction leads to fewer flowers and ends with the solitary pedunculate female flower, arrived in parallel in *Streblus* sect. *Streblus*, *Phyllochlamys*, *Pseudostreblus*, *Taxotrophis*, *Pseudotrophis*, and *Paratrophis*, in *Trophis* sect. *Maillardia*, and, perhaps, in the African *Neosloetiopsis*.

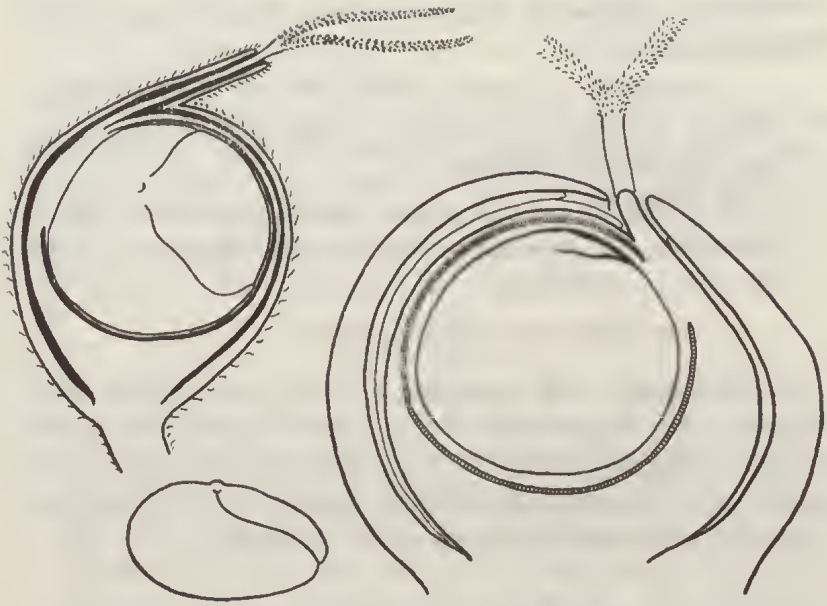


Fig. 10. Fruits in section, × 5. *Streblus* (*Bleekrodea*) *insignis* (Bl.) Corner, left, with embryo. *Streblus* (*Sloetia*) *elongatus* (Miq.) Corner, right, with thickened fruit-base; the lignified endocarp hatched.

Pulpy fruit-base. The drupes of *Streblus* sect. *Phyllochlamys*, *Sloetia*, and *Taxotrophis* have a strongly swollen base and they actually dehisce crescentically over the apex in a plane at right angles to that of the style. When this happens in *S. elongatus*, and presumably in the other species, the seed is forcibly ejected by the snapping together of the two sides of the swollen, white, edible and sweet-tasting base. It seems a good character for a genus, but there are transitions with slightly fleshy base as in sect. *Bleekrodea* (drupe dehiscent at the apex), and in sect. *Pseudotrophis* and *Paratrophis* in which the drupe is mostly, if not always, indehiscent. The drupelets of *Ficus* are often fleshy at the base and, in a few species, dehisce at the apex to liberate the seed into the fig-cavity, but the character has no classificatory value. Nevertheless, it may be a primary distinction between *Streblus* and *Morus*, though most species of *Streblus* seem to have lost it.

Pulpy tepals. Together with the small seed, the pulpy fruiting tepals are the chief distinction of *Morus*. The Madagascan *Ampalis* and *Pachytrophe* have also pulpy tepals, but this character occurs in *Maclura* with which they seem more nearly allied. Pulpy tepals occur, too, in many groups of *Ficus*, particularly sect. *Ficus*. The character seems to contrast with that of *Streblus*, and this is the main reason why I refrain from uniting *Streblus* with *Morus*.

Pistillode. This feature offers three states which may be a basis of classification:—

1. Pistillode quadrate-columnar; *Morus, Ampalis, Pachytrophe; Streblus* sect. *Streblus, Taxotrophis, Pseudotrophis,* and *Paratrophis; Trophis.*

2. Pistillode minute, spicate, subulate, or conic; *Fatoua, Neosloetiopsis, Sloetiopsis; Streblus* sect. *Bleekrodea, Pseudostreblus,* and *Sloetia.*

3. Pistillode none; *Clarisia, Sorocea.*

In Artocarpeae with pistillode it is the second kind, which appears as the degeneration of the sterile ovary towards the final state of complete absence. The quadrate-columnar state is that typical of Urticaceae with inflexed stamens. *Streblus,* therefore, seems to show stages in the loss of the pistillode.

Ampalis Bojer and **Pachytrophe** Bur.

Bojer, Hort. Maurit. (1837) 291; Bur. DC Prodr. 17 (1873) 234; Leandri, Fl. Madag. fam. 55 (1952) 6, 9.—*Streblus* Lour. subgen. *Parastreblus* Bl. Mus. Bot. Lugd. Bat. 2 (1856) 80 (= *Ampalis*).

These two small genera of Madagascar resemble *Streblus* in many ways but the fruiting tepals become fleshy as in *Morus* and, indeed, as in *Maclura. Ampalis* has the embryo of *Maclura,* consisting of two small flat cotyledons and a rather long accumbent radicle. *Pachytrophe* has an embryo like that of several species of *Streblus* sect. *Paratrophis,* with foliaceous conduplicate cotyledons and incumbent radicle, but this embryo also occurs in *Maclura* sect. *Cardiogyne.* The ovule of *Pachytrophe* is attached to a much thickened placenta which becomes a woody plug at the side of the seed, and this feature occurs in various Moraceae, without mark of affinity, such as *Broussonetia kurzii, Pararto-carpus, Streblus solomonensis, Treculia,* and *Trophis branderhorstii.* It seems as if both genera are related with *Maclura,* as relics of its less specialised ancestry, and, if so, this will necessitate a re-definition of Artocarpeae, or the fusion of it with Moreae. Compare, however, *Neosloetiopsis.*

Morus L.

The ovate-cordate lamina of *Morus,* with plicate vernation, corresponds with the state of tree-evolution seen in *Ficus* subgen. *Sycomorus* and in various groups of subgen. *Ficus.* From it the simpler, inrolled, leaf of *Streblus* has been derived.

M. macroura Miq. Pl. Jungh. 1 (1851) 42.—*M. laevigata* Wall. ex Hook. Fl. Br. Ind. 5 (1888) 492.—*M. alba L.* var. *laevigata* Bur. DC Prodr. 17 (1873) 245.

I can see no distinction whatever between these two species and, therefore, reduce *M. laevigata*. The species becomes, then, a wide-spread tree from Sikkim to Hainan with a relict status in Sumatra, as a mountain tree, and, perhaps, in Java though it may have been introduced to this country from Sumatra. Comparable is the group of *Ficus hirta* in *Ficus* sect. *Ficus*.

Streblus Lour.

Fl. Cochineh. (1790) 615; Blume. Mus. Bot. Lugd. Bat. 2, (1856) 79, f. 30; Miq. Fl. In. Bat. 1, 2 (1859) 277; Bur. DC Prodr. 17 (1873) 218; Baill. Hist. Pl. 6 (1875) 146, 195; Benth. et Hook. Gen. Pl. 3 (1880) 359; Engl. Nat. Pflanzenf. 3, 1 (1894) 78, f. 57 A-C.—*Achymus* Vahl ex Juss. Diet. Sc. Nat. 1, suppl. (1816) 31.—*Achimus* Poir. id. 5 (1827) 51.—*Epicarpurus* Bl. Bijdr. (1824) 488.—*Albrandia* Gaud. Voy. Freye. Bot. (1826) 509.—*Albradia* D. Dietr. Syn. Pl. 5 (1852) 280.—*Calius* Blaneo, Fl. Filip. (1837) 698; Bur. DC Prodr. 17 (1873) 278.—*Bleekrodea* Bl. Mus. Bot. Lugd. Bat. 2 (1856) 87; Bur. DC Prodr. 17 (1873) 254; Baill. Hist. Pl. 6 (1875) 147, 198; Benth. et Hook. Gen. Pl. 3 (1880) 358; Engl. Nat. Pflanzenf. 3,1 (1894) 71, f. 50 C,D; Leandri, Fl. Madagasc. fam. 55 (1952) 5.—*Paratrophis* Bl. Mus. Bot. Lugd. Bat. 2 (1856) 81; Bur. DC Prodr. 17 (1873) 235; Baill. Hist. Pl. 6 (1875) 143, 191; Benth. et Hook. Gen. Pl. 3 (1880) 364; Engl. Nat. Pflanzenf. 3, 1 (1894) 72; Cheeseman, Man. N. Zeal. Fl. (1906) 631.—*Taxotrophis* Bl. Mus. Bot. Lugd. Bat. 2 (1856) 77; Miq. Fl. Ind. Bat. 1,2 (1859) 278; Bur. DC Prodr. 17 (1873) 216; Baill. Hist. Pl. 6 (1875) 146, 195; Benth. et Hook. Gen. Pl. 3 (1880) 358; Engl. Nat. Pflanzenf. 3, 1 (1894) 77; Hutchinson. Kew Bull. (1918) 147.— *Sloetia* Teysm. et Binn. ex Kurz, J. Linn. Soc. Bot. 8 (1864) 168; Bur. DC Prodr. 17 (1873) 257; Baill. Hist. Pl. 6 (1875) 147, 198; Benth. et Hook. Gen. Pl. 3 (1880) 365; Engl. Nat. Pflanzenf. 3, 1 (1894) 79.—*Diplocos* Bur. DC Prodr. 17 (1873) 215; Baill. Hist. Pl. 6 (1875) 148. 199. *Phyllochlamys* Bur. DC Prodr. 17 (1873) 217; Baill. Hist. Pl. 6 (1875) 146, 196; Benth et Hook Gen. Pl. 3 (1880) 359; Engl. Nat. Pflanzenf. 3, 1 (1894) 77.—*Pseudomorus* (Endl.) Bur. Ann. Sc. Nat. ser. 5, 11 (1869) 372; DC Prodr. 17 (1873) 249; Baill. Hist. Pl. 6 (1875) 143, 191; Benth et Hook. Gen. Pl. 3 (1880) 364; Engl. Nat. Pflanzenf. 3, 1 (1894) 72; Skottsberg, Act. Hort. Gotob. 15 (1944) 347; Stearn, J. Arn. Arb. 28 (1947) 426.—*Pseudostreblus* Bur. DC Prodr. 17 (1873) 219; Baill. Hist. Pl. 6 (1875) 146, 195; Benth. et Hook. Gen. Pl. 3 (1880) 357; Hook. Fl. Br. Ind. 5 (1888) 487; Engl. Nat. Pflanzenf. 3, 1 (1894) 71.—*Uromorus* Bur. DC Prodr. 17 (1873) 236.—*Pseudotrophis* Warb. Bot. Jahrb. 13 (1891) 294; Engl. Nat. Pflanzenf. Naehtr. 1 (1897) 119.—*Teonongia* Stapf. Hook. Ic. Pl. 30 (1911) t. 2947; Gagnep. Fl. Gen. I.-C. 5 (1928) 710, f. 86.—*Dimerocarpus* Gagnep. Bull. Mus. Hist. Nat. Paris 27 (1921) 441; Bull. Soc. Bot. Fr. 70 (1923) 204; Fl. Gen. I.-C. 5 (1928) 704.—*Diplothorax* Gagnep. Bull. Soc. Bot. Fr. 75 (1928) 98; Fl. Gen. I.-C. 5 (1928) 705.—*Chevalierodendron* Leroy, Compt. Rend. Ac. Sci. Paris 227 (1948) 146.—[*Balanostreblus* Kurz = *Sorocea*, vid. Jarrett. J. Arn. Arb. 39 (1958) 107.].

Trees, unarmed or spinous, monoecious or dioecious. Leaves distichous, mostly oblong-elliptic to lanceolate, denticulate or entire, mostly short-petiolate, without glands. Inflorescences axillary, bisexual or unisexual, pedunculate, varying cymose, racemose, spicate, and capitate, or the female flower solitary. Male flower with a pistillode, 3–5 merous, mostly 4–merous; tepals more or less valvate, free or shortly joined; filaments inflexed in bud; anthers small, reniform, extrorse. Female flowers 4–merous; tepals decussate, imbricate, free or more or less joined; ovary superior. Drupe rather large, 5–14 mm. wide, thinly fleshy, often with a thickened fleshy base, dehiscent or not, the thin tepals investing the drupe or not. Seed large, round, invested by the thin membranous endocarp; embryo various. Cystoliths amphigenous, hypergenous, or none, not papillate except sect. *Streblus;* microscopic gland-hairs various; hairs simple, aseptate, smooth except sect. *Streblus;* stomata superficial. Species 22, Asia, Australasia, (Africa ?); 13 in Malaysia.

As reconstituted, this genus represents the existing remains of the Proto-Moraceae with most generalised inflorescence. Vegetatively it has advanced to the applanate foliage with distichous leaves. The inflorescences show every reduction to the spicate condition, and the female to the one-flowered state. The fruit seems to retain traces of dehiscence. Sterile the genus may be confused with some groups of *Ficus,* but the leaves invariably lack glands. *Trophis,* in the Old World, differs not only in flower but in the hypogenous cystoliths. See, also, sect. *Sloetia.*

sect. **Bleekrodea** (Bl.) Corner stat. nov.—*Bleekrodea* Bl.

Unarmed, monoecious. Inflorescence bisexual, composed of 1–2 female flowers surrounded by more or less pedicellate male flowers, solitary. Male flower with 4–5 tepals, gamophyllous in the lower half; pistillode minute, conic. Female perianth utricular, minutely 4-dentate, investing the ovary; style and stigmatic arms long. Drupe with a thinly fleshy base, dehiscent, enclosed in the enlarged utricular perianth; endocarp not or scarcely differentiated. Cotyledons thick, fleshy, unequal, not folded; radicle short. Cystoliths amphigenous, not papillate; microscopic gland-hairs 1–4-celled, cruciate; hairs smooth, often hooked at the tip; epidermal cells undulate-stellate. Species 2, Borneo, Madagascar. Type, *S. insignis* (Bl.) Corner.—The inflorescence recalls *Fatoua,* but in all other respects the section is near sect. *Streblus.*

sect. **Paratrophis** (Bl.) Corner stat. nov.—*Paratrophis* Bl.; *Pseudomorus* (Endl.) Bur.; *Uromorus* Bur.; *Chevalierodendron* Leroy.

Unarmed, dioecious. Male spike unbranched, with a sterile groove; flowers sessile, 4–merous, 4–partite, valvate; pistillode quadrate-columnar. Female spike many to 1–flowered; flowers in 2 rows, sessile. Bracts ovate-lanceolate or peltate-reniform. Drupe without fleshy base, the tepals little enlarged (except *S. perakensis*), indehiscent. Embryo curved; cotyledons equal, foliaceous and conduplicate to small and flat, not much thickened; radicle rather long, incumbent. Cystoliths hypergenous or none, not papillate; microscopic gland-hairs various; hairs smooth; epidermal cells generally polygonal (subundulate in *S. solomonensis*); hypodermis none or 1-celled (*S. glaber, S. perakensis, S. urophyllus*). Species 9, Asia, Australasia. Type, *S. heterophyllus* (Bl.) Corner.

sect. **Phyllochlamys** (Bur.) Corner stat. nov.—*Phyllochlamys* Bur.

Twigs spinous. Dioecious. Male inflorescence capitate or very shortly racemose, without interfloral bracts; flowers pedicellate, 4–merous, tepals gamophyllous in the lower half; pistillode quadrate-columnar. Female flower solitary. Drupe with thick fleshy base, ? dehiscent, much exceeded by the enlarged foliaceous tepals. Cotyledons thick, fleshy, subequal; radicle short. Cystoliths hypergenous, not papillate, or also scattered on the lower side of the lamina along the veins; gland-hairs ?; prismatic crystals abundant in the sheath of the veins; epidermal cells mainly polygonal; hypodermis 1-celled. Species 1, Asia, *S. taxoides* (Heyne) Kurz.—This section is very close to sect. *Pseudotrophis* and *Taxotrophis*.

sect. **Pseudostreblus** (Bur.) Corner stat. nov.—*Pseudostreblus* Bur.

Unarmed. Monoecious. Male inflorescence subspicate, branched, with a sterile groove; flowers sessile to shortly pedicellate, 5–merous; tepals free, imbricate; pistillode minute, conic. Female flower solitary, pedunculate; tepals 4. Drupe not thickened at the base, ? indehiscent, invested by the much enlarged tepals. Embryo curved; cotyledons fleshy, unequal; radicle short. Cystoliths none; microscopic gland–hairs clavate, multicellular; hairs smooth, microscopic; epidermal cells undulate; hypodermis none. Species 1, Asiatic mainland, Hainan; *S. indicus* (Bur.) Corner.

sect. **Pseudotrophis** (Warb.) Corner stat. nov.—*Pseudotrophis* Warb.; *Dimerocarpus* Gagnep.

Unarmed or with spinous twigs. Dioecious. Male inflorescence spicate, unbranched, with a sterile groove; bracts ovate-lanceolate to peltate-reniform; flowers sessile, 4–merous; pistillode quadrate-columnar. Female inflorescences racemose, 8–1–flowered; flowers more or less pedicellate. Drupe with thick fleshy base, dehiscent, more or less covered by the enlarged tepals. Embryo curved;

cotyledons thick, fleshy, unequal, the smaller spathulate or cylindric and surrounded by the large; radicle short. Cystoliths amphigenous, not papillate; microscopic gland-hairs 1-many celled, capitate; hairs smooth; epidermal cells polygonal to undulate; hypodermis 1-celled. Species 3, Asia. Type, *Pseudotrophis laxiflora* Warb. = *S. ilicifolius* (Vidal) Corner.

sect. **Sloetia** (Teysm. et Binn.) Corner stat. nov.—*Sloetia* Teysm. et Binn.

Unarmed. Monoecious. Inflorescences spicate, bisexual or male, with a sterile groove. Male flowers sessile, many, trimerous; pistillode minute, spicate. Female flowers 0–4 per spike, 4-merous. Drupe with thick fleshy base, dehiscent, more or less covered by the enlarged tepals. Cotyledons fleshy, generally very unequal, but varying equal; radicle very short. Cystoliths amphigenous, small, not papillate; microscopic gland-hairs 4–8-celled, cruciate to capitate-peltate; hairs smooth; upper epidermal cells polygonal; hypodermis none. Species 1, Malaya, Sumatra; *S. elongatus* (Miq.) Corner.

sect. **Streblus**.—*Achymus* Vahl (*Achimus* Poir.); *Albrandia* Gaud. (*Albradia* D. Dietr.); *Calius* Blanco; *Epicarpurus* Bl.; *Teonongia* Stapf; *Diplothorax* Gagnep.

Unarmed. Monoecious or dioecious. Inflorescence bisexual and capitate with a central sessile female flower surrounded by males, or unisexual with the male capitate and the female as a solitary pedunculate flower. Male inflorescence with few small bracts surrounding the capitulum, not between the flowers; tepals 4–5, free or shortly joined; stamens 4 (–2); pistillode small, subconic, columnar to quadrate, with 2 minute stigmata. Female flower with 1–2 minute bracts at the base of the peduncle, sometimes one on the peduncle, and 2 larger bracteoles at the base of the perianth; tepals 4, free; style short, with 2 long stigmatic arms. Drupe dehiscent or not, enclosed at first in the enlarged tepals, without fleshy base. Embryo curved; cotyledons thick, fleshy, equal to very unequal; radicle short, incumbent. Cystoliths amphigenous, papillate as the hairs; microscopic gland-hairs 1–4-celled, capitate; no crystal-cells in the epidermis; epidermal cells undulate-stellate. Species 2, South-east Asia; type, *S. asper* Lour.

sect. **Taxotrophis** (Bl.) Corner stat. nov.—*Taxotrophis* Bl.; *Diplocos* Bur.; *Pseudotrophis* Warb.

Twigs spinous. Dioecious. Male inflorescence racemose, unbranched, without a sterile groove; bracts ovate-lanceolate; flowers 4-merous, pedicellate, often unevenly spaced; pistillode quadrate-columnar. Female inflorescence shortly racemose, few-flowered to 1-flowered. Drupe without a fleshy base. Cotyledons subequal, folded, radicle long; or cotyledons fleshy, unequal, radicle short. Cystoliths ? Species 3, Asia. Type, *S. spinosus* (Bl.) Corner = *Taxotrophis javanica* Bl.

Key to the sections of Streblus

1. Inflorescence cymose, often condensed, bisexual, with 1–2 protogynous female flowers in the centre; or the male inflorescence capitate (without a sterile groove) and the female flower solitary. Cotyledons very unequal, one strongly thickened or both fleshy and equal; radicle short.
  2. Spinous tree. Fruiting tepals much exceeding the drupe with fleshy base. Male inflorescence capitate; pistillode quadrate-cylindric. Female flower solitary. Dioecious. Ceylon to Timor *Phyllochlamys.*
  2. Unarmed. Fruiting tepals equal to or shorter than the drupe.
    3. Female perianth with free tepals. Inflorescence bisexual or the male capitate and the female flower solitary; pistillode conic to columnar. Monoecius or dioecious. Ceylon to Celebes .... *Streblus.*
    3. Female perianth utricular, covering the drupe but free. Inflorescence bisexual. Pistillode minute conic. Madagascar, Borneo *Bleekrodea.*
1. Male inflorescence elongate-racemose, simple or branched, or spicate. Female flowers spicate or solitary.
  4. Male inflorescence branched racemose-spicate, with a sterile groove; flowers 5-merous; pistillode minute conic. Female flower solitary, 4-merous; tepals covering the large drupe. Cotyledons unequal, fleshy. Monoecious, unarmed. India, China, Thailand *Pseudostreblus.*
  4. Male inflorescence unbranched; flowers 4-merous or 3-merous.
    5. Spike bisexual with a sterile groove; male flower 3-merous; pistillode minute conic; female flower 4-merous. Drupe dehiscent with fleshy base, covered by the tepals. Cotyledons equal, fleshy, or one much reduced. Unarmed. Malaya, Riouw, Sumatra *Sloetia.*
    (Male flower 4-merous. East Africa ..... *Sloetiopsis*).
    5. Spikes unisexual, dioecious. Flowers 4-merous. Pistillode quadrate-columnar.
      6. Male and female flowers pedicellate, the racemes without a sterile groove. Spinous. Ceylon to Flores ..... *Taxotrophis.*
      6. Male flowers sessile, the male spike with a sterile groove.
        7. Female flowers more or less pedicellate. Drupe fleshy at the base, dehiscent, more or less covered by the enlarged tepals. Cotyledons thick, unequal, one large and fleshy. Spinous or not. India to Molucca Isl. ..... *Pseudotrophis.*
        7. Female flowers sessile, more or less distichous, or solitary and pedunculate. Drupe not fleshy at the base, ? indehiscent, mostly not covered by the tepals. Cotyledons various. Unarmed. Malaysia, Australasia ..... *Paratrophis.*
        (West Africa; pistillode minute, spicate .. *Neosloetiopsis*).

Streblus sect. **Bleekrodea**

Key to the Species

Male flowers pedicellate, rather laxly clustered, equal to or exceeding the female flower and fruit. Radicle very short. Stipules indurate, persistent. Lamina 8–21 × 3–8 cm. Borneo ..... *S. insignis.*

Male flowers subsessile, in clusters shorter than the female flower and fruit. Radicle shortly elongate, incumbent on the smaller cotyledon. Lamina generally small. Varying deciduous. Madagascar *S. madagascariensis.*

S. insignis (Bl.) Corner comb. nov.—*Bleekrodea insignis* Bl. Mus. Bot. Lugd. Bat. 2 (1856) 88, t.28. Type, Korthals, G. Sakoembang, Borneo, at Leiden.

S. madagascariensis (Bl.) Corner comb. nov.—*Bleekrodea madagascariensis* Bl. id. 88; Leandri, Fl. Madagasc. fam 55 (1952) 5.

Streblus sect. **Paratrophis**

Key to the Species

1. Bracts reniform or peltate. Male inflorescences often long, female often many-flowered, never 1-flowered. Lamina more or less membranous, usually without hypodermis. Micronesia, Melanesia, Polynesia.
   2. Cotyledons flat, rather small; radicle incumbent. Lamina often scabrid, the basal nerves often as long as the lateral; cystoliths none. Male spike 2–18 cm. long; female 5–22 mm. long, 2–9-flowered. Monoecious or dioecious ..... *S. pendulinus.*
   2. Cotyledons foliaceous, conduplicate, the radicle incumbent in the sinus of the cotyledons. Lamina smooth, basal nerves shorter than the lateral.
      3. Male spikes 1–5 cm. long; female 6–25 mm. long, 3–8-flowered. Drupe 4 mm. wide, red. Leaves often small; cystoliths abundant on the upper side. New Zealand ..... *S. heterophyllus.*
      3. Male and female spikes longer, many-flowered. Lamina often with 1–3 intercostals; cystoliths none.
         4. Male and female spikes 10–20 cm. long. Lamina 9–30 × 3–15 cm.; lateral nerves 7–14 pairs; petiole 15–65 mm. *S. anthropophagorum.*
         4. Spikes –10 cm. long. Lamina 8–20 × 3–10 cm.; petiole 10–20 mm.
            5. Stigmatic arms very short. Lateral nerves 8–11 pairs *S. solomonensis.*
            5. Stigmatic arms –1.5 mm. long, distinct.
               6. Lateral nerves 10–15 pairs. Drupe black .... *S. tahitensis.*
               6. Lateral nerves 6–8 pairs. Drupe red ..... *S. smithii.*
1. Bracts ovate-lanceolate, sessile. Male and female spikes 10–25 mm. long, often few-flowered, or the female flower solitary. Lamina narrowly elliptic to lanceolate, mostly thinly coriaceous and with a hypodermis (1-cell thick); petiole 2–12 mm.; intercostals none.
   7. Fruiting tepals much enlarged, covering the drupe; stigmata very short. Male spike –10 mm. long. Female flower solitary. Cotyledons somewhat thickened, conduplicate; radicle rather short. Cystoliths hypergenous, sparse, or none. Prismatic crystals in the lower spidermis along the veins. Malaya ..... *S. perakensis.*
   7. Fruiting tepals scarcely enlarged, not concealing the drupe. Male spike 10–25 mm. long. Female spike 1–9-flowered. Cotyledons flat, not conduplicate; radicle rather long, incumbent. Cystoliths none. Small sphaerocrystals in the lower epidermal cells.
      8. Lamina dentate, shortly acuminate, often stiffly coriaceous; lateral nerves 6–13 pairs. Male flowers 3–7 per spike, 2.5–3.5 mm. wide in bud, subglomerate. New Guinea ..... *S. urophyllus.*
      8. Lamina entire or crenulate, rather long attenuate or acuminate or caudate; lateral nerves 9–18 pairs. Male flowers often numerous, smaller, not glomerate. Malaya to New Guinea and Queensland *S. glaber.*

S. anthropophagorum (Seem.) Corner comb. nov.—*Trophis anthropophagorum* Seem. Fl. Vit. (1868) 258, t. 68.—*Uromorus anthropophagorum* (Seem.) Bur. DC Prodr. 17 (1873)

236.—*Paratrophis anthropophagorum* (Seem.) Benth. et Hook. ex Drake 111. Ins. Mar. Pacif. f. 7 (1892) 296.—*P. ostermeyri* Rechinger, *P. viridissima* Rechinger, *P. zahlbruckneri* Rechinger, Fedd. Rep. 5 (1908) 130.

Distr. Fiji, Samoa, Cook Isl., Niue.

The very long, many-flowered, male and female inflorescences and the large leaves, often with rather long petioles, distinguish this species. In Fiji and Samoa it varies into forms with shorter inflorescences, which seem exactly intermediate with *S. tahitensis;* such are the three species of Rechinger, described from Upolu (Samoa), and not specifically distinct. To this complex belong *S. smithii* and, possibly, *S. solomonensis*. They need field-study. For instance, it is not clear if the long inflorescences and large leaves are borne on saplings, and that they become smaller as the tree grows larger. Does *S. anthropophagorum* become as large a tree, –20 m. high, as *S. solomonensis* ?

This group of species suggests a Pacific centre for the genus *Streblus,* whence the species have migrated and, in the Moraceous manner, become smaller in leaf and inflorescence, as they have diverged. The genus has reached Hawaii but not, apparently, the American tropics.

S. glaber (Merr.) Corner comb. nov.—*Gironniera glabra* Merr. Philip. J. Sci. 1 (1906) suppl. 42.—*Paratrophis glabra* (Merr.) v. Steen. J. Bot. 72 (1934) 8.—*Chevalierodendron glabrum* (Merr). Leroy, Compt. Rend. Ac. Sci. Paris 227 (1948) 146.—*Aphananthes negrosensis* Elmer, Leafl. Philip. Bot. 2 (1909) 575.—*Pseudostreblus caudatus* Ridley, J. Fed. Mal. St. Mus. 6 (1915) 54.—*Streblus laevifolius* Diels, Bot. Jahrb. 67 (1935) 171.—(*Excoecaria baccifera* Elm. ined., Elmer 22014).

var. **glaber**

Distr. Malaya, Borneo, Philippine Isl., Celebes, New Guinea; mountain forest, 700–2,500 m. alt.

var. **australianus** Corner var. nov.—*Paratrophis australiana* C. T. White, Contr. Arn. Arb. 4 (1933) 15.

Alabastra mascula minora –1 mm. lata, plura. Lamina crenulata.

Distr. Queensland; Kajewski 1378, 1383, Herberton Range.

In leaf, inflorescence, and fruit, *S. glaber* is the most attenuate species of the section and it has the widest range.

S. heterophyllus (Bl.) Corner comb. nov.—*Epicarpurus microphyllus* Raoul, Ann. Sci. Nat. ser. 3, 2 (1844) 117.—*Taxotrophis microphylla* (Raoul) F.v.M. Fragm. Phyt. Austral. 6 (1868) 193.—*Paratrophis microphylla* (Raoul) Cockayne, Bot. Notes Kennedy's Bush and Sci. Res. (1915) 3.—*Paratrophis heterophylla* Bl. Mus. Bot. Lugd. Bat. 2 (1856) 81.

var. **heterophylla**

Male spikes –25 mm. long; female spikes 6–12 mm. long, 3–8-flowered. Drupes 1 (–3) per spike, 4 mm. wide. Lamina small, –35 mm. long, the juvenile lamina pinnatifid to serrate.

Distr. New Zealand.

var. **elliptica** Kirk.—*Paratrophis heterophylla* Bl. var. *elliptica* Kirk, Tr. N.Z. Inst. 29 (1897) 500, t. 46.—*Trophis opaca* Banks et Sol. ex Hook. f. Fl. Nov. Zel. 1 (1853) 224.—*P. banksii* Cheeseman, Man. N. Zeal. Fl. (1906) 633.—*P. opaca* Druce, Rep. Bot. Exch. Cl. Br. Isles (1916–17) 639.

Male spikes –5 cm. long; female spikes –25 mm. long, 8–25-flowered. Drupes several per spike, –6 mm. wide. Lamina –8.5 cm. long, crenate-dentate.

Distr. New Zealand.

That this is only a variety of *S. heterophyllus* is shown by the hybrids recorded by Allen as × *Paratrophis micropaca* (Genetica 9, 1927, 145; id. 7, 1925, 290, f.3).

The combination *S. microphyllus* is antedated by Kurz's synonym of *S. taxoides.*

S. pendulinus (Endl.) F.v.M. Fragm. Phyt. Austral. 6 (1868) 192. —*Morus pendulina* Endl. Prodr. Fl. Norf. (1833) 40.—*M. brunoniana* Endl. Atakta Bot. (1835) t. 32.—*Streblus brunonianus* (Endl.) F. v. M. l.c. (1868) 192—*Pseudomorus brunoniana* (Endl.) Bur. Ann. Sci. Nat. ser. 5, 11 (1869) 373.—*Pseudomorus sandwicensis* Degener, Fl. Hawaii. (1938) 21/22. —*Ps. brunoniana* (Endl.) Bur. var. *australiana* Bur., v. *obtusata* Bur., v. *pendulina* (Endl.) Bur., v. *scabra* Bur. l.c. (1869) 373.—*Ps. brunoniana* v. *sandwicensis* (Degener) Skottsberg, Act. Hort. Gotob. 15 (1944) 347.—*Ps. pendulina* (Endl.) Stearn, J. Arn. Arb. 28 (1947) 427.

This is a variable plant. When young, it has large leaves with 10–16 pairs of lateral nerves. Larger trees have smaller leaves with 7–12 pairs of lateral nerves. The larger leaves are ovate-elliptic to ovate-oblong; the smaller are elliptic to elliptic-lanceolate and less toothed. I doubt if the three or four varieties which have been made are more than such differences in growth, though some collections have scabrid leaves. Almost identical differences occur in *Malaisia scandens* and are not to be distinguished in the field. Of *S. pendulinus* I have seen 33 collections from the whole range of the species and have been unable to draw any sharp line. Leaves typical of *P. sandwicensis* occur on collections from Micronesia and the side-twigs of these have the leaves of var. *australiana;* collections from Queensland may have the subacute leaves of v. *obtusata* (New Caledonia). There is no sectional distinction between *Pseudomorus* and *Paratrophis.*

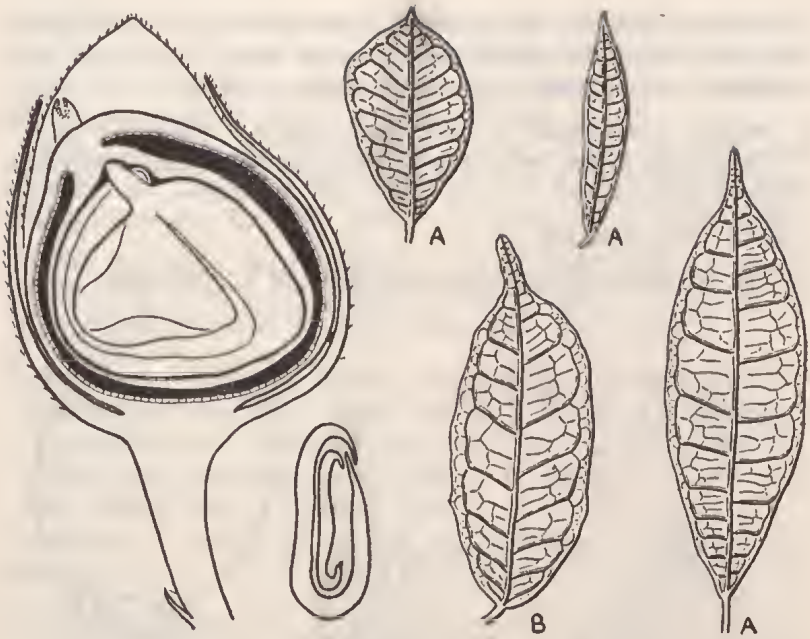


Fig. 11. *Streblus perakensis* Corner. Leaves, × ½; A, coll. Forest Ranger s.n., Chikus, 1933; B, Ridley 16171. Fruit and embryo in section, × 6; coll. For. Dept. 27338.

S. perakensis Corner sp. nov. Fig. 11.

Arbor parva glabra inermis, foliis distichis. Ramuli 1–1.5 mm. crassi, fusco-brunnei. Stipulae 1.3–3.5 mm. longae, caducae. Lamina 2.5–12 × 0.7–4 cm., anguste elliptica v. lanceolata v. suboblongata, ad apicem mucronatum attenuata v. acuminata, ad basim anguste cuneata v. anguste rotundata, integra v. subdenticulata, coriacea, laevis, sicco brunnea; costis lateralibus utrinsecus 8–15, patentibus, subtus elevatis, inarcuatis, intercostis nullis; costis basalibus brevibus; petiolo 2–7 mm. longo. Inflorescentia mascula axillaris 1–3, immatura –5 mm. longa, breviter pedunculata, uno latere sterilis, flores c. 6 sessiles secundos gerens; bracteis 1 mm. longis, ovatis, obtusis; tepalis 4, extus puberulis; staminibus 4; pistillodio minuto, 4-angulato. Flos femineus solitarius, breviter pedunculatus. Drupa c. 7 mm. lata, tepalis decussatis ovato-subacutis puberulis duobus eternis brevioribus obtecta; pedunculo 4–9 mm. longo, bracteis 1–2 parvis basim versus praedito; tepalis externis 5–7.5 mm. longis, internis 8–10 mm.; stylo nullo v. brevissimo; stigmatibus 2 subulatis 0.7 mm. longis; endocarpio tenuissimo subsclerotico. Embryon curvatum; radicula brevi recta; cotyledonibus inaequalibus, minori a majori implicato. Cystolitha nulla v. pauca hypergena.

Distr. Malaya (Perak, Pahang); For. Dept. 27338 (Chikus Forest Res., leg C. L. Carrier, fructu; typus, herb. Singapore); Forest Ranger s.n., Chikus Forest Res. March 1933, *lelimau*, floribus masculis; Ridley 16171, Kuala Teku.

S. crenato armato comparanda, differt costis lateralibus pluribus, stylo subnullo, drupa basim versus haud incrassata, cotyledonibus subaequalibus, cystolithis nullis v. sparsis.

S. smithii (Cheeseman) Corner comb. nov.—*Paratrophis smithii* Cheeseman Trans. N.Z. Inst. 20 (1888) 148; Man. New Zeal. Fl. (1906) 631.

Distr. New Zealand.

This is near to *S. anthropophagorum* and *S. tahitensis*.

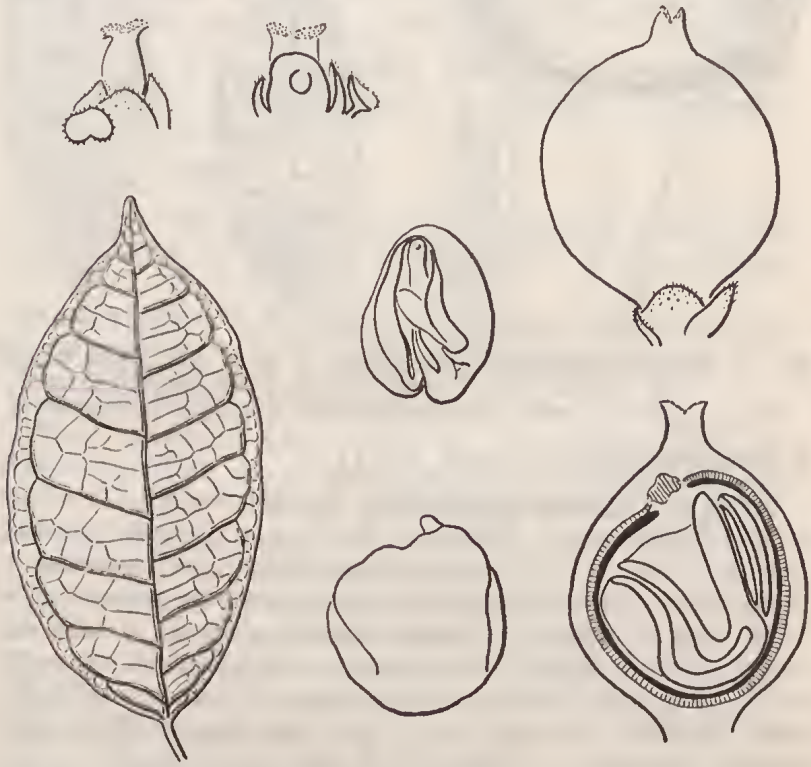


Fig. 12. *Streblus solomonensis* Corner. Leaf, × ½. Flower, × 6. Fruit and embryo, × 4. Coll. Kajewski 2396.

S. solomonensis Corner sp. nov. Fig. 44.

Arbor 20 m. alta, glabra, foliis distichis. Ramuli 1.5–2 mm. crassi, fusco-olivacei dein pallide ochracei. Stipulae –6 mm. longae, caducae. Lamina 8–12 × 3–9 cm., elliptica, saepe subasymmetrica, apice –14 mm. longo acuminata, basi cuneata, integra, membranacea, laevis, sicco griseo-viridis; costis lateralibus utrinsecus 8–11, subtus vix elevatis; intercostis 1–3 laxis; costis basalibus brevibus; petiolo 10–20 mm. longo. Inflorescentia mascula ? Inflorescentia feminea –15 mm. longa, in fructu –5 cm. longa, axillaris 1–2, floribus sessilibus distichis; pedunculo 2–6 mm. longo; bracteis 0.5–0.7 mm. longis, reniformibus subpeltatis, minute fimbriatis, inferioribus multis sterilibus; tepalis 4 decussatis, 1 mm. longis, ovatis subacutis v. obtusis; stylo brevissimo;

stigmatibus 2, 0.5 mm. longis. Drupae 3–5 per infructescentiam, 7–8 mm. latae, tepalis vix amplificatis 1.5 mm. longis; endocarpio ligneo tenui. Embryon curvatum; radicula recta longa; cotyledonibus subaequalibus, plicatis. Cystolitha nulla.

Distr. Bougainville Isl., Guadalcanal Isl.; Kajewski 2006, Bougainville Isl., Koniguru, Buin, 800 m. alt., *keru;* Kajewski 2396, Guadalcanal Isl., Berande River, *torgapbagi* (typus, herb. Kew).

This is said to be a common tree in rain-forest, the young leaves being cooked and eaten, the timber used for houses. The extremely short style and stigmatic arms distinguish it.

S. tahitensis (Nadeaud) Corner comb. nov.—*Uromorus tahitensis* (Nadeaud) Bur. DC Prodr. 17 (1873) 237.—*Pseudomorus brunoniana* var. *tahitensis* Nadeaud, En. Pl. Tahiti, p. 43.—*Paratrophis tahitensis* (Bur.) Benth. et Hook. ex Drake, Ill. Ins. Mar. Pacif. f. 7 (1892) 296.

Possibly a variety of *S. anthropophagorum.* I have seen no material.

S. urophyllus Diels, Bot. Jahrb. 67 (1935) 172.

var. **urophyllus**

Distr. New Guinea, 2,400–3,000 m. alt.

Closely allied with *S. glaber* and perhaps a high mountain state of it.

var. salicifolius Corner v. nov.

Frutex 3 m. altus. Lamina 5–14 × 0.6–1.5 cm., oblongo-lanceolata, acuta v. subacuminata, basi cuneata, denticulata v. integra, coriacea; costis lateralibus utrinsecus 18–25 rectangulatis; petiolo 3–7 mm. longo.

Distr. New Guinea; L. J. Brass 30220, Terr. New Guinea, Eastern Highlands, Mt. Wilhelm, east slopes, 3,000 m. alt., typus herb. Leiden.

Streblus sect. **Phyllochlamys**

S. taxoides (Heyne) Kurz, For. Fl. Burm 2 (1877) 465.—*Trophis taxoides* Heyne ap. Roth, Nov. Pl. Ind. Or. (1821) 368.—*T. taxiformis* Spreng. Syst. Veg. 3 (1826) 902.—*T. spinosa* Roxb. Fl. Ind. 3 (1832) 762.—*Epicarpurus timorensis* Decne. Nouw. Ann. Mus. Hist. Nat. 3 (1834) 499, t. 21.—*E. spinosus* (Roxb.) Wight, Ic. Ind. 6 (1835) 7, t. 1962 (partim).—*Taxotrophis roxburghii* Bl. Mus. Bot. Lugd. Bat. 2 (1856) 78.—*Phyllochlamys spinosa* (Roxb.) Bur. DC Prodr. 17 (1873) 218.—*Streblus microphyllus* Kurz, Prel. Rep. For. Pegu (1875) App. A, p. cxviii; App. B, p. 84 (in clavi); For. Fl. Burm 2 (1877) 464 (in clavi).—*S. taxoides* (Heyne) Kurz var. *microphylla* Kurz, For. Fl. Burm. 2 (1877) 465.—*Phyllochlamys wallichii* King, Hook. Fl. Br. Ind. 5 (1888) 489.—*P. taxoides* (Heyne) Kds.

Exkursionfl. Java 2 (1912) 89.—*P. taxoides* var. *parvifolia* Merr. Philip. J. Sci. 17 (1920) 247.—*P. tridentata* Gagnep. Fl. Gen. I.-C. 5 (1928) 714.—*Taxotrophis poilanei* Gagnep. id. 701.

Distr. Ceylon, India, Indochina, Thailand, Hainan, Malaya, Java, Lesser Sunda Isl. to Timor, Celebes (S.E.), Mindoro, Palawan.

I am indebted to Dr. Chew Wee Lek for the synonymy of this species.

Streblus sect. **Pseudostreblus**

S. indicus (Bur.) Corner comb. nov.—*Pseudostreblus indicus* Bur. DC Prodr. 17 (1873) 219.

Distr. Khasia Mts., North Thailand, Yunnan, Kwangsi-Kwangtung border, Hainan.

This seems a local or rare plant. I have seen merely six collections:—Hook. f. et Thompson (Epicarpurus 8), Kerr 6453, Sino-Soviet Exp. (1957) 8137 (Yunnan), F. C. How 43790 and 73223 (Hainan), and W. T. Tsang 22641 (Kwangsi). The last collection gives "fairly common in dry soil; fruit yellow".

Streblus sect. **Pseudotrophis**

Key to the Species

1. Unarmed. Lamina membranous-chartaceous, acuminate, with 1–6 intercostals. Male spike 40–140 mm. long. Cotyledons somewhat unequal. Twigs and lamina often drying yellowish. Cystoliths amphigenous; no crystal cells in epidermis ..... *S. macrophyllus.*

1. Spinous. Lamina coriaceous, acute or attenuate. Male spike shorter. Cotyledons very unequal, the inner not folded.

   2. Male spike 10–50 mm. long; female 2–6-flowered; bracts reniform. Lamina 6–20 × 3.5–10 cm., often spinous-dentate. Cystoliths hypergenous; single prismatic crystals abundant in the upper epidermal cells and along the veins beneath ..... *S. ilicifolius.*

   2. Male spike 5–10 mm. long; female flower solitary; bracts ovate. Lamina 3–9 × 1–4 cm., acute, crenate-denticulate, base rounded to cordate. Cystoliths amphigenous; crystal cells none in epidermis *S. crenatus.*

      (Unarmed. Leaf-base cuneate. Drupe-base not thickened. Cystoliths none or few and hypergenous; crystal-cells along the veins on the underside of the leaf ..... *S. perakensis*).

S. crenatus (Gagnep.) Corner comb. nov.—*Taxotrophis crenata* Gagnep. Fl. Gen. I.-C. 5 (1928) 702, f. 82.

Distr. Indochina (Cambodia, Laos, Cochinchina).

This comes very near to *S. taxoides,* but the male spike, though very short, has a sterile groove and the fruiting tepals are not larger than the drupe. Nevertheless it seems impossible to distinguish sterile plants and those with young female flowers.

S. ilicifolius (Vidal) Corner comb. nov.—*Taxotrophis ilicifolius* Vidal, Rev. Pl. Vasc. Filip. (1886) 249.—*Pseudotrophis laxiflora* Warb. Bot. Jahrb. 13 (1891) 294.—*Taxotrophis obtusa* Elmer, Leafl. Philip. Bot. 5 (1913) 1813.—*T. triapiculata* Gamble, Kew Bull. (1913) 188.

Distr. Chittagong, Burma, Indochina, Thailand, Hainan, Malaya, Philippine Isl., Celebes, Molucca Isl., Key Isl., Timor.

I am indebted to Dr. Chew Wee Lek for this synonymy. I have also seen the type of *P. laxiflora* Warb., loaned from Berlin; it is the more easterly state of *S. ilicifolius* with few or no spinous leaf-teeth.

S. macrophyllus Bl. Mus. Bot. Lugd. Bat. 2 (1856) 80.—*Diplocos ? macrophyllus* (Bl.) Bur. DC Prodr. 17 (1873) 216.—*Paratrophis mindanaensis* Warb. Perk. Fr. Fl. Philip. 1 (1904) 165. —*P. caudata* Merr. Philip. J. Sci. 1 (1906) Suppl. 183.—*Taxotrophis mindanaensis* Elm. Leafl. Philip. Bot. 5 (1913) 1815.—*T. balansae* Hutch. Kew Bull. (1918) 151.—*Dimerocarpus brenieri* Gagnep. Bull. Mus. Hist. Nat. Paris 27 (1921) 441.

Distr. Indochina, Malaya, Borneo, Celebes, Philippine Isl.

The types have been studied by Dr. Chew Wee Lek and myself. The species has been reduced erroneously to *S. ilicifolius*.

Streblus sect. **Sloetia**

S. elongatus (Miq.) Corner comb. nov. *Artocarpus elongatus* Miq. Fl. Ind. Bat. Suppl. (1861) 172, 419.—*Sloetia sideroxylon* Teysm. et Binn. ex Kurz, J. Linn. Soc. Bot. 8 (1864) 168, t. 13. —*Sl. pinangeana* D. Oliver, Hook. Ic. Pl. (1886) t. 1531.—*Sl. wallichii* King, Hook. Fl. Br. Ind. 5 (1888) 493.

Distr. Malaya (Penang to Singapore), Riouw Archipelago, Sumatra.

This well-known timber-tree of Malaya is strangely limited in distribution and seems not to occur in Borneo. Its affinities are also strange. The bisexual spicate inflorescence with few female flowers is repeated only in the insufficiently known *Sloetiopsis* of East Africa (4-merous male flowers; fruit unknown). If the male and female flowers were on different inflorescences *S. elongatus* would agree with sect. *Pseudotrophis,* as *S. macrophyllus,* except for the minute conic pistillode and the 3-merous male flowers. *Neosloetiopsis* (West Africa), also insufficiently known, may represent this dioecious state, but it may be allied rather with *Ampalis.* On the other hand, if the bisexual spike were contracted into a head, the affinity would be with sect. *Bleekrodea,* except for the perianth. Then, again, if the bisexual spike were extended into a branched raceme, sect. *Sloetia* would be the antecedent condition to sect. *Pseudostreblus.* Thus, this timber-tree is not a unique monotypic genus but a central species in the complex of *Streblus.*

Streblus sect. **Streblus**

Key to the Species

1. Lamina smooth, membranous, lanceolate-acuminate, base attenuate. Monoecious, the male inflorescence with or without a female flower. Male flowers with 4–5 tepals and stamens; pistillode quadrate. Female tepals 3–4 mm. long (anthesis), ? the fruiting tepals not reflexed; stigmatic arms 3–4 mm. long. Drupe dehiscent *S. tonkinensis.*

1. Lamina typically rough, chartaceous-coriaceous, attenuate at the apex, often narrowly rounded-cuneate at the base. Tepals 4. Pistillode columnar, not quadrate, with 2 minute stigmata. Female tepals 2 mm. long (anthesis), reflexed in fruit; stigmatic arms lengthening 6–12 mm. in fruit. Drupe indehiscent Cotyledons very unequal .. *S. asper.*

   2. Dioecious, rarely monoecious. Male head without a female flower; stamens 4 ..... v. *asper.*

   2. Monoecious. Male head often with a female flower in the centre. Stamens 2 ..... v. *monoica.*

S. asper Lour. var. **asper.**—*Diplothorax tonkinensis* Gagnep. Bull. Soc. Bot. Fr. 75 (1928) 98.

Distr. Ceylon, India, South China, Hainan, Indochina, Thailand, Malaya (north), Sumatra (north), Java, Bali, Lombok, Sumbawa, Celebes, Philippine Isl.

This species is absent from the Riouw-pocket of south Malaya, south Sumatra, and, apparently, all of Borneo. I do not give the full synonymy which is well-known. The type of *D. tonkinensis* consists of a twig with male inflorescences and another with female. The female perianth consists of four tepals, and is not utriculate as Gagnepain described.

var. **monoica** (Gagnep.) Corner stat. nov.—*Streblus monoicus* Gagnep. Lec. Not. Syst. 14 (1950) 36.

This is intermediate with *S. tonkinensis* and comes from the same region (Laos, Xieng-Kouang; Spire 176 and 200).

S. tonkinensis (Dub. et Eberh.) Corner comb. nov.—*Bleekrodea tonkinensis* Dub. et Eberh. Compt. Rend. Ac. Sci. Paris 114 (1907) 631; Bull. Econ. Indoch. 10, 868–870 (ut *Streblus* sp.); id, 13, 175 (ut *Bleekrodea*).—*Teonongia tonkinensis* (Dub. et Eberh.) Stapf Hook. Ic. Pl. 30 (1911) t. 2947; Gagnep. Fl. Gen. I.-C. 5 (1928) 710, f. 86.

Distr. Tonkin, along the Chinese frontier and in Ninh-Binh and Hoa-Binh south of the Red River.

This is very like *S. asper,* with which Gagnepain partly confused it. Indeed, in view of *S. asper* v. *monoica,* it is not clear how distinct *S. tonkinensis* may be. The joining of the inner tepals of the female flower is more marked than in *S. asper,* but not a specific difference.

Streblus sect. **Taxotrophis**

Key to the Species

1. Female spike 2–6-flowered; style 0.5–1 mm. long, the stigmatic arms 2 mm. long. Bracts ovate. Fruiting tepals generally enlarged. Embryo with long radicle and subequal, folded cotyledons. Lateral nerves 6–9 pairs ..... *S. zeylanicus.*

1. Female flower solitary. Radicle short, the cotyledons very unequal.

   2. Bracts ovate. Style 3–4 mm. long, the stigmatic arms 1–2 mm. Fruiting tepals not or little enlarged. Lamina drying yellow-brown; lateral nerves 6–10 (–12) pairs ..... *S. spinosus.*

   2. Bracts peltate. Style very short, the stigmatic arms 1 mm. long. Fruiting tepals enlarged. Lamina often with spinous teeth; lateral nerves 10–14 pairs ..... *S. laxiflorus.*

S. laxiflorus (Hutch.) Corner comb. nov.—*Taxotrophis laxiflora* Hutch. Kew Bull (1918) 151.—*T. eberhardtii* Gagnep. Fl. Gen. I.-C. 5 (1928) 700.

Distr. Indochina, Malaya (Perlis, Kedah, Penang, Perak).

Examination of the type of *T. eberhardtii* by Dr. Chew Wee Lek showed that it differed in no way from *T. laxiflora.* Whether the pistillode is 3-lobed, 4-lobed, or practically entire, though emphasized by Gagnepain, is immaterial.

S. spinosus (Bl.) Corner comb. nov.—*Urtica spinosa* Bl. Bijdr. (1825) 507.—*Taxotrophis javanica* Bl. Mus. Bot. Lugd. Bat. 2 (1856) 77, t. 26.—*T. spinosa* (Bl.) v. Steen. Backer Bekn. Fl. Java 6 (1948) 9.

Distr. Sumatra, Java, Lesser Sunda Isl. to Timor.

S. zeylanicus (Thw.) Kurz, For. Fl. Burm. 2 (1877) 464.—*Epicarpurus zeylanicus* Thw. Kew J. 4 (1852) 1; id. 3 (1851) t. 11. *Taxotrophis zeylanica* Thw. En. Pl. Ceyl. (1864) 264.—*Diplocos zeylanica* (Thw.) Bur. DC Prodr. 17 (1873) 215.—*Taxotrophis caudata* Hutch. Kew Bull. (1918) 149.

Distr. Ceylon, India, Burma, China, Indochina.

I am indebted to Dr. Chew Wee Lek for the synonymy of this species, which he has checked from the types.

Species Incertae Sedis

S. mitis Kurz, For. Fl. Burm. 2 (1877) 464; Hook. Fl. Br. Ind. 5 (1888) 489.

Unknown to Hooker, who wrote "probably not a Streblus". I have seen no specimen.

Trophis P. Br.

Nat. Hist. Jamaica (1756) 357; Linn. Syst. Nat. ed. 10 (1759) 1289; Sp. Pl. ed. 3, 2 (1764) 1451; Trécul, Ann. Sci. Nat. ser. 3, 8 (1847) 146; Bur. DC Prodr. 17 (1873) 251; Baill. Hist. Pl. 6 (1875) 143, 192; Benth. et Hook. Gen Pl. 3 (1880) 365; Engl. Nat. Pflanzenf. 3, 1 (1894) 73; Engler, Bot. Jahrb. 40 (1908) 543, f.1; Woodson and Schery, Ann. Mo. Bot. Gdn. 47 (1960) 119, f. 37; (*nomen conservandum*).—*Bucephalon* L. Sp. Pl. (1753) 1190; ed. 3, 2 (1764) 1661; (*nomen rejiciendum*).—*Maillardia* Frapp. et Duch. in Maillard, Notes sur l'île Réunion (1863) annexe P, 3; Bur. DC Prodr. 17 (1873) 220; Leandri, Fl. Madagasc. fam. 55 (1952) 15.—*Calpidochlamys* Diels, Bot. Jahrb. 67 (1935) 173.—? *Skutchia* Pax et Hoffm. ex Morton, J. Wash. Ac. Sci. 27 (1937) 306.

Trees or shrubs, unarmed, dioecious. Leaves distichous. Stipules paired, small, caducous. Inflorescences axillary, solitary or paired, pedunculate, paniculate, racemose, or spicate and then with a sterile groove; bracts very small. Flowers 4-merous. Male tepals valvate, joined below; filaments inflexed in bud; pistillode quadrate-columnar. Female tepals small, free; ovary inferior, the ovule immersed in the receptacle; style short, with 2 long stigmatic arms. Drupe inferior, the persistent tepals little enlarged, fleshy with chartaceous to ligneous endocarp, indehiscent. Seed rounded to oblong, 5–12 mm. wide, or the endocarp angled. Embryo straight or curved; cotyledons fleshy, not folded, equal or subequal; radicle very short to rather long, incumbent. Species 11, Trop. America (3), Madagascar (5), Malaysia (3). Type; *T. americana* Linn.

subgen. **Prototrophis** Corner subgen. nov.

Inflorescentiae paniculatae v. racemosae, floribus pedicellatis, bracteis minutis. Embryo ?. Typus, *T. mexicana* Bur.

subgen. **Trophis**

Inflorescentiae spicatae, floribus sessilibus, masculae sulco sterili praeditae, bracteis peltatis.

sect. **Trophis.**—Endocarpium chartaceum. Embryon rectum; cotyledonibus crassis, subglobosis, aequalibus; radicula brevissima. Spica feminea floribunda. Stigmata longiuscula, ex integro puberrula. Cystolitha amphigena. Typus, *T. americana* L.

sect. **Calpidochlamys** (Diels) Corner stat. nov.;—Endocarpium ligneum, 0.2–0.3 mm. crassum, toro ligneo in loco hili obturatum. Embryon curvatum; cotyledonibus crassiusculis, curvatis, haud plicatis, subaequalibus; radicula longiuscula, incumbenti. Spica feminea pauciflora. Stigmata brevia, unilateraliter papillosa. Cystolitha hypogena. Typus, *T. drupacea* (Diels) Corner. Asia, spp. 3.

sect. **Maillardia** (Frapp. et Duch.) Corner stat. nov.;—Endocarpium ? tenue. Embryon ? curvatum.; cotyledonibus valde inaequalibus, majore plicato, alterum amplectenti; radicula brevissima. Flores feminei solitarii v. binati. Cystolitha hypergena. Madagascar, spp. 4; Reunion, sp. 1.

Key to the species of sect. Calpidochlamys

1. Female inflorescence 15–40 mm. long, many-flowered. Endocarp not angled. Lamina acuminate, base cuneate; lateral nervcs 9–16 (20) pairs ..... *T. philippinensis.*

1. Female inflorescence 30–70 mm. long, with few fertile flowers. Endocarp 3-angled, pyramidal.

   2. Lamina acuminate, basc rounded; lateral nerves 15 pairs *T. drupacea.*

   2. Lamina attenuatc or subacuminate, base cuneate; lateral nerves 8–10 pairs ..... *T. branderhorstii.*

T. branderhorstii (Diels) Corner comb. nov.—*Calpidochlamys branderhorstii* Diels, Bot. Jahrb. 67 (1935) 173.

Distr. Neth. New Guinea.

Possibly not separable from *T. drupacea.* I have examined the type, Branderhorst 273.

T. drupacea (Diels) Corner comb. nov.—*Calpidochlamys drupacea* Diels, Bot. Jahrb. 67 (1935) 173.

Distr. North-east New Guinea (Sepik-district).

I have found no specimen of this.

T. philippinensis (Bur.) Corner comb. nov.—*Uromorus philippinensis* Bur. DC Prodr. 17 (1873) 237; Vidal Cat. Pl. Prov. Manila (1880) 43.—*Paratrophis philippinensis* (Bur.) F. Vill. Noviss. App. Blanco Fl. Filip. ed. 3 (1880) 198; Vidal, Phan. Cuming. Philip. (1885) 145; Rev. Pl. Vasc. Filip. (1886) 250; Merr. En. Philip. 2 (1923) 36.—*Sloetia minahassae* Kds. N.O. Cel. Versl. (1898) 612, 645; Suppl. 2, t. 5; Suppl. 3, p. 3.—*Paratrophis grandifolia* Elm. Leafl. Philip. Bot. 5 (1913) 1814; Merr. En. Philip. 2 (1923) 36.

Distr. Philippine Isl. (widespread), Celebes, Flores, Soemba, Halmahera, New Guinea, New Britain.

Artocarpeae R. Br.

Bot. Congo (1818) 454; Gaud. Voy. Freyc. Bot. (1826) 511; Bartl. Ord. Nat. (1830) 104; Endl. Gen. Pl (1841) 278; Suppl. 1, 1375; Suppl. 4 (1842) 36; Miq. Mart. Fl. Bras. 4, 1 (1852) 79, 81; Bur. DC Prodr. 17 (1873) 281, 284; Baill. Hist. Pl. 6 (1875) 167; Bcnth. et Hook. 3 (1880) 343, 346.—*Broussonetieae* Gaud. Voy. Freyc. Bot. (1826) 508; Bur. DC Prodr. 17 (1873) 221; Benth. et Hook. Gen. Pl. 3 (1880) 345 (subtribus); Engl. Nat. Pflanzenf. 3, 1 (1894) 73; Dalla Torre ct Harms, Gen. Siph. (1900) 120.—*Euartocarpeae* Tréc. Ann. Sci. Nat. ser. 3, 8 (1847) 77, 108; Benth. et Hook. Gcn. Pl. 3 (1880) 347; Engl. Nat. Pflanzenf. 3, 1 (1894) 80; Dalla Torre et Harms, Gcn. Siph. (1900) 121.

Inflorescences unisexual (in a few cases bisexual), monoecious or dioecious. Female inflorescence globose-capitate or thickly spicate, many-flowered, syncarpous or not; involucre of one row of bracts or none; ovaries free or immersed in sockets, or connate with the receptacle. Male inflorescences paniculate, racemose, spicate, or capitate, with or without a sterile groove; stamens 4–1; filaments straight or inflexed in bud; anthers extrorse; pistillode present or not. Seed small or large. Embryos various. Trees, shrubs, climbers, spinous or not. Gen. 15 (Asia 7, Africa 2, America 8); spp. 95 (Asia 68, Africa 7, America 20).

Key to the Asiatic Genera of Artocarpeae

1. Female tepals 4, free (at least in the distal half), well-developed, decussate, imbricating, fleshy in fruit. Bracts and/or tepals with 2–7 immersed yellow glands. Seed compressed, with ligneous endocarp. Dioecious, often spiny ..... *Maclura.*

1. Female perianth differently constructed, without immersed yellow glands.
   2. Male inflorescence racemose-spicate, unbranched, with a sterile groove; filaments inflexed in bud; pistillode present. Female perianth utricular; ovaries not in receptacular loculi; styles long. Embryo curved. Dioecious, unarmed.
      3. Syncarp globose, thickly set with slender stalked bracts of various shapes more or less covering the drupes. Seeds 2–3 mm. long; endocarp crustaceous to ligneous. Cotyledons equal, conduplicate to plane; radicle long, accumbent. Stipules membranous *Broussonetia.*
      3. Syncarp with few strongly projecting drupes each invested by the utricular perianth, the bracts short. Seed 6–7 mm. long; endocarp membranous. Cotyledons very unequal, the large thickly fleshy and folded. Climber ..... *Malaisia.*
   2. Male inflorescence clavate or capitate; if spicate, then without a sterile groove and with the filaments straight in bud.
      4. Male flowers 4-merous; filaments inflexed in bud; pistillode present. Female perianth reduced to 4 minute teeth; ovaries embedded in sockets of the receptacle; styles long. Embryo curved, transversely elongate; cotyledons unequal, conduplicate, fleshy; radicle short. Dioecious spiny climbers ..... *Plecospermum.*
      4. Male flowers with 4–1 stamens, the filaments straight in bud; pistillode none. Styles often short. Embryo elongate longitudinally. Unarmed trees (? *Prainea scandens*).
         5. Dioecious. Male and female heads similar, globose. Perianths utricular; ovaries superficial. Stamen 1. Drupes projecting strongly from the syncarp. Embryo straight; cotyledons thick equal, plane; radicle very short ..... *Prainea.*
         5. Monoecious. Drupes embedded in the more or less fleshy syncarp.
            6. Male heads usually of different shape from the female, varying spicate to clavate or capitate; flowers superficial; stamen 1. Female perianth utricular, much reduced, or none; ovaries sunk in receptacular sockets or concealed beneath the layer of connate utricular perianths. Embryo straight or slightly curved; cotyledons thick, equal or unequal; radicle short ..... *Artocarpus.*
            6. Male and female heads similar, globose, distinctly involucrate with bracts. Stamens 2–3, sunk like the ovaries in receptacular sockets, the filaments and style projecting between the free conic or truncate tepals. Embryo curved; radicle rather long, ascending ..... *Parartocarpus.*

Artocarpus J. R. and G. Forster

Char. Gen (1776) 101, t. 51; Jarrett, J. Arn. Arb. 40 (1959) 113–368; id. 41 (1960) 73–140.

This genus presents the extreme reduction of the male inflorescence as a spike or head of minute unistaminate flowers with tubular perianth and minute anther. The female inflorescence retains a well-developed, if unusual, utricular perianth in subgen. *Artocarpus,* but the perianth disappears more or less entirely in subgen. *Pseudojaca.* The ovaries are superior in subgen. *Artocarpus,* though hidden from the outside by the connate middle parts of the perianths, but they become inferior in sockets of the receptacle in subgen. *Pseudojaca.* The fruiting perianths of subgen. *Artocarpus* become fleshy, at least in their proximal parts surrounding the ovaries, thus making the false aril around the false seed. In subgen. *Pseudojaca* the pulpy character of the fruit is transferred to the receptacular tissue which forms, thus, the whole pulpy body of the false fruit. Ripe syncarps of subgen. *Artocarpus* must be torn open to eat the false aril; those of subgen. *Pseudojaca* can be bitten directly, as an apple. This kind of syncarp resembles that of *Plecospermum,* but there are so many differences between it and *Pseudojaca* in other respects that the two must be regarded as parallel conclusions in Moraceous fruits. The state of *Pseudojaca* is presumably derived by simplification from that of *Artocarpus* by loss of the free internal parts of the perianths followed by loss of the free external parts. Detailed developmental studies of these female inflorescences are needed in a variety of species to clarify the exact construction of the syncarps.

Broussonetia L'Herit. ex Vent.

Tabl. Regn. Veg. 3 (1799) 547 (gen. conserv.); Bl. Mus. Bot. Lugd. Bat. 2 (1856) 85; Miq. Fl. Ind. Bat. Suppl. (1861) 415; Bur. DC Prodr. 17 (1873) 223; Baill. Hist. Pl. 6 (1875) 143, 192, f. 102–107; Benth. et Hook. Gen. Pl. 3 (1880) 361; Engl. Nat. Pflanzenf. 3, 1 (1894) 76, f. 54, 55.—*Broussonetia* Ortega, Nov. Pl. Descr. (1798) 61, t. 7.—*Papyrius* Lam. Ill. Gen. Pl. (1798) t. 762.—*Allaeanthus* Thw. Hook. J. Bot. Kew Gard. Misc. 6 (1854) 302, t. 9b; Bur. DC Prodr. 17 (1873) 222; Benth. et Hook. Gen. Pl. 3 (1880) 361; Hook. Fl. Br. Ind. 5 (1888) 490; Engl. Nat. Pflanzenf. 3, 1 (1894) 74 (ut Allacanthus).—*Smithiodendron* Hu, Sunyatsenia 3 (1936) 106.

Dioecious unarmed trees, shrubs, or climbers, often (? always) deciduous. Leaves spirally arranged, opposite, or distichous, palmately lobed to undivided, generally cordate to rounded or widely cuneate at the base, dentate to entire, membranous; intercostals numerous; stipules membranous. Bracts and perianth without immersed yellow glands. Male inflorescence racemose to spicate, with a sterile groove; bracts ovate to clavate, truncate, or umbonate, the interfloral bracts generally stalked, those bordering the sterile groove sessile; flowers shortly pedicellate to sessile;

tepals 4, joined in the lower half, valvate; filaments 4, inflexed in bud; pistillode spicate, minute. Female inflorescence capitate, globose, without a sterile groove; bracts as in the male, becoming stipitate in fruit; perianth utricular with 2–4 small lobes or teeth; ovary sessile or becoming stipitate in fruit (sect. *Broussonetia*); style 1 (–2), long. Syncarp globose, 10–25 mm. wide, the flowers not connate, ripening orange-red, more or less pulpy. Drupes thinly pulpy, invested by the thinly pulpy, yellow to red, perianth. Seeds 1.7–2.5 mm. long, ovoid-compressed, faintly keeled; endocarp crustaceous to ligneous, smooth or asperate. Embryo curved; cotyledons equal, thinly fleshy, conduplicate to flat; radicle long, incumbent. Cystoliths hypergenous, hypogenous, or none, often as cystolith-hairs; microscopic gland-hairs 1–3-celled, rather large, capitate; hairs smooth or papillate, often hooked (especially microscopic hairs); sphaerocrystal-cells in the lower epidermis along the veins, or none. Species ? 7.

sect **Broussonetia**

Drupe stipitate within the sessile perianth. Seed slightly compressed, papillate-asperate, crustaceous, the keel double at the base. Cotyledons flat. Cystoliths hypergenous or none. Leaves spirally arranged to distichous. Spp. 4; type, *B. papyrifera* (L.) Vent.

sect. **Allaeanthus** (Thw.) Corner stat. nov.—*Allaeanthus* Thw.

Drupe sessile. Seed compressed, smooth, ligneous, the keel not double. Cotyledons conduplicate or flat. Cystoliths hypogenous. Leaves distichous. Male bracts often ovate, sessile. Spp. 3; type, *B. zeylanica* (Thw.) Corner.

There are no major differences between these sections, which are not generically distinct. There appears to be an undescribed species from West Borneo, represented by the sterile collections NIFS bb 8015 and 8016; possibly it belongs to sect. *Allaeanthus*, but its leaves have no cystoliths.

Key to the Species of sect. Allaeanthus

1. Climber. Syncarp –10 mm. wide. Seeds with the endocarp much thickened into a lip at the hilar end. Cotyledons conduplicate corrugated. Lamina crenate-dentate; lateral nerves 3–6 (–8) pairs; stipules entire. Male spike –5 cm. long ..... *B. kurzii.*
1. Trees. Syncarps –20 mm. wide. Seeds without the thickened lip to the endocarp. Lateral nerves 7–15 pairs.
   2. Lamina serrate; stipules denticulate. Male spike –6 cm. long. Cotyledons ? corrugate ..... *B. zeylanica.*
   2. Lamina and stipules entire. Male spike 10–26 cm. long. Cotyledons flat ..... *B. luzonica.*

B. kurzii (Hook. f.) Corner comb. nov.—*Allaeanthus kurzii* Hook. f. Fl. Br. Ind. 5 (1888) 490; Kurz, For. Fl. Burm. 2 (1877) 466 (ut *Malaisia tortuosa*); Gagnep. Fl. Gen. I.-C. 5 (1928) 721.

Distr. Assam, Upper Burma, Yunnan, Laos, Cochinchina, Thailand.

This large deciduous climber is at once distinguishable from *Malaisia* by the numerous close intercostals.

B. luzonica (Blanco) Bur. DC Prodr. 17 (1873) 224.—*Morus luzonica* Blanco, Fl. Filip. (1837) 703.—*Broussonetia luzoniensis* Blanco, Fl. Filip. ed. 2 (1845) 488.—*Allaeanthus luzonicus* (Blanco) Vidal, Noviss. App. (1880) 198.

var. luzonica

Pubescent.—Philippine Isl. (Luzon).

var. **glabra** (Warb.) Corner comb, nov.—*A. glaber* Warb. Perk. Fragm. Fl. Philip. 1 (1904) 166.—*A. luzonicus* (Blanco) Vidal var. *glaber* (Warb.) Merr. En. Philip. 2 (1923) 37.

Puberulous, soon glabrous.

Distr. Luzon, Basilan, Mindoro, Celebes (Gorontalo, Moena).

B. zeylanica (Thw.) Corner comb. nov.—*Allaeanthus zeylanicus* Thw. Hook. J. Bot. Kew Gard. Misc. 6 (1854) 302, f. 9b; Worthington, Ceylon Trees (1959) pl. 425.

Bureau described the cotyledons of this species, which is known only from Ceylon, as strongly corrugated-foliaceous. It seems that they must resemble those of *B. kurzii,* but all the seeds of the collections which I could examine, including the type, were empty.

Maclura Nutt.

Gen. Amer. Pl. 2 (1818) 233 (gen. conserv.); Bur. DC Prodr. 17 (1873) 227; Benth. et Hook. Gen. Pl. 3 (1880) 363; Engl. Nat. Pflanzenf. 3, 1 (1894) 74; Lemée, Dict. Phan. 4 (1932) 230.—*Vanieria* Lour. Fl. Cochinchin. (1790) 564.—*Toxylon, Joxylon* Raf. Am. Month. Mag. (1817) 118 and (1818) 188, 195.—*Chlorophora* Gaud. Voy. Freyc. Bot. (1826) 509.—*Fusticus* Raf. New Fl. Am. 3 (1836) 43.—*Sukaminea* Raf. id. 44.—*Cudrania* Tréc. Ann. Sci. Nat. ser. 3, 8 (1847) 122 (gen. conserv.); Bur. Ann. Sci. Nat. ser. 5, 11 (1869) 377; DC Prodr. 17 (1873) 285; Baill. Hist. Pl. 6 (1875) 145, 194; Benth. et Hook. Gen. Pl. 3 (1880) 374; Hook. Fl. Br. Ind. 5 (1888) 538; Engl. Nat. Pflanzen. 3, 1 (1894) 82, f. 60B, C; Renner, Bot. Jahrb. 39 (1907) 361.—*Cudranus* Rumph. ex Miq. Fl. Ind. Bat. 1, 2 (1859) 290; Rumph. Herb. Amb. V, 22, t. 15, 16.—*Cardiogyne* Bur. DC Prodr. 17 (1873) 232.—*Milicia* Sim, For. Fl. Port. E. Africa (1909) 97, t. 72.

Dioecious trees, shrubs, climbers, generally with axillary spines. Leaves spirally arranged to distichous, simple, without glands. Male inflorescences paniculate, spicate with a sterile groove, or capitate. Female inflorescences capitate or shortly spicate. Bracts and/or tepals with 2–7 immersed yellow glands. Bracts spathulate to clavate or none. Male flowers 4-merous; tepals free; anthers small, extrorse to laterally dehiscent; filaments inflexed or straight in bud; pistillode subulate or as a slender sterile ovary or none. Female flowers sessile, free or connate proximally; tepals 4, decussate, obtuse, free or gamophyllous to the middle, fleshy in fruit;

ovary free or sunk in sockets in the receptacle; stigmatic arms 1–2, short or long. Drupes very thinly pulpy, enclosed in the fleshy perianth, generally not projecting, often concrescent below into a fleshy syncarp. Seed compressed, with more or less ligneous endocarp 2.5–10 mm. long. Embryo curved; radicle long, asymmetrically incumbent to accumbent; cotyledons equal, folded or not, rather thin. Cystoliths amphigenous or none; microscopic gland-hairs 4-celled, capitate; generally with sphaerocrystal cells in the lower epidermis, at least along the veins; hypodermis none; hairs smooth. Species 12, America, Africa, Asia.

Key to the Sections of Maclura

1. Filaments straight in bud. Style or stigmatic arms short, 1–2.5 mm. long. Male heads capitate. Spines axillary, not on short leafy shoots. Cotyledons folded or flat. Cystoliths none. Trees, shrubs, climbers. Asia, Australasia ..... sect. *Cudrania.*
1. Filaments inflexed in bud. Style or stigmatic arms 8–20 mm. long.
   2. Male heads capitate. Ovaries immersed in sockets of the receptacle. Style undivided. Syncarp fleshy. Cotyledons much folded. Cystoliths none. Spines ending short leafy shoots, or decurved with 1–2 scale-leaves. Climber. Africa ..... sect. *Cardiogyne.*
   2. Male heads not capitate. Ovaries not in sockets. Cotyledons flat, small. Trees.
      3. Male inflorescence paniculate, ebracteate; flowers pedicellate. Stigmatic arms 1–2. Syncarp depressed subglobose, 8–14 cm. wide. Cystoliths none. Generally spiny. America .... sect. *Maclura.*
      3. Male inflorescence spicate with a sterile groove; flowers sessile. Style undivided. Syncarp globose to shortly oblong, smaller. Cystoliths amphigenous. Spinous or not. America, Africa *sect. Chlorophora.*

sect. **Maclura.**—*Maclura* subgen. *Eumaclura* Bl. Mus. Bot. Lugd. Bat. 2 (1856) 82.

Tree, generally spinous. Inflorescences apparently ebracteate. Male inflorescence paniculate; flowers pedicellate; tepals free; filaments inflexed in bud; pistillode ? none. Female tepals with 2 immersed yellow glands; ovaries not in sockets of the receptacle; stigmatic arms 1–2, 9–20 mm. long. Syncarp massive, fleshy, the drupes immersed. Seeds 9–10 mm. long. Cotyledons flat, thin; radicle obliquely incumbent. Cystoliths none. Species 1, *M. pomifera* (Raf.) Schneid. (*M. aurantiaca* Nutt.).

sect. **Chlorophora** (Gaud.) Bur. DC Prodr. 17 (1873) 228.—*Chlorophora* Gaud., *Milicia* Sim.

Trees spinous or not. Inflorescences bracteate; bracts and tepals with immersed yellow glands. Male inflorescence spicate with a sterile groove; tepals free; filaments inflexed in bud; pistillode as a small flattened ovary. Ovaries not embedded in sockets of the receptacle; style undivided, 8–10 mm. long. Syncarp –20 mm. wide. Seeds 2.5–4 mm. long. Cotyledons flat, thin; radicle accumbent. Cystoliths amphigenous, often sparse below. Species 5, America, Africa. Type, *M. tinctoria* (L.) Don.

America:—**M. tinctoria** (L.) Don.

Africa:—**M. excelsa** (Welw.) Bur.

M. regia (A. Chev.) Corner comb. nov.—*Chlorophora regia* A. Chev. Bull. Soc. Bot. Fr. 58 (1912) 209.

Madagascar:—**M. greveana** (Baill.) Corner comb. nov.—*Ampalis greveana* Baill. Grandid. Hist. Madag. Pl. (1891) t. 293A.—*Chlorophora greveana* (Baill.) Leandri, Mem. Inst. Sci. Madag. ser. B, 1 (1948) 18; Fl. Madag. fam. 55 (1952) 12, f. III 1–8.

M. humberti (Leandri) Corner comb nov.—*Chlorophora humberti* Leandri, l.c. (1948) 20; l.c. (1952) 14, f. III 9.

This section needs further resolution. The American species is generally spiny and has globose female head and syncarp; there may be two species. The African and Madagascan species are unarmed. *M. greveana* has a globose female head and syncarp, but the other three have distinctly oblong female heads and syncarps. In *M. excelsa,* too, the lamina is less reduced than in other species of the genus and has 14–18 pairs of lateral nerves. *Chlorophora* was first sunk in *Maclura* by Endlicher (Gen. Pl. 1841, 277).

sect. **Cardiogyne** (Bur.) Corner stat. nov.—*Cardiogyne* Bur.

Climber with short leafy shoots ending in a spine, or the decurved axillary spine with 1–2 scale-leaves. Inflorescences bracteate; tepals with 2 immersed yellow glands. Male inflorescence capitate; flowers sessile; filaments inflexed in bud; pistillode ligulate. Female perianths 4-partite, gamophyllous below and connate laterally at the base; ovaries sunk in sockets of the receptacle; style undivided, –18 mm. long. Syncarp –20 mm. wide, the drupes concealed. Seed 5–6 mm. long. Cotyledons much folded; radicle obliquely incumbent. Cystoliths none. Species 1, Africa.

M. africana (Bur.) Corner comb. nov.—*Cardiogyne africana* Bur. DC Prodr. 17 (1873) 232.

sect. **Cudrania** (Tréc.) Corner comb. nov.—*Cudrania* Tréc., *Vanieria* Lour., *Cudranus* Rumph. ex Miq.—*Maclura* Nutt. subgen. *Leptosura* Bl. Mus. Bot. Lugd. Bat. 2 (1856) 83.

Trees, shrubs, climbers, with leafless axillary thorns in place of short shoots. Male and female inflorescences capitate, both bracteate; bracts subulate, lanceolate, spathulate, to subpeltate, with 2 immersed yellow glands, often 2–4 bracts per flowers, often adnate to the tepals, usually several sterile bracts at the base of the capitulum. Tepals free or gamophyllous in the lower half, with 2–7 immersed yellow glands in each. Male flowers with the filaments straight in bud; pistillode subulate. Female perianths free or connate in the lower part; ovaries free or embedded in sockets of the receptacle; style short, undivided or with two short

arms. Syncarp fleshy, –40 mm. wide, the drupes generally concealed. Seeds 4–9 mm. long. Cotyledons broad with infolded margins and obliquely incumbent radicle, or small and flat with accumbent radicle. Cystoliths none. Species 5, Asia, Australasia. Type, *Maclura cochinchinensis* (Lour.) Corner.

Ser. **Liberae** Corner ser. nov.

Flores feminei liberi, ovario superficiali, stylo saepissime bilobato. Flores masculi filamentis quam antheris exsertis bis usque quater longioribus. Semina 5–9 mm. longa. Radicula accumbens. Species 2. Typus, *M. fruticosa* (Roxb.) Corner.

Ser. **Connatae** Corner ser. nov.

Flores feminei partibus inferioribus connati, tepalis basim versus gamophyllis, ovario in cavo parvo receptaculi immerso, stylo indiviso raro ramulo dentiformi praedito. Flores masculi filamentis quam antheris brevioribus v. vix longioribus, antheris vix exsertis. Semina 3–5 mm. longa. Cotyledones marginibus inflexis, radicula eorumdem uno lateri incumbenti. Species 3. Typus, *M. cochinchinensis* (Lour.) Corner.

Key to the species of sect. Cudrania

1. Female flowers free; ovary superficial; style mostly with 2 stigmatic arms. Filaments 2–4 times as long as the exsert anthers ser. *Liberae*.

  2. Tepals free; style less than 0.5 mm. long; stigmatic arms thick, blunt; filaments flattened, anther minute. Syncarp –15 mm. wide, irregularly lobate from the separately projecting fruits. Seed 5–9 mm. long; endocarp 0.3 mm. thick. Cotyledons subequal, rather thick. Twigs, petioles, puberulous to glabrous. Lamina long acuminate, base cuneate; lateral nerves 4–5 pairs, oblique, scarcely inarching; basal nerves 1/3–2/3 lamina; intercostals 3–8, regular *M. fruticosa*.

  2. Perianth tubular in the lower half; style 1.5 mm. long; stigmatic arms slender, as long; filaments cylindric; anthers 1.5 mm. long. Syncarp –4 cm. wide, fleshy, evenly subglobose. Seed 7–8 mm. long; endocarp 0.6–0.7 mm. thick, very hard. Cotyledons rather thin. Twigs, petioles, underside of veins fulvous brown tomentose. Lamina obtuse to acute, base rounded or subcordate; lateral nerves 4–6 pairs, inarching; basal nerves not elongate; intercostals 3–5, faint ..... *M. thorelii*.

1. Female flowers connate at the base, the perianth tubular in the lower part; ovaries in sockets of the receptacle; style simple, rarely with a minute branch. Filaments shorter or slightly longer than the not or scarcely exsert anther. Syncarp 15–25 mm. wide, fleshy, evenly subglobose. Seed 3–5 mm. long; endocarp 0.2 mm. thick. Cotyledons thin, with infolded edges; radicle obliquely incumbent. Basal nerves of lamina short ..... ser. *Connatae*.

  3. Lateral nerves inarching strongly, 6–9 (–14) pairs; intercostals none or indistinct; petiole 3–15 mm. Tepals closely villosulous, all with 2 immersed glands. Filaments very short. Climber *M. cochinchinensis*.

  3. Lateral nerves ascending, slightly inarching; intercostals 2–5, distinct. Filaments 1–1½ times as long as the anthers. Petiole often longer.

4. Tree or shrub. Lamina-base rounded to widely cuneate; lateral nerves 3–5 pairs, often very oblique; petiole –35 mm. long. Male heads 7–10 mm. wide; tepals with 2 immersed glands *M. tricuspidata.*

4. Climber. Lamina-base cuneate; petiole –20 mm. long. Male heads 5–7 mm. wide; tepals (male) thinly puberulous, generally without immersed glands ..... *M. amboinensis.*

5. Lateral nerves 6–9 pairs ..... v. *amboinensis.*

5. Lateral nerves 4–6 pairs ..... v. *paucinervia.*

M. amboinensis Bl. Mus. Bot. Lugd. Bat. 2 (1856) 84.—*Cudrania amboinensis* (Bl.) Miq. Fl. Ind. Bat. 1, 2 (1859) 290 (ut *Cudranus*).—*C. grandifolia* Merr. Philip. J. Sci. 18 (1921) 52.

var. **amboinensis**

Lateral nerves 6–9 pairs.

Distr. Thailand, Malaya, Sumatra, Java, Borneo, Celebes, Amboina (type, leg. Zippel), New Guinea.

var. **paucinervia** Corner var. nov.—*C. grandifolia* Merr.

Costae laterales utrinsecus 4–6.

Distr. Philippine Islands, New Guinea. Typus, Elmer 15530 (Luzon, Mt. Bulusan, prov. Sorsogon, det. *Cudrania javanensis* Tréc.; herb. Kew).

M. cochinchinensis (Lour.) Corner comb. nov.—*Vanieria cochinchinensis* Lour. Fl. Cochinch. (1790) 564.—*Cudrania javanensis* Tréc. Ann. Sci. Nat. ser. 3, 8 (1847) 123, pl. 3, f. 76–85.—*C. obovata* Tréc. id. 126.—*Maclura javanica* Bl., *M. timorensis* Bl. Mus. Bot. Lugd. Bat. 2 (1856) 83.—*C. cochinchinensis* (Lour.) Kudo et Masumune, Ann. Rept. Taihoku Bot. Gard. 2 (1932) 272.—*C. cambodiana* Gagnep. Bull. Soc. Bot. Fr. 72 (1925) 808; Fl. Gen. I.-C. 5 (1928) 729, f. 89, 90.

Distr. Ceylon, India, China, Japan to New Britain, Australia, and New Caledonia.

There are several other well-established synonyms of this common species.

var. **pubescens** (Tréc.) Corner comb. nov.—*Cudrania pubescens* Tréc. Ann. Sci. Nat. ser. 3, 8 (1847) 125.

Twigs and underside of leaves brown hairy or velvety, but with all transitions to the glabrous state of v. *cochinchinensis.*

var. **bancrofti** Bailey, Compr. Cat. Queensl. Pl. (1910) 504.

Foliage variegated.

M. fruticosa (Roxb.) Corner comb. nov.—*Batis fruticosa* Roxb. Fl. Ind. 3 (1832) 763.—*Cudrania fruticosa* Wight ex Kurz, For. Fl. Burm. 2 (1877) 434; Hook. Fl. Br. Ind. 5 (1888) 539.—*Vanieria fruticosa* (Wight) Chun, J. Arn. Arb. 8 (1927) 21.

This species is remarkable in two ways. The very tips of the flattencd filaments are contracted and slightly inflexed, as a vestige of the state with normally inflcxed filaments. Then, as many of the fcmale flowers seem sterile or do not fruit, the drupes project individually from the infructescence, each in its own decussate fleshy perianth, simulating the syncarp of *Malaisia.*

M. thorelii (Gagnep.) Corner comb, nov.—*Cudrania thorelii* Gagnep. Bull. Soc. Bot. Fr. 72 (1925) 810; Fl. Gen. I.-C. 5 (1928) 725.

This species approaches ser. *Connatae* in the tubular lower half of the perianth. It is remarkable for the large, strongly exsert anthers, 1.5 mm. long, with filamcnts 3–4 mm. long, and for the large syncarp, –4 cm. wide. If there were 2–3 stamcns, instead of 4, the species would be truly artocarpoid, but the flattened seed with thick endocarp and the embryo place it in *Maclura.*

M. tricuspidata Carr. Rev. Hort. (1864) 390, f. 37; id. (1872) 56, f. 7.—*Cudrania triloba* Hance, J. Bot. 6 (1868) 49; Hook. Ic. Pl. (1888) t. 1792.—*C. tricuspidata* (Carr.) Bur. Lavallée Arb. Segrez. (1877) 243.—*Morus integrifolia* Lév. et Van. Bull. Ac. Interm. Geogr. Bot. 17 (1907) 210; Rehder, J. Arn. Arb. 17 (1936) 73.—*Vanieria tricuspidata* (Carr.) Hu, J. Arn. Arb. 5 (1924) 228.—*V. triloba* (Hancc) Satake, J. Fac. Sci. Tokyo sect. 3, Bot. 3 (1931) 497.

The inflorescences and syncarp of this species seem identical with these of *M. cochinchinensis.* It seems that many twigs, particularly the upper ones, are unarmed. As a silk-worm tree it is said to be as good as *Morus* but too thorny for convenient picking.

Macludrania hybrida André (Rev. Hort. 1905, 362) is said to bc a hybrid between *M. pomifera* and this species. The few sterile specimens that I have secn in herbaria could not be distinguished from *M. pomifera.*

Malaisia Blanco

Fl. Filip. (1837) 789.—*Dumartroya* Gaud. Voy. Bonite (1844) t. 97.—*Cephalotrophis* Bl. Mus. Bot. Lugd. Bat. 2 (1856) 75, t. 27.

The position of this monotypic genus is problematic. The male flowcr and embryo resemble those of *Streblus* sect. *Sloetia.* The female flower resembles that of *Streblus* sect. *Bleekrodea.* The male inflorescence fits *Streblus* but thc contracted female inflorescence, which is not exactly capitate, and the fleshy syncarp, particularly, agree rather with *Prainea.* Furthermore, the yellow resin-cells of the drupe-wall in *Malaisia* agree with the yellow glands of *Maclura* and the resin-cells of *Artocarpus.* The genus seems a relic of the ancestors of *Prainea* and *Artocarpus.*

The sole species is *M. scandens* (Lour.) *Planch.* The second species, which is generally dragged in without enquiry, is *M. puberula* (Miq.) Bur., but after examining the type I can find no other difference than the 4-merous male flower, which seems at most varietal. Similar variation occurs in *Streblus* sect. *Sloetia.*

Parartocarpus Baill.

Adansonia 11 (1875) 294; Jarrett, J. Arn. Arb. 41 (1960) 320.

This genus is well-named because it shows the durian-factors developed in parallel with those of *Artocarpus.* In *Parartocarpus* the free bracts and tepals become the spines of the syncarp, not the tips of the utricular perianths; it is the ovary-wall or exocarp of the drupe which becomes the false aril of the false seed, not the proximal parts of the perianth. In fact, the drupe of *Parartocarpus* in size and succulence, with well-developed endocarp, is more primitive than any drupe or drupelet of Moraceae. The "straps" between the drupes of *Artocarpus* subgen. *Artocarpus* are the undeveloped perianths of unfertilised or sterile flowers; in *Parartocarpus* they are straps of receptacular tissue between the flowers as in subgen. *Pseudojaca.* The large anthers and 2–3 stamens indicate, also, a less advanced state than *Artocarpus.* Thus *Parartocarpus* has advanced to the sunken ovaries of subgen. *Pseudojaca* while remaining less advanced in other respects. It is an off-shoot of pre-Artocarpus which has attained the syncarp of subgen. *Pseudojaca* by parallel evolution.

Plecospermum Tréc.

Ann. Sci. Nat. ser. 3, 8 (1847) 124, pl. 4, f. 121–126.

Spiny dioecious climbers, some of the twigs modified into leafless spines. Leaves distichous. Inflorescences capitate, pedunculate; bracts small, lanceolate-obtuse, both bracts and tepals without immersed glands; flowers sessile, 4-merous. Male perianth shortly gamophyllous; filaments inflexed in bud; pistillode filiform or as a minute ovary. Female heads with the ovaries immersed singly in sockets of the receptacle; tepals minute, round the mouth of the socket; ovary free from the receptacular wall; styles 1–2, long, undivided. Syncarp fleshy, bulging from the included seeds, with many aborted flowers. Seeds 7–9 mm. long, plump; endocarp membranous. Embryo large, curved; radicle very short; cotyledons very unequal, both folded and fleshy, the larger surrounding the smaller, both with long stalks. Cystoliths none. Species 2 (–3). India, Ceylon, Burma, Indochina, Thailand, Andaman Isl.

This is another problematic relic, related perhaps with *Malaisia.* The two species resemble *Maclura* sect. *Cudrania* in climbing habit, leaf, and spines, but the seed and embryo are those of *Malaisia,* and the inflorescences are an advance on this genus towards *Artocarpus* subgen. *Pseudojaca.* Experimental hybridisation may elucidate the affinity.

Key to the species of Plecospermum

Glabrous or finely puberulous. Lamina 5–8 cm. long. Style 1, 3–5 mm. long. Syncarp 10–15 mm. wide, finely brown velvety .. *P. spinosum.*

Twigs, stipules, young leaves, inflorescences, and syncarp brown tomentose. Lamina 6–14 × 3–8 cm. Styles 1 or 2, 10–13 mm. long. Syncarps 15–30 mm. wide ..... *P. andamanicum.*

P. andamanicum King, Hook Fl. Br. Ind. 5 (1888) 491—*Cudrania poilanei* Gagnep. Bull. Soc. Bot. Fr. 72 (1925) 809; Fl. Gen. I.-C. 5 (1928) 724 (excl. Poilane 10038, floribus masculinis = *Maclura cochinchinensis*).

Distr. Laos, Annam, Cochinchina, Burma, Thailand, Andaman Isl.

To judge from herbarium-material, this seems to be deciduous.

P. spinosum Trécc. l.c.; Hook. Fl. Br. Ind. 5 (1888) 491; Alston, Kandy Fl. (1938) 34, f. 183.—*Trophis spinosa* Heyne, Willd. Sp. Pl. 4 (1806) 734.—*T. aculeata* Roth, Nov. Sp. Pl. (1821) 368.—*Batis spinosa* Roxb. Fl. Ind. 3 (1832) 762.

Distr. Ceylon, India.

Evergreen ?

P. bureaui Richter, Termeszetrarzi Futezek 15 (1895) 296.

This is unknown to me.

Species Excludendae

P. cuneifolium Thw. is *Maclura cochinchinensis* (Lour.) Corner.

P. laurifolium Baill. is *Pachytrophe obovata* Bur. var. *laurifolia* Leandri, Mem. Inst. Sci. Madag. ser. B, 1 (1948) 16; Fl. Madag. fam. 55 (1952) 11, f.2.

P. obovatum Bur. ex Richter is *Pachytrophe obovatum* Bur.

Prainea King

Hook. Fl. Br. Ind. 5 (1888) 546; Jarrett, J. Arn. Arb. 40 (1959) 30.

This genus agrees with *Artocarpus* in the capitate male and female inflorescences, the tubular perianths, the single stamen with straight filament and small anther, and the short stigmatic arms. Yet it is dioecious and the syncarp, so unlike that of *Artocarpus,* resembles closely that of *Malaisia.* Further, both *Prainea* and *Malaisia* have membranous endocarp. The perianth of *Prainea* has many clusters of yellow resin-cells in its mesophyll, such as occur in the ovary (pericarp) wall of *Malaisia,* but not, so it seems, in the floral parts of *Artocarpus.* On the other hand, *Prainea* has the peltate (4–8-celled) microscopic gland-hairs and mesophyll resin-cells of subgen. *Artocarpus* and it lacks the cystoliths of *Malaisia;* this last point, however, is of very doubtful value and there are very rudimentary cystoliths along the underside of the veins in some species of *Prainea.* A microscopic character of *Prainea* is the strongly stellate form of the epidermal cells of the leaf.

A peculiarity of *Prainea,* described by Jarrett, lies in the manner in which the ovule is moved from a subapical position in the ovary at anthesis to a sub-basal position in fruit. It is possible, therefore, that the embryo is developed transversely inside the ovule though longitudinally in relation to the ovary-cavity, such as happens in *Plecospermum. Parartocarpus* has the same peculiarity, but it differs in so many ways from *Prainea* that the similarity seems to be parallel.

According as one or other character is emphasized, so *Prainea* inclines to *Malaisia* or to *Artocarpus,* and retains its own character.

Treculia Decne ex Trec.

Ann. Sci. Nat. ser. 3, 8 (1847) 108.

This genus, even its best known species *T. africana,* requires much more investigation. It is placed near *Artocarpus,* but it lacks the characteristic female perianths of subgen. *Artocarpus* and it does not have the sunken ovaries of subgen. *Pseudojaca.* The slender umbonate-peltate bracts of the syncarp much resemble those of *Broussonetia. T. africana* is said to be dioecious but solitary specimens in Malaya fruit and seed; their fruit-heads are strongly protogynous and then develop copious male flowers with dehiscent stamens and, apparently, viable pollen, while the seeds are forming; some small heads are wholly male. As a monoecious and partly monoclinous plant it has the character antecedent to Brosimeae. The male flower with 2–4 stamens and large anthers resembles that of *Parartocarpus* but retains a utricular perianth. The drupe resembles that of *Parartocarpus,* but the embryo is orientated the other way round, having the radicle away from the raphe-side of the seed. The genus may be a parallel with *Artocarpus,* but, to show how inadequate published descriptions may be, there seems from the literature little to choose between the African *Acanthotreculia,* generally sunk in *Treculia,* and subgen. *Pseudojaca.*

Olmedieae Tréc.

Ann. Sci. Nat. ser. 3, 8 (1847) 126; Miq. Mart. Fl. Bras. 4, 1 (1852) 79; Bur. DC Prodr. 17 (1873) 281; Benth. et Hook. Gen. Pl. 3 (1880) 346; Engl. Nat. Pflanzenf. 3, 1 (1894) 83; Dalla Torre et Harms. Gen. Siph. (1900) 121.

Inflorescences unisexual, discoid, obconic, or urceolate, with an involucre of 1-several rows of bracts, the male many-flowered, the female many to 1-flowered; flowers sessile. Stamens 8–1; filaments straight in bud; anthers introrse or extrorse; pistillode present or not. Ovaries superficial or immersed. Infructescence syncarpous or not. Seeds large. Embryo various. Monoecious or dioecious. Trees, shrubs, not spinous. Gen. 18 (America 13, Africa 2, Asia 4); species 69 (America 58, Africa 5, Asia 6).

Antiaris Lesch.

Ann. Mus. Hist. Nat. Paris 16 (1810) 478, t.22 (gen. conserv).

Seventeen species have been described. After studying the abundant collections in London, Paris, Leiden, Singapore, and Bogor, I have reduced the number to four, namely *A. africana, A. toxicaria,* and the two Madagascan species *A. humbertii* and *A. madagascariensis.* Several of the proposed species are clearly synonyms, but the variability of the wide-spread *A. toxicaria* is the real cause of the superfluity and, indeed, of the uncertainty. On broad principles only one species may be recognised because there are no essential differences, merely variations of size and shape, in leaf and fruit. Thus, the small leaf distinguishes *A. humbertii;* the ovate-elliptic, tapered leaf may distinguish *A. toxicaria* var. *macrophylla;* the prominent venation distinguishes *A. africana;* but, without fruit, *A. madagascariensis* cannot be distinguished from *A. toxicaria.* These distinctions are supported geographically and ecologically. *A. africana* belongs to the drier forests of west and central Africa, where its timber is recognised as different from that of *A. toxicaria.* The Madagascan species belong to the xerophytic scrub on calcareous and sandstone rock. In contrast, *A. toxicaria* is a primary rain-forest tree of the lowland hylea and, in this capacity, has the widest and most continuous range of any Moraceous plant, from West Africa to South China and Fiji. It is absent from Madagascar and other Mascarene islands, from the Australian mainland, and from New Caledonia. It reaches 1,500 m. alt. in North Borneo and New Guinea and its occurrence in South China suggests a certain adaptability to a seasonal climate. On the periphery of its range occur the other species.

The nearest allies of the genus seems to be the American *Olmedia* and *Pseudolmedia,* both with a single superficial ovary, more or less gamophyllous perianth, and distinctly exsert anthers. *Ogcodeia* differs more in having several flowers in the female inflorescence. The little known *Mesogyne* of Africa may be another species of *Antiaris,* but its stamens are extrorse and the ovary is partly superior. Though placed by Engler in Dorstenieae, the filaments of *Mesogyne* are straight in the bud and the inflorescences accord well with *Antiaris.*

Habit. A. toxicaria is a large tree. The form cultivated in the Solomon Islands, Fiji, and Tonga is a shrub or small tree. Its leaves and large fruits place it in var. *macrophylla,* collections of which from New Guinea and New Hebrides seem to show all gradations to large trees. Perhaps, nevertheless, there is a dwarf form. *A. africana* is also a large tree. The Madagascan species are small trees or shrubs. The evidence of field-notes shows that all the species have intermittent growth and that, as adult plants, they become deciduous.

Saplings. The saplings of *A. toxicaria* have brown-hispid or setose-scabrid leaves and twigs. The leaves are larger, thinner, more obovate, more attenuate to the base, and more toothed than the adult leaves which, with the twigs, seem to become more shortly hairy and, finally, practically glabrous. Nevertheless, there may be persistently hairy and persistently less hairy varieties. *A. rufipila* Miq. was based on a fertile, brown-hispid specimen. The sapling form seems identical in *A. africana.* In both the adult foliage becomes coriaceous, but the feature is much more pronounced in *A. africana.* Since specimens of saplings are commonly collected for identification, they make the wide use of *A. toxicaria* desirable.

Fruit. The size and shape of the fruit, or drupe (omitting the stalk), is important. *A. africana* and *A. toxicaria* have ellipsoid or pyriform drupes, the size of which increases from Africa to Polynesia. There is some overlap but all African collections have small drupes, 10–15 × 7–12 mm. when dried, compared with the Far Eastern drupes, 20–45 × 17–26 mm., when dried. In western Malaysia there is considerable variation but no fruits so large as the eastern. Celebes seems the boundary. Here are trees with small fruits indistinguishable from the African var. *welwitschii,* trees with large fruits and leaf-shape approaching var. *macrophylla,* and others exactly resembling the intermediate var. *toxicaria.* Celebes is also a meeting ground for east-west variation in figs, e.g. *F. tinctoria.* The Madagascan species have nearly spherical drupes almost as large as those of *A. toxicaria* var. *macrophylla;* and this shows that they are not the same species as on the African mainland. Now, in *Ficus* as a rule, the further a species is from its geographical centre of alliance the smaller are its fig-fruits. Applying this rule to *Antiaris, A. toxicaria* must have spread westwards from eastern Malaysia and Australasia and to this far eastern centre of alliance the Madagascan species relate. The progressive xerophily of the leaf in *A. toxicaria* conforms with this westward trend. Yet, *Antiaris* has no close ally in eastern Malaysia, and it is absent from New Caledonia, the figs of which are predominantly allied in subgen. *Pharmacosycea* with those of tropical America. Nevertheless, as *Trophis* shows the alliance between America and Polynesia or Eastern Malaysia, so may *Antiaris* at the end of its evolutionary course.

The fruit-variation is summarised in the accompanying table. Two collections from Soemba are without fruit and cannot be placed exactly. One collection from east Flores (Solor Isl.) is sterile but appears to be var. *macrophylla.* Of four collections from Timor, two belong to var. *macrophylla* (NIFS bb. 20,062, and 27,073), the others being without fruit.

TABLE OF FRUIT-SIZES IN ANTIARIS

(Measurements refer to the dried drupe, excluding the stalk)

—	Drupe (mm.)	Country	Leaf-shape
A. africana	10–15 × 9–10	Africa	as in var. *toxicaria*
A. toxicaria			
v. *welwitschii*	10–15 × 7–12	Africa	do.
v. *toxicaria*	15–25 × 11–20	Continental Asia to Celebes	obovate, acuminate
	12–20mm. long	Celebes	do.
v. *macrophylla*	20–25 × 17–20	Moluccas	Ovate-elliptic. attenuate
	25–38 × 20–26	New Guinea	do.
	30–45 × 22–25	Solomon Isl. Fiji	do.
	20–24 × 17–19	Philippines	do.
A. humbertii	20–30 × 20–30	Madagascar	as in var. *toxicaria*
A. madagascariensis	do.	do.	do.

Toxicity. There is much conflicting evidence on the toxicity of the latex and seeds of *A. toxicaria*. That many trees have poisonous latex, used for arrow-poison in West and Central Malaysia, is well known. The poison is caused by cardiac glycosides, particularly antiarin. Yet, there are reports of harmless trees (*A. innoxia* Bl.) and there seem to be no reports of such arrow-poisons from the trees of Africa, New Guinea, and Melanesia. Bisset informs me *in litt.* that in these cases the glycoside-content is probably very low. The fruits of *A. toxicaria* are eaten with impunity though those of the Madagascan species are said to be poisonous. Bisset (1957) found essentially the same cardiac glycosides in *Antiaris, Antiaropsis,* and the American *Ogcodeia*. This chemical evidence suggest the derivation of the American allies of *Antiaris* from the New Guinea centre of *Antiaropsis*.

Key to the species and varieties of Antiaris

1. Drupes subglobose 20–30 mm. wide. Madagascar.
   2. Lamina –4 × 3 cm., harshly scabrid; lateral nerves 5–6 pairs *A. humbertii.*
   2. Lamina larger, becoming more or less smooth; lateral nerves 8–14 pairs ..... *A. madagascariensis.*
1. Drupes ellipsoid or pyriform.
   3. Costal and intercostal venation strongly raised on the underside of the scabrid, coriaceous lamina. Drupe 10–15 mm. long *A. africana.*
   3. Intercostal venation not or scarcely raised. Adult lamina subscabrid or smooth ..... *A. toxicaria.*
      4. Lamina ovate-elliptic, attenuate. Drupe 20–45 × 17–26 mm. Moluccas, Philippines, eastwards ..... v. *macrophylla.*
      4. Lamina elliptic-obovate, acuminate.
         5. Drupe 12–25 mm. long. Asia to Celebes ..... *v. toxicaria.*
         5. Drupe 10–15 mm. long. Africa ..... v. *welwitschii.*

A. africana Engl. Bot. Jahrb. 33 (1902) 119; Keay, Fl. W. Trop. Afr. ed. 2, 1, pt. 2 (1958) 612.

Lamina as in *A. toxicaria* v. *toxicaria* but strongly coriaceous, strongly marked beneath by the raised costas and intercostals. Male inflorescence –15 mm. wide. Drupe 10–15 × 9–10 mm., ellipsoid.

West and central Africa, in drier forest.

An earlier name may well be *A. challa* (Schw.) Engl., though this is generally reduced to *A. toxicaria* v. *welwitschii.* Saplings of *A. africana* seem indistinguishable from those of *A. toxicaria.*

A. humbertii Leandri, Not. Syst. 13 (1948) 175; Fl. Madag. fam. 55 (1952) 32, f. vi.

Lamina –4 × 3 cm., small, cordate at the base, subacuminate, harshly scabrid-hairy; lateral nerves 5–6 pairs, not prominent beneath. Drupe 20–30 mm. wide, subglobose, poisonous.

Madagascar; shrub or small tree in xerophytic bush.

A. madagascariensis H. Perrier, Arch. Bot., Bull 1–4 (1927) 70; Leandri, Fl. Madag. fam. 55 (1952) 32, f. vi.

Lamina as in *A. toxicaria* v. *toxicaria.* Drupe 20–30 mm. wide, subglobose, poisonous.

Madagascar; on sandstone and calcareous rocks, more or less xerophytic.

A. toxicaria Lesch. l.c.

v. **toxicaria**

Lamina mostly elliptic obovate, acuminate, base cordate to cuneate and often somewhat asymmetric, thinly to rather strongly coriaceous, subscabrid to smooth when adult. Male inflorescence –20 mm. wide. Drupe 12–25 × 11–20 mm., ellipsoid to pyriform.

Distr. Ceylon, India, Burma, South China, Hainan, Indochina, Thailand, Andaman Isl., Malaya, Sumatra, Java, Borneo, Celebes; rainforest to 1,500 m. alt.

The leaves vary greatly in size and shape even on the same twig. Possibly each new shoot bears a regular succession of differing leaves.

var. **macrophylla** (R.Br.) Corner stat. nov.—*Antiaris macrophylla* R.Br. Flind. Voy. 2 (1814) 602, t. 5.—*A. bennettii* Seem. Bonplandia 9 (1861) 259; id. 10 (1862) 3, t. 7. Arbor toxicaria mas, Rumph. Herb. Amb. 2, 263, t. 87.

Lamina ovate-elliptic or elliptic, attenuate to the acute apex, base cordate to widely cuneate, scabridulous to smooth. Drupe 20–45 × 17–26 mm. Tree or shrub.

Distr. Philippine Isl. Molucca Isl., Timor, (? Flores, Solor Isl.), (? Soemba), New Guinea, Solomon Isl., New Hebrides, Fiji, Tonga, North Australia (Company's Isl. off Arnhem Land); lowland rainforest.

The shrubby plant of Melanesia may be a cultivar spread by sea-farers.

var. **welwitschii** (Engl.) Corner stat. nov.—*Antiaris welwitschii* Engl. Bot. Jahrb. 33 (1902) 118; Keay, Fl. W. Trop. Afr. ed. 2, 1, pt. 2 (1958) 613.—*A. usambarensis* Engl. id. 119.—*A. kerstingii* Engl. Veg. Erde 9, 3 (1), (1915) 33.—? *Ficus challa* Schw. Bull. Herb. Boiss. 4, app. 2 (1896) 144.—? *A. challa* (Schw.) Engl. Veg. Erde 9, 3 (1), (1915) 33.—*A. challa* Blatt. Rec. Bot. Surv. Ind. 8 (1923) 446.

Leaf as in v. *toxicaria*. Male inflorescence –15 mm. wide. Drupe 10–15 × 7–12 mm.

Distr. Tropical Africa; lowland forest tree.

I maintain this variety in deference to the geographical homogeneity, the larger fruited specimens which occur in Asia not having been collected from Africa, but specimens from Celebes match those from Africa almost exactly in leaf and fruit; in no way can I distinguish the leaf of this variety from that of var. *toxicaria*. Possibly the male inflorescence is slightly smaller. Several herbarium sheets show that the variety is monoecious, as in the whole genus.

A. challa may be *A. africana*. I have been unable to see the type.

List of species and synonyms in Antiaris

A. africana Engl.

A. bennettii Seem. is *A. toxicaria* Lesch. var. *macrophylla* (R.Br.) Corner.

A. challa (Schw.) Engl. is *A. africana* Engl. or *A. toxicaria* Lesch. var. *welwitschii* (Engl.) Corner.

A. challa Blatt. is *A. toxicaria* Lesch. var. *welwitschii* (Engl.) Corner.

A. dubia Span. is *A. toxicaria* Lesch. var. *toxicaria.*

A. humbertii Leandri.

A. innoxia Bl. is *A. toxicaria* Lesch. var. *toxicaria.*

A. kerstingii Engl. is *A. toxicaria* Lesch. var. *welwitschii* (Engl.) Corner.

A. macrophylla R.Br. is *A. toxicaria* Lesch. var. *macrophylla* (R.Br.) Corner.

A. madagascariensis H. Perrier.

A. palembanica Miq. is *Artocarpus dadah* Miq.

A. rufa Miq. is *A. toxicaria* Lesch. var. *toxicaria.*

A. saccidora (Nimmo) Dalz. is *A. toxicaria* Lesch. var. *toxicaria.*

A. toxicaria Lesch.

A. turbinifera Hemsl. is not *Antiaris.* The type at Kew from the Solomon Isl. seems to be a mixture of fallen leaves, flowers, and fruits from as many different trees.

A. usambarensis Engl. is *A. toxicaria* Lesch. var. *welwitschii* (Engl.) Corner.

A. welwitschii. Engl. is *A toxicaria* Lesch. var. *welwitschii* (Engl.) Corner.

A. zeylanica Seem. is *A. toxicaria* Lesch. var. *toxicaria.*

Antiaropsis K. Schum.

Fl. Kaiser-Wilhelmsl. (1889) 40; Laut. et K. Schum. Fl. Deutsch. Schutzgeb. Suds. (1901) 267; Diels, Bot. Jahrb. 67 (1935) 174.

So far as concerns the female inflorescence this genus is central in the Olmedieae. The superior ovaries, the free tepals, and the interfloral bracts render it the least specialised of the tribe. If this inflorescence were bisexual, containing male and female pedicellate flowers, and became urceolate, it would represent a big step towards the receptacle of *Ficus. Sparattosyce* Bur., of New Caledonia, represents dioecious *Antiaropsis* with such an urceolate receptacle splitting open at anthesis of the male flowers and at maturity of the syncarp; at anthesis of the female receptacle the

styles project through its ostiole in a manner not known in *Ficus,* though conceivably its ancestral state. *Sparattosyce* has been placed in the Ficeae, but is not blastophagous and its anthers are extrorse; in *Antiaropsis* and *Ficus* they are introrse, which is unusual in the family.

Antiaropsis is a leptocaul tree. If converted into an ancestral pachycaul, it would have the possibilities of the non-blastophagous *Ficus*-ancestor. I have defined *Ficus* not only on its inflorescence but on its blastophagy, and have, therefore, transferred *Sparattosyce* to the Olmedieae. The work of Bisset (1957) on the cardiac glycosides of Moraceae has shown that *Antiaris, Antiaropsis, Castilloa, Ogcodeia,* and *Pseudolmedia* have much the same glycosidal content, particularly in possessing antiarin and antioside, but that *Sparattosyce,* as he informs me *in litt.*, does not have them.

There may be a second species of the genus, which passes as *A. decipiens* var. *parvifolia* Diels. One collection of this (T. McAdam s.n., Wau, Terr. New Guinea, 1939) has a small female inflorescence, 4–5 mm. wide, with a single female flower. Whether it is merely depauperate or a new species, the collections are insufficient to decide, but it shows how the one-flowered state of *Antiaris* may have arisen

Brosimeae Tréc.

Ann. Sci. Nat. ser. 3, 8 (1847) 138; Miq. Mart. Fl. Bras. 4, 1 (1852) 79; Bur. DC Prodr. 17 (1873) 282; Benth et Hook. Gen. Pl. 3 (1880) 346; Engl. Nat. Pflanzenf. 3, 1 (1894) 87; Dalla Torre et Harms, Gen. Siph (1900) 122.

Inflorescences bisexual, discoid, capitate-globose or urceolate, more or less involucrate. Female flower central, solitary, surrounded by numerous sessile, superficial male flowers. Stamens 4–1; filaments inflexed or straight in bud; anthers (? extrorse), varying subglobose with transverse equatorial dehiscence; pistillode none. Ovary superficial or more or less immersed in the receptacle. Seed medium-size to large. Embryo (so far as known) straight; radicle short; cotyledons not folded, equal or unequal. Trees, unarmed. Genera 8 (Africa 7, America 1); species 44 (Africa 38, America 6).

I include in this tribe *Craterogyne* Lanjouw, which was placed in Dorstenieae.

Dorstenieae Gaud.

Voy. Freyc. (1826) 510.

I consider that this tribe contains only the genus *Dorstenia.* I refer *Craterogyne* to Brosimeae and *Mesogyne* to Olmedieae.

Ficeae Gaud.

Voy. Freyc. (1826) 510.

I consider that this tribe contains only the genus *Ficus*. I refer *Sparattosyce* to Olmedieae.

Genera Excludenda

Conocephaloideae: *Cecropia* L., *Coussapoa* Aubl., *Musanga* R.Br., *Myrianthus* Beauv., *Poikilospermum* Zipp., and *Pourouma* Aubl. to be transferred to Urticaceae.

Stenochasma Miq. belongs with Urticaceae.

Botrymorus Miq. is *Pipturus* Wedd. (see Koord. et Val., Bijdr. 12, 1910, 724).

Metatrophis F. Brown, Bull. Bish. Mus. Honolulu n. 130 (1935) 34.—This may be Urticaceae or Euphorbiaceae.

In conclusion, I express my gratitude to Dr. Chew Wee Lek, of the Singapore Botanic Gardens, for his critical and detailed help in the treatment of Conocephaloideae, *Streblus* sens. lat., and Urticaceae in general.

References

BECHTEL, A. R. (1921). The Floral Anatomy of the Urticales. Am. J. Bot., 386–410.

BERNBECK, F. (1932). Vergleichende Morphologie der Urticaceen und Moraceen Infloreszenzen. Goebel, Bot. Abhandl. 19, 1–100.

BISSET, N. G. (1957). Cardiac Glycosides, Part III. Ann. Bogor. 2, 219–223.

CORNER, E. J. H. (1954). The Durian Theory Extended. Phytomorphology 4, 263.

CORNER, E. J. H. (1960). Taxonomic Notes on Ficus, 1–5. Gard. Bull. Sing. 17, 368–485; id. 18, 1–69.

HALLIER, H. (1905). Provisional scheme of the natural (phylogenetic) system of Flowering Plants. New Phytol. 4, 151–162.

HALLIER, H. (1912). L'origine et le systeme phylétique des Angiospermes. Arch. Néerl. Sci. Exact. Nat. ser. 3, 1, 146–234.

HUTCHINSON, J. (1959). Families of Flowering Plants.

JARRETT, F. M. (1959). Studies in Artocarpus and Allied Genera. I, General Considerations; Journ. Arn. Arb. 40, 1–29. II, A Revision of Prainea; id., 30–37. III, A Revision of Artocarpus subgen. Artocarpus; id., 113–368.

JARRETT, F. M. (1960). Studies in Artocarpus and Allied Genera. IV, A Revision of Artocarpus subgen. Pseudojaca; id, 41, 73–140. V, A Revision of Parartocarpus and Hullettia; id., 320–340.

PARKIN, J. (1951). The Protrusion of the Connective beyond the Anther. Phytomorph. 1, 1–8.

RENNER, O. (1907). Beitrage zur Anatomie und Systematik der Artocarpeen und Conocephaleen, inbesondere der Gattung Ficus. Bot. Jahrb. 39, 319–448.

TIPPO, O. (1938). Comparative Anatomy of the Moraceae and their presumed Allies. Bot. Gaz. 100, 1–99.

TRÉCUL, A. (1847). Memoire sur la Famille des Artocarpées. Ann. Sci. Nat. scr. 3, 8, 38–157.

WEDDELL, H. A. (1857). Considérations Générales sur là Famille des Urticacées. Ann. Sci. Nat. ser. 4, 8, 307–398.

WOODSON, R. E. (1960). Flora of Panama (Moraceae). Ann. Mo. Bot. Gard. 47, 135.

Some New Dipterocarpaceae from Borneo

By P. S. Ashton

Botany School, Cambridge University

A Forester's Manual of Brunei's Dipterocarps is in preparation. The present paper provides descriptions for species which will be included in the Manual but which have not as yet been published. Of these several have been recognised for some time past by foresters; *Hopea vaccinifolia, Shorea geniculata,* and *S. myrionerva* were recognised but not described by Symington over twenty years ago, and these names were used by him and subsequent collectors on herbarium sheets. Wyatt-Smith prepared, but did not complete, a paper on the three *Parashorea* species, and I am grateful to him for handing this over to me for completion. *S. rubra, S. agami,* and *S. flaviflora* were names suggested by G. H. S. Wood, and preparatory notes were made by him for description of the latter. *S. slooteni* was described by him in ms. as *S. vanslooteni,* and *S. pilosa* as *S. tomentosa.* The very distinct *S. isoptera* was named by Wood in ms. as *Neohopea isoptera,* but I am of the opinion that its affinities are too close to *Shorea* to merit generic status.

Kepong code letters were assigned to several of the species here described:

P. macrophylla	=	P. sp. P.
P. parvifolia	=	P. sp. D.
P. smythiesii	=	P. sp. C.
S. acuta	=	S. sp. V.
S. agami	=	S. sp. L. and S. sp. G_3
S. amplexicaulis	=	S. sp. P.
S. faguetioides	=	S. sp. T.
S. minor	=	S. sp. X_3
S. revoluta	=	S. sp. V
S. rubella	=	S. sp. A_3 and S. sp. H_3
S. rubra	=	S. sp. J_3
S. slooteni	=	S. sp. N_1

I am particularly grateful for the continued encouragement and advice of Mr. B. E. Smythies, Conservator of Forests at Kuching, and one time State Forest Officer, Brunei, who has put his great knowledge of Borneo's Dipterocarps at my disposal; to Mr. E. J. H. Corner, F.R.S., for advice on numerous points and for correcting the proofs; to Inche Yakin bin Long, State Forest Officer, Brunei,

for his enthusiastic support and for his aid in obtaining for me the type material of *Hopea garangbuaya, Parashorea macrophylla,* and *Shorea bullata;* and to Dr. W. Meijer, Forest Botanist, Sandakan, for his close co-operation and for supplying notes on several species. Lastly, but by no means least, I wish to record the friendly and ever helpful partnership of Ladi anak Bikas, Asah anak Unyong, Mujah anak Guang, and Sengelang anak Nantah, who climbed the trees and obtained the collections on which these descriptions are largely based, and with whom I spent three very happy years exploring the forests of Brunei.

Thanks are also due to Mr. Brian Golding of the Botany School, Cambridge University, for his painstaking preparation of the plates.

This paper is the first of several which will be jointly published with Dr. Meijer, in order to bring our greatly increasing knowledge of Borneo Dipterocarpaceae up to date.

HOPEA FLUVIALIS Ashton s.n.

H. pedicellatae (Brandis) Sym. et *H. griffithii* Kurz affinis sed lobis minoribus calycis in fructu et lamina differt.

Ramuli, perulae, stipulae, petiolique griseo-brunneo-tomentosi; lamina primo griseo-brunneo-tomentosa, dein glabrescens. Ramuli apicem versus –1.5 mm. diam., glabrescentes, leves, lenticellis parvis inconspicuis punctati; internodis 8–20 mm. longis. Gemmae –1 mm. longae, ovoideae. Stipulae –2 mm. longae, lineares, fugaces. Lamina 7–12 × 2.8–4.8 cm., lanceolato-ovata, tenuis, basi anguste vel late cuneata, subaequali, apice in acumen caudato –1.5 cm. longum attenuato; costis lateralibus primariis utrinsecus c. 10 confertis angustis, angulo 60°–80° exorientibus, ad marginem curvatis, secundariis vix minus evolutis, basalibus marginem secundum ad 1/3 laminae elongatis; intercostis obscuris reticulatis; costa media subtus applanata vel paullum elevata, supra prominenti. Petiolus 7–10 mm. longus, –1.5 mm. diam., sicco niger. Lamina delapsa fusco-brunnea, costa intensius vel nigrescenti. Racemi –6 cm. longi, semel vel bis ramosi, stipitis basi in fructu –1.25 mm. diam., 1–3 axillares, raro terminales, ex integro teretes, semper breviter griseo-pubescentes; ramulis –1.5 cm. longis, –7 flores gerentibus; bracteolis –2 mm. longis, ovato-acuminatis, glabrescentibus. Alabastrum –4 mm. longum, ellipsoideum, breviter pedicellatum. Calyx glabrescens, ad marginem setulosus; lobis externis 2 ovato-acuminatis, internis 3 tenuioribus, elliptico-mucronatis. Corolla in vivo viridi-flava, petlis lineari-lanceolatis, externe conferte pubescentibus, intus glabris. Stamina 15, verticillis 3, bina cum solis alternata; filamentis basim versus applanato-dilatatis, superne gradatim filiformibus; antheris subglobosis, loculis interioribus quam exterioribus paullum minoribus; aristis quam antheras 2-plo longioribus. Ovarium ovoideum glabrum; stylo filiformi, tereti, ovarium aequanti; sine stylopodio distincto.

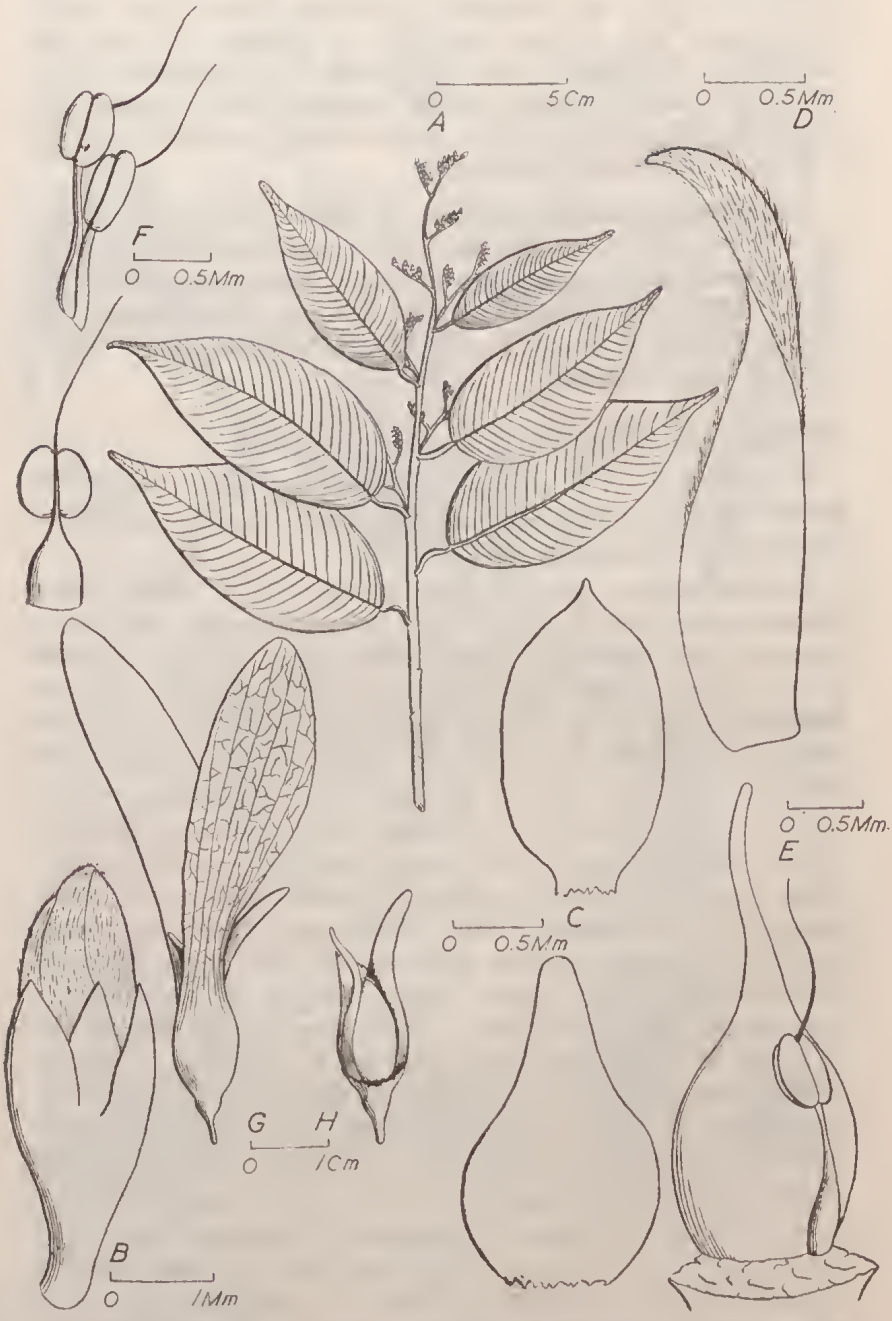


Plate 1. *Hopea fluvialis.*

a, Flowering twig. b, Flower bud. c, Sepals (outer below, inner above). d, Petal. e, Ovary. f, Stamens (lateral view above, frontal below). g, Fruit. h, Nut.

(a–f from Kep 34492; g, h, from Brun 3394).

Pedicellus in fructu –4 mm. longus, basi –1 mm. diam., superne incrassatus. Fructus in racemo erectus. Calyx glaber; lobis longioribus 2–5.5 × 1 cm., spatulatis, subacutis, basim versus angustatis –4 mm. latis, partibus basalibus –7 × 5 mm., dilatatis, non incrassatis, vix saccatis; lobis brevioribus 3, inaequalibus, 1–2.5 cm. longis, acutis, hastatis, basibus saccatis nucem obtegentibus, adpressis. Nux –15 × 6 mm., glabra, anguste ovoidea, ad stylopodium breve acutum attenuata.

Collections. *Indonesian Borneo:* bb 20448, Puruktjau. *Brunei:* Brun 3394, 5668, 794, 412, Kuala Belalong; Brun 5219, S. Belalong above Kuala Empan; Brun 125, 127, Kuala Ingei; Brun 722, Kuala Temburong Machang-Kuala Sekurop, Temburong; Kep 34492, Pajarai, S. Belait; Kep 34523, S. Melayan, Belait (Holotypus in Herb. Kepong).

HOPEA GARANGBUAYA Ashton s.n.

H. cernuae T. et B., *M. mengerawan* Miq. affinis, sed lamina maiore latiore multo crassiore, coriacissima, floribus maioribus, staminum aristis minute papillosis differt.

Ramuli, perulae, stipulae, petioli, laminaeque ex integro glabri. Ramuli apicem versus –2 mm. diam., robusti, teretes, leves, fusco-rubro-brunnei, lenticellis minutis orbicularibus punctati. Gemma –2 × 1 mm. ovoidea. Stipulae –4 mm. longae, lineares, fugaces. Lamina 11–16 × 6–10 cm., late ovata, crasse coriacea, basi obtuse, apice in acumen –1.2 cm. longum angustum subabrupte attentuato, margine paullum revoluto, costis lateralibus primariis utrinsecus 8–11, curvatis, dryobalanoidiis, sed prominentibus, angulo 60°–70° exorientibus; costis lateralibus secundariis brevibus; intercostis distinctis, conferte scalariformibus, a costa media angulo 90° exorientibus; costa media lata, subtus prominenti tereti, supra paullum elevata. Petiolus 2–2.5 cm. longus, –2.5 mm. diam., robustus, sicco niger. Lamina delapsa ex integro flavo-olivacea. Racemi –9 cm. longi, ordine semel ramosi, stipitis basi in fructu –1.5 mm. diam., terminales vel 1–2 axillares, ex integro teretes, glabri; ramulis –3 cm. longis, –6 flores secundos gerentibus; bracteis bracteolisque ignotis. Alabastrum –6 × 2.5 mm. magnum, ellipsoideum, distincte pedicellatum. Calyx extus glabrescens, intus glaber, margine breviter setoso; lobis externis 2 ovato-acuminatis; lobis internis 3 tenuibus, suborbicularibus obtusis. Petala –1.2 cm. longa, lineari-lanceolata, acuta, partibus in alabastro expositis glabrescentibus, aliter glabra. Stamina 15, verticillis 3, bina cum solis alternata; filamentis gracilibus, attenuatis; antheris oblongis, loculis exterioribus quam interioribus paullum maioribus; aristis quam antheras 2–3–plo longioribus, basi tuberculis glandulosis prominentibus punctatis. Ovarium ovoideum basi glabra, dimidio apicali conferte setoso, in stylum attenuato; stylopodio indistincto,

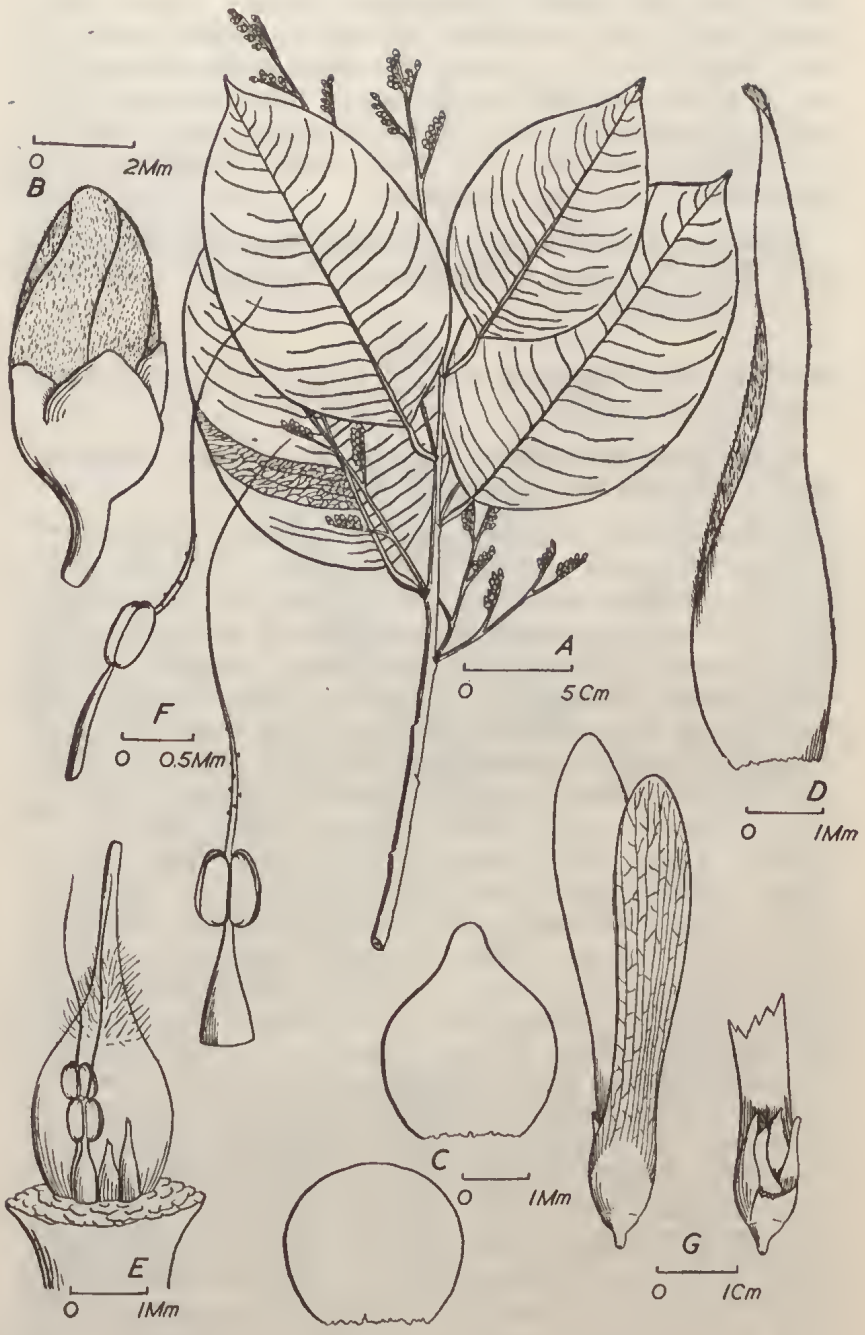


Plate 2. *Hopea garangbuaya.*

a, Flowering twig. b, Flower bud. c, Sepals (outer above, inner below). d, Petal. e, Ovary and stamens. f, Stamens (left, lateral; right posterior, view). g, Left, fruit; nut.

(a–e from Brun 2006a; f, g, from 2006e).

stylo ovarium aequanti, filiformi, attenuato, dimidio basali conferte setoso, aliter glabro. Pedicellus in fructu c. 3 mm. longus, basim fructui versus incrassatus. Calyx glaber, conferte imbricatus; lobis longioribus 2, 7 × 1.5 cm., plus minus loratis, obtusis, partibus basalibus 1 cm. latis, non incrassatis, tenue saccatis, subauriculatis; lobis minoribus 3, –2 × 1.2 cm., ovatis, acutis basibus ut in lobis longioribus. Nux –20 × 9 mm., ovoidea, attenuata, glabra, stylopodio –4 mm. longo apiculato.

Collections. *Brunei:* S 1658, 2055, 5768, Batu Apoi; Brun 3347, Brun 2006a (Holotypus in Herb. Kew), Ulu Senuko, Labu; Brun 713, Ulu S. Labu.

I

HOPEA VACCINIFOLIA Ridl. ex Ashton:—*Hopea vaccinifolia* Ridl. nomen nudum.

H. bracteatae Burck affinis, sed racemis brevissimis, laminis minimis, corolla revoluta, staminis 10 differt.

Ramuli, perulae, stipulae, petiolique conferte pallide griseo-brunneo-pubescentes. Ramuli apicem versus –0.5 mm. diam., graciles, plurimum horizontale alterne ramosi, dein glabrescentes, leves, fusco-rubro-brunnescentes; internodis –8 mm. longis. Gemmae minutae. Stipulae –1.25 mm. longae, breviter hastatae, acutae, fugaces. Lamina 1–2.5 (3) × 0.4–1.2 cm., chartacea, apice breve obtuso, vel in arboribus maturis –5 mm. longis late acuminatis; costis lateralibus primariis utrinsecus c. 6, subdryobalanoidiis, obscurissimis; costis lateralibus secundariis angustissimis; intercostis reticulatis; costa media angusta, subtus applanata vel paullum elevata, supra depressa. Petiolus –2 mm. longus, –0.5 mm. diam., gracilis, sicco fusco-brunneo-puberulus vel nigrescens. Lamina delapsa ex integro pallide griseo-brunnescens, sicca involuta. Racemi –1.2 cm. longo, inconstanter semel ramosi, stipitis basi in fructu 0.5 mm. diam.; –2 axillares, breves, teretes, glabri; ramulis brevibus, –3 flores gerentibus; bracteolis minutis, deltoidiis, subpersistentibus, glabris. Alabastrum parvum, ovoideum, subsessile. Calyx ad apicem marginibus setosis, aliter glaber; lobis externis 2 ovatis, acutis, lobis internis 3 late suborbicularibus, obtusis, quam illis tenuioribus. Corolla in vivo fusco-vinosa, rotata vel reflexa; petalis oblongis, obtusis, glabris, multo-contortis, aetate expandi basim versus tubiforme imbricatis. Stamina 10, subaequalia; filamentis basim versus dilatatis, superne abrupte attenuatis filiformibus; antheris subglobosis, loculis exterioribus quam interioribus paullum longioribus; aristis gracilibus, quam antheras 2-plo longioribus, apicem stylopodii attingentibus. Ovarium stylopodiumque cylindricum, truncatum, podio apicali puberulo, aliter glabrum; stylo brevi, abrupto. Pedicellus in fructu c. 1 mm. longus. Calyx glaber; lobis subaequalibus, –4 × 3.5 mm., ovatis acutis vel obtusis incrassatis, tenue saccatis. Nux –8 × 6 mm., ovoidea, glabra, ad apicem mucronata.

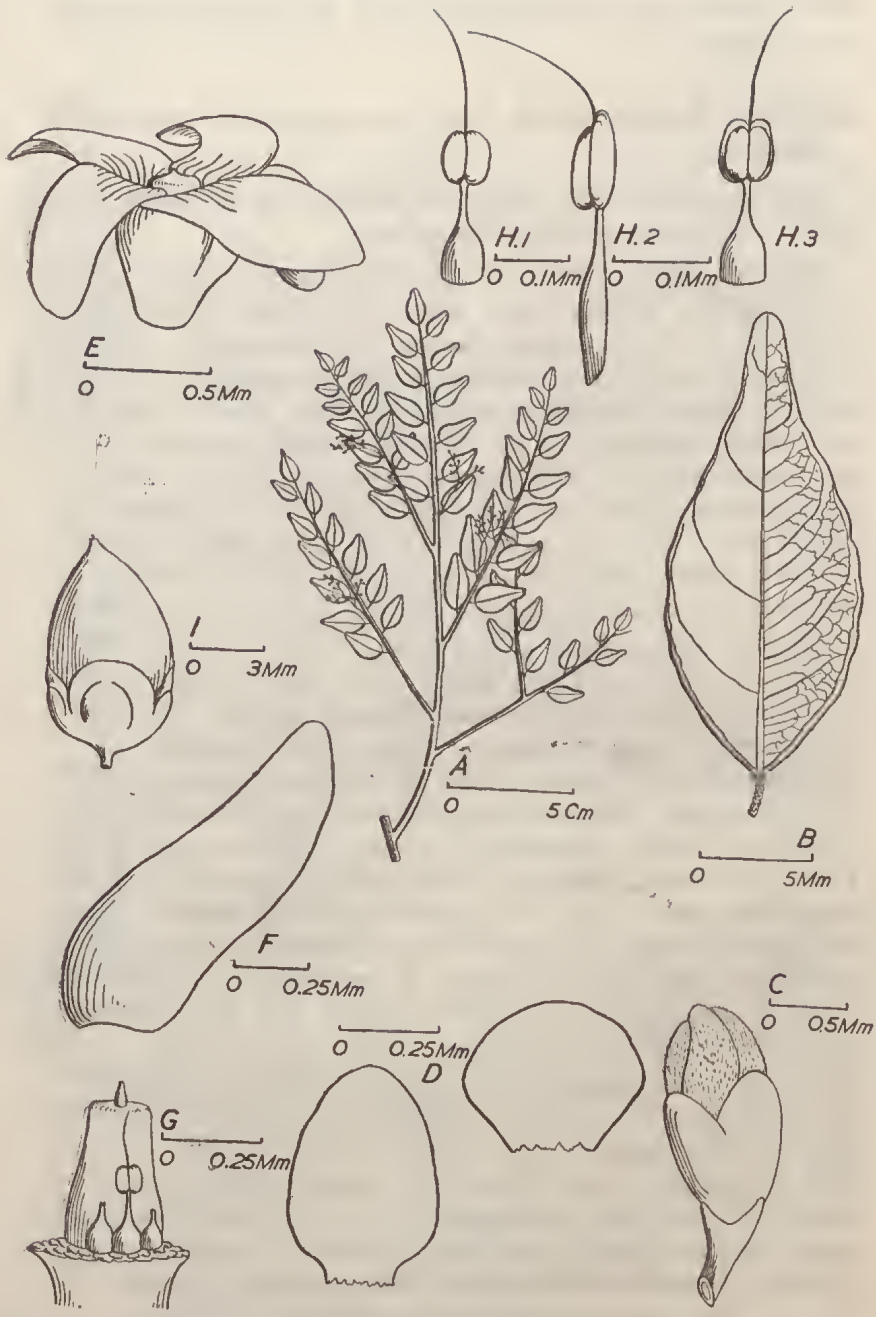


Plate 3. *Hopea vaccinifolia.*

a, Flowering twig. b, Leaf. c, Flower bud. d, Sepals (left, outer; right, inner). e, Corolla. f, Petal. g, Ovary. h, Stamens (1, frontal; 2, lateral; 3, from inside). i, Fruit. (a–h from Brun 3035; i from Kep 35567).

Collections. *Brunei:* Kep 30614, 30630, Andulau F.R.; Kep 35567, Pengkalan Ran; SFN 10494, Brun 3035, Labi Rd, M.5; Brun 140, R. Ingei. *Sarawak:* Brun 5564, Hose 583 (Holotypus in herb. Kew) Marudi.

HOPEA WYATTSMITHII Wood ex Ashton:—*H. wyattsmithii* Wood, msc.

H. glaucescentis Sym. affinis, sed lobis calycis in fructu quam nucem brevioribus subaequalibus differt.

Ramuli, perulae, stipulae, petioli laminaeque ex integro glabri. Ramuli apicem versus –1 mm. diam., fusco-rubro-brunnei, leves; internodis 1.5–3 cm. longis. Gemma –1.5 mm. diam., ovoidea. Stipulae –2 mm. longae, lineares, fugaces. Lamina 9–14 × 5.5–9 cm., late ovata vel elliptica, basi late cuneata, raro obtusa, apice in acumen caudatum –2 cm. longum abrupte attenuato; costis lateralibus primariis utrinsecus 4–8, remotis, propter costas laterales secundarias breves prominentes diffusis et irregulariter dispositis, basi 2–3 utrinsecus primo ad costam mediam decurrentibus, dein rectis, aliter curvatis, angulo 40°–50° exorientibus; intercostis remotis, scalariformibus, a costa media > 90° exorientibus; costa media angusta, subtus applanata, supra acuta. Petiolus 1.2–1.7 cm. longus, –2 mm. diam., sicco niger. Lamina delapsa ex integro pallide griseo-brunnea. Racemi –6 cm. longi, semel ramosi, stipitis basi in fructu –1 mm. diam., terminales vel –2 axillares, ex integro glabri, teretes vel paullum compressi; ramulis –1.5 cm. longis, –6 flores secundos gerentibus; bracteolis parvis, deltoideis, glabris. Alabastrum –3 mm. longum, subglobosum. Calyx glabrescens, margine breviter setoso, expansus; lobis subaequalibus, late ovatis vel suborbicularibus, obtusis. Petala oblongo-lanceolata, acuta, partibus in alabastro expositis conferte tomentosis, aliter glabris. Stamina 15; verticillis 3, bina cum solis alternata; filamentis basim versus dilatatis, sub antheris abrupte attenuatis; antheris late oblongis, loculis subaequalibus; aristis angustis, quam antheras 2–plo longioribus. Ovarium stylopodiumque pyriforme, ovario glabro, stylopodio quam ovarium paullum longiori, breve puberulo, style brevi glabro. Pedicellus in fructu –2.5 mm. longus, –2 mm. diam. Calyx nuxque glaber, calyce quam nucem breviore; lobis 5 subaequalibus, –10 × 8 mm., ovatis, subacutis, paullum saccatis, incrassatis, conferte inbricatis, ad nucem adpressis, foramine apicali –3 mm. diam. apice nucis exposito. Nux –1 × 1 cm., ovoidea, apice acuto, stylopodio vestigiali.

Collections. *North Borneo:* San 15061, Beaufort (Holotypus in Herb. Kew); San 16467, Tawau. *Brunei:* Brun 885, Ulu Tutong at the second stone rapid; S 5589, Brun 833, Andulau F.R.; Kep 35475, S. Biang: S 5809, Bt. Patoi.

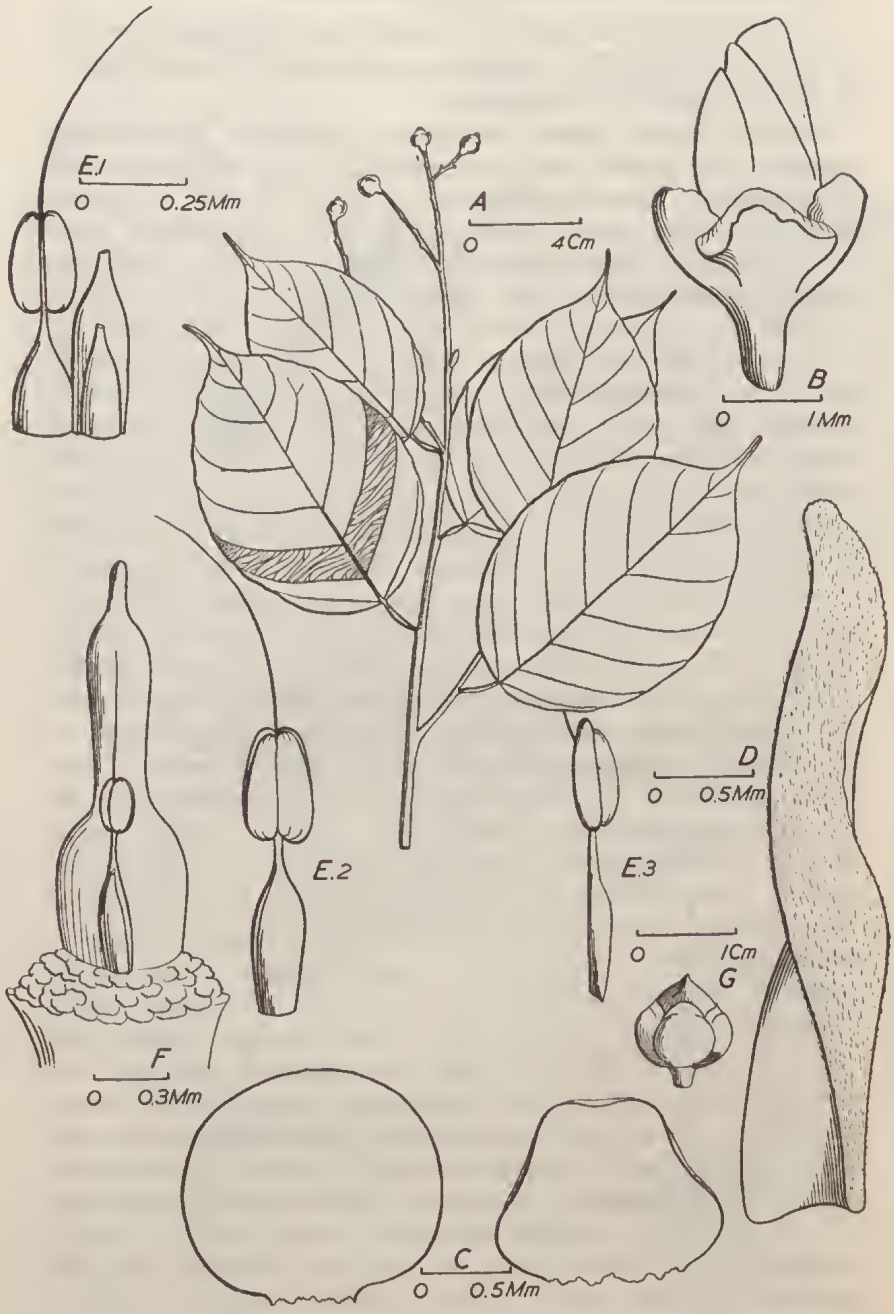


Plate 4. *Hopea wyattsmithii.*

a, Fruiting twig. b, Flower bud. c, Sepals (left, inner; right, outer). d, Petal. e, Stamens (1, frontal; 2, from inside; 3, lateral). f, Ovary. g, Fruit.

(a, g, from San 16467; b–f from San 15061).

PARASHOREA MACROPHYLLA Wyatt Smith ex Ashton:—

P. macrophylla Wyatt Smith, nomen nudum.

Lamina maxima subtus glauca, costis lateralibus multis, ramulis compressis, cicatricibus stipularum amplexicaulibus, lobis calicis in fructu longissimis distinguitur.

Ramuli, perulae, externi stipularum, petiolacque valde breviter conferte plane pallide ochraceo-tomentosi, interni stipularum laminaeque glabri. Ramuli apicem versus –12 × 5 mm., compressi, dein terescentes, pallide rubro-brunnescentes; cicatricibus stipularum angustis amplexicaulibus; cicatricibus foliorum ellipticis, magnis, prominentibus; foliis alternis; internodis 1–4 cm. longis. Gemma –9 × 8 mm., linearis, acuta, glaucescens. Stipulae –15 × 2.5 cm., linearcs, subacutae, caducae. Lamina 30–50 × 16–24 cm., tenuis, oblongo-elliptica, subtus argenteo-glauca, basi subcordata, apice obtuso vel breve acuminato, abrupte attenuato; costis lateralibus utrinsecus 28–36, confertis, rectis, sed ad marginem curvatis, angulo 25°–50° exorientibus basi excepta, subtus prominentibus, glabris, non glaucis, plicis obscuris inter costas subpersistentibus; intercostis angustis, conferte scalariformibus, a costis lateralibus diagonale exorientibus; costa media crassa, subtus tereti, supra vix prominenti. Petiolus 3–5 cm. longus, –5 mm. diam., teres, sicco pallide ochraceo-tomentosus. Lamina delapsa supra ochraceo-brunnescens, subtus pallide purpureo-brunnescens, glaucescens, costis pallide fuscis. Inflorescentiae paniculatae, –6 cm. longae, bis opposito-ramosae, stipitis basi in fructu –4 mm. diam., terminales vel axillares, rigidae, rectae, breviter pallide griseo-brunneo-pubescentes; bracteis –4 × 2.5 cm., magnis, ovatis, acutis, saccatis, externe conferte breviter pubescentibus, intus glabris; bracteolis –12 ×8 mm., ut in bracteis. Flores maturi ignoti. Alabastra ellipsoidea, calyce externe conferte, intus sparsim tomentoso, lobis subaequalibus, anguste ovatis, acutis; petalis oblongis, obtusis; staminis 15 subaequalibus; filamentis brevibus deltoidiis; antheris lineare-oblongis, loculis internis 2 quam externis 2 paullum brevioribus; aristis prominentibus, angustis, attenautis, quam antheris ½-plo longioribus; ovario conico, breviter pubescenti, ad stylopodium prominens anguste cylindricum attenuato. Pedicellus in fructu brevis. Calyx in fructu sparsim puberulus, dein glabrescens, basim versus confertius; lobis longioribus 3, –22 × 1.8 cm., anguste spatulatis, crassis, fragilibus, ad apicem subacutis, basim versus –5 mm. latis gradatim attenuatis, partibus basalibus –16 × 8 mm., ellipticis, saccatis, ad nucem adpressis; lobis brevioribus 2, –12 × 0.7 cm., linearibus, inaequalibus, basim versus –5 mm. latis gradatim attenuatis, partibus basalibus –5 × 5 mm., quam illos plure saccatis. Nux –2.5 × 1.2 cm., ellipsoidea, conferte griseo-brunneo-tomentosa, stylopodium versus attenuata, stylopodio –6 mm. longo, lineari.

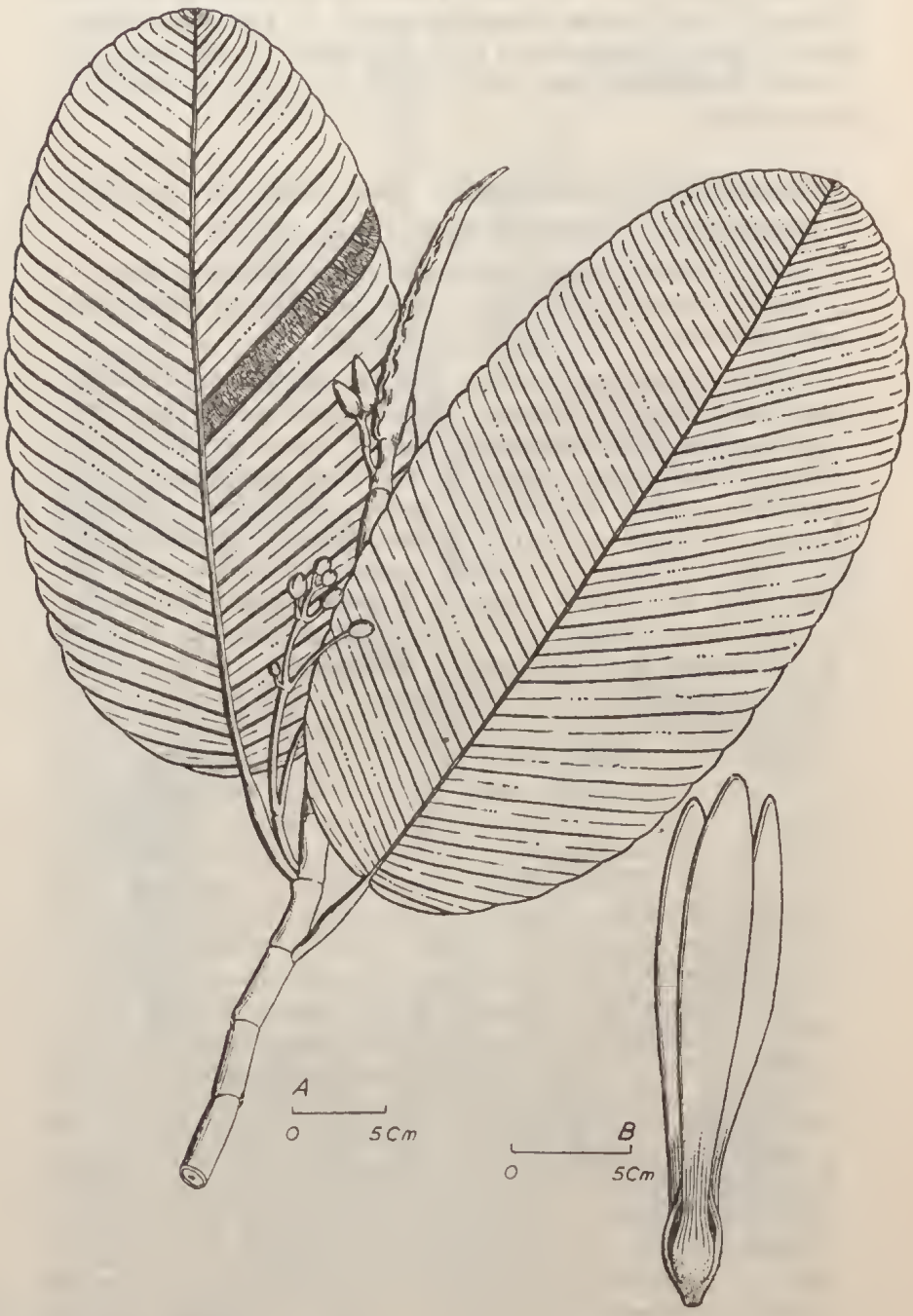


Plate 5. *Parashorea macrophylla.*

a, Flowering twig. b, Fruit.

(a from Brun 2002; b from s.n., S. Tubai.

Collections. *Sarawak:* No. 81848, S. Naut, Bakong; Brun 5423, S. Sut, Rejang; s.n., S. Tubai, Limbang; Pursglove 5207, Tau Range; S 1281, Baram. *Brunei:* Brun 901, S. Kebubok, Tutong; Brun 3136, Ulu Biang; San 17377, Kep 48483, S. Belalong; Kep 30388: S. Motong; Brun 2002: Kuala Belalong (Holotypus in Herb. Kew).

PARASHOREA PARVIFOLIA Wyatt Smith ex Ashton:—

Parashorea parvifolia Wyatt Smith, nomen nudum.

Lamina parva applanata non glauca, costis lateralibus utrinsecus c. 9 angustis, curvatis, vix elevatis, intercostis remotis scalariformibus, petiolo longo gracili glabro distinguitur.

Perulae stipulaeque sparsim breviter pallide flavo-brunneo-tomentosae, ramuli stipulaeque primo breviter pallide flavo-brunneo-tomentosi dein glabrescentes. Ramuli apicem versus –1 mm. diam., teretes, apicem aversus glabrescentes leves fusco-brunnei, lenticellis minutis orbicularibus sparsi; cicatricibus stipularum brevibus, angustis, sursum vel deorsum directis; internodis 1–2.5 cm. longis. Gemma –3 × 1 mm., anguste lanceolata, acuta. Stipulae –3.5 mm. longae, angustae, acutae, fugaces. Lamina 6–9 × 3–4.5 cm., elliptica vel ovata, non glaucescens, basi late cuneata, apice in acumen anguste vel caudate –1.5 cm. longum attenuato; costis lateralibus utrinsecus 8–10, angustis curvatis, subtus prominentibus, laxis, angulo 50°–60° exorientibus; intercostis scalariformibus vel paullum reticulatis, laxis, a costis lateralibus c. 90° exorientibus; costa media angusta, subtus prominenti, supra depressa. Petiolus 1–1.8 cm. longus, –1 mm. diam., dimidio distali incrassato, geniculatus, sicco nigrescens. Lamina delapsa supra flavo-brunnea, subtus pallide fusca. Racemi –4 cm. longi, semel ramosi, stipitis basi in fructu –1.5 mm. diam., terminales vel axillares, teretes, recti, penduli, sparsim breviter pallide flavo-brunneo-tomentosi; bracteis bracteolisque ignotis. Alabastrum –4.5 × 3 mm., ellipsoideum, obtusum. Calyx externe conferte griseo-brunneo-tomentosus, intus glaber; lobis lineari-deltoideis, subaequalibus, subacutis, ad corollam in alabastro non adpressis. Corolla in vivo alba, petalis ellipticis obtusis, partibus in alabastro expositis breviter tomentosis. Stamina 15, interiora 5 quam exteriora 10 paullum longiora styli parte quartaria apicali superata; filamentis basim versus applanato-dilatata, sub antheris subabrupte attenuatis; antheris lineare oblongis; aristis brevibus, supra antheras paullum extrusis. Ovarium subglobosum, conferte tomentosum; stylo quam ovarium 3-plo longiore, filiformi, tertia parte basali breviter pubescenti, aliter glabro. Pedicellus in fructu –2 mm. longus, brevis. Calyx in fructu apicem versus glabrescens, basim versus puberulus; lobis longioribus 3–8.5 × 1.7 cm., late spatulatis, obtusis, basim versus –3 mm. latis attenuatis; partibus basalibus –7 mm. lato, non dilatatis, paullum incrassatis, valvatis, a nuce

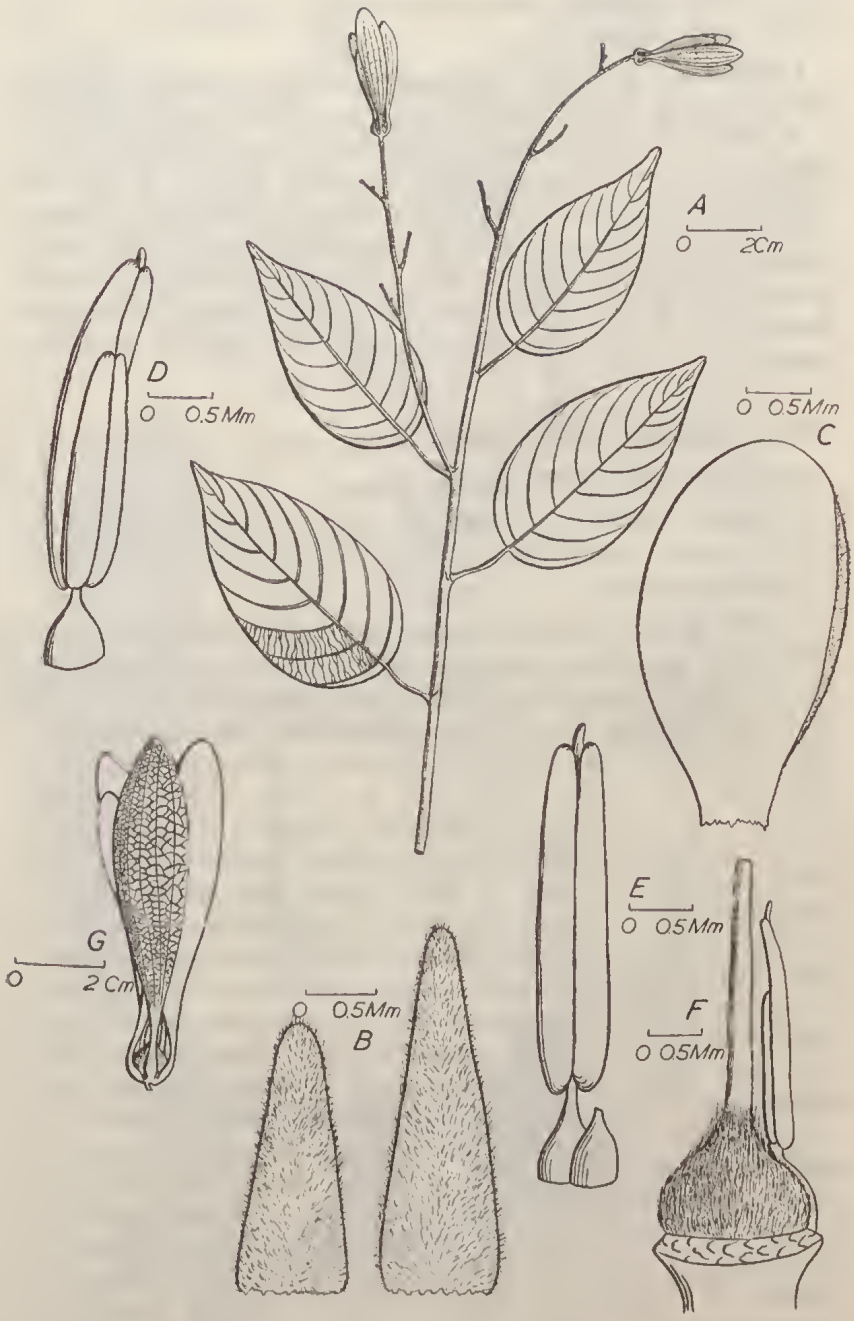


Plate 6. *Parashorea parvifolia.*

a, Fruiting twig. b, Sepals (right, outer; left, inner). c, Petal. d, Stamen (from inside). e, Stamen (frontal view). f, Ovary. g, Fruit.

(a from Brun 3074; b–f from Brun 3013; g from Brun 3381).

maturitanti repulsis; lobis brevioribus 2, –7.5 cm. longis, subaequalibus, saepe illos subaequalibus. Nux –1.5 × 1.3 cm., ellipsoidea, obtusa, pallide verrucoso-lenticellata; stylopodio –1 mm. longo, brevi, abrupto.

Collections. *Sarawak:* Haviland 2810/2331, Belaga, Rejang (Holotypus, in Herb. Kew); Pickles 3431, R Kenaban, Plieran; S A 0308, Ulu Baram; Brun 3159, Ulu Limbang. *Brunei:* Kep 34567, Pak Andaki; Kep 37057, Kiudang, Tutong; S 1693 S. Kiaput, Tutong; Brun 2604, Kuala Temburong Machang; Brun 2528, Ulu Temburong-Medamit watershed; Brun 3013, 3074, Bangar; Brun 3381, 455, S 5731, 5732, Kuala Belalong. *North Borneo:* San A 4331, Kota Belud; Kep 80463, Pangi. *Indonesian Borneo:* bb 10165, 17811, 18165, 18314, 17954, Tidung; bb 11772, Bulungan.

PARASHOREA SMYTHIESII Wyatt Smith ex Ashton:—*P. smythiesii* Wyatt Smith, nomen nudum.

P. lucidae Kurz affinis, sed lobis calycis in fructu longioribus, lamina maiore, petiole breviore, conferte breviter tomentoso, costis lateralibus utrinsecus 14–18 differt.

Ramuli, perulae, petiolique semper pallide flavo-ochraceo-tomentosi; costae intercostae laminaque subtus sparsim scabrido-tomentosi. Ramuli apicem versus –3 mm. diam., teretes vel striati; dein teres glabrescentes, leves, fusco-brunnescentes; cicatricibus stipulatis –1.5 mm. longis, angustis, plus minus horizontalibus; internodis 1–2 cm. longis. Gemma –5 × 3 mm., ovoidea obtusa. Stipulae –10 × 4 mm., late hastatae, subacutae. Lamina 10–15 × 4–7 cm., tenuis, subtus argenteo-glauca, elliptico-oblonga, basi obtusa, apice in acumen –5 mm. longum plus minus abrupte attenuato; costis lateralibus utrinsecus 14–18, rectis, angulo 30°–45° exorientibus; inter costas obscuris plicatis persistentibus; intercostis scalariformibus distinctis; a costis lateralibus c. 90° exorientibus; costa media subtus prominenti, supra angusta paullum depressa. Petiolus 1.5–2.2 cm. longus, –2.5 mm. diam., brevis, crassus, sicco pallide brunneo-tomentosus. Lamina delapsa supra flavo-brunnea, subtus pallide hebes purpuro-brunnea. Racemi –10 cm. longi, bis ramosi, stipitis basi in fructu –1.5 mm. diam.; terminales vel axillares, angulati vel compressi, semper breviter pallide griseo-brunneo-tomentosi; ramulis brevibus, –5 flores gerentibus; bracteis –8 × 3 mm., oblongis, obtusis, externe breviter pubescentibus, intus glabrescentibus; bracteolis –4 × 3 mm., late ellipticis, alabastrum obtegentibus adpressis, externe conferte tomentosis. Alabastrum –7 × 4 mm., ovoideum, obtusum. Calyx externe breviter conferte pallide griseo-brunneus; lobis anguste ovatis, lobis externis 3 obtusis, quam lobis internis paullum longioribus et angustioribus; lobis internis 2 acutis, subacuminatis. Corolla in vivo alba; petalis ellipticis obtusis, partibus in alabastro expositis

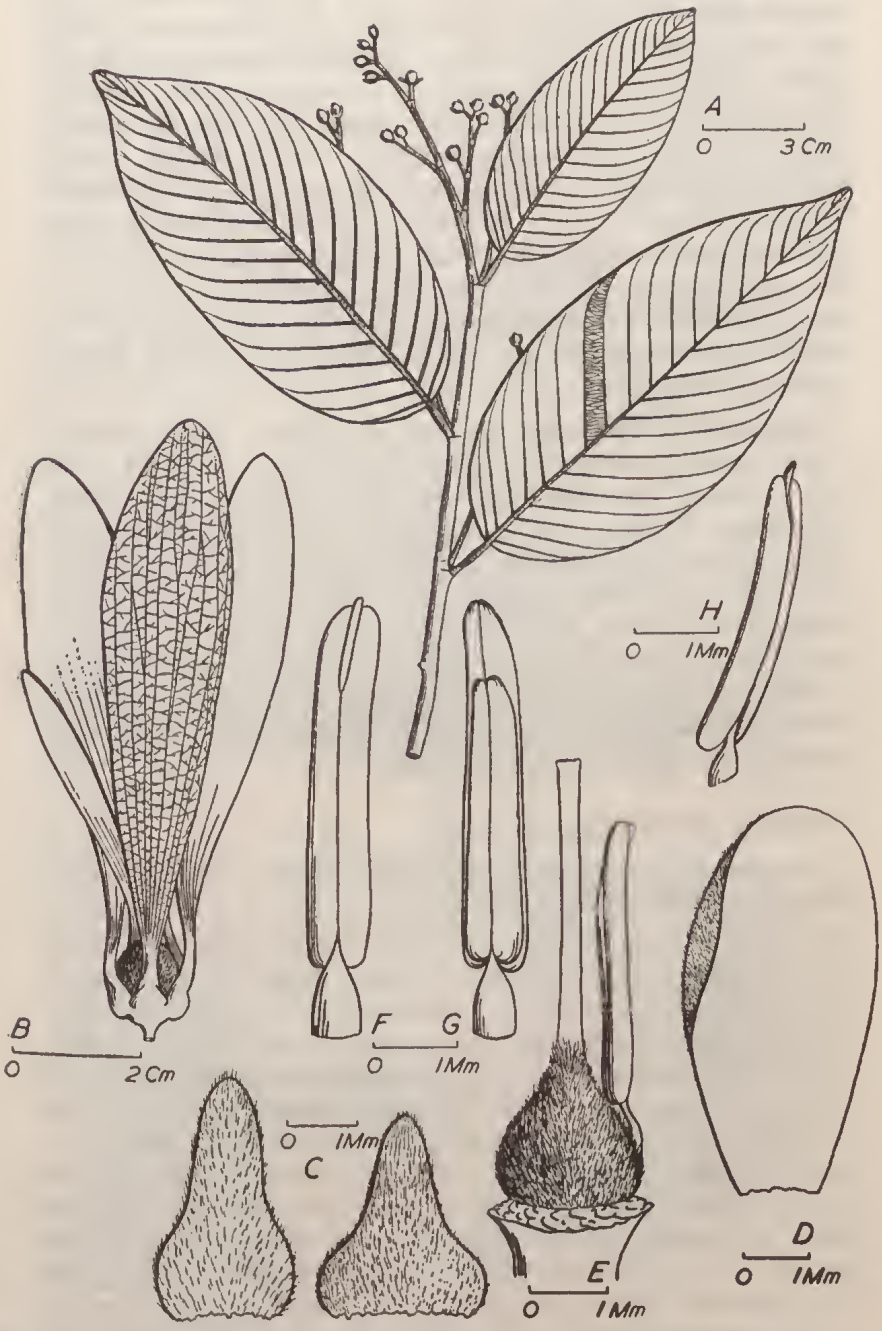


Plate 7. *Parashorea smythiesii.*

a, Flowering twig. b, Fruit. c, Sepals (outer, left; inner, right). d, Petal. e, Ovary. f, Stamen (frontal view). g, Stamen (inside view). h, Stamen (fronto-lateral view). (a, c–h, from Brun 2000; b from Kep 35456).

breviter tomentosis. Stamina 15, interiora 5 quam exteriora 10 paullum longiora; filamentis basim versus applanato-dilatatis, sub antheris abrupta attenuatis; antheris lineare oblongis, prope apicem styli attingentibus; aristis brevibus, apices antherorum non superantibus. Ovarium ovoideum, conferte tomentosum; stylo filiformi, quam ovarium 3-plo longiore, tertia parte basali breviter tomentosa, aliter glabra. Pedicellus in fructu –2 mm. longus, brevis. Calyx in fructu apicem versus glabrescens, basim versus puberulus; lobis longioribus 3, –10 × 1.7 cm., anguste obtusis, basim versus –2.5 mm. latis gradatim attenuatis; partibus basalibus –6 × 3.5 mm., paullum saccata, incrassata; lobis brevioribus 2, –70 × 7 mm., spathulatis, ad basim angustis. Nux –13 × 9 mm., ovoidea, conferte fulvo-tomentosa, ad stylopodium lineare –4 mm. longum subabrupte attenuata.

Collections. *Indonesian Borneo:* bb 18320, 17890, Tidung. *North Borneo:* San 18604, 18720, Tawau; San A 1732, A 1703, San A 4091, Beaufort; San A 3284, Sipitang, Kep 80261, S. Lukutan; San A 3967, Kalabakan, Tawau. *Sarawak:* S 123, S. Miah, Balleh, Rejang; S A 424, Balleh. *Brunei:* Kep 35488, Brun 3016, 3169, Bt. Biang; S 1667, Biang; Kep 35456, 35445, 35448, S 2102, 2104, Kep 35458, Bt. Patoi; San 17071, S 5738, Brun 472, 2000a (Holotypus in Herb. Kew), 3129, Kuala Belalong; S 1657, Bt. Apoi; Kep 80138, Peradayan F.R.; Brun 308, Batu Apoi-Sebatu watershed; Brun 5217, S. Belalong above Kuala Empan; S 5590, 5593, Ulu Senuko, Labu.

SHOREA ACUTA Ashton s.n.

S. macropterae Dyer affinis, sed lamina maiore coriaceore, costis prominentioribus, tomento differt.

Ramuli, perulae, stipulae, petiolique semper conferte, breviter, plane, pallide brunneo-tomentosi; costae subtus costaque media supra primo conferte breviter plane pallide brunneo-tomentosae, dein glabrescentes. Ramuli apicem versus –4 mm. diam., dein teretes glabrescentes, leves, pallide roseo-brunnescentes; internodis 1–4 cm. longis; cicatricibus stipularum primo –3 × 1 mm., cuneatis, transversis. Gemma 6–10 × 4–6 mm., ovoidea, subacuta. Stipulae –12 ×5 mm., oblongae, obtusae. Lamina 14–26 × 6.5–12 cm., ex integro glaber, basi obtusa vel late cuneata, apice in acumen –2 cm. longum anguste attenuato; intercostis lateralibus utrinsecus 10–13, subtus prominentibus, basi angulo 90° aliter 45°–55° exorientibus; intercostis angustis, sinuatis, conferte scalariformibus, costis lateralibus diagonale exorientibus; costa media subtus prominenti, tereti, supra angusta, paullum depressa. Petiolus 1.5–2 cm. longus, 3–4 mm. diam., crassus, sicco pallide brunneo-pubescens vel nigrescens. Lamina delapsa supra pallide roseo-brunnea, subtus luteo-ferruginea. Racemi –18 cm.

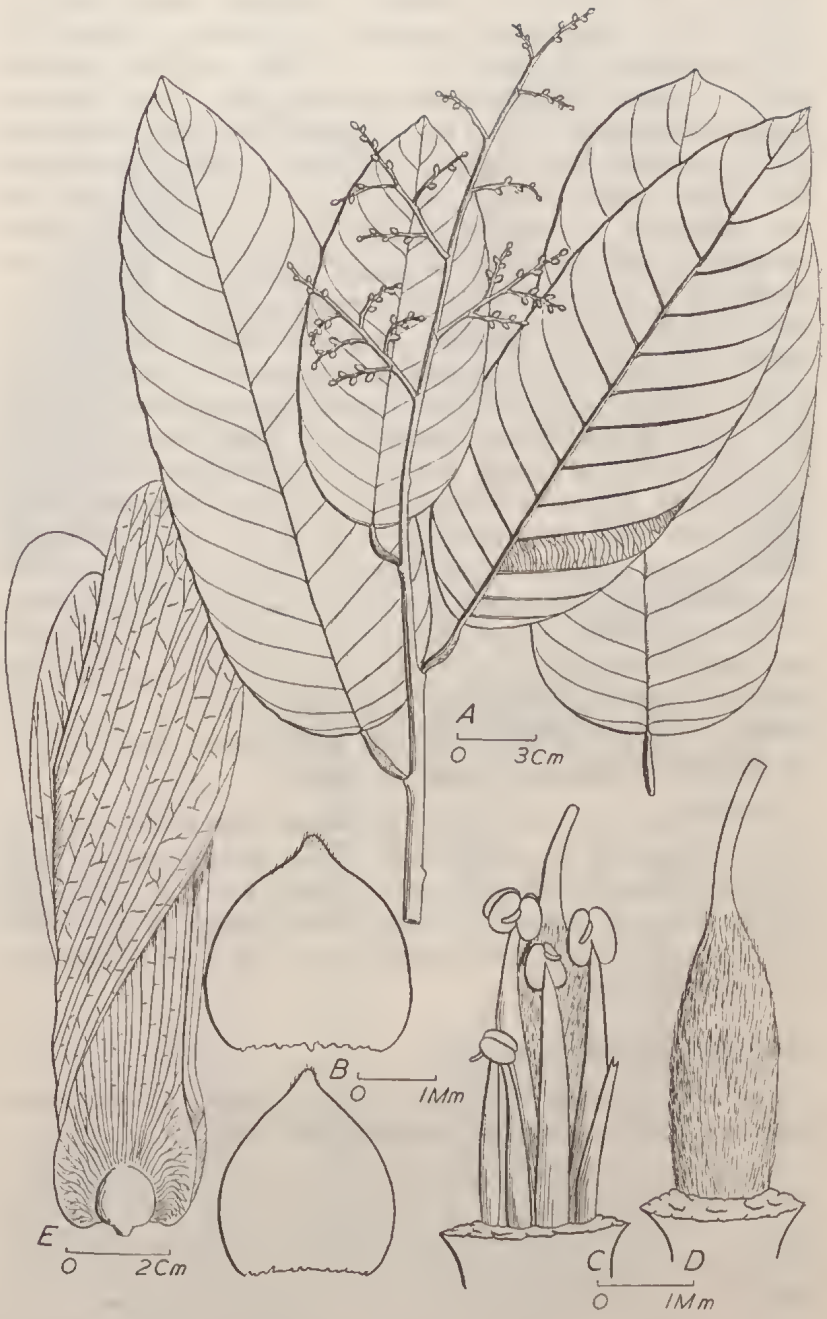


Plate 8. *Shorea acuta.*

a, Flowering twig and leaf. b, Sepals (outer, above; inner, below). c, Ovary and androecium. d, Ovary. e, Fruit.

(a–d from Brun 3076; e from s.n., Bt. Teraja).

longi, semel vel bis ramosi, stipitis basi in fructu –3 mm. diam., terminales vel axillares, ex integro compressi, semper breviter pallide brunneo-pubescentes; ramulis –6 cm. longis, –9 flores distichos gerentibus; bracteolis –3.5 × 2.5 mm., ellipticis, obtusis, externe breviter flavido-brunneo-tomentosis, intus glabris, caducis. Alabastrum –9 × 4 mm., anguste ellipsoideum, obtusum. Calyx externe breviter conferte pallide flavido-alutaceo-tomentosus, intus glaber; lobis subaequalibus, ovatis, subacutis. Corolla in vivo fusco-rubra, partibus in alabastro expositis pallide brunneo-tomentosis; petalis linearibus, subacutis. Stamina 15, verticillis inaequalibus 3, interna 5 longissima ovarium paullum superantia; filamentis ad antheras gradatim attenuatis, aristis brevibus, dein reflexis. Ovarium stylopodiumque quam stylum c. 3-plo longiore anguste conicum vel ovoideum, apicem versus asperum tomentosum, basim versus breviter tomentosum; stylo filiformi, glabro. Pedicellus in fructu –1 mm. longus, –2.5 mm. diam., fructu subsessili. Calyx in fructu basim versus breviter pubescens, aliter glabrescens; lobis longioribus 3, –15 × 2.8 cm., spatulatis, obtusis, basim versus –1.5 cm. latis attenuatis; partibus basalibus –1.8 cm. lato, ad pedicellum abrupte terminatis, discis centralibus –8 × 7 mm. ovatis saccatis incrassatis, auriculis duobus lateralibus; lobis brevioribus 2, –8 × 0.7 cm., linearibus, inaequalibus, partibus basalibus ut in lobis longioribus. Nux –3 × 2 cm., ovoidea, conferte pallide badio vel pallide alutaceo-tomentosa, ad stylopodium brevem acutum attenuata.

Collections. *Sarawak:* S 1922, S. Bakong, Baram; *Brunei:* Kep 30505, Brun 500, Bt. Biang; Kep 47042, 'Brunei'; Kep 35545, Pengkalan Ran; S 1924 (Holotypus in Herb. Kew), S. Liang; Kep 30579, Ukong; S 1906, 2171, Kep 80088, 30596, 30607, 30628, 80096, S 4950, Brun 3291, 3076, 3164, San 17474, Andulau F.R.; s.n., Bt. Teraja.

SHOREA AGAMI Ashton s.n.

S. virescentis Parijs affinis, sed floribus minoribus, basi fructus impressa, laminis maioribus coriaceoribus differt.

Ramuli, perulae, stipulae, petioli, costaque media subtus primo pallide brunnescentes, dein glabrescentes. Ramuli apicem versus 2–3 mm. diam., leves, fusco-brunnescentes vel nigrescentes, teretes, saepe lenticellis minutis pallidis punctati; cicatricibus stipularum brevibus inconspicuis; internodis 1–3 cm. longis. Gemma c. 4 × 2.5 mm., ovoidea vel falcata, obtusa, paullum pubescens vel glabrescens, stipulae c. 10 × 3 mm., oblongae, obtusae, externe breviter pubescentes, intus glabrae, caducae. Lamina 10–15 × 6–10 cm., late ovoidea vel oblonga, coriacea, basi obtusa vel cuneata, apice in acumen late deltoideum 0.5–1 cm. longum subabrupte attenuato; costis lateralibus utrinsecus 9–13, remotis,

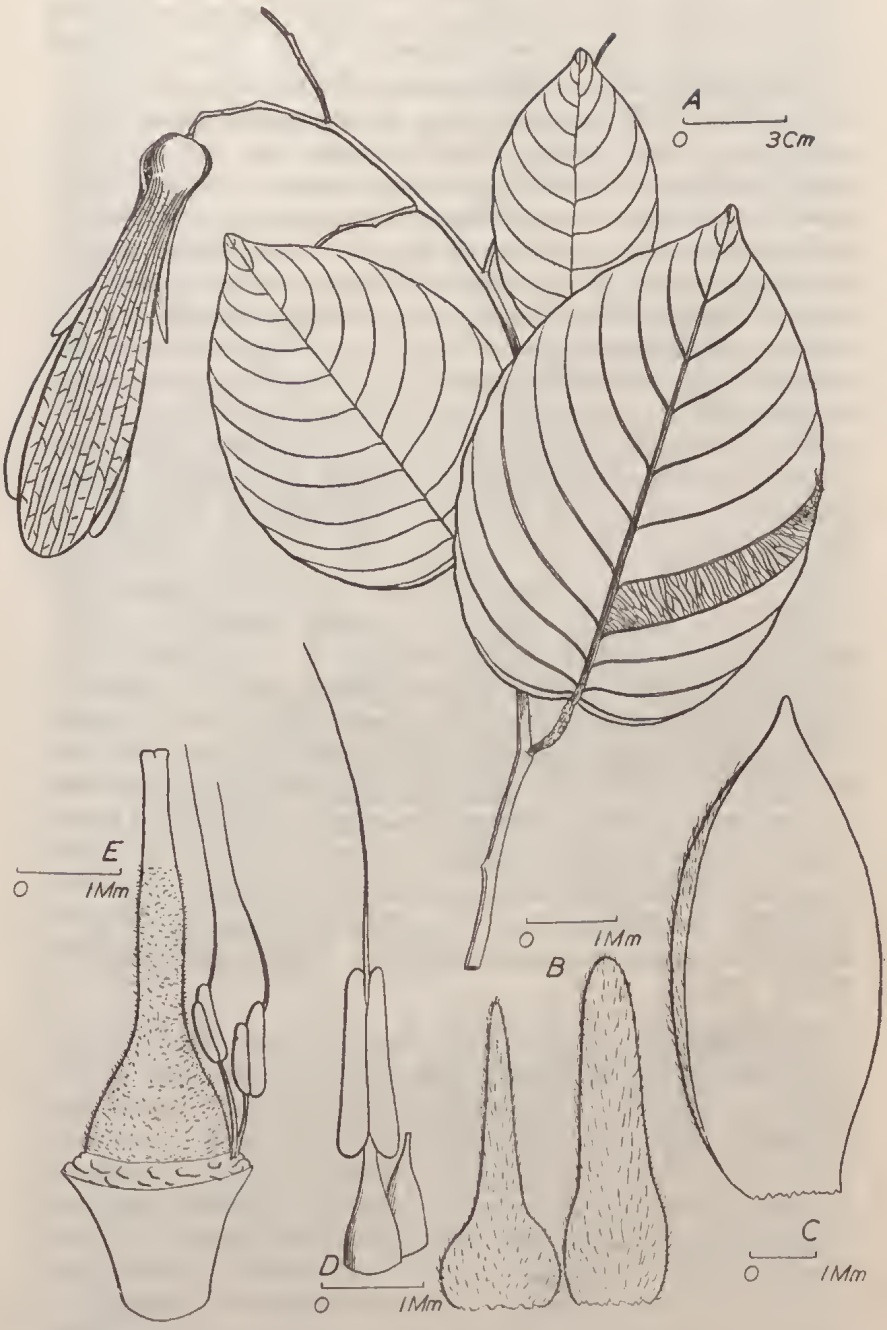


Plate 9. *S. agami.*

a, Fruiting twig. b, Sepals (left, inner; right, outer). c, Petal. d, Stamen (frontal view). e, Ovary.

(a from San 15402, b–e from Kep 30525).

curvatis, ad basim laminae angulo c. 90°, apicem versus eiusdem angulo 40° exorientibus. Petiolus 1–1.5 cm. longus, 1.5–2 mm. diam., sicco niger. Lamina delapsa supra fusco-brunnescens, subtus ex integro viride-brunnescens. Racemi 6–10 cm. longi, semel vel bis irregulariter ramosi, stipitis basi in fructu –1.5 mm. diam., terminales vel axillares, basim versus teretes, apicem versus angulati, primo breviter pallide fulvo-tomentosi, dein glabrescentes; ramulis brevibus, –5 flores gerentibus; bracteis fugacibus; bracteolis –3 mm. longis, anguste ellipticis, subacutis, externe breviter pallide alutaceo-fulvo-tomentosis, intus puberulentibus, caducis Alabastrum –5 × 2.5 mm., parvum, anguste ellipsoideum, subacutum. Pedicellus c. 0.5 mm. longum. Calyx conferte pallide flavido-alutaceo-tomentosus; lobis externis 3 anguste ovatis, subacuminatis; lobis internis 2 prominente caudato-acuminatis, quam lobis externis 2/3-plo longioribus angustioribus. Petala parva, ovato-elliptica, acuta, partibus in alabastro expositis conferte tomentosis, aliter externe puberulentia. Stamina 15, verticillis subaequalibus 3, filamentis ut antheras longis, paullum angustis, attenuatis, antheris oblongis, apicem versus paullum attenuatis; aristis quam antheras c. 3-plo longioribus, gracilibus, apicem styli attingentibus. Ovarium ovoideum, conferte tomentosum, stylo quam ovarium paullum longiori, dimidio basali sparsim tomentoso, dimidio distali glabro, crasse filiformi, apicem versus obscure trifureo. Pedicellus in fructu –3 mm. longus, brevis, crassus. Calyx primo breviter pubescens, dein glabrescens; lobis longioribus, 3, 10–12 × 1.5–2.2 cm., spatulatis, obtusis, basim versus –5 mm. latis gradatim attenuatis, partibus basalibus 1–1.5 cm. latis, multum saccatis, incrassatis; lobis brevioribus 2, –6 × 0.4 cm., inaequalibus, linearibus, anguste acutis, partibus basalibus ut in lobis longioribus. Nux –2 × 1.5 cm., laber, ovoidea, ad stylopodium 3–4 mm. longum attenuata, vasi ad pedicellum impresso.

Collections. *Brunei:* Kep 35449, Bt. Patoi; Kep 30483, S. Keduan; Kep 34401, S. Lumut; Kep 37249, Bangar; Kep 48108, Labi Hills; Kep 48153, B. Rampayoh; Kep 48160, S. Lumut; Kep 48206, Bt. Gatas; Kep 48209, 48211, Balai Tarunan; Kep 48491, Brun 3092, S 1939, Andulau F.R.; Brun 3135, Kuala Temburong Machang; Brun 211, S. Topi, Ulu Belait; Kep 30525 (Holotypus in Herb. Kepong), Labi Hills; Brun 739, Kuala Sekurop; S 1632, Kenapol, Labi Hills F.R.; S. 1636, Labi Hills F.R. *North Borneo:* San 16947, 16987, Beaufort; San 17797, Sibubu R., Sipitang; S A379, S. Rayoh, Sabah; San A 3129, A 3477, A 3131, 15385, 15402, Sandakan; San A 3160, Kudat. *Indonesian Borneo:* Meijer 2464, Tarakan; bb 13617, Karangan R., NW of Sangkulirang; bb 17963, 17870, 33002, Tidung. *Sarawak:* S 1537, Bt. Meringgit, Merapok, Lawas

SHOREA AMPLEXICAULIS Ashton s.n.

S. beccarianae Burck affinis, sed ramulis angustioribus vix compressis, cicatricibus stipularum amplexicaulibus, petiolo breviore differt.

Novellae primo pallide alutaceo-pubescentes vel brunneo-tomentosae, dein glabrescentes vel sparsim tomentosae. Ramuli apicem versus –2 × 3 mm. diam., paullum compressi, dein teretes, graciles, pallide griseo-alutacei, glabri, leves; internodis 1–3 cm. longis; cicatricibus stipularum amplexicaulibus, c. 0.5 mm. latis, horizontalibus. Gemma 10–15 × 3–5 mm., hastata, acuta. Stipulae –25 × 8 mm., hastatae, subacutae, subpersistentes. Lamina 11–21 × 5–8 cm., elliptica, coriacea, in vivo novella magenta, basi cuneata, apice in acumen –1 cm. longum attenuato; costis lateralibus utrinsecus 9–12, angulo 50°–70° exorientibus, subtus prominenti; intercostis distinctis, scalariformibus, remotis; costa media subtus prominenti, tereti, supra plus minus applanata. Petiolus 1.5–2 cm. longus, –2 mm. diam., brevis, sicco pallide griseo-brunnea. Lamina delapsa supra pallide purpureo-brunnescens, subtus rubro-brunnea. Racemi –24 cm. longi, semel ordine ramosi, stipitis basi in fructu –3 mm. diam., terminales vel axillares, laxi, ex integro graciles, compressi, primo saepe aureo-tomentosi, dein glabrescentes; bracteis –13 × 8 mm., lanceolatis, acutis, glabris, fugacibus; bracteolis –11 × 5 mm., oblongis, obtusis, externe glabrescentibus vel puberulentibus, intus glabris, subpersistentibus. Alabastrum –10 × 3.5 mm., lanceolatum, obtusum. Calyx externe conferte breviter pallide griseo-tomentosus, intus glaber; lobis subaequalibus, anguste deltoideis, obtusis, basi paullum expansis. Corolla in vivo pallide flava, petalis lineare-lanceolatis, subacutis, partibus in alabastro expositis breviter pubescentibus. Stamina 15, verticillis 3, interna 5 quam alia paullum longiora; filamentis latis, verticillis conjunctis, sub antheris abrupte attenuatis; antheris anguste oblongis; aristis quam antheras 2–3-plo longioribus, non reflexis. Ovarium ovoideum, dimidio distali puberulenti vel glabrescenti, dimidio basali glabro; stylopodio indistincto; stylo quam ovarium paullum longiore, filiformi, glabro. Pedicellus in fructu –2 mm. longus, –4 mm. diam. Calyx in fructu breviter puberulens vel glabrescens, ad basim impressus; lobis longioribus 3, –18 × 3 cm., oblongo-spatulatis, obtusis, basim versus –2 cm. latis attenuatis, partibus basalibus –1.6 × 2.2 cm., late ovatis, saccatis, incrassatis; lobis brevioribus 2, –13 × 0.8 cm., basi ut in lobis longioribus. Nux –3.7 × 2.5 cm., late ovoidea, plane conferte pallide aureo-alutaceo-tomentosa, ad apicem conicum abrupte attenuata, stylopodio brevi acuto.

Collections. *North Borneo:* San 15071, 15122, 15072. Beaufort: San 15106, Pangi. *Indonesian Borneo:* bb 29636, 29666, 29663, 29702, 31420, 31419, Muara Tewe: bb 32780, 32781, 32774, 32779, Tarakan; Meijer 2218, Kostermans 8711, Nunukan, Tarakan; bb 29306, 29309, Bulungan; bb 31260, 31200, 31201,

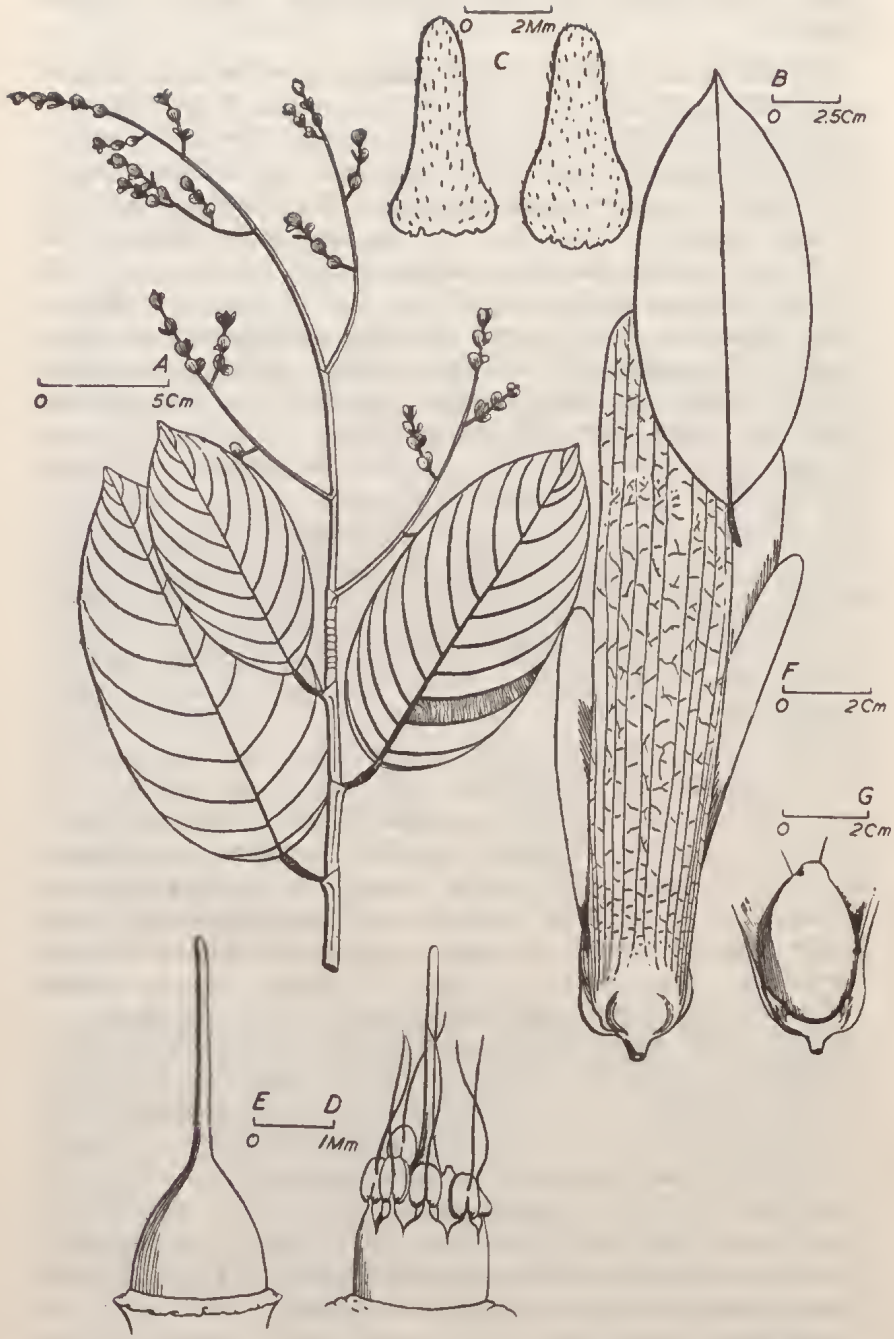


Plate 10. *S. amplexicaulis.*

a, Flowering twig. b, Leaf. c, Sepals (left, inner; right, outer). d, Ovary and androecium. e, Ovary. f, Fruit. g, Nut.

(a–e from Jacobs 5323; f, g, from Brun 3261).

31202, 31203, 29636, 27023, 28121, 27006, 27024, 30208, 30209, 30207, 26429, Melawi. *Brunei:* Kep 30374, Temburong; Brun 751, Base of Bt. Tanggoi, Temburong; Brun 3151, 3006, Bangar; S 5719, Kuala Belalong; Kep 30572, 30574, 35550, 35551, Tutong R.; Kep 28653, Bt. Kerita, Ladan Hills; S 1675, Mile 3, Ladan Hills; Kep 30633, Bt. Ladan; Kep 37086, 37087, Bt. Arong F.R.; Kep 32590, Balai Rotan; Kep 34559, Kuala Seladan, Tepiku; Kep 34566, Pak Andaki; Kep 34584, Pak Gabal; Kep 34596, Bt. Menggelang; Kep 48201, Balai Halim; Kep 80094, S 1860, 1927, 1937, 5580, Brun 555, 3261 (Holotypus in Herb. Kew), Andulau F.R.; Kep 30386, Kep 30387, S 1633, 1937, Kep 30389, 30460, 39638, Labi Hills F.R.; Kep 48184, Bt. Kenapol, Labi; S 2131, Bt. Teraja. *Sarawak:* S 247, Semengoh F.R.; S 6502, Simanggang; Clemens 21965, Sarawak; S 1683, Lawas; Jacobs 5323 Belaga.

SHOREA ANDULENSIS Ashton s.n.

S. pauciflorae King affinis, sed corolla ianthina, ovario glabro, lamina minore subtus glauca differt.

Ramuli, perulae, costa media supra, stipulae, petiolique, breviter conferte pallide flavido-alutaceo-tomentosi, costaeque subtus sparsius eodem tomentosi. Ramuli apicem versus 1.5–2 mm. diam., primo compressi, dein teretes, sicco nigrescentes, lenticellis minutis orbicularibus pallidioribus punctati, leves, glabri, angusti; internodis c. 1–1.5 cm. longis, brevibus; cicatricibus stipularum inconspicuis. Gemma 3–6 × 1.5–3 mm., ovoidea, compressa, subacuta. Stipulae –14 × 5 mm., hastatae, subacutae. Lamina 6–9 × 3–5 cm., elliptico-ovata, basi obtusa, apice in acumen –8 mm. longum attenuato; in arboribus maturis subtus glauca; costis lateralibus utrinsecus 10–13, rectis, marginem versus abrupte curvatis, subtus angustate prominentibus, angulo 40°–50° exorientibus basi excepta; intercostis angustis, scalariformibus, sinuatis, a costis lateralibus diagonale exorientibus. Petiolus 1–1.2 cm. longus, 1–1.5 cm. latus, sicco cremeo-glauco-tomentosus, rugosus. Lamina delapsa supra pallide purpureo-brunnescens, subtus plus minus glauca, dein saepe cere glauca attrita fusco-rufo-brunneam; margine saepe paullum revoluto. Racemi –12 cm. longi, semel vel bis ramosi, stipitis basi in fructu –2, 5 mm. diam., terminales vel axillares, ex integro teretes vel paullum compressi, semper breviter conferte griseo vel pallide ferrugineo-tomentosi; ramuli –10 flores distichos gerentibus; bracteis bracteolisque –3 × 1.25 mm., ovatis, subacutis, externe breviter griseo-pubescentibus, intus glabrescentibus. Alabastrum –8 × 2.5 mm., anguste ovoideum, subacutum, calyce expanso. Calyx externe conferte breviter tomentosus, intus puberulens; lobis subaequalibus, ovatis, acutis vel paullum acuminatis, internis 2 quam externis 3 paullum acuminatioribus. Corolla in vivo pallide ianthina, ad marginem pallidior;

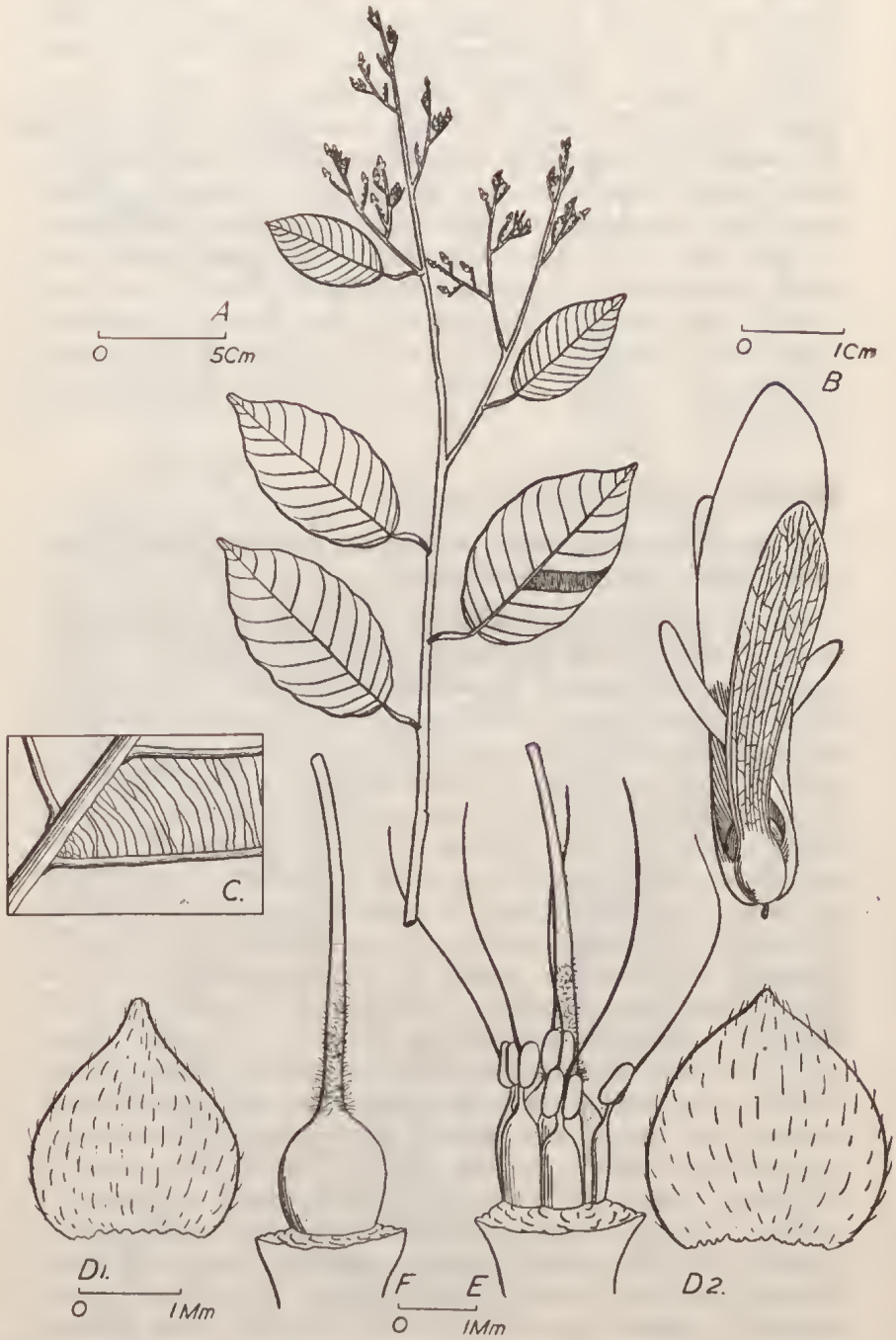


Plate 11. *S. andulensis.*

a, Flowering twig. b, Fruit. c, Part of lamina undersurface. d, Sepals (1, outer; 2, inner). e, Ovary and androecium. f, Ovary.
(a–f, from Brun 3263).

petalis lineari-lanceolatis, anguste acutis, nectis, partibus in alabastro expositis breviter tomentosis, basim versus saccatis. Stamina 15, verticillis 3, bina cum solis alternata; interna 5 quam alia vix longiora; filamentis basim versus applanato-dilatatis, ad medium abrupte attenuatis, antheris late oblongis; aristis quam antheras 3-plo longiori, rectis, non reflexis, internis 5 prope apicem styli attingentibus. Ovarium parvum, globosum, glabrum, stylopodio indistincto; stylo quam ovarium 2-plo longiori, filiformi, dimidio basali sparsim tomentoso, aliter glabro. Pedicellus in fructu c. 3 mm. longus, c. 1 mm. diam., gracilis. Calyx in fructu breviter pubescens, basim versus confertius pubescens, in aetate maturandi sicco aureo-luteus; lobis longioribus 3, –5 × 1.2 cm., late spatulatis, obtusa, basim versus –2.5 mm. latis attenuatis, partibus basalibus c. 6 × 4 mm., anguste ovatis, incrassatis, saccatis; lobis brevioribus 2, –2.5 × 0.2 cm., linearibus, subaequalibus, basim versus ut in lobis longioribus. Nux –1.4 × 0.7 cm., ovoidea, breviter pallide griseo-alutaceo-pubescens, ad stylopodium –1 mm. acutum abrupte attenuata.

Collections. *Brunei:* Brun 5435, 3263 (Holotypus in Herb. Kew), 3030, 3275, San 17523, Andulu F.R.; Brun 3332, Bt. Patoi; Brun 878, Bt. Bedawan; S 2122, Bt. Teraja; Brun 173, R. Ingei. *Sarawak:* S 5637. Bt. Bubong Rumah, Lawas; Brun 809, Sourabaya-Merapok track, Kayangeran East F.R., Lawas.

SHOREA ANGUSTIFOLIA Ashton s.n.

S. xanthophylla Sym. affinis, sed petiolo pubescenti, lamina minore, coriaceore, sine costis lateralibus differt.

Perulae petiolique semper pilis brevissimis pallide brunneis punctati; ramuli stipulaeque pilis minutis pallidis brunneis primo sparsim punctati, dein glabrescentes. Ramuli apicem versus 1.5–2 mm. diam., recti, teretes, pallide flavido-brunnescentes, rugosi, fissi, facie floccis parvulis chartaceis exfolia. Gemma 0.5–1.5 × 1 mm., parva, ovoidea, obtusa. Stipulae –3 mm. longae, lineares, fugaces. Lamina novella in vivo fusco-violescens; lamina 8–14 × 2.5–4 cm., ovato-lanceolata, coreacea, basi cuneata, apice in acumen 1–1.5 cm. longum gradatim attenuato; costis lateralibus utrinsecus 8–9 (10), vix prominentibus, curvatis, remotis, angulo 50°–60° exorientibus; costa media subtus vix elevata, intercostis conferte scalariformibus. Petiolus 6–8 mm. longus, c. 1.5 mm. latus, brevis fissis minutis, sicco distincte pallide brunneus vel pallide cremeo-griseus. Lamina delapsa griseo-viridis, non crispata sed margine saepe undulato. Racemi –10 cm. longi, ordine semel vel bis ramosi, stipitis basi in fructu –1.5 mm. diam., terminales vel axillares, graciles, laxi, ex integro teretes, breviter pallide griseo-alutaceo-pubescentes; ramulis –2 cm. longis, –8 flores distichos gerentibus; bracteolis parvis, fugacibus. Gemma –2.5 × 1.5 mm., lanceolata, acuta. Calyx externe breviter tomentosus, intus

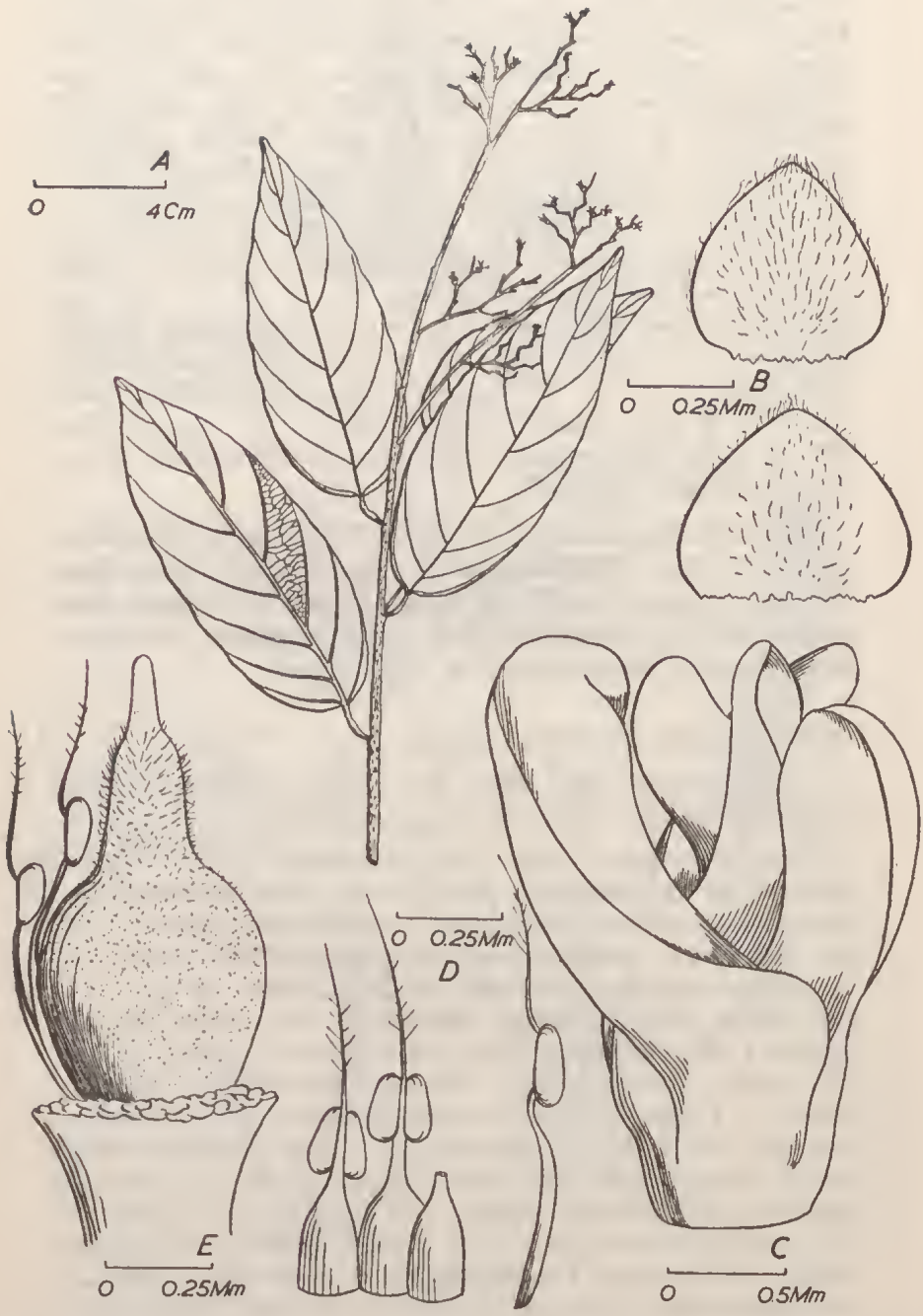


Plate 12. *S. angustifolia.*

a, Flowering twig. b, Sepals (above, outer; below, inner). c, Corolla. d, Stamens (left, frontal view; right, lateral view). e, Ovary.

(a–e from Brun 778).

glaber, lobis ovatis, acutis, lobis internis 2 quam externis 3 tenuoribus, ad basim costrictioribus. Corolla in vivo pallide flava, aetate expandi basim versus imbricata, scyphiformis, apicem versus expansa; petalis linearibus, partibus in alabastro expositis breviter tomentosis, apicem versus nectis. Stamina 15, in verticillis 3 inaequalibus, bina cum solis alternata; filamentis basim versus dilatatis, apicem versus filiformibus; antheris oblongis; aristis quam antheras 1–2-plo longioribus, apicem styli attingentibus, apicem versus ciliatis. Ovarium ovoideum, basi glabra, aliter breviter tomentosum, stylopodio conico, tomentoso, stylo brevi glabro; stylo styloporioque ovarium aequanti. Fructus ignotis.

Collections. *North Borneo:* Kep 80302, Gaya F.R. *Indonesian Borneo:* bb 17915, 17919, 17760, Tidung; bb 12583, E. Kutai; bb 31774, Melawi; bb 11050, 21201, 21199, 21184, 21158, 21187, 21155, 22754, Puruktjau; bb 18988, 19555, Berau; bb 11200, Bulungan; bb 20143, Sampit; bb 20627, 20629, Boven Mahakam; bb 19987, Boven Dayak. *Brunei:* Brun 3393, 5682, Kuala Belalong; Brun 520, Bt. Patoi; Brun 748, Kuala Sekurop, Temburong; Brun 778, Kuala Temburong Machang, Temburong (Holotypus in Herb. Kew).

SHOREA ASAHI Ashton s.n.

S. maxwellianae King, *S. biawak* Ashton affinis, sed lamina coriacea, costa subtus supraque applanata differt.

Novellae primo brevissime pubescentes, dein glabrescentes, stipulae persistenter. Ramuli apicem versus c. 0.75 mm. diam., graciles, teretes, fusco brunnei vel nigri, lenticellis minutis pallidioribus conferte punctati; cicatricibus stipularum parvis, horizontalibus, inconspicuis. Gemma c. 1.5 × 1 mm., parva, falcata, sicco nigrescens. Stipulae –5 mm. longae, anguste deltoideae, fugacae. Lamina 6–10 × 3–5 cm., ovata, coriacea, non glauca, basi late cuneata, subaequali, apice in acumen c. 1 cm. longum anguste attenuato; costis lateralibus utrinsecus 6–7, angustis, curvatis, applanatis, angula c. 60° exorientibus; costa media indistincta, subtus supraque applanata; intercostis scalariformibus, confertis, angustissimis, indistinctis, a costa media angulo 90° exorientibus vel sursum directis, marginem versus a costis lateralibus angulo c. 90° exorientibus. Petiolus c. 1 cm. longus, c. 1 mm. diam., sicco nigrescens. Lamina delapsa supra obscure purpureo-brunnescens, subtus pallide flavido-brunnescens, ex integro nitens. Racemi –12 cm. longi, semel ramosi, stipitis basi in fructu –1 mm. diam., terminales vel axillares, ex integro graciles, teretes, recti, conferte cremeo-tomentosi; ramulis –7 mm. longis, brevibus, 'zigzag', –4 flores secundos conferte gerentibus; bracteolis –2 mm. longis, ellipticis, acutis, puberulentibus, fugacis. Alabastrum –2 mm. longum, globosum. Calyx externe breviter pubescens, intus glaber; lobis externis 3 ovato-deltoideis, subacutis; lobis internis

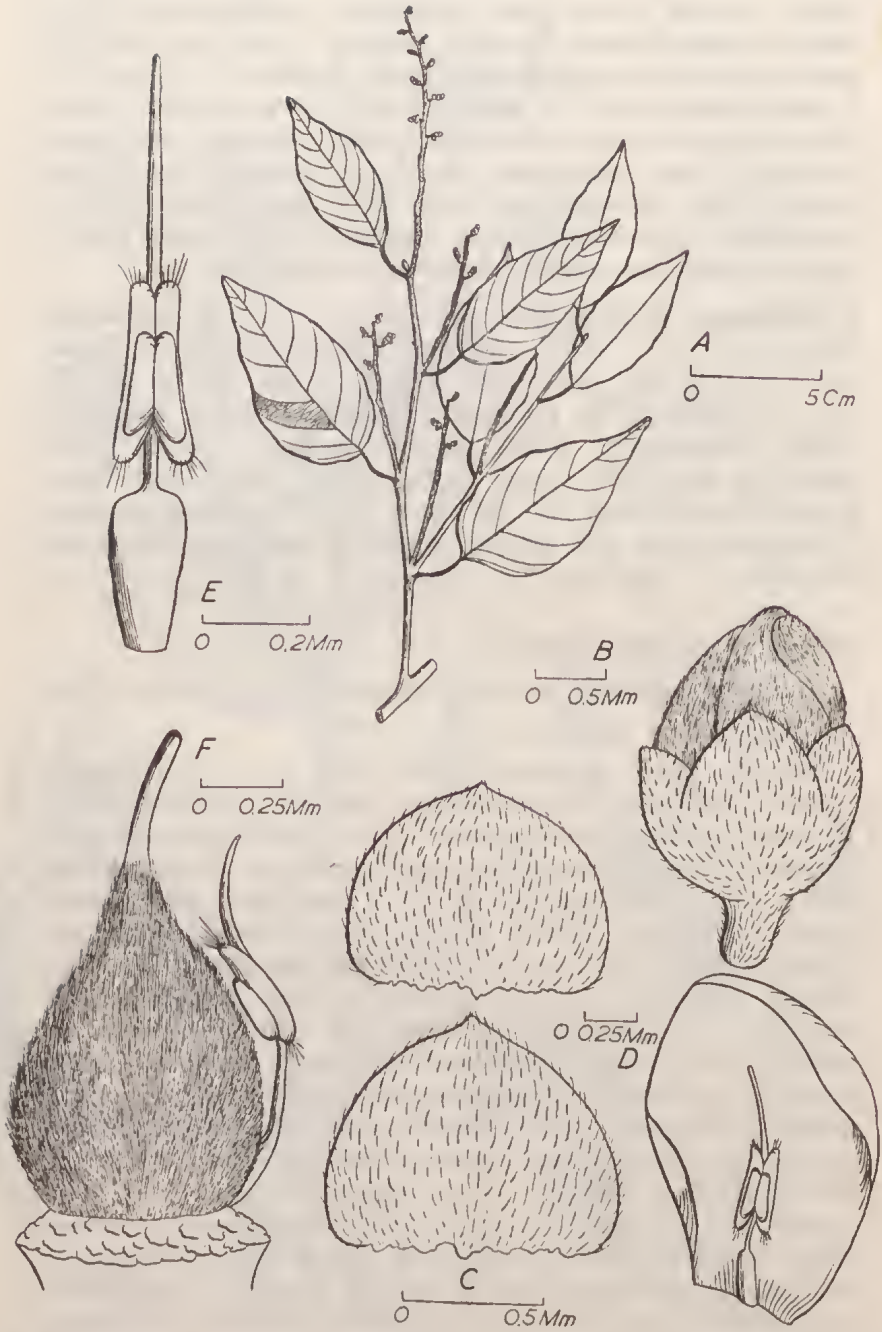


Plate 13. *S. asahi.*

a, Flowering twig. b, Flower bud. c, Sepals (inner above; outer below). d, Petal. e, Stamen (from inner side). f, Ovary.

(a–f from Kep 37183).

2 quam illis minoribus, latius ovatis, minoribus acutis. Corolla in vivo alba; petalis elliptico-oblongis, acutis, externe breviter pubescentibus, intus puberulentibus. Stamina c. 30, subaequalibus; filamentis basim versus applanato-dilatatis ad medium abrupta attenuatis, apicem versus filiformibus, breviter barbatis; antheris anguste oblongis, loculis interioribus quam exterioribus majoribus, apice breviter barbato; aristis quam antheras 2-plo longioribus, crassis, apicem versus barbatis. Ovarium stylopodiumque ovoideum, conferte tomentosum, in stylum breve gracile glabrum attenuatum. Pedicellus in fructu –2 mm. longus. Calyx sparsim alutaceo-pubescens; lobis –4 × 4 mm. brevibus subaequalibus nucem adpressis. Nux –11 × 6 mm. oblongo-ovoidea acuta conferte alutaceo-pubescens.

Collections. *Brunei:* Kep 37183, Bt. Bedawan (Holotypus in Herb. Kepong); Brun 772, Kuala Temburong Machang, Ulu Temburong; Brun 5632, Bt. Ulu Tutong; S 1183, Bt. Teraja. *North Borneo:* San 24279, M. 5, Telupid road, Beluran.

SHOREA BIAWAK Ashton s.n.

S. maxwellianae King affinis, sed lobis calycis in fructu quam nucem brevioribus differt.

Ramuli petiolique primo breviter pallide alutaceo-pubescentes, dein glaber, perulae semper iidem pubescentes, laminae glabrae. Ramuli apicem versus –1 mm. diam., graciles, teretes, multum ramosi, dein pallide vel fusco-brunnescentes, leves vel lineare striati; internodis 1.2–3 cm. longis; cicatricibus stipularum minutis, brevibus, inconspicuis. Gemma –1 mm. longa, parva. Stipulae ignotae. Lamina 6–10 × 2.5–4.5 cm., tenuis, ovata, basi obtusa vel late cuneata, saepe subaequali, apice in acumen –1.5 cm. longum angustum vel caudatum attenuato; costis lateralibus utrinseeus 5–6, angustis, subtus paullum prominentibus, supra paullum depressis, curvatis, angulo 50°–60 exorientibus; domatiis parvis puberulentibus axillaribus; intercostis indistinctis, scalariformibus, a costa media c. 90° exorientibus; costa media subtus paullum prominenti, supra paullum prominenti vel applanata. Petiolus 7–10 mm. longus, –1 mm. diam., gracilis, sicco nigrescens. Lamina delapsa sicco ex integro pallide virido-brunnea. Racemi –14 cm. longi, semel ramosi, stipitis basi in fructu –1 mm. diam., terminales vel 1-axillares, ex integro teretes, semper breviter sparsim pallide cremeo-brunneo-pubescentes; ramulis –6 mm. longis, brevioribus, paullum secundis, –6 flores secundis conferte gerentibus; bracteolis –2 mm. longis, ovatis, acutis, breviter puberulentibus, fugacis. Alabastrum –1.5 mm. longum, globosum. Calyx externe breviter tomentosus, intus glaber; lobis late ovatis, acutis, subaequalibus, internis 2 quam externis 3 paullum brevioribus, tenuioribus, latioribus. Corolla in vivo cremea, petalis ellipticis, obtusis, externe breviter puberulentibus, intus

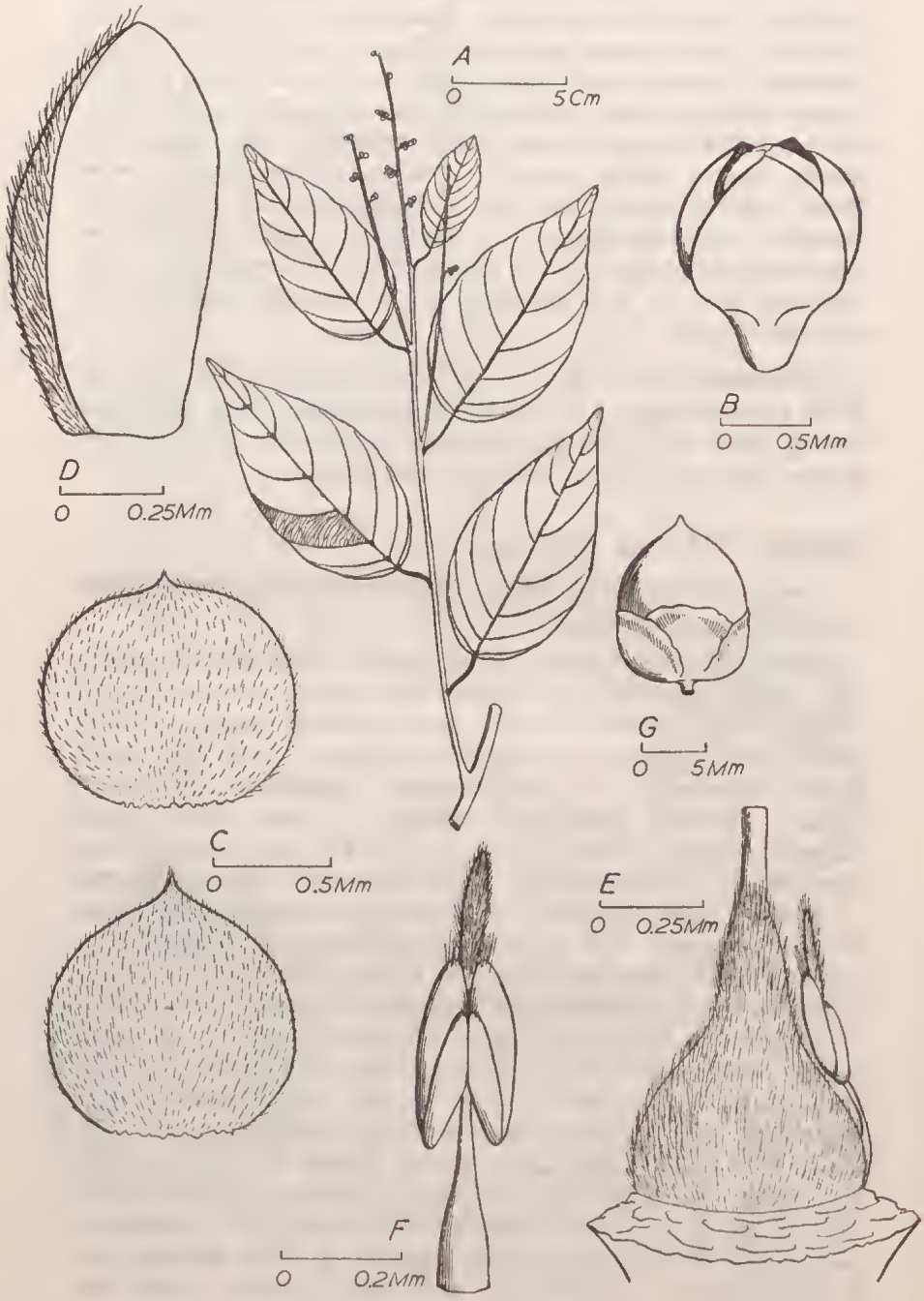


Plate 14. *S. biawak.*

a, Flowering twig. b, Flower bud. c, Sepals (inner above, outer below). d, Petal. e, Ovary. f, Stamen (inner side). g, Fruit.
(a–f from Brun 3005, g from Brun 3369).

glabris. Stamina c. 35; filamentis gracilibus, glabris, attenuatis; antheris anguste oblongis, apicem versus attenuatis; loculis interioribus quam exterioribus paullum maioribus, apice breviter barbato; aristis quam antheras paullum brevioribus, conferte barbbtis. Ovarium stylopodiumque ovoideum vel pyriforme, conferte tomentosum, stylo brevi glabro. Pedicellus in fructu –2 mm. longus, brevis. Calyx quam nucem brevior; lobis subacqualibus, –7 × 9 mm., suborbicularibus, obtusis, tenuibus, ad nucem conferte adpressis, semper breviter pallide alutaceo-puberulentibus. Nux –13 × 10 mm., subglobosa, conferte pallide alutaceo-pubescens, apice in stylopodio –1.5 mm. lineari abrupte attenuato.

Collections. *Brunei:* Brun 3356, 3351, Ulu Senuko, Labu; Brun 3385, Kuala Belalong; Brun 3005, 3369 (Holotypus in Herb. Kew) Bangar.

SHOREA BULLATA Ashton s.n.

S. flemmichii Sym. affinis, sed lamina maiore, sparsius tomentosa, paullum bullata, staminum aristis longissimis undulatis, stylo longiore differt.

Stipulae externe, ramuli, petioli, costae subtusque semper aspere scabrido-fulvo-cristato-tomentosi, stipulae intus breviter pubescentes. Ramuli apicem versus c. 2 mm. diam., primo cristato-tomentosi, dein glabri, tenue chartaceo exfoliati, pallide brunnei, teretes, multum ramosi; internodis 1–2 cm. longis, brevibus; cicatricibus stipularum brevibus, transversis, tomento obscuris. Gemma 3–4 × 2–3 mm., late ovoidea, subacuta. Stipulae –7 × 2 mm., anguste hastatae, acutae. Lamina 6.5–10 × 3–4.5 cm., elliptico- vel oblongo-obovata, bullata; saepe tenue concava, basi anguste obtusa vel late cuneata attenuata, apice obtuso vel in acumen –6 mm. longum breviter attenuato; margine revoluto; costis lateralibus utrinsecus 10–12, angulo variabile exorientibus; intercostis laxe scalariformibus, costatis, a costis lateralibus 90° exorientibus; costis supra depressis. Petiolus 0.8–1 cm. longus, c. 1.5 mm. diam., brevis, sicco fulvo-tomentosus. Lamina delapsa supra pallide griseo purpurescens, subtus fusco-rubro-purpurescens; tomento cristato distincte aureo-fulvo. Racemi –11 cm. longi, semel vel bis (terminales) ordine ramosi; stipitis basi in fructu –1.5 mm. diam., terminales vel axillares, ex integro teretes, laxi, ad basim conferte rubro-brunneo-tomentosi, ad apicem brevius pallidius tomentosi; ramulis –3.5 cm. longis, –8 flores plus minus secundis gerentibus; bracteis ignotis; bracteolis –6 × 3.5 mm., late ellipticis, obtusis, breviter pallide griseo-puberulentibus. Alabastrum –15 × 3 mm., lineare obtusum. Calyx parvus, externe conferte pallide griseo-tomentosus, intus glaber; lobis subaequalibus, late ovatis vel suborbicularibus. Corolla in vivo pallide cremea, basim versus rosea; petalis linearibus, obtusis, partibus in alabastro expositis conferte tomentosis, corolla delapsa paullum connata. Stamina 15,

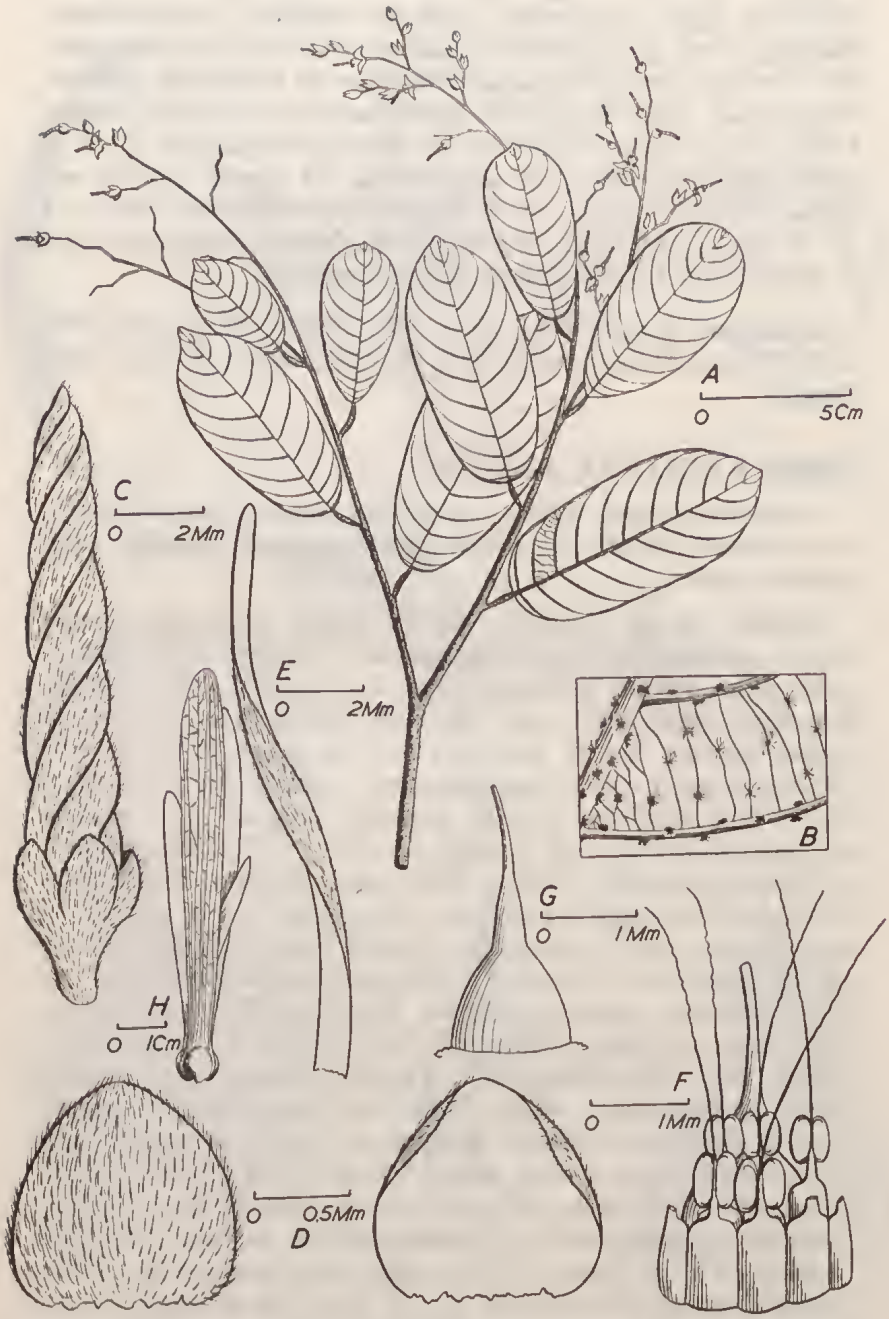


Plate 15. *S. bullata.*

a, Flowering twig. b, Part of lamina undersurface. c, Flower bud. d, Outer sepal (from outside, left; from inside, right). e, Petal. f, Androecium and gynoecium. g, Gynoecium. h, Fruit.

(a–g from Brun 2003a; h from Brun 2003c).

verticillis confertissimis 3, bina cum solis alternata, antheris internis 5 supra aliis extrusis, externis 10 subaequalibus; filamentis basi connatis, applanato-dilatatis, ad medium abrupte attenuatis, apicem versus filiformibus; antheris oblongis; aristis quam antheras –4-plo longioribus, apicem styli superantibus, gracillimis, sinuato-crispulatis. Ovarium stylopodiumque ovoideum, conferte breviter tomentosum; stylo quam illis prope 2-plo longiori, dimidio basali incrassato, setoso. Pedicellus in fructu –1 mm. longus. Calyx basim versus sparsim pallide alutaceo-pubescens, apicem versus glabrescens; lobis longioribus 3, –9 × 1.3 cm., spatulatis, obtusis, basim versus angustatis –5 mm. latis; partibus basalibus –6 × 6 mm., prominente saccatis incrassatis; lobis brevioribus 2, 2–5 × 0.3 cm., linearibus, obtusis, partibus basalibus ut in lobis longioribus. Nux –10 × 7 mm., ovoidea, breviter conferte cremeo-tomentosa, acuta.

Collections. *Brunei:* Brun 924, Andulau F.R.; S 5773, Bt. Biang; Brun 2003 (Holotypus in Herb. Kew), S. 5798, Bangar.

SHOREA DOMATIOSA Ashton s.n.

S. atrinervosae Sym. affinis, sed fructu maiore, lamina tenuore, petiolo angustiore, longiore, costis lateralibus angustioribus, domatiis prominentibus differt.

Domatiae stipulae externeque pubescentes, aliter novelli glabri. Ramuli apicem versus c. 1.5 mm. diam., graciles, multum ramosi, sicco saepe compressi vel rugosi, fusco-brunnei vel nigrescentes, leves, lenticellis minutis pallidis rotundatis punctati; internodis 1–2 cm. longis; cicatricibus stipularum brevibus, pallidis, horizontalibus, inconspicuis. Gemma c. 4 × 2 mm., ovoidea, acuta. Stipulae c. 6 × 2.5 mm., ovatae, anguste obtusae, basi paullum constricta, caducae. Lamina 6.5–10 × 3–7 cm., late ovata vel obovata, tenuis, subtus in arboribus maturis glaucescens, basi obtusa vel subcordata, apice in acumen c. 8 mm. longum subabrupte attenuato; costis lateralibus utrinsecus (8)9–10(12), angustis, curvatis, subtus paullum prominentibus, angulo 45°–65° exorientibus, domatiis axillaribus prominentibus; intercostis angustis, confertis, scalariformibus, sinuatis. Petiolus 1.5–2.5 cm. longus, c. 1 mm. diam., gracilis, geniculatus, dimidio apicali incrassato, sicco nigrescens. Lamina delapsa supra purpureo-grisea, subtus in arboribus novellis ex integro griseo-brunnea, in arboribus maturis glauca costis nigris. Racemi, bractei, bracteolique ignoti. Alabastrum –1.3 × 4 mm., fusceforme. Calyx externe breviter pubescens, intus glaber; lobis externis 3 late ovatis subacutis, internis 2 anguste ovatis, acutis. Petala linearia, in alabastro vix contorta, obtusa, partibus in alabastro expositis sparsim pubescentibus, aliter glabra. Stamina c. 25–30; filamentis basim versus applanatis, ad antheris attenuatis; antheris late oblongis, loculis internis 2 quam externis 2 brevioribus; ad apicem sparsim setosis; aristis quam

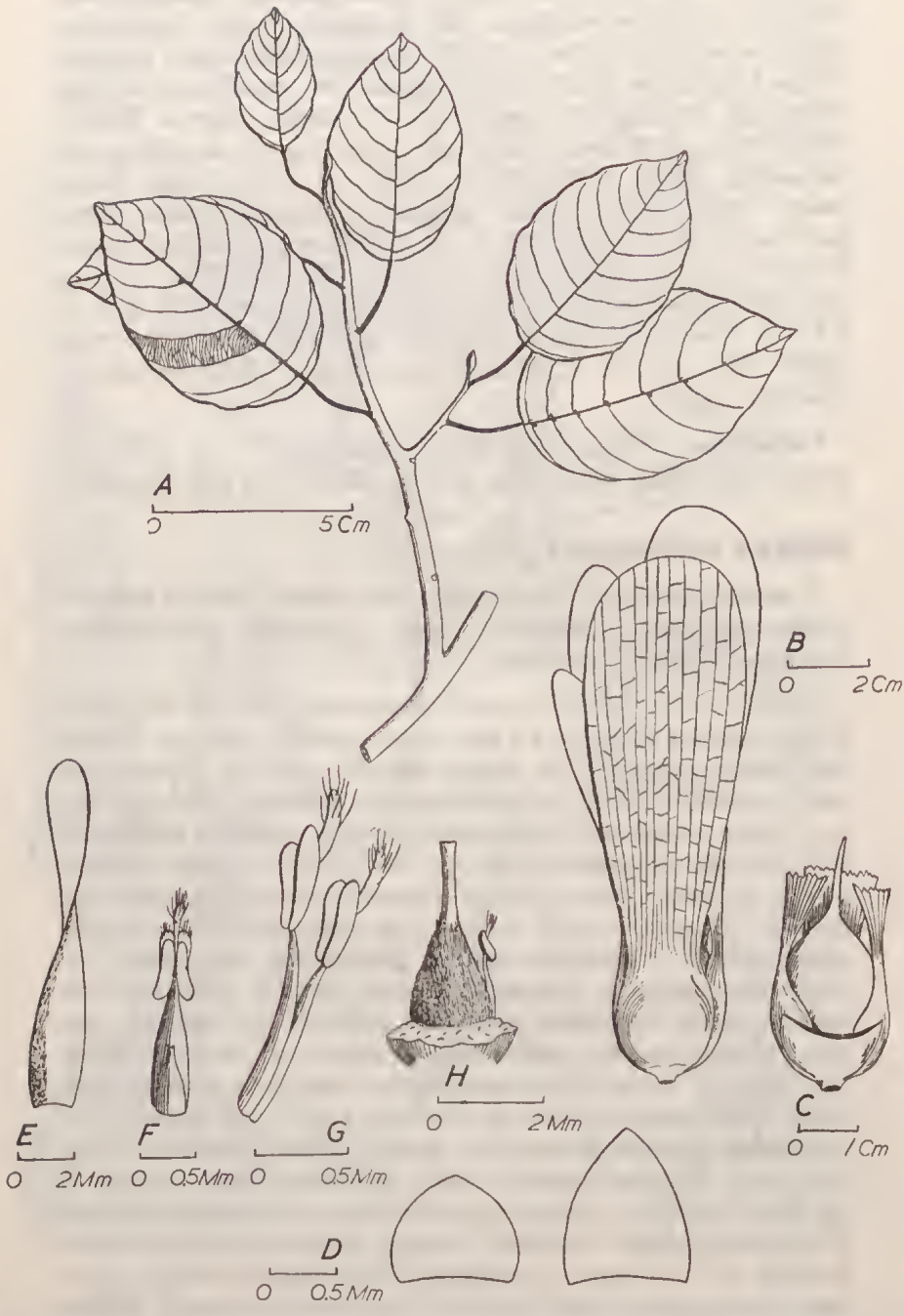


Plate 16. *S. domatiosa.*

a, Leafy twig. b, Fruit. c, Nut. d, Sepals (left, inner; right, outer). e, Petal. f, Stamen (frontal view). g, Stamens (lateral view). h, Ovary.

(a from S 1782; b, c, from San 16601; d–h from San 21492).

antheris ½-plo longioribus, crassis, ± conferte setosis. Ovarium ovoideum, conferte tomentosum basi excepta; stylopodio quam ovarium. 1½-plo longiori, longissimo, basim versus pubescenti, aliter glabro. Pedicellis in fructu –1 mm. longus, crassus. Calyx glaber; lobis longioribus 3, –13 × 3 cm., late spatulatis, obtusis, basim versus angustatis –8 mm. latis; partibus basalibus –1.8 × 1.6 cm., ellipticis saccatis incrassatis; lobis minoribus 2, –7 × 1.2 cm., anguste spatulatis, partibus basalibus ut in lobis longioribus. Nux –3.5 × 2.5 cm., ovoidea, conferte breviter cremeo-pubescens, ad apicem acutum attenuata, stylopodio –1 cm. longo filiformi.

Collections. *North Borneo:* San A 308, Saliwagon M. 64, Beaufort; San 15164, A 306, A 302, 16604, 16601 (Holotypus in Herb. Kepong), Ulu Sipitang; San 21492, Tawau; *Sarawak:* S 1782, Bt. Berayong, Lawas. *Brunei:* S 5726, Brun 3395, 5665, 5210, Kuala Belalong; Brun 305, S. Batu Apoi-Sebatu watershed; Brun 888, Base of Bt. Bedawan; Kep 39645, Labi F.R.

SHOREA FAGUETIOIDES Ashton s.n.

Shoreae faguetianae Heim affinis, sed lamina tenuiore, latiore, basi saepe subcordata, petiolo longiore, differt.

Ramuli novell interdum pallide alutaceo-tomentosi, interdum glabri, perulae, stipulae laminaeque glabri. Ramuli apicem versus –3 mm. diam., primo subcompressi, sicco nigri, dein teretes, pallide brunnescentes, minute striati vel rugulosi. Gemma 3–4 × 2.5 mm., obtuso-ovoidea, glabra, sicco nigra. Stipulae –1.7 × 0.6 cm., anguste deltoideae, saccatae, ad apicem obtusae, tarde caducae. Lamina 12–18 × 5–7 cm., anguste ovata, tenuis, basi late cuneata vel subcordata, subaequali, apice in acumen –2 cm. longum gradatim attenuato; costis lateralibus utrinsecus 10–15, angustis sed conspicuis, 60°–70° exorientibus, intercostis scalariformibus, a costis lateralibus diagonale exorientibus. Petiolus 2.2 –3 cm. longus, –2 mm. diam., sicco, niger. Lamina delapsa fusco-virido-brunnescens, costis subtus prominente nigris, sicca involuta. Racemi –15 cm. longi, ordine 2–3 ramosi, stipitis basi in fructu –1.2 mm. diam., terminales vel axillares, ex integro teretes, laxi, semel breviter pallide griseo-brunneo-pubescentes, sicco rugosi; ramulis –2 cm. longis, –7 flores gerentibus; bracteolis parvis, fugacibus. Alabastrum –2.5 × 1.5 mm., parvum, ellipticum, obtusum. Calyx externe conferte breviter pubescens, intus glaber; lobis ovatis, acutis, internis 2 quam externis 3 paullum minoribus, tenuioribus, ad basim constrictioribus. Corolla aetate florendi pallide cremea, ad basim imbricata et gracile scyphiformis, apicem versus expansa; petalis linearibus, apices versus spiraliter contortis, partibus in alabastro expositis pubescentibus. Stamina 15, verticillis 3 inaequalibus, bina cum solis alternata; filamentis angustis, attenuatis, basi dilatata, paullum gibbosa, apice filiformi; antheris subglobosis; aristis angustis, quam antheras 3-plo longioribus,

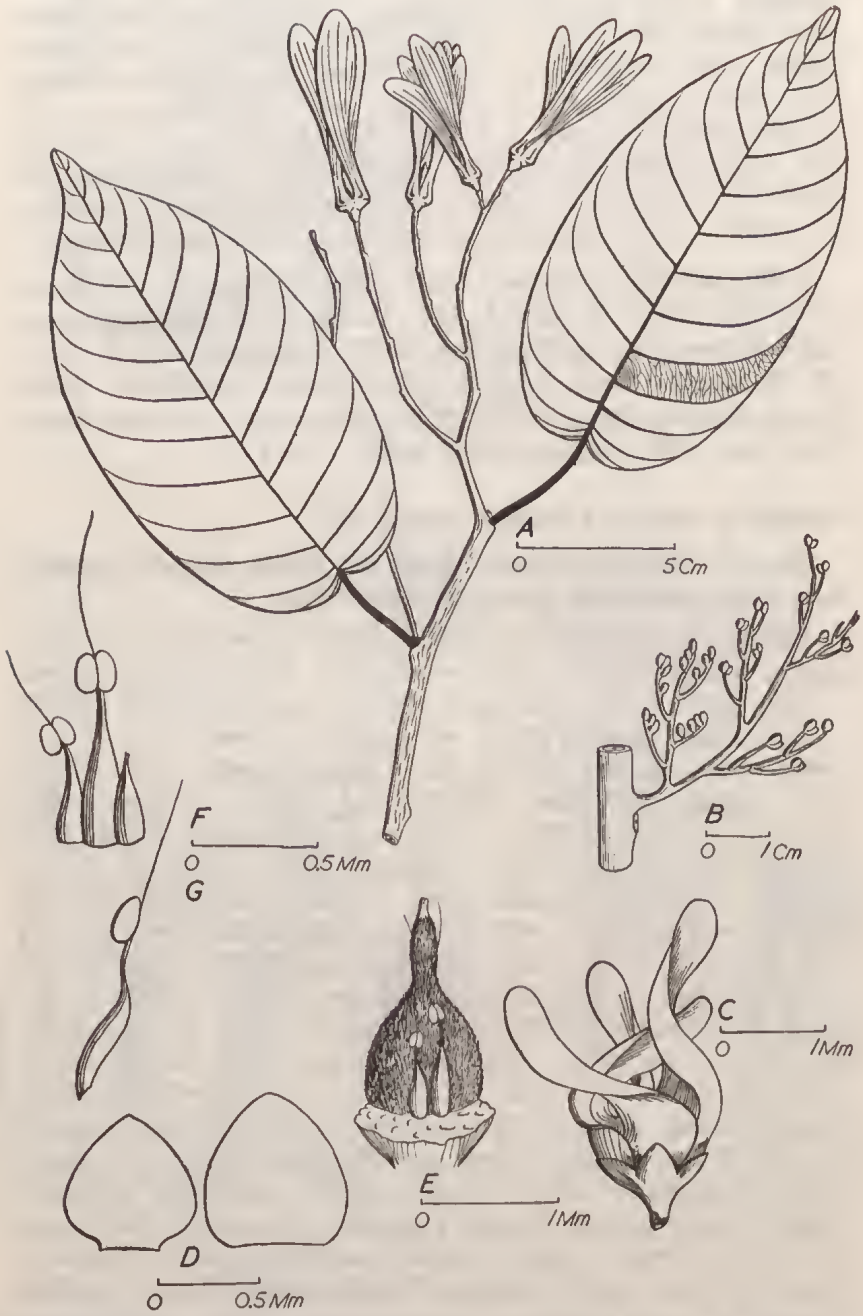


Plate 17. *S. faguetioides.*

a, Fruiting twig. b, Inflorescence. c, Flower. d, Sepals (left, inner; right, outer). e, Ovary. f, Stamens (frontal view). g, Stamen (lateral view).

(a from S 1771; b–g from S 1804).

apicem versus paullum ciliatis, internis 5 apice stylo superantibus. Ovarium ovoideum, sparsim tomentosum, stylopodio cylindrico, quam ovarium breviore confertius tomentoso, stylo glabro. Fructus subsessilis. Calyx in fructu ad pedicellum attenuatus, basim versus puberulens, apicem versus glabrescens; lobis longioribus 3, –7 × –1.5 cm., late spatulatis, tenuibus, obtusis, basim versus –4 mm. latis angustatis; partibus basalibus –5 mm. lata, prominente tuberculatis, incrassatis; lobis brevioribus 2, –5 × 0.7 cm., aliter ut in lobis longioribus. Nux –20 × 6 mm., oblongo-obovoidea, pallide alutaceo-tomentosa, ad stylopodium –3 mm. longum angustum attenuata.

Collections. *Indonesian Borneo:* bb 22875, G. Pering, Sanggau: bb 29609, Long Bleh, W. Kutei; bb 18294, Tidung. *Sarawak:* S A 0301, Bt. Ngili, Sadong; S A 069, Nanga Mujan, Batang Ai; S 1804, Ulu Berawan, Limbang; S 1771, Bt. Pengalih, Lawas (Holotypus in Herb. Kew). *Brunei:* Kep 35674, Labi Hills F.R.; Kep 35466, Bt. Patoi; Kep 80137, Peradayan F.R.; S 1664, Biang; S 5805, Bangar; Brun 3340, 5645, S 5810, Bt. Patoi; S 5733, 5702, Kuala Belalong.

SHOREA FLAVIFLORA Wood ex Ashton:—*S. flaviflora* Wood msc.

S. kunstleri King affinis, sed floribus maioribus, calyce glabro fimbriato incrassato, antheris magnis reniformibus, lamina attenuatiore undulata differt.

Ramuli, petioli, laminaeque primo pallide griseo-pubescentes, cristis minutis adpressis stellatis, dein glabrescentes, perulae stipulae externeque semper pubescentes, stipulae intus semper puberulentes. Ramuli apicem versus 2–3 mm. diam., ex integro teretes, leves, dein glabri, pallide brunnei; internodis 1.5–4 cm. longis; cicatricibus stipularum c. 1.5–2 mm. longis, angustis, sursum directis, ramulos semicircumdatis. Gemma 6–12 × 1.5–3 mm., falcata, acuta. Stipulae –24 × 7 mm., anguste hastatae, fugacae. Lamina 12–18 × 5.5–7 cm., tenuis, anguste ovata, basi obtusa vel anguste cuneata, apice in acumen –1.5 cm. longum angustum attenuato; costis lateralibus utrinsecus 6–7, curvatis, remotis, angustis, subtus prominentibus, domatiis parvis axillaribus, angulo 40°–50° exorientibus; costa media supra applanata; intercostis angustissimis, a costis lateralibus diagonale exorientibus, conferte scalariformibus. Petiolus 2–3 cm. longus, c. 1.5 mm. diam., sicco rugoso-nigrescens. Lamina delapsa supra griseo-brunnescens, subtus ferrugineo-vel rubro-nigrescens, margine undulato. Racemi –15 cm. longi, bis ramosi, stipitis basi in fructu –2 mm. diam., terminales vel axillares, pendentes, ex integro teretes, sicco rugosi, breviter sparsim pallide griseo-pubescentes vel glabrescentes; ramuli –12 flores distichos gerentibus; bracteolis –5 × 2.5 mm.,

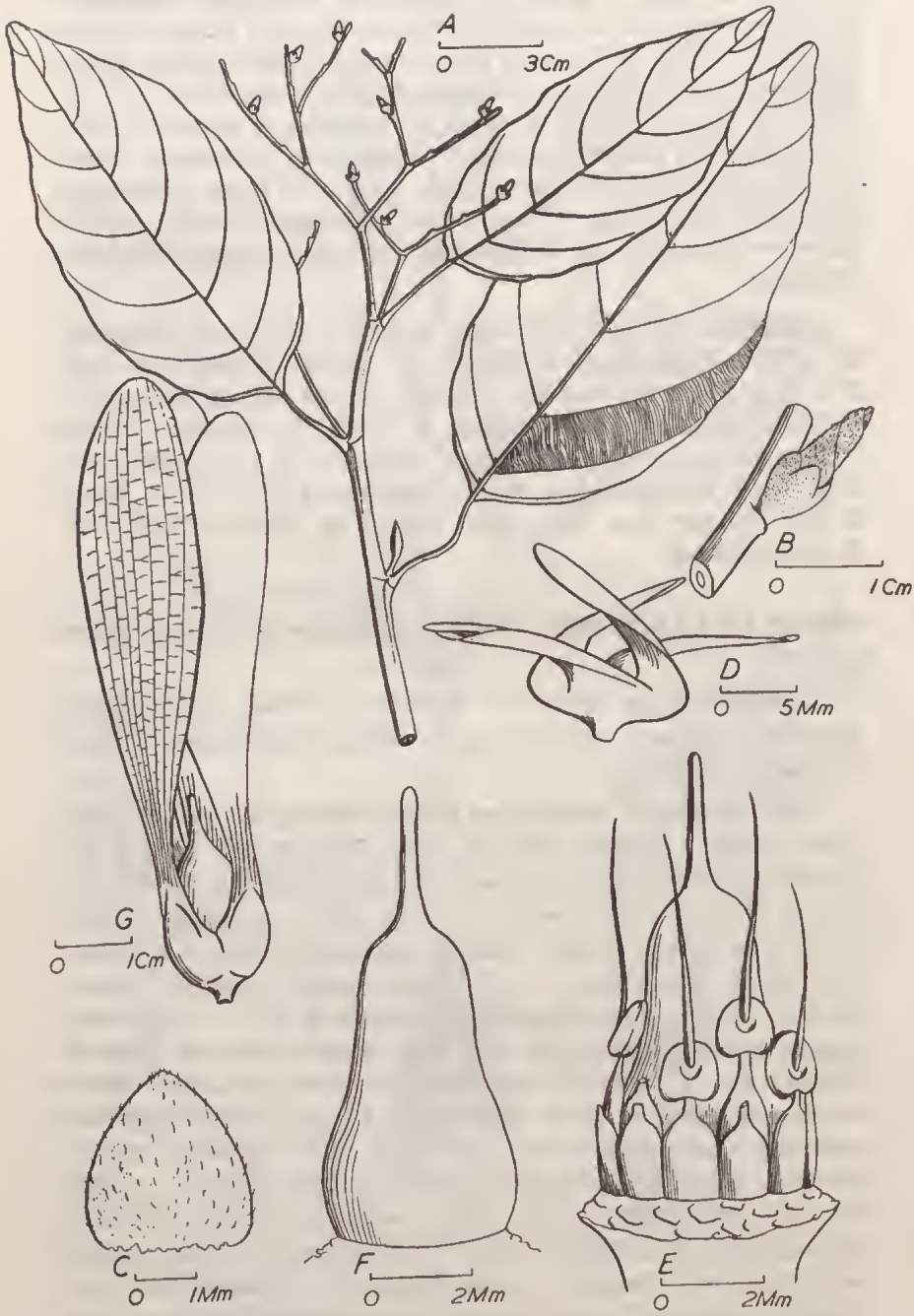


Plate 18. *S. flaviflora.*

a, Flowering twig. b, Flower bud. c, Outer sepal. d, Corolla. e, Ovary and androecium. f, Ovary. g, Fruit.

(a–f from Brun 5664; g from Brun 5211).

ellipticis, obtusis, externe conferte breviter pallide griseo-tomentosis, intus sparsim pubescentibus. Alabastrum –14 × 4.5 mm., fusciforme, obtusum. Calyx glaber, margine fimbriato excepto; lobis aequalibus, late ovatis, incrassatis, ad corollam conferte adpressis. Corolla in vivo fusco-flava, petalis lineare-lanceolatis, acutis, basi firmiter connatis, multum contortis nectisque, partibus in alabastro expositis breviter tomentosis, aetate florendi dimidio basali imbricato late scyphiformi. Stamina 15, verticillis inaequalibus 3; filamentis basim versus dilatato-applanatis, apicem versus abrupte attenuatis, filiformibus; antheris magnis, reniformibus, loculis interioribus quam exterioribus paullum minoribus; aristis quam antheris 3-plo longioribus. Ovarium pyriforme, breviter conferte tomentosum; stylo ovarii stylopodiique aequali, dimidio supra antheris longissimis superanti, filiformi, glabro. Pedicellus in fructu c. 3 mm. longus, c. 2.5 mm. latus. Calyx glaber; lobis longioribus 3, –13 × 3 cm., late spatulatis, obtuso, basim versus –11 mm. latis gradatim attenuatis, partibus basalibus –1 × 1.2 cm., abrupte prominente saccatis, incrassatis; lobis brevioribus 2–9 × 1.3 cm., subaequalibus, basim versus ut in lobis longioribus. Nux –2.5 × 1.3 cm. (stylopodio incluso), ovoideum, ad stylopodium –10 × 2 mm. gradatim attenuatum, breviter conferte pallide alutaceo-tomentosum.

Collections. *North Borneo:* San 15098, 15109 (Holotype in Herb. Kepong), Pangi, Beaufort; San 16389, Ranau; San 16475, Balong. *Sarawak:* S 3529, Upper Plieran. *Brunei:* Brun 5664, 5211, Bt. Belalong; Brun 5276, Ulu Ropan-Belalong watershed; S 5739, Kuala Belalong; Brun 781, Kuala Temburong Machang; Brun 736, Kuala Sekurop, Temburong.

SHOREA GENICULATA Sym. ex Ashton:—*S. geniculata* Sym. nomen nudum.

S. inappendiculatae Burck affinis, sed nuce maxima globosa, lobis calycis in fructu brevibus subaequalibus, lamina late ovata, petiolo longissimo differt.

Novellae ex integro glabrae. Ramuli apicem versus c. 3 mm. diam., crassi, multum ramosi, teretes, pallide brunnei vel nigrescentes, leves; internodis 2.5–4 cm. longis, nodis prominentibus, cicatricibus petiolarum orbicularibus, elevatis, cicatricibus stipularum 2–3 mm. longis, rectis, pallidis, sursum directis, vix distinctis. Gemma 4–7 × 1–1.5 mm., linearis vel falcata, acuta, sicco nigrescens. Stipulae –10 × 3 mm., anguste oblongae, acutae, fugacae. Lamina 11–17 × 7–13 cm., late ovata vel suborbicularis, coriacea, subtus glauca, basi obtusa vel subcordata, apice in acumen –8 mm. longum abrupte attenuato vel obtuso; costis lateralibus utrinsecus 9–11, angulo 40°–50° exorientibus; intercostis sinuatis, conferte scalariformibus angustis. Petiolus 4–6.5 cm. longus, c. 2

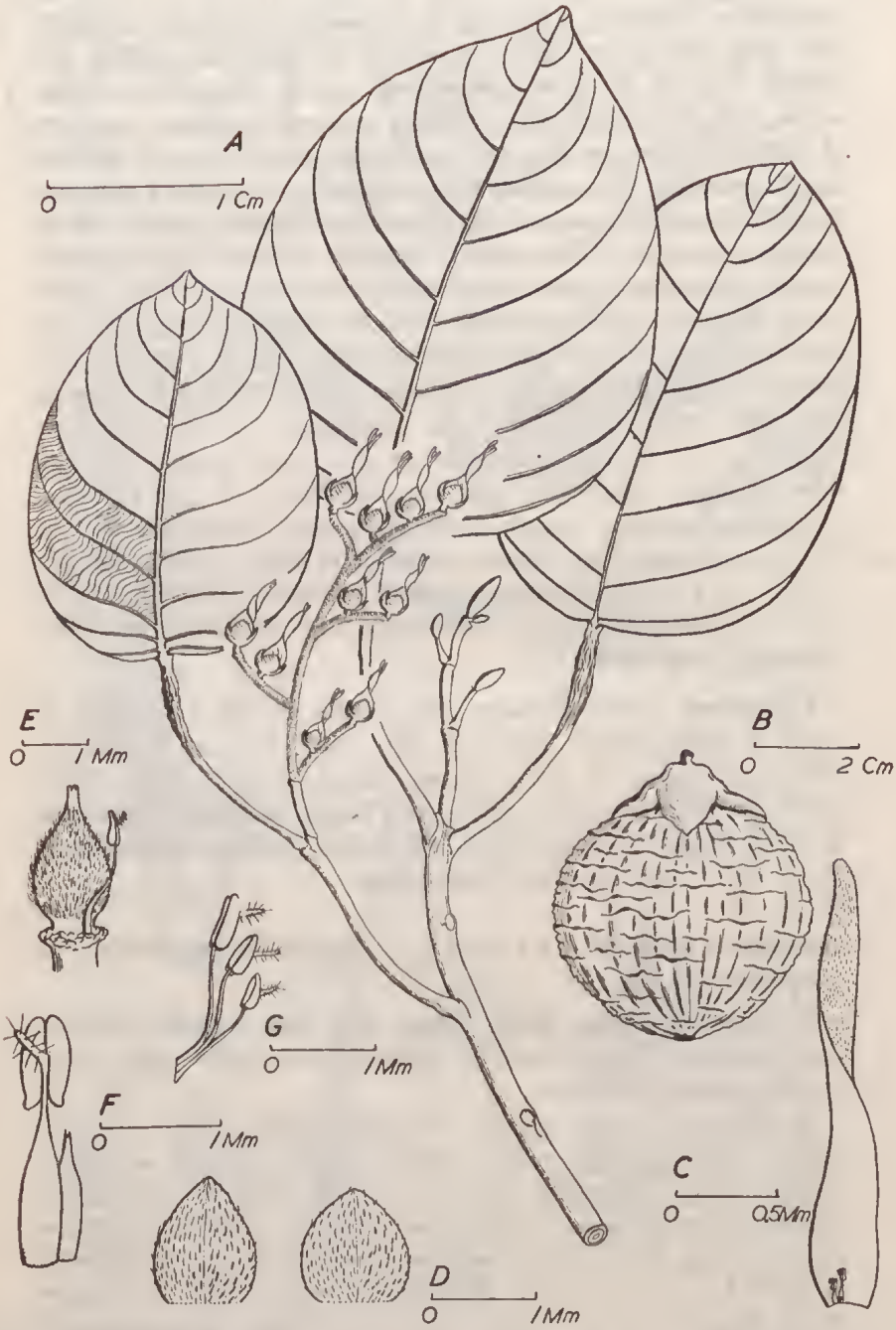


Plate 19. *S..geniculata.*

a, Flowering twig. b, Fruit. c, Petal. d, Sepals (left, outer; right, inner). e, Ovary. f, Stamens (frontal view). g, Stamens (lateral view).

(a, c–g from Brun 3264, b from Brun 1037).

mm. diam., sicco nigrescens. Lamina delapsa supra pallide viride-brunnescens, subtus glauca, costis nigrescentibus. Racemi –12 cm. longi, semel ordine ramosi, stipitis basin in fructu –2 mm. diam.; terminales vel axillares, ex integro plus minus teretes, primo conferte breviter pallide alutaceo-pubescentes, dein glabrescentes; ramulis –1.5 cm. longis, –4 flores secundos gerentibus; bracteolis –4 mm. longis, oblongis, puberulentibus, fugacis. Alabastrum –20 × 4 mm., magnum, lineare-lanceolatum. Calyx externe breviter pubescens, intus glaber; lobis ovatis, acutis, externis 3 quam internis 2 paullum longioribus, brevioribus. Corolla in vivo cremea, petalis –2.5 em. longis, linearibus, ex integro pubescentibus. Stamina c. 55, subaequalia; filamentis basi applanato-dilatatis, apicem versus filiformis, attenuatis; antheris oblongis, glabris, loculis interioribus quam exterioribus paullum minoribus; aristis quam antheras paullum brevioribus, sed prominentibus, crassis, setosis. Ovarium styopodiumque late ovoideum, conferte tomentosum, basi glabro, apice in stylum breve latum trifurcatum glabrum abrupte attenuato; stigmate minuto. Pedicellus in fructu –3 mm. longus, –4 mm. diam., brevis. Calyx quam nucem brevior, sparsim pallide griseo-alutaceo-pubescens; lobis c. 1.5 cm. longis latisque, aequalibus, incrassatis, deltoideis, subacutis, apicibus ad basim nucis adpressis. Nux –5 cm. longa lataque, globosa, conferte breviter pallide griseo-alutaceo-tomentosa, sicco longitudine striata, transverse rugosa, apice obtusa, stylopodio c. 1.5 mm. longo brevi.

Collections. *Brunei:* S 1852, Tapangan Sapi; Kep 37074, Bt. Ligi; S 1902, 1929, Kep 80092, 48486, 48452, 47041, Brun 3264 (Holotypus in Herb. Kew), 1037, 919, 3060, 3188, 618, San 17470, Andulau F.R.; Kep 35553, 35549, Pengkalan Ran; Kep 12988, Tutong R., hills west of Ukong.

SHOREA ISOPTERA Ashton:—*Neohopea isoptera* Wood msc.

Shorcis aliis facile potest distinguere; alabastro globoso, staminibus 15 glabris, filamentis latis brevibus, aristis latis brevibus, stylo brevissimo, receptaculo lato tenui, lobis calycis expansis subaequalibus distinguitur.

Novellae glabrae, racemis exceptis. Ramuli apicem versus –1.5 mm. diam., ex integro graciles, fusco-rubro-brunnei vel nigrescentes, leves, teretes; internodis 2–4 cm. longis; cicatricibus stipularum brevibus, inconspicuis. Gemma –1 mm. longa, parva, globosa, sicco nigrescens. Stipulae eaducae, ignotae. Lamina 9–16 × 5–8 cm., ovata, basi late cuneata vel obtusa in petiolum –2 mm. decurrenti; apice in acumen –1.5 cm. longum angustum subabrupte attenuato; margine undulato; costis lateralibus utrinsecus 9–11, curvatis, subtus paullum elevatis, supra depressis, angulo 45°–65° exorientibus; intercostis scalariformibus, sinuatis, angustis; costa media subtus tereti, paullum prominenti, supra plus minus applanata. Petiolus 1.3–2 cm. longus, –1.5 mm. latus, sicco nigrescens. Lamina delapsa ex integro hebete virido-brunnea, supra

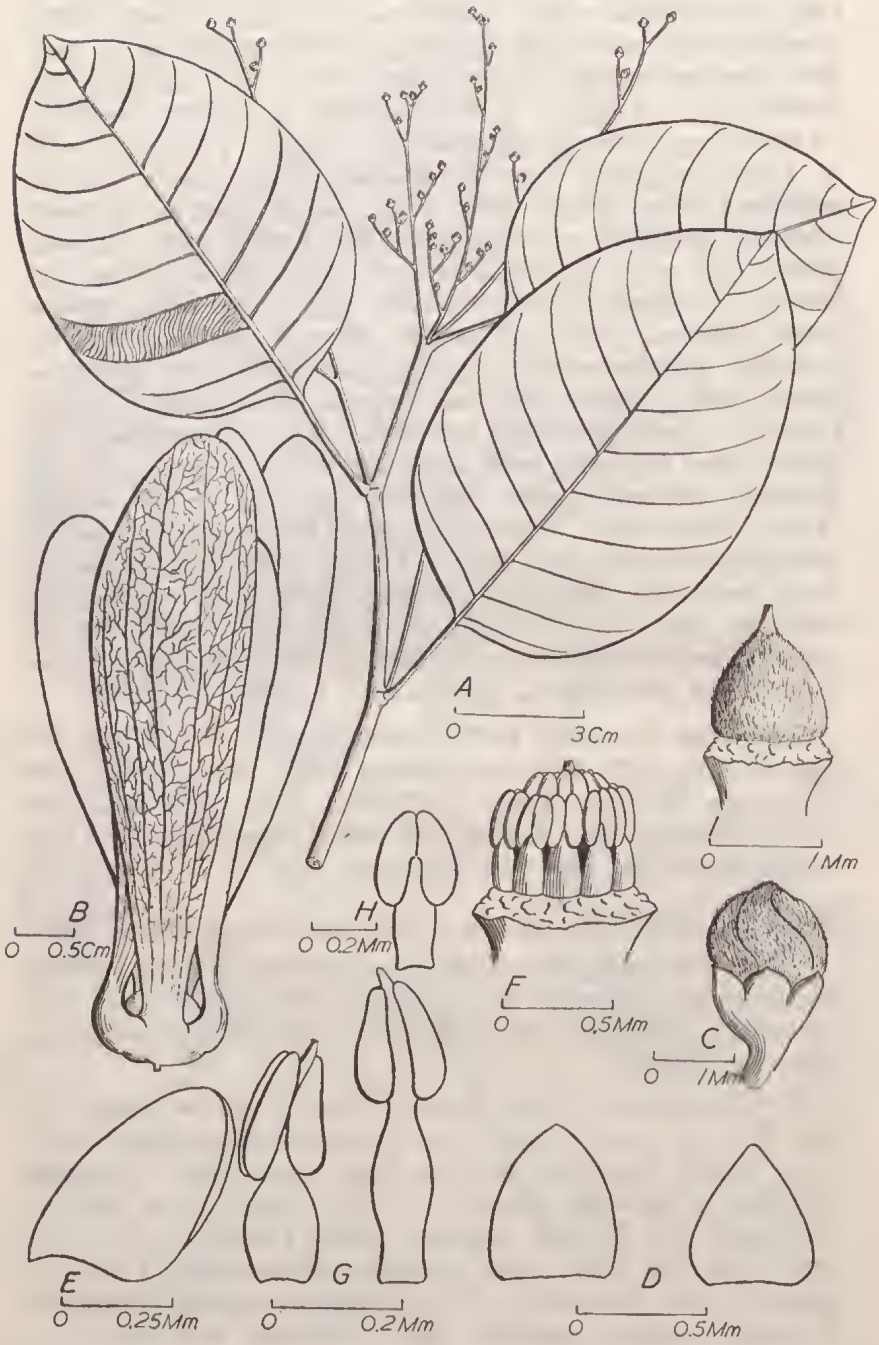


Plate 20. *S. isoptera.*

a, Flowering twig. b, Fruit. c, Flower bud. d, Sepals (left, outer; right, inner). e, Petal. f, Androecium. g, Stamens (from within). h, Outer stamen (frontal view). i, Ovary. (a, c–i from Brun 3018; b from Brun 3343).

paullum rubrior. Racemi –11 cm. longi, bis ordine ramosi, stipitis basi in fructu –1.5 mm. diam., terminales vel 1-plures axillares, ex integro teretes vel paullum commpresses, laxi, super breviter grisco-puberulentes; ramosis –5 cm. longis; ramulis –1 cm. longis, brevibus, –6 flores secundos conferte gerentibus; bracteis ignotis; bracteolis –1 mm. longis, linearibus, pubescentibus, fugacis. Alabastrum –1.5 mm. longum, globosum. Calyx externe breviter pubescens, intus glaber; lobis subaequalibus, imbricatis, acutis; externis 3 ovatis, internis 2 deltoideis. Corolla in vivo cremea, petalis externe conferte tomentosis, intus breviter pubescentibus, oblongis, obtusis, multum contortis. Stamina 15, verticillis 3, bina cum solis alternata; filamentis crassis compressis, ad antheras vix attenuatis; antheris oblongis glabris, 4–loculis, loculis subaequalibus vel exterioribus quam interioribus paullum maioribus; aristis brevibus, crassis, glabris, apices antherorum non superantibus. Ovarium stylopodiumque ovoideo-conicum, basi glabro; apicem versus breviter pubescenti, in stylo brevi glabro abrupte terminatum; stigma minuta. Pedicellus in fructu –1.5 mm. longus, brevis. Calyx ad basim puberulens, apicem versus glabrescens; lobis 5 subaequalibus, –5.5 × 1.5 cm., spatulatis, obtusis, in aetate maturo rotatis, basim versus –5 mm. latis attenuatis; partibus basalibus paullum expansis, imbricatis; receptaculo –9 mm. diam., tenui. Nux –9 × 10 mm., ovoidea, latior quam longa, breviter pallide-griseo-brunneo-pubescens, apice in stylopodium –4 mm. longum acutum subabrupte attenuato.

Collections. *Sarawak:* S 7978, Lundu. *North Borneo:* San 4394, 3955, Bettotan; San 15111, Beaufort; San A 4318, Tenom San A 307, Saliwagon, M. 64, Beaufort; San 16603, Sipitang; San 15202 (fr. excl.), 15222, Pangi. San A 4336: Kota Belud. *Brunei:* Brun 5676, Kuala Belalong; S 5563, Bt. Peradayan; Kep 80132, 80133, Peradayan F.R.; Brun 3343, 3018 (Holotypus in Herb. Kew), Bt. Patoi.

N.B. The fruit of San 15202 represents Dryobalanops sp.

SHOREA LADIANA Ashton s.n.

S. maxwellianae King, *S. biawak* Ashton affinis, sed lobis calycis in fructu quam nucem brevioribus, subaequalibus, lamina maiore coriacea, costis differt.

Ramuli petioli novellaeque breviter pubescentes, perulae semper griseo-tomentosae, lamina glabra. Ramuli apicem versus 1.5–2 mm. diam., graciles, teretes, pallide brunnei, multum ramosi, leves vel rugulosi, internodis 2–4 cm. longis; cicatricibus stipularum parvis, paullum deorsum curvatis, inconspicuis. Gemma c. 1 × 0.5 mm., parva, conica. Stipulae ignotae. Lamina 10–14 × 4.5–7.5 cm., ovata, utrinsecus aequalis vel subaequalis, coriacea, basi

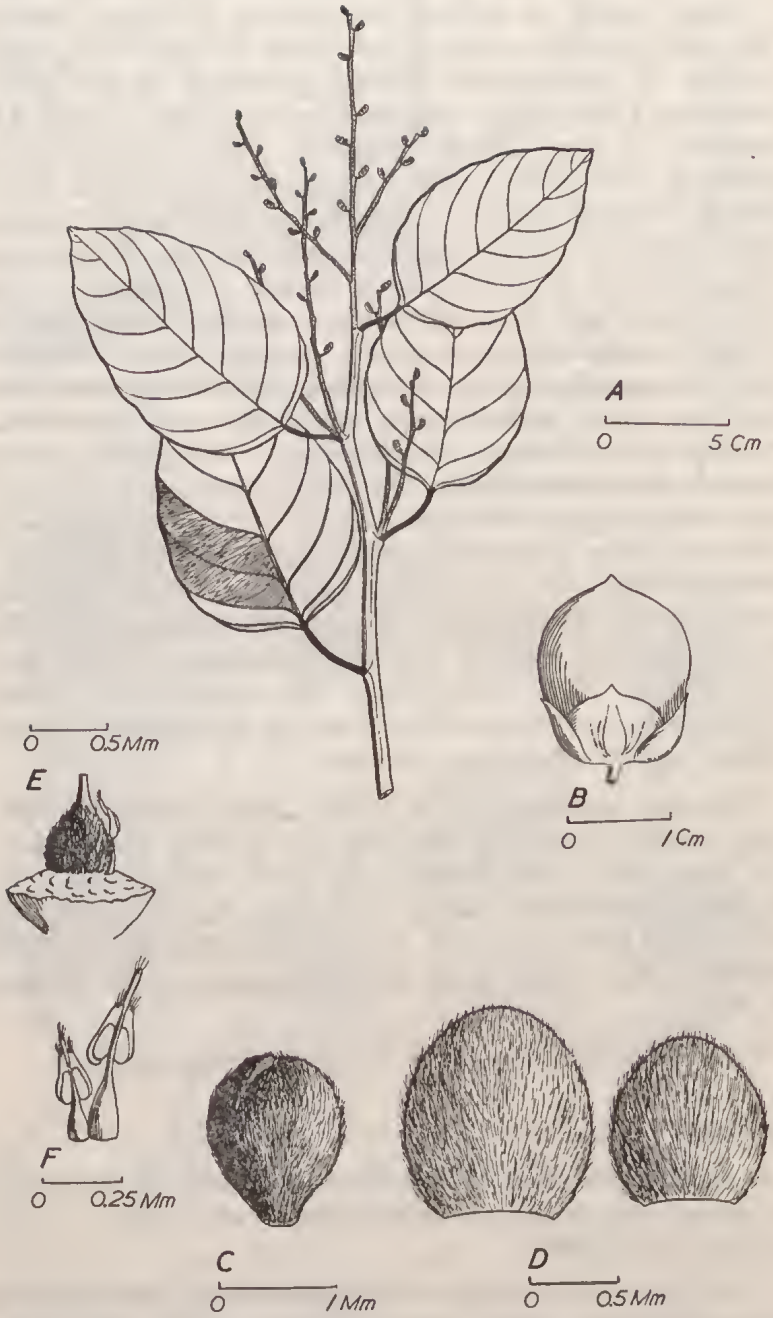


Plate 21. *S. ladiana.*

a, Flowering twig. b, Fruit. c, Flower bud. d, Sepals (left, outer; right, inner). e, Ovary. f, Stamens (inner side).

(a, c–f, from S 11076; b from Brun 2622).

obtusa vel late cuneata, apice in acumen 1–1.5 cm. longum gradatim attenuato; costis lateralibus utrinsecus 5–6, subtus prominentibus, remotis, curvatis, angulo 40°–50° exorientibus; intercostis angustis, indistinctis, conferte scalariformibus, a costa media 90° exorientibus; margine saepe paullum revoluto. Petiolus 1–2.2 cm. longus, c. 1.25 mm. diam., sicco nigrescens. Lamina delapsa supra fusco-rubro-brunnescens, subtus pallidius melleo-brunnescens, ex integro nitens. Racemi –15 cm. longi, semel vel bis ramosi, stipitis basi –2 mm. diam., terminales vel –2 axillares, recti, ex integro paullum compressi, laxi, semper breviter pallide cremeo-griseo-pubescentes; ramulis –8 mm. longis, brevibus, 'zigzag', –9 flores secundos conferte gerentibus; bracteolis –1.5 mm. longis, ovato-deltoideis, acutis, breviter pubescentibus, fugacis. Alabastrum –1.5 mm. longum, globosum (Alabastrum maturum ignotum). Calyx externe conferte tomentosus, intus glaber; lobis suborbicularibus, subaequalibus. Petala late elliptica. Stamina 30–35; filamentis brevibus, attenuatis; antheris oblongis, loculis interioribus quam exterioribus maioribus, apice breviter barbato; aristis brevibus, barbatis. Ovarium ovoideum, conferte tomentosum, stylo brevi glabro. Pedicellus in fructu –3 mm. longus, gracilis, tomentosis. Calyx quam nucem brevior, lobis 5 subaequalibus, c. 8 × 8 mm., late ovatis, breviter puberulentibus, subacutis, incrassatis, tenue saccatis, conferte ad nucem adpressis. Nux –1.7 × 1.4 cm., obovoideo-globosa, conferte breviter pallide alutaceo-tomentosa, apice in stylopodium c. 1 mm. longum angustum acutum abrupte attenuato.

Collections. *Sarawak:* S 11076 (Holotypus in Herb. Kew) 0188, 1625, Semengoh F.R. *Brunei:* Brun 5543, 2629, 2622, Andulau F.R.

SHOREA MONTICOLA Ashton s.n.

S. pauciflorae King affinis, sed lamina maiore, incrassatissima, subtus aureo-lepidota, costis lateralibus utrinsecus 13–16 differt.

Ramuli, petioli, et costae subtus primo breviter pallide flavido-alutaceo-tomentosi, dein glabrescentes, perulae semper similiter tomentosae. Ramuli apicem versus –3 mm. diam., teretes, crassi, lenticellis minutis pallidis ellipticis verruculosis punctatis, pallide brunnei; internodis 1.5–5 cm. longis; cicatricibus stipularum subamplexicaulibus vel amplexicaulibus, 0.5 mm. latis, pallidis, prominentibus. Gemma 5–10 × 2–4 mm., anguste ovata, acuta, falcata. Stipulae ignotae. Lamina 8–13 × 5–8 cm., multum coriacea, elliptica, primo aureo-lepidota; basi obtusa vel late cuneata, apice in acumen –5 mm. longum, brevem, late deltoideum, abrupte attenuato; costis lateralibus utrinsecus 13–16, ad marginem curvatis, angulo 45°–55° exorientibus; intercostis angustis, conferte scalariformibus, a costis lateralibus diagonale exorientibus; costa media subtus prominenti, acuta, supra glabra depressa.

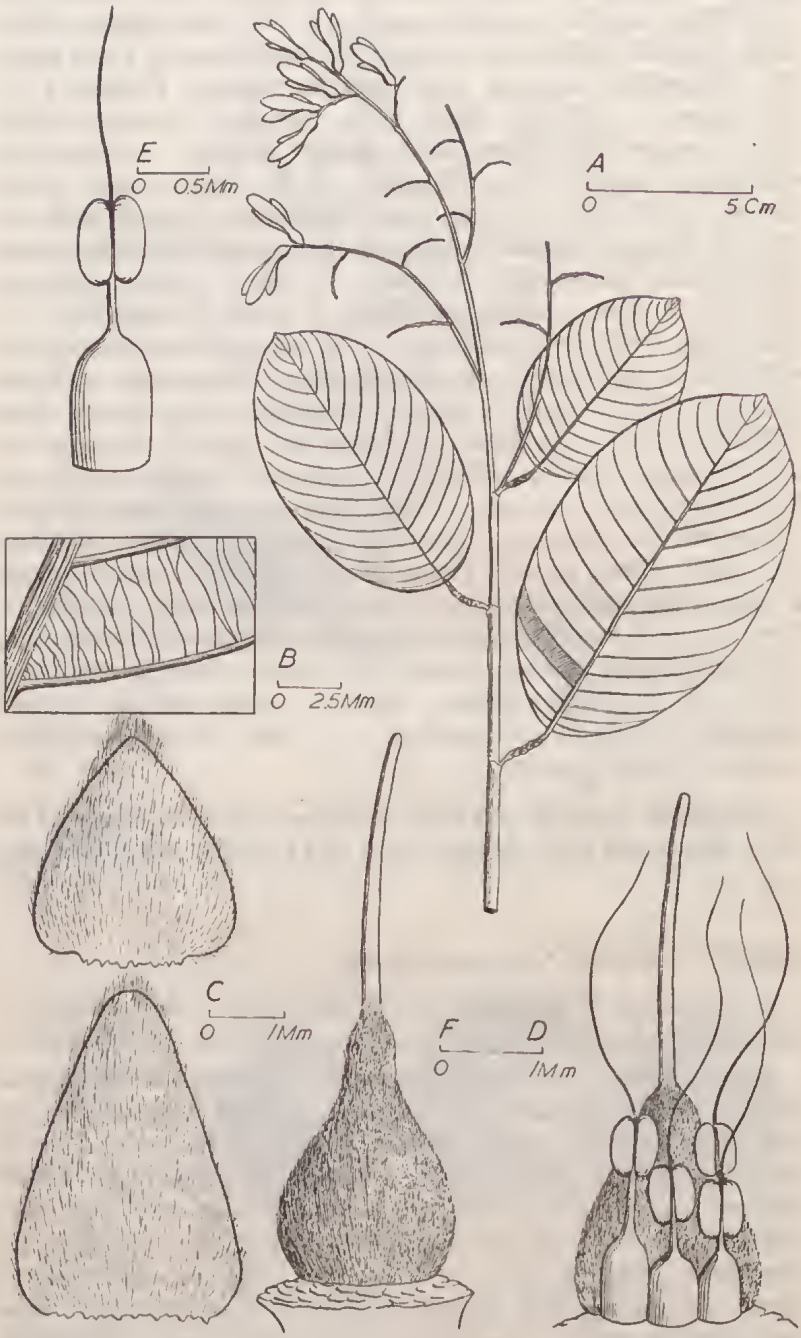


Plate 22. *S. monticola.*

a, Twig with young fruit. b, Part of lamina undersurface. c, Sepals (below, outer; above, inner). d, Ovary and androecium. e, Stamen (frontal view). f, Ovary.

(a and b from Clemens 31885, c–f from Hallier 678).

Petiolus 2–2.5 cm. longus, c. 2 mm. diam., sicco niger. Lamina delapsa supra nitens, pallide griseo- vel luteo-brunnea; subtus griseo- vel aureo-lepidota, costis subtus griseis vel nigrescentibus. Racemi –12 cm. longi, semel ramosi, stipitis basi in fructu –2 mm. diam.; terminales vel axillares, teretes, conferte pallide flavido-brunneo-pubescentes; ramulis –12 flores gerentibus; bracteis bracteolisque ignotis. Alabastrum –7 × 3 mm., lanceolatum, subacutum. Calyx externe breviter pubescens, intus glaber; lobis externis 3 anguste ovatis, obtusis, quam internis 3 1½-plo longioribus; lobis internis 2 latius ovatis, acutis, basibus constrictis. Petala oblonga, obtusa, partibus in alabastro expositis breviter tomentosis. Stamina 15, verticillis 3, interna 5 quam alia paullum longiora; filamentis basim versus applanato-dilatatis, ad medium abrupte attenuatis, apicem versus filiformibus; antheris late oblongis; aristis quam antheras 2–3-plo longioribus, gracilibus. Ovarium stylopodiumque pyriformibus, breviter tomentosum; stylo ovarium aequanti, filiformi, glabro. Fructus maturus ignotus. Pedicellus in fructu –1 mm. longus, –3 mm. diam., brevissimus. Calyx basim versus puberulus, aliter glabrescens; lobis maioribus 3, c. 7 × 1.5 cm., spatulatis, obtusis, supra basi vix attenuatis; partibus basalibus –1.5 × 1.5 cm., incrassatis, tenue saccatis; lobis minoribus 2, –3.5 × 0.6 cm., lineare oblongis, partibus basalibus ut in lobis longioribus. Nux –1.6 × 1.6 cm., ovoidea, acuta, conferte breviter tomentosa.

Collections. *Indonesian Borneo:* Hallier 678, Summit of G. Semedoen. *North Borneo:* San 16704, Gunong Lumaku, 1650 m; San 16914, Kundasan, 1200 m; Clemens 31885, Penibukan, Kinabalu, 1650 m (Holotypus in Herb. Kew), s.n. (J. Wyatt Smith), Kg. Kangeran, 800 m; San A 4353, Penibukan, Keningau, 1000 m; San A 4372, Penibukan, Keningau, Trus Madi, 1350 m; Kep 80446, Tambunan, 1000 m. *Sarawak:* S 9135, G. Penrissen, W Sarawak, 1000–14000 m. *Brunei:* Brun 2360, 2377, Gunong Pagon Periok, 1600 m.

SHOREA MYRIONERVA Sym. ex Ashton:—*S. myrionerva* Sym., nomen nudun.

S. macropterae Dyer, *S. slooteni* Ashton affinis, sed lamina longissima, tenui, costis lateralibus multis supra applanatis, subtus sparsim tomentis, racemis brevibus axillaribus saepe ramifloris, lobis calycis in fructu prominentius auriculatis distinguitar.

Ramuli petiolique semper aspere cristis pallide badiis punctati, costae subtus, perulae, stipulaeque brevius cristatae; lamina dein glabrescens. Ramuli apicem versus 2.5–3.5 mm. diam., crassi, recti, vix ramosi, teretes, sicco rufo-tomentosi; internodis 2–5 cm. longis; cicatricibus stipularum –2 × 1 mm., pallidis, connatis. Gemma

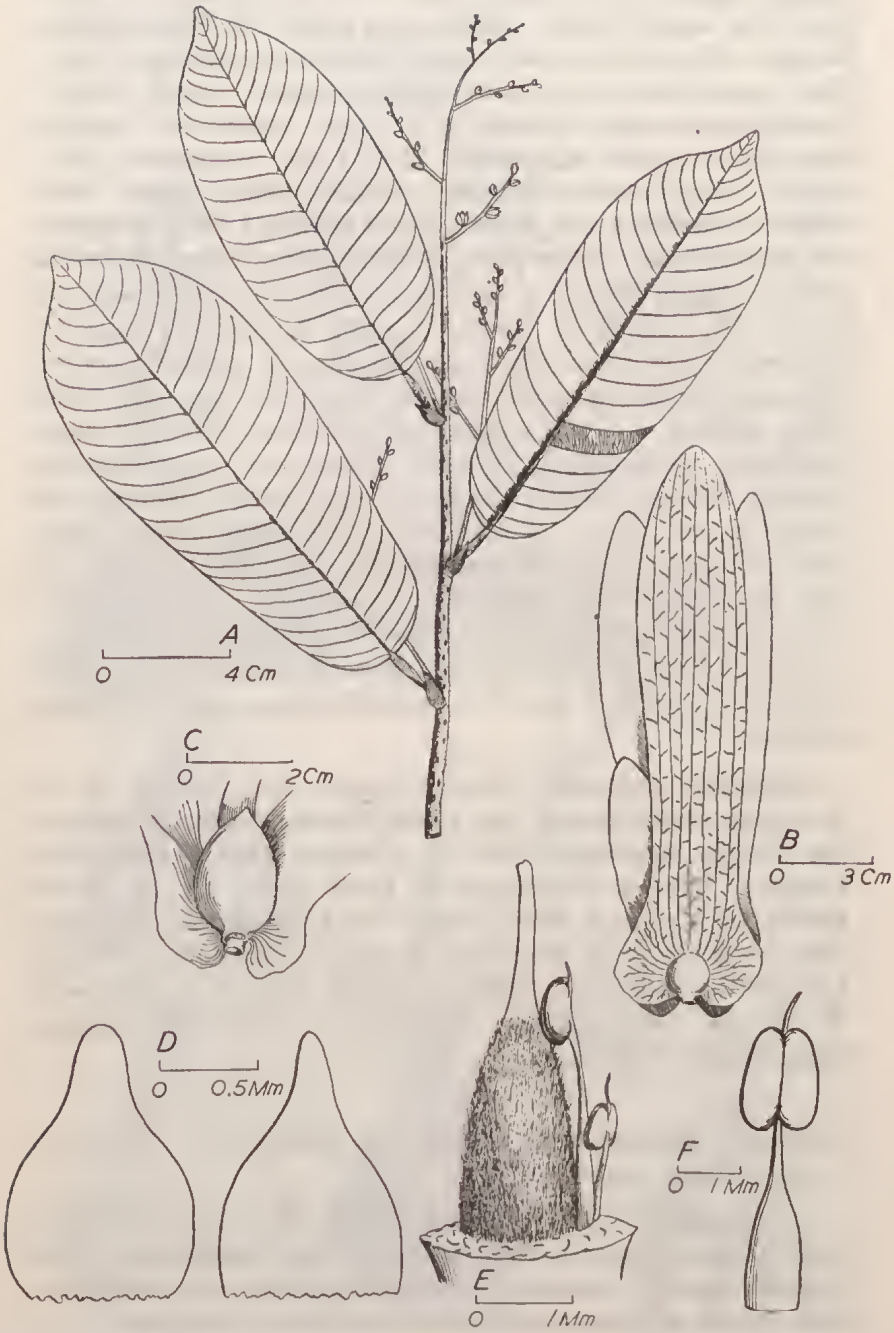


Plate 23. *S. myrionerva.*

a, Flowering twig. b, Fruit. c, Nut. d, Sepals (outer, left; inner right). e, Ovary. f, Stamen (from inside).

(a. d–f, from Jacobs 5371; b and c from S 1519).

–10 × 7 mm., compressa, perulis foliaceis numerosis laxe composita. Stipulae –15 × 7 mm., subpersistentes, in arboribus novellis persistentioribus, late hastatae, basi subauriculata, apice subacuto; in vivo magentae. Lamina 12–22 × 4.5–9 cm., anguste onlonga, tenuis, in vivo primo magenta, basi obtusa, apice in acumen –8 mm. longum late deltoideum abrupte attenuato; costis lateralibus utrinsecus 24–28, angustis, confertis, subtus prominentibus, apicem versus curvatis; intercostis anguste scalariformibus; a costis lateralibus angulo 90° exorientibus; costa media supra depressa. Petiolus 1.25–2 cm. longus, 2–2.5 mm. diam., brevis, crassus, sicco nigrescens. Lamina delapsa subtus fusco-rufo-brunnescens, supra fuscius-purpureo-brunnescens, semper plus minus applanata. Racemi –8 cm. longi, semel ramosi, stipitis basi in fructu –2 mm. diam., axillares, raro terminales, saepe ramiflori, ex integro teretes, sicco striati, laxi, basim versus cristis badiis sparsim punctati; ramulis brevibus –5 flores distichos gerentibus; bracteis –8 × 1.5 mm., lineare-lanceolatis, acutis; bracteolis –5 × 3 mm., ovatis, obtusis, externe puberulentibus, intus glabris. Alabastrum –5 × 3 mm., ellipticum, rotundatum. Calyx externe breviter conferte pubescens, intus glaber; lobis subaequalibus, ovatis, obtusis, externis 3 quam internis 2 paullum angustioribus. Corolla in vivo fusco-rubra, marginem versus alba (Jacobs), petalis anguste ovatis, partibus in alabastro expositis conferte flavido-aureo-tomentosis. Stamina 15, verticillibus inaequalibus 3, interna 5 quam alia multum longiora, prope apicem styli extensa; filamentis crassis, ad antheras gradatim attenuatis; aristis brevibus, dein reflexis. Ovarium stylopodiumque anguste conicum vel pyriforme, breviter pubescens; stylo quam ovarium stylopodiumque paullum breviori, late filiformi, glabro. Pedicellus in fructu –4 mm. longus, c. 3 mm. diam., glaber, ad basim fructus dilatatus. Calyx glaber; lobis longioribus 3, –17 × 2.5 cm., oblongis, tenue chartaceis, obtusis, basibus ad centra saccatis, incrassatis, auriculis –1.5 cm. latis tenuibus lateralibus 2; lobis brevioribus 2, subaequalibus, –8 × 07 cm., linearibus saccatis nec auriculatis. Nux –2.5 × 1.2 cm., glabra, glaucescens, ellipsoidea, ad stylopodium c. 1.5 mm. longum acutum celeriter attenuata.

Collections. *North Borneo:* Kep 80268, 80269, S. Lukutan Beaufort. *Sarawak:* S 0920/1928, S. Segan, Bintulu; S A 0314, Long Bunau, Pata; S A 0421, Balleh; S 1519, Merapok, Lawas (Holotypus Herb. Kepong); S 1805, Ulu Berawan, Limbang; S 2901, R. Kenaban, Upper Plieran; Kep 79349, Lambir Hills; S 00279, Beseri F.R., S. Babong, Suai; Jacobs 5371, Belaga. *Brunei:* Kep 30480, Ulu Belait; Kep 48268, Andulau F.R.; Kep 39630, Batu Apoi; Brun 5218, S. Belalong above Kuala Empan, Ulu Temburong; Brun 5200, San 17378, Kuala Belalong.

SHOREA PATOIENSIS Ashton s.n.

S. gibbosae Brandis lamina similis, sed fructus glaber, calyx quam nucem brevior, lonis subaequalibus differt.

Stipulae perulaeque breviter fimbriatae, gemmae novellae ramulique in arboribus maturis saepe teniussime pulverulento albocerati, foliae glabrae. Ramuli apicem versus c. 1 mm. diam., graciles, teretes, leves vel rugulosi, sicco fusco-rubro-nigrescentes vel nigri. Gemma c. 3 × 1 mm. (in arboribus novellis –4 × 2 mm.), anguste ovoidea, obtusa, perulis distincte expansis, non adpressis; sicco nigrescentibus. Stipulae c. 8 × 2 mm., oblongae, breve acutae. Lamina 5–8 × 2–3.5 cm., tenuis, ovata, utrinsecus subaequalis, saepe costa media oblique inflecta, basi plus minus late cuneata, juxta petiolum –1 mm. decurrenti, apice in acumen anguste c. 1 cm. longum gradatim attenuato; costis lateralibus utrinsecus 7–9, angustis quanquam prominentibus, curvatis, angulo 35°–45° exorientibus; costa media supra paullum elevata, subtus prominente elevata; intercostis conferte scalariformibus. Petiolus 7–10 mm. longus, c. 1 mm. diam., gracilis, sicco nigrescens. Lamina delapsa griseo-brunnescens, sursum quam deorsum pallior, lutior, sicca involuta. Racemi –9 cm. longi, semel vel bis ramosi, stipitis basi in fructu –2 mm. diam., terminales vel axillares, paullum breves confertique, graciles, ex integro teretes, semper breviter pallide griseo-brunneo-pubescentes; ramulis –1 cm. longis, –6 flores gerentibus; bracteolis minutis, fugacis. Alabastrum –3.5 × 1.5 mm., lanceolatum, acutum. Calyx conferte rubro-brunneo-tomentosus; lobis minimis, suborbicularibus, obtusis; lobis internis 2 quam lobis externis 3 paullum tenuioribus, basi costrictis. Corolla in vivo fusco-flava, aetate florendi basim versus imbricata scyphiformis, apicem versus revoluta expansa necta; petalis linearibus, partibus in alabastro expositis breviter pubescentibus. Stamina 15, verticillis 3, bina cum solis alternata, inaequalibus; filamentis paullum brevibus, basim versus dilatatis, ad medium abrupte attenuatis, apicem versus filiformibus; antheris subglobosis; aristis antheras aequantibus, apicem versus breviter ciliatis, apicem styli vix attingentibus. Ovarium ovoideum, breviter pubescente; stylopodio cylindrico pubescenti, stylo brevi glabro. Pedicellus in fructu c. 1 mm. longus, brevis. Calyx breviter caduce pallide flavido-alutaceus, margine semper fimbrillato; lobis 3–5 mm. longis latisque, late ovatis, ad basim nucis adpressis, basim versus conjunctis scyphum –5 mm. diam. factis. Nux –15 × 8 mm., parva, oblongo-ellipsoidea, striata, aetate maturandi prope glabra, apice obtuso.

Collections. *Brunei:* Brun 3324 (Holotypus in Herb. Kew), 3017, Kep 85465, S 5811, Bt. Patoi; Kep 80127, 80113, 80139, S 5562, Peradayan F.R.; S 5757, 5710, 5746, Kuala Belalong. *Sarawak:* S 1807, Bt. Tegaria, Ulu Berawan, Limbang.

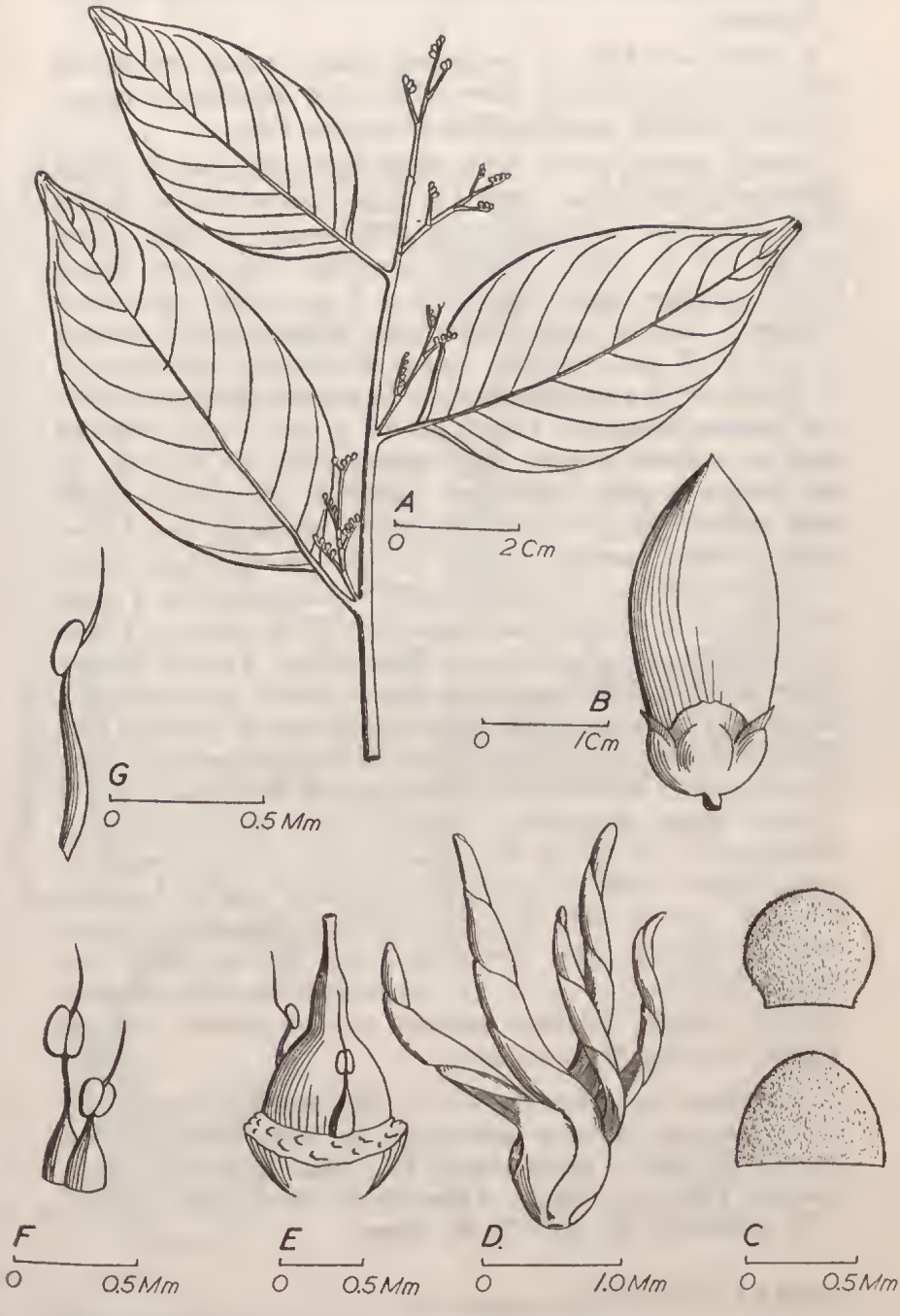


Plate 24. *S. patoiensis.*

a, Flowering twig. b, Fruit. c, Sepals (inner, above; outer below). d, Corolla. e, Ovary. f, Stamens (frontal view). g, Stamens (lateral view).

(a, c–g, from Brun 3324; b from Brun 3324).

SHOREA PILOSA Ashton s.n.:—*S. tomentosa* Wood msc; non *S. tomentosa* Hort. Bog. ex Pierre; non *S. tomentosa* Miq. ex Brandis.

S. pinangae Scheff., *S. beccarianae* Burck, affinis, sed lamina minore, tomento conferto aureo, cicatricibus stipularum amplexicaulibus, domatiis prominentibus tomentosis differt.

Ramuli, perulae, petioli, costa media supra subtusque, et lamina costaeque subtus semper conferte scabrido-aureo-tomentosi; lamina supra stipulaeque puberulentes vel glabrescentes. Ramuli apicem versus 2–2.5 mm. diam., paullum compressi, dein teretes, fusco-brunnei, multum ramosi; internodis 2–3 cm. longis; cicatricibus stipularum angustis, prope transversis, amplexicaulibus. Gemma 3–7 × 1.5–3 mm., ovoidea, obtusa vel subacuta. Stipulae –3.5 × 1.5 cm., in vivo magenta, paullum persistentes, hastatae, acutae, basi paullum constricta. Lamina 10–17 × 4–7.5 cm., ovata vel elliptica, paullum coriacea, basi obtusa, paice in acumen –1.2 cm. longum anguste deltoideum subabrupe attenuato; margine saepe paullum revoluto; costis lateralibus utrinsecus 12–15 confertis, paullum curvatis, angulo 45°–50° exorientibus; domatiis pilosis axillaribus; intercostis conferte scalariformibus, a costis lateralibus c. 90 exorientibus. Petiolus 1–1.2 cm. logus, c. 2 mm. diam., brevis, sicco aureo-brunneo-tomentosus. Lamina delapsa subtus aureo-brunneo-tomentosa, supra pallide rubro-brunnea. Racemi –14 cm. longi, semel ramosi, stipitis basi in fructu –2 mm. diam., terminales vel axillares, semper ex integro aureo-tomentosi, teretes; bracteis, bracteolis, floribusque ignotis. Pedicellus in fructu –3 mm. longus diametroque, crassus. Calyx glabrescens, lobis longioribus 3, –17 × 2.5 cm., subaequalibus, oblongo-spatulatis, obtusis, basim versus –1.2 cm. latis attenuatis; partibus basalibus c. 1.2 × 1.5 cm., latis, incrassatis, multum saccatis, ad nucem obtectum adpressis; lobis brevioribus 2, –12 × 1 cm., aliter ut in lobis longioribus. Nux c. 2 × 1.7 cm., ovoidea, ad apicem anguste conicum abrupte attenuata, conferta breviter pallide alutaceo-tomentosa; stylopodio brevi acuto.

Collections. *North Borneo:* San A 1748, Beaufort; San 16721, Ulu Mendalong, Sipitang (Holotypus in Herb. Kew). *Brunei:* Brun 5091, Mile 7, Kuala Abang Rd., Brun 2636, Ulu Lumut, Andulau F.R.; Kep 80108, Labu Estate; San 17528, S 1930, 1932, Andulau F.R.; S 5777, Bt. Biang.

SHOREA REVOLUTA Ashton s.n.

S. parvifoliae Dyer affinis, sed racemis longioribus rigidioribus rectioribus, lamina maiore coriaceiore subtus nitenti, costis lateralibus prominentioribus laxioribus, margine prominenti revoluto differt.

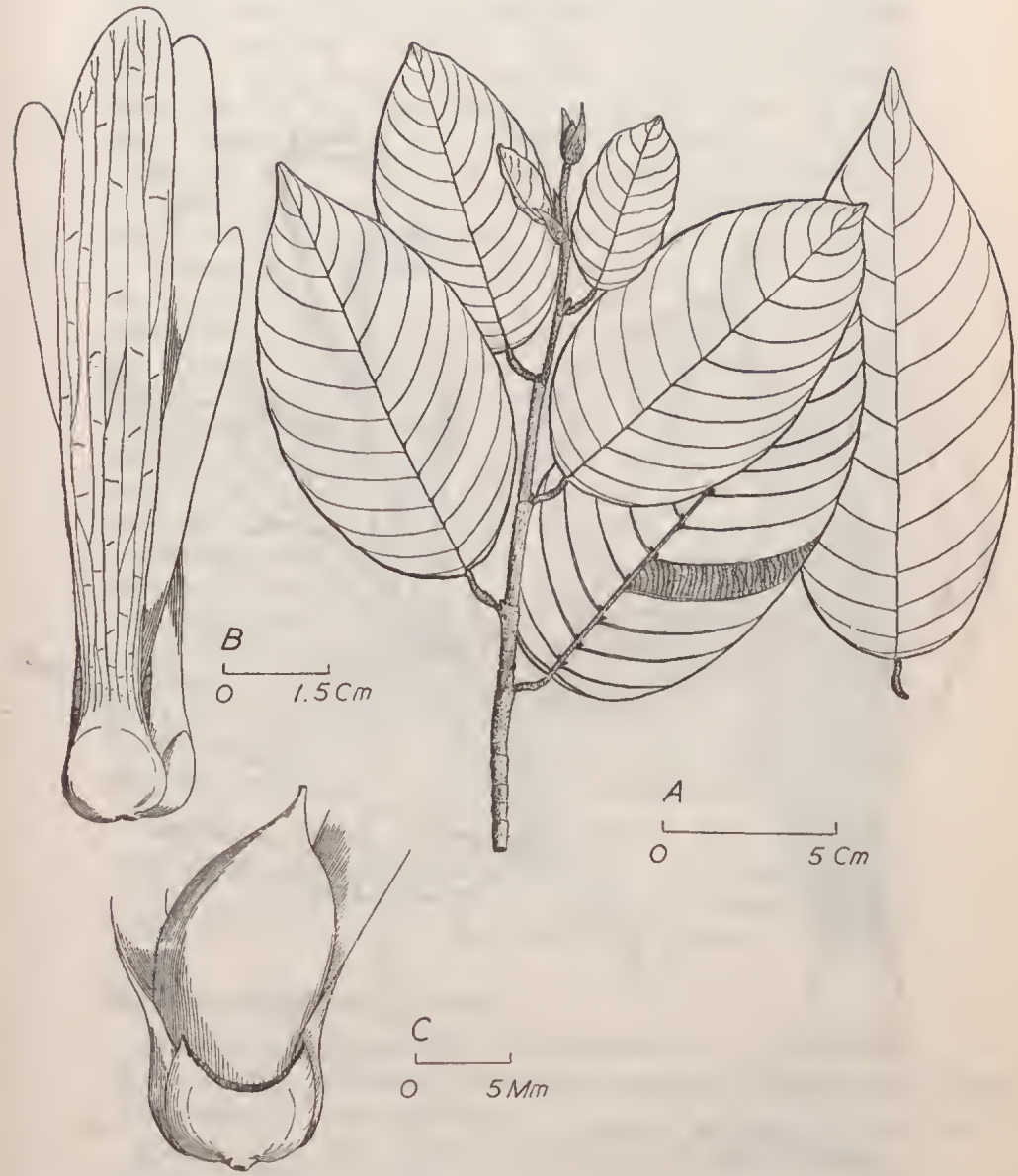


Plate 25. S. *pilosa*.

a, Leafy branch. b, Fruit. c, Nut.
(a from Brun 5091; b and c from San 16721).

Plate 26. *S. revoluta.*

a, Twig with young fruit. b, Fruit.
(From S 5914).

Ramuli, perulae, stipulae externae, petiolique semper sparsim pallide brunneo- vel fulvo-scabrido-cristato-tomentosi, stipulae intus plane pubescentes, costae subtus, costa media supra brevius tomentosi vel glabrescentes. Ramuli apicem versus 2–3 mm. diam., primo teretes vel paullum striati compressi, dein teretes, crassi, glabrescentes, fusco-brunnei, lenticellis minutis orbicularibus pallidis punctati; internodis 1.5–4 cm. longis; cicatricibus stipularum primo –2 mm. longis, horizontalibus, angustis, inconspicuis. Gemma 4–7 × 3–5 mm., ovoidea, compressa, obtusa vel subacuta. Stipulae –15 × 7 mm., ellipticae vel oblongae, obtusae. Lamina 10–15 × 5.5–10 cm., ovata, coriacea; basi obtusa vel subcordata, apice in acumen –1.5 cm. longum angustum attenuato, margine revoluto; costis lateralibus utrinsecus 9–12, curvatis, subtus prominentibus, remotis, basim versus angulo c. 90° exorientibus, apicem versus angulo c. 45° exorientibus; domatiis axillaribus parvis glabris; intercostis angustis, scalariformibus, a costis lateralibus diagonale exorientibus; costa media angusta, supra paullum depressa. Petiolus 1.2–1.5 cm. longus, c. 2 mm. diam., crassus, sicco brunneo-tomentosus vel nigrescens. Lamina delapsa supra flavido-brunnea, subtus fusco-ferruginea. Racemi –22 cm. longi, semel vel bis ramosi, stipitis basi in fructu 2–3 mm. diam., terminales vel axillares, rigidi, conferte pallide brunneo-vel fulvo-scabrido-cristato-tomentosi; bracteis, bracteolis, floribusque ignotis. Pedicellus in fructu –1.5 mm. longus, gracilis. Calyx in fructu puberulens; lobis longioribus 3, –7.5 × 1.3 cm., tenuibus, spatulatis, obtusis, basim versus –3 mm. latis attenuatis, partibus basalibus c. 6 × 5 mm., ovatis, incrassatis, saccatis; lobis brevioribus 2, –35 × 2 mm., subaequalibus, linearibus, acutis basibus ut in lobis longioribus. Nux –15 × 8 mm., ovoidea, pallide alutaceo-pubescens; stylopodio c. 1.5 mm. longo, brevi, attenuato.

Collections. *North Borneo:* San 15135, Mengalong F.R.; *Sarawak:* s.n., Meragang F.R., Lawas; S 5618, Bt. Bubong Rumah, Lawas; S 5914 (Holotypus in Herb. Kew), Bt. Sagan, Limbang. *Brunei:* S 5814, Brun 5646, Bt. Patoi; S 5782, Biang.

SHOREA RUBELLA Ashton s.n.

Antherae ovariumque Sect. Anthoshoreae Heim similes, sed arista staminis brevissima, filamentis loratisque differt; in illis notationibus sine propinquatibus.

Perulae stipulaeque externe semper plane minute pallide roseo-alutaceo-pubescentes, stipulae intus puberulentes; ramuli, petioli, laminaeque primo similiter tomentosi, dein glabrescentes. Ramuli apicem versus 2–3 mm. diam., apicem versus sicco striati compressi, dein leves, teretes, crassi, pallide brunnei; internodis 2–4 cm. longis, multum ramosis; cicatricibus stipularum primo c. 1.5 mm. longis, plus minus transversis, anguste cuneatis. Gemma 6–9 × 2–3 mm., anguste ovoidea vel paullum falcata. Stipulae

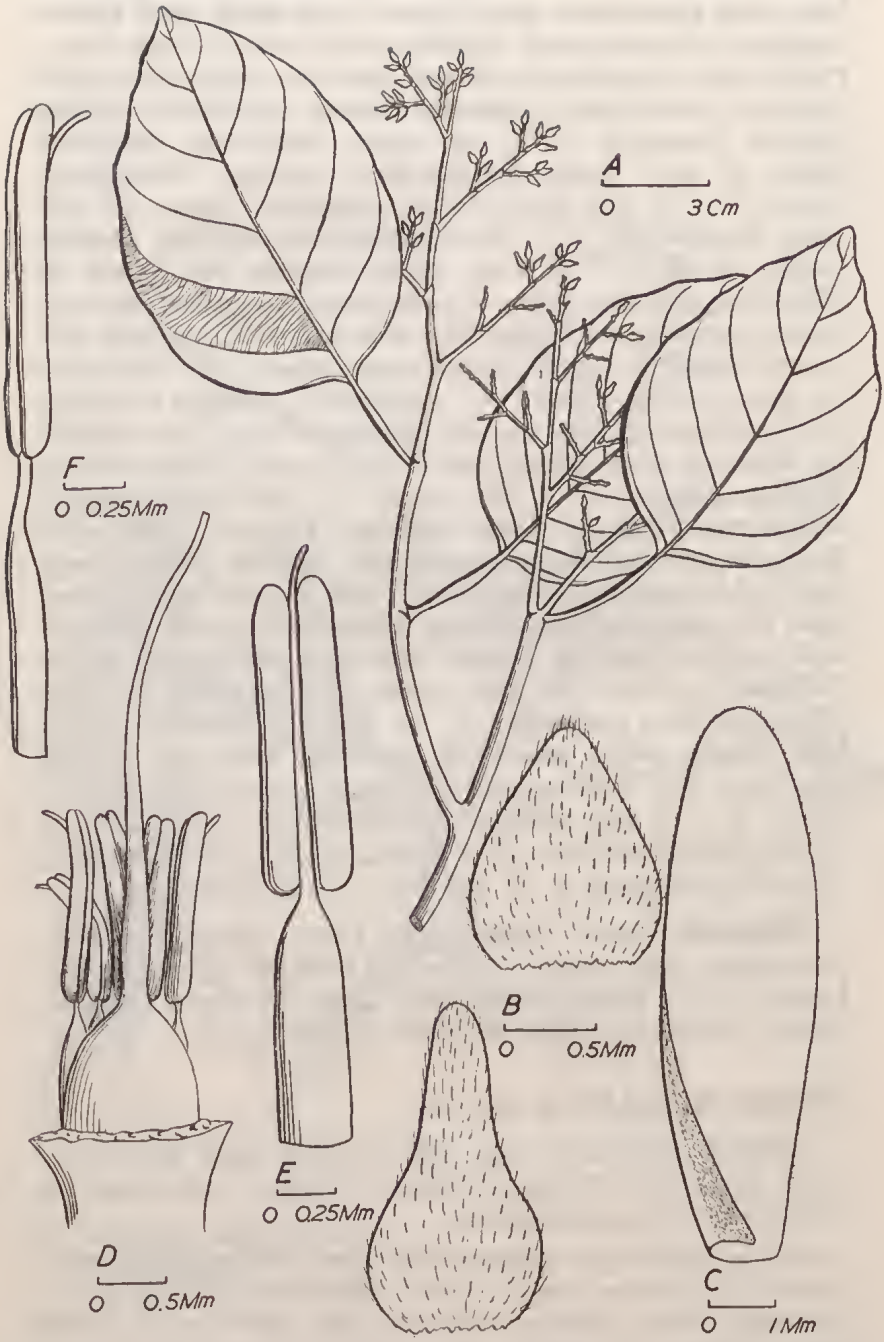


Plate 27. *S. rubella.*

a, Flowering branch. b, Sepals (outer, below; inner, above). c, Petal. d, Ovary. e, Stamen (frontal view). f, Stamen (lateral view).

(a–f from Brun 3078).

–18 × 6 mm., hastatae vel falcatae, acutae. Lamina 9.5–14 × 6–8 cm., late ovata, crasse coriacea, subtus cremeo-glauca, basi obtusa, apice in acumen c. 1 cm. longum plus minus abrupte attenuato; margine saepe paullum revoluto; costis lateralibus utrinsecus 5–7, prominentibus, curvatis, angulo c. 40°–50° exorientibus, saepe domatiis axillaribus minutis; intercostis a costis lateralibus c. 90° exorientibus, conferte scalariformibus; costa media supra applanata vel paullum depressa. Petiolus 2.2–3.5 cm. longus, c. 2.5 mm. latus, sicco glaucus vel nigrescens. Lamina delapsa supra roseo-brunnea, nitens, subtus cremeo-glauca (in arboribus novellis rubro-brunneus). Racemi –15 cm. longi, semel vel bis ramosi, stipitis basi in fructu –2 mm. diam., terminales vel axillares, sicco striati, semper ex integro breviter conferte roseo-brunnescente-pubescentes; ramulis –5 cm. longis, –5 flores distichos gerentibus; bracteis bracteolisque ignotis. Alabastrum –7 × 3 mm., anguste ovoideum, acutum. Calyx externe breviter conferte pallide roseo-griseo-pubescens, intus glaber; lobis ovatis subaequalibus, internis 2 quam externis 3 paullum latioribus, paullum brevioribus. Corolla in vivo pallide rosea, basim versus fuscior; petalis oblongis, obtusis, vix contortis, delapsis vix connatis, partibus in alabastro expositis breviter tomentosis. Stamina 15, subaequalia, verticillis 3, bina cum solis alternata, circum ovarium conferta, filamentis loratis, sub antheris abrupte attenuatis, apicem ovarii attingentibus; antheris filamentos aequalibus, lineare-oblongis, angustis; aristis brevibus crassis, paullum reflexis. Ovarium parvum, globosum, glabrum; stylopodio indistincto, stylo quam ovarium 3-plo longiore, glabro, filiformi. Fructus maturus ignotus. Calyx in fructu novello pubescenti; lobis maioribus 3 quam minoribus 2 multum longioribus. Nux ovoidea, conferte pubescens.

Collections. *North Borneo:* San A 1750, Beaufort. *Sarawak:* S 9474, S. Iran, Pelagus. *Brunei:* S 1909, Belait; S 1907, Arboretum, Kampong Gana; S 1925, Kep 36027, 80084, 81925, 48487, 48460, San 17564, Brun 3078 (Holotypus in Herb. Kew), 616, Andulau F.R.; Kep 30574, S. Tutong; Kep 30585, Tutong; Kep 48162, S. Lumut; Kep 34529, S. Tepiku; Kep 34578, Pak Gabal; Kep 35569, Pengkalan Ran; Kep 35667, Labi Hills F.R.

SHOREA RUBRA Ashton s.n.

S. parvifoliae Dyer, *S. dasyphyllae* Foxw. affinis, sed lamina. coriaceore, tomento conferte fusco-ferrugineo differt.

Ramuli, perulae, stipulae, petioli, costa media supra, lamina subtusque semper conferte fusco-rufo-brunneo-tomentosi, stipulis intus quam externe brevius sparsius tomentosis. Ramuli apicem versus –1.5 mm. diam., teretes, multum ramosi, dein rufo-brunnescentes, leves, lenticellis parvis pallidis orbicularibus punctati; internodis 1–1.5 cm. longis; cicatricibus stipularum primo c. 1 mm. longis, brevibus, tenuibus, deorsum curvatis. Gemma 4–7 × 3–4.5

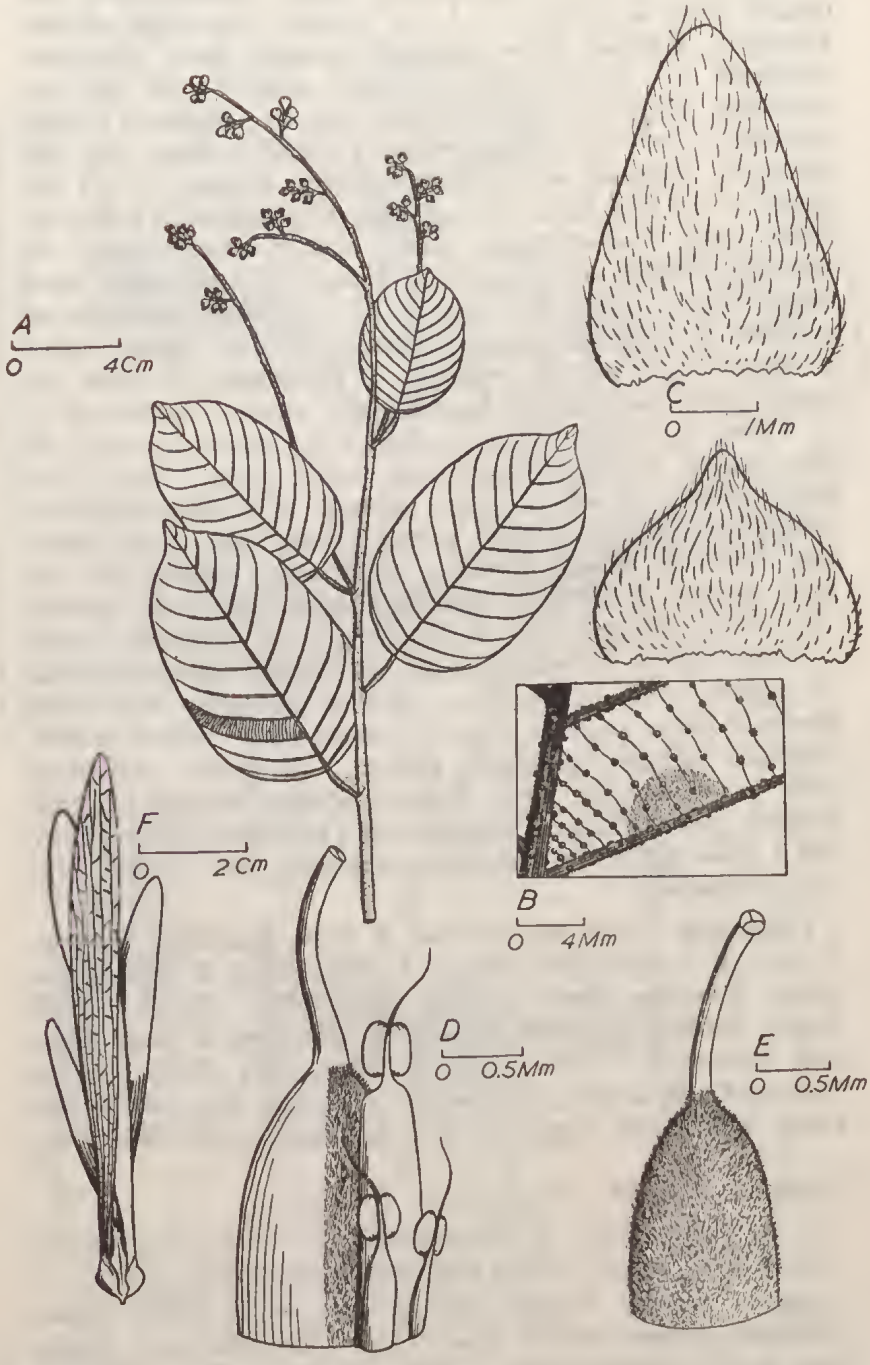


Plate 28. *S. rubra.*

a, Flowering twig. b, Part of lamina (undersurface). c, Sepals (outer, above; inner, below). d, Ovary and stamens. e, Ovary. f, Fruit.

(a–e from S 9475; f from S 2112).

mm., compressa, ovoidea, late acuta. Stipulae –16 × 5 mm., hastatae, basi attenuata, subacutae. Lamina 8–12 × 4–7.5 cm., late ovata; basi obtusa, apice in acumen –1.3 cm. longum (saepe brevem) abrupte attenuato, margine paullum revoluto; costis lateralibus utrinsecus 11–13, subtus prominentibus, ad apices curvatis, angulo 40°–50° exorientibus; intercostis angustis, conferte scalariformibus, a costis lateralibus diagonale exorientibus; costa media subtus prominenti, tereti, supra angusta paullum depressa. Petiolus 1–1.4 cm. longus, c. 1.5 mm. diam., sicco rufo vel purpureo-griseo-tomentosus. Lamina delapsa supra purpurescens, subtus rufescens, dein indistincte purpurescens vel grisea. Racemi –14 cm. longi, semel vel bis ordine ramosi, stipitis basi in fructu –2 mm. diam., terminales vel axillares, ex integro teretes, recti, striati, conferte fusco-rufo-brunneo-tomentosi; ramulis brevibus, confertis, –5 flores distichos gerentibus; bracteolis –4 × 3.5 mm., late ovatis, subacutis, circum alabastro imbricatis, externe breviter pallide alutaceo-pubescentibus, intus sparsium pubescentibus. Alabastrum –7 × 4 mm., ellipsoideum vel subglobosum, obtusum. Calyx externe conferte pallide griseo-tomentosus, intus glaber; lobis externis 3 deltoideo-ovatis obtusis, lobis internis 2 late ovatis acutis quam illis minoribus. Corolla in vivo pallide flavida, partibus in alabastro expositis breviter tomentosis; petalis lineari-oblongis, subacutis. Stamina 15, verticillis 3 inaequalibus, interna 5 quam alia prope 2-plo longiora; filamentis externis 10 ad antheras gradatim attenuatis, internis 5 late loratis, sub antheris abrupte attenuatis; antheris subglobosis; aristis quam antheras brevioribus, dein paullum reflexis. Ovarium stylopodiumque ovoideo-conicum, conferte tomentosum basi excepto; stylo quam ovarium breviore glabro. Pedicellus in fructu c. 1 mm. longus diametroque, brevis. Calyx in fructu breviter tenue puberulus vel glabrescens; lobis longioribus 3, –11 × 1.6 cm., anguste spatulatis, anguste obtusis, basim versus –4 mm. attenuatis; partibus basalibus –8 × 6 mm., multum saccatis, incrassatis; lobis brevioribus 2, –4.5 × 0.4 cm., subaequalibus, linearibus, acutis, partibus basalibus ut in lobis longioribus. Nux –10 × 9 mm., late ovoidea, alutaceo-velutinata, in stylopodium –2 mm. longum acutum abrupte attenuata.

Collections. *North Borneo:* San 15124, 15085, Beaufort; San 17008, 17013, 17010, 17023, Tambunan; San 16638, 16556, 15187, 15190, 15193, Sipitang; San 15124, Pangi; San 16355, Ranau; San 16577, Ulu Moyah. *Brunei:* S 1677, Kep 48492, Andulau F.R.; S 1691, S. Kiaput, Tutong; S 2112, Bt. Teraja; Brun 364, Ulu Katop-Ulu Senuko watershed, Ulu Batu Apoi; S 5754, Kuala Belalong; Brun 2615, Kuala Temburong Machang; Brun 784, Kuala Sekurop. *Sarawak:* S 9475, S. Iran, Pelagus (Holotypus in Herb. Kew); Jacobs 5464, Belaga; S 9413, Kuching; S 117, S. Miah, Rejang; S 166, S. Merirai, Ulu Balleh; S 6525, G. Menuku.

SHOREA SLOOTENI Ashton:—*S. vanslooteni* Wood msc.

S. macropterae Dyer affinis, sed lamina maiori, costis lateralibus multis supra depressis, ramulis crassis compressis, staminum aristis externis 10 vix reflexis, ovario angusto, stylo longiore differt.

Ramuli, perulae, stipulae externe, petiolo laminaeque subtus semper conferte pallide fulvo-scabrido-cristato-tomentosi, cristis brevibus, duris, verrucosis; stipulae intus pubescentes, costa media supra breviter pubescens. Ramuli apicem versus –5 × 3 mm., primo compressi, striati, dein teretes, crassi, basibus cristorum persistentibus verrucosis; internodis 1–3 cm. longis; cicatricibus stipularum primo –3 mm. longis, basi –0.5 mm. lata, cuneatis, paullum sursum directis. Gemma 6–10 × 5–8 mm., late ovoidea, paullum compressa, obtusa. Stipulae –25 × 8 mm., oblongae, obtusae. Lamina 11–22 × 4–7 cm., late oblonga, coriacea, basi obtusa, apice in acumen 1.5 cm. longum abrupte attenuato; costis lateralibus utrinsecus (25) 27 –34, confertis, subtus prominentibus, supra depressis, ad marginem curvatis, angulo 50°–60° exorientibus; intercostis conferte scalariformibus, prominentibus, a costis lateralibus paullum diagonale vel ad 90° exorientimus; costa media subtus prominenti, tereti, supra multum depressa. Petiolus 1.7–2.5 cm. longus, c. 3 mm. diam., crassus, sicco rufo-brunneo-tomentosus. Lamina delapsa supra pallide ferruginea, subtus fusco-ferruginea, utrinsecus inflexa, scaphiformis, Racemi –18 cm. longi, semel vel bis ordine ramosi, stipitis basi in fructu –4 mm. diam., terminales vel axillares, ex integro crassi, fragiles, plus minus compressi, conferte pallide fulvo-scabrido-tomentosi, ramulis brevibus, –4 flores gerentibus; bracteolis –3 × 2 mm., ovatis vel deltoideis, obtusis, externe conferte flavido-brunneo-pubescentibus, intus glabris, caducis. Alabastrum –12 × 7 mm., ovoideum vel ellipsoideum, obtusum. Calyx externe breviter conferte virido-brunneo-tomentosus, intus glaber; lobis externis 3 ovatis, acuminatis, quam lobis internis 2 acutis longioribus. Corolla in vivo pallide flava, petalis lanceolatis, subacutis, partibus in alabastro expositis conferte breviter tomentosis. Stamina 15, verticillis 3, bina cum solis alternata; interna 5 basim styli attingentia, quam aliis 2-plo longioribus, his inaequalibus filamentis ad antheras gradatim attenuatis, in alabastrum paullum nectis; antheris globosis; aristis internis 5 quam antheras brevioribus dein reflexis, externis 10 quam antheras 2-plo longioribus, vix reflexis. Ovarium stylopodiumque anguste ovoideum vel lanceolatum, dimidio distali sparsim setoso, stylo ovarium prope aequali, late filiformi, glabro. Pediccllus in fructu –3 mm. longus diametroque, brevis, crassus. Calyx in fructu nitens, breviter puberulens, apicem versus sparsus; lobis longioribus 3, –17 × c. 1.75 (–4) cm., inaequalibus, linearc-oblongis, obtusis, basim versus vix attenuatis, partibus basalibus ad pedicellum abrupte attenuatis, discis centris –12 × 12 mm. sacceatis incrassatis, nuce adpressis, auriculis lateralibus 2, –1 cm. latis; lobis brevioribus 2, 5.5–12.5 × 0.7 cm.,

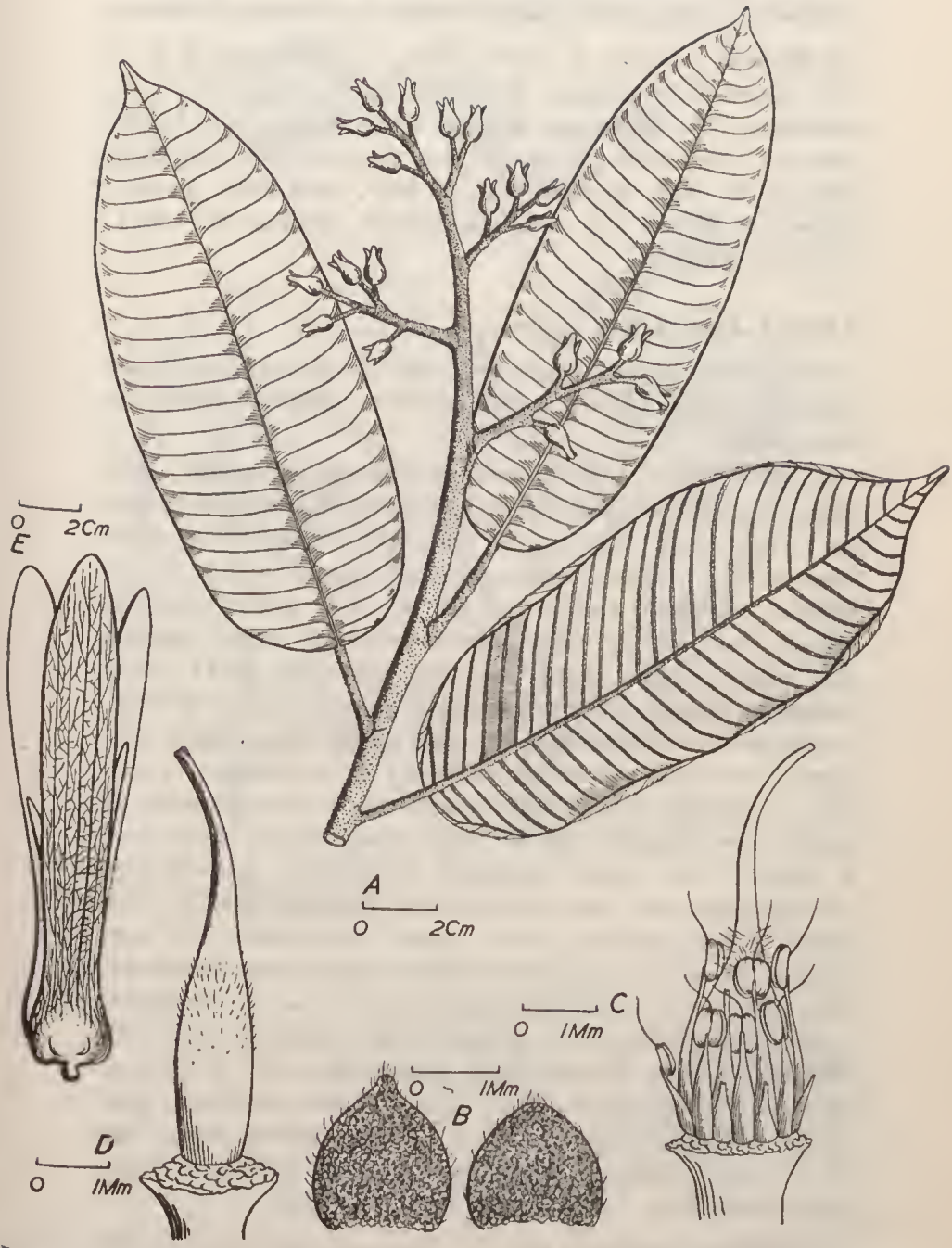


Plate 29. *S. slootenii.*

a, Twig with young fruit. b, Sepals (outer, left; inner, right). c, Stamens and Ovary. d, Ovary. e, Fruit.

(a from S 11053; b–d from Brun 3070; e from S 1516).

inaequalibus, linearibus, basibus ut in lobis longioribus. Nux –3.5 × 1.5 cm., ovoideum, stylopodio –4 mm. longo acuto gradatim attenuato; conferte breviter pallide brunneo- vel autoceo-pubescens.

Collections. *Sarawak:* S 11053, 1616, 157, Semengoh F.R.; S 1516, Lawas. *North Borneo:* San 16922, Bt. Sipitang; San 15160, Mengalong F.R. (Holotypus in Herb. Kew). *Brunei:* Kep 35560, Tutong R.; Kep 35561, Pengkalan Ran; Kep 48470, S 5586, Brun 5436, 3270, 3070, Andulau F.R.; S 5807, Brun 3175, Bangar. *Indonesian Borneo:* bb 7097, Sambas, W. Borneo; bb 14614, 14509, E. Kutei.

VATICA CORIACEA Ashton s.n.

Vatica teysmannianae Burck affinis, sed lamina coriaceore, apice obtusa vel retusa, petiolo breviore crassiore, calyce ad basim dissecto, differt.

Novellae primo conferte breviter ochraceo-tomentosae, dein glabrae; gemmae semper similiter tomentosae. Ramuli apicem versus –5 mm. diam., crassi rugosi, dein fusci vel nigri glabri leves. Gemma –7 × 5 mm., ovoidea subacuta. Stipulae –13 × 5 mm. hastatae subacutae. Lamina 6.5–15 × 2.2–6 cm. coriacissima obovata, basi anguste obtusa, apice obtuso vel retuso, margine plus minus revoluto; costis lateralibus utrinsccus 10–11, supra subtusque paullum elevatis indistinctis curvatis angulo 50°–60° exorientibus; intercostis angustis; costa media crassa, subtus prominenti, supra paullum elevata. Petiolus 1–1.5 cm. longus, –3 mm. diam., sicco niger. Lamina delapsa ochraceo- vel fusco-brunnea, ex integro leves. Racemi –20 cm. longi, semel ramosi, stipitis basi in fructu –3 mm. diam., terminales vel axillares, primo pallide ochraceo-tomentosi, dein glabrescentes, bracteis stipitatis saepe foliatis, subpersistentibus, aliter fugacis. Alabastrum –1.8 mm. longum; calyce conferte breviter pallide griseo-brunneo-pubescenti. Flores aliter ut in Vaticis aliis. Pedicellus in fructu –7 mm. longus, 1 mm. diam., gracilis. Calyx externe breviter pubescens, intus glabrescens, ad basim dissectus; lobis longioribus 2, –7 × 2.3 cm., oblongis obtusis, apicem versus –3.5 mm. latis subabrupte attenuatis; lobis brevioribus 3, –20 × –6 mm., hastatis, acutis. Nux –8 × 8 mm., globosus, breviter pubcrulus vel glabrescens, rugulosus, saepe stylo –2 mm. longo lineari terminatus.

Collections. *Sarawak:* S 362, 372 (Holotypus in Herb. Kew), Bt. Sebandar, Lundu; S 10296, 10296A, Bako N.P.; S 10390, 10391, Bt. Serepah, Kuching; S 7295, Selang F.R.; S 6344, G. Pueh F.R.; 18/58, Bt. Kayangeran, Merapok, Lawas. *Brunei:* S 4134, Brun 5155, Berakas F.R.; Brun 5652, Bt. Patoi.

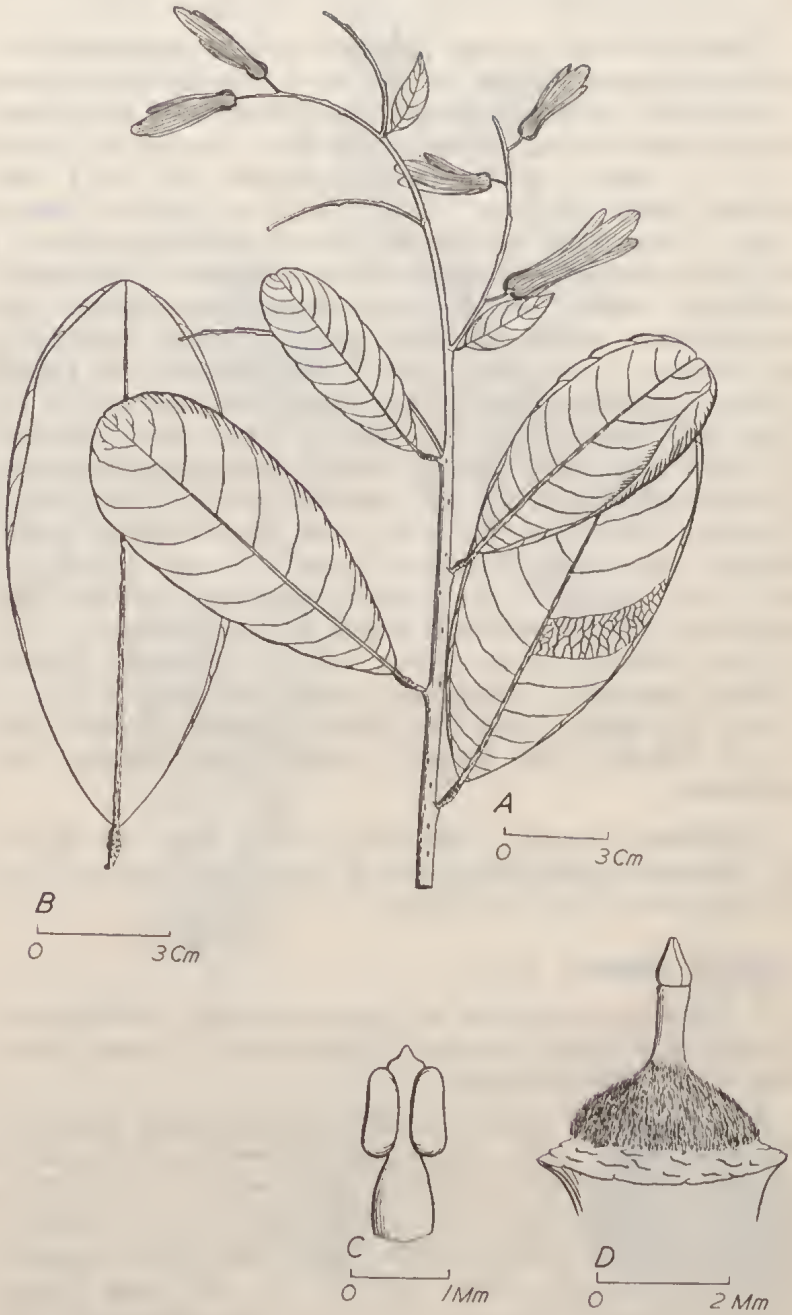


Plate 30. *Vatica coriacea.*

a, Fruiting twig. b, Leaf. c, Stamen. d, Ovary.
(a and b from S 10296a; c and d from S 10296).

VATICA PARVIFOLIA Ashton s.n.

V. micranthae V.Sl. affinis, sed lamina minore, costis lateralibus vix elevatis, angustis, tomento longiore ferrugineo differt.

Ramuli, novellae, perulae, petiolique conferte ferrugineo-pulverulento-tomentosi, stipulae breviter iidem. Ramuli apicem versus –1 mm. diam., plurimum ramosi, dein glabrescentes, leves, fusco-brunnescentes vel nigrescentes; internodis c. 1 cm. longis. Gemma –3 × 1.5 mm., ovoidea, subacuta. Stipulae –5.5 × 1 mm., lineares, caducae. Lamina 2.8–6 × 1–2.3 cm., coriacea, anguste ovata vel lanceolata, basi obtusa, apice in acumen caudatum –1 cm. longum attenuato; costis lateralibus utrinsecus c. 8, indistinctis, applanatis, multum curvatis, angulo 60°–75° exorientibus; costa media angusta, subtus prominenti, supra applanata. Petiolus 6–9 mm. longus, –1 mm. diam., sicco ferrugineo-tomentosus. Lamina delapsa ex integro pallide flavido-brunnescens. Racemi –2 cm. longi, semel ramosi, stipitis basi in fructu –1 mm. diam., terminales vel axillares, ex integro teretes, conferte ferrugineo-pulverulento-tomentosi. Alabastrum –6 mm. longum, parvum; calyce griseo-brunneo-tomentoso; corolla in vivo alba; aristis brevibus, obtusis, floribus aliter typicis. Pedicellus in fructu –3 mm. longus, –0.7 mm. diam., gracilis. Calyx in fructu glabrescens vel ad basim puberulus; lobis ad pedicellum liberis; lobis longioribus 2, –6 × 1.7 cm., oblongis, anguste obtusis, supra basi revolutis, ad basim abrupte constrictis, subaequalibus; lobis brevioribus 3, –10 × 7 mm., late ovatis, acutis, basi cordatis, multum revolutis. Nux –5 × 3.5 mm., late ovoidea, obtusa, obtusa, breviter fulvo pubescens.

Collections. *Sarawak:* Jacobs 5518, S 5127, Bako N.P.; S 371, Bt. Sebandar, Lundu (Holotypus in Herb. Kew). *Brunei:* Brun 2007, Bt. Puan; Kep 34475, Badas.

VATICA VINOSA Ashton s.n.

V. dulitensis Sym. affinis, sed costis lateralibus pluribus prominentibus, lobis calycis minoribus, incrassatioribus, revolutis, persistente vinoso-tomentosis differt.

Ramuli, perulae, stipulae, petioli, costae subtusque plus minus semper breviter plane fusco-purpureo-tomentosi, sub laminis quadam tenus atterrentes. Ramuli apicem versus –1.5 mm. diam., graciles, plurimum ramosi, dein glabrescentes, pallide grisentes vel brunnescentesque maculosi, saepe fissulis lamellulisque superfixi; internodis 8–15 mm. longis. Gemma –1.5 mm. longa lataque, ovoidea, obtusa. Lamina 6–15 × 1.5–4.5 cm., spatii varii, elliptica vel lanceolata, basi anguste obtusa vel cuneata, apice in acumen angustum –1.2 cm. longum attenuato; costis lateralibus primariis utrinsecus 12–20, angustis, subtus plus minus prominente elevatis, curvatis, confertis angulo 50°–70° exorientibus, secundariis brevibus angustis; costa media angusta, subtus prominenti,

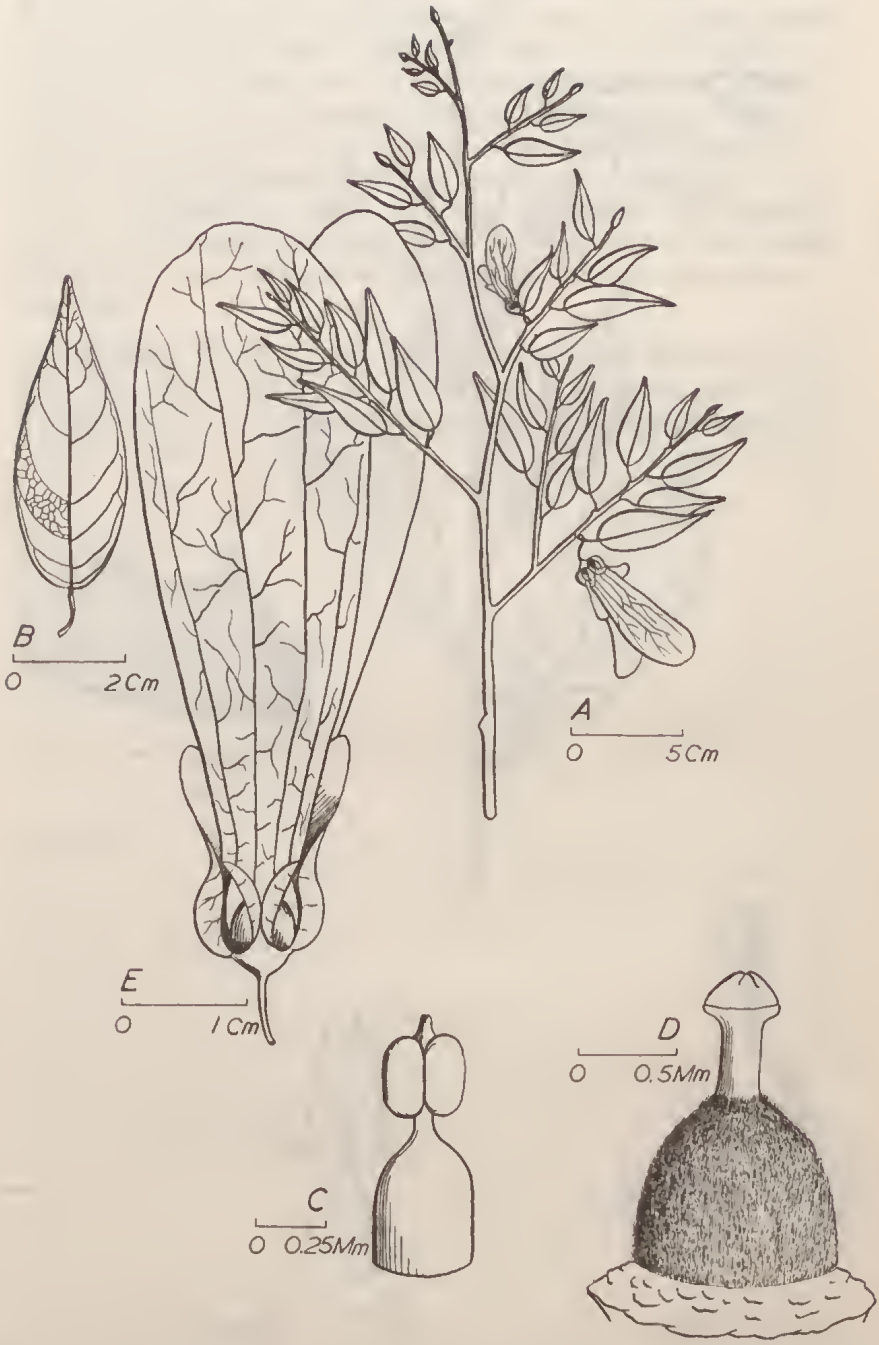


Plate 31. *Vatica parvifolia.*

a, Fruiting twig. b, Leaf. c, Stamen (frontal view). d, Ovary. e, Fruit. (a and e from S 371; b–d from Jacobs 5518).

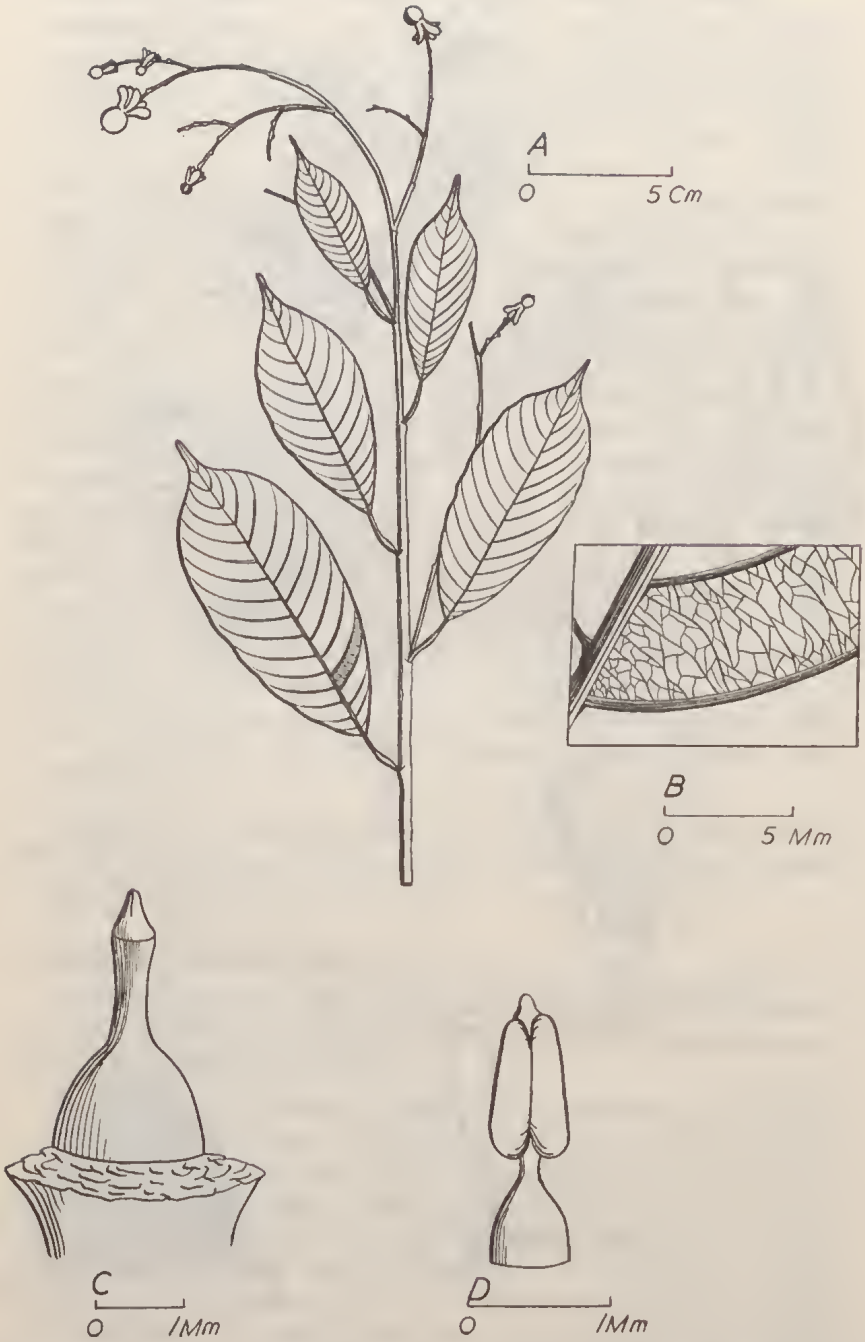


Plate 32. *Vatica vinosa.*

a, Fruiting twig. b, Part of lamina undersurface. c, Ovary. d, Stamen. (a and b from Brun 764; c and d from Brun 3383).

tereti, supra applanata. Petiolus 6–13 mm. longus, –1 mm. diam., gracilis, sicco purpureo-tomentosus vel nigrescens. Lamina delapsa ut integro pallide grisco-brunnescens. Racemi –7 cm. longi, semel vel bis ramosi, stipitis basi in fructu –1.5 mm. diam., terminales vel axillares, semel ramosi, conferte breviter plane purpureo-tomentosi. Alabastrum –6 mm. longum, parvum. Calyce breviter cinereo-purpurescens; corolla in vivo cremia, aristis brevibus obtusis, floribus aliter typicis. Calyx in fructu purpureo-tomentosus, lobis –9 × 8 mm., obovatis, plus minus revolutis, incrassatis, ad basim reflexis, apicem versus gradatim recurvis, rotatis. Nux –8 mm. longa lataque, globosa, saepe stylopodio brevi apicali, conferte purpureo-tomentosa.

Collections. *Brunei:* S 5753, Brun 3383, Kuala Belalong; Brun 357, Ulu Senuko-Ulu Katop watershed, Batu Apoi; Brun 764, Kuala Sekurop, Temburong (Holotypus in Herb. Kew); Kep 48465, Andulau F.R.

Studies in Systematic Bark Morphology

III.* Bark Taxonomy in Dipterocarpaceae

By T. C. Whitmore

St. John's College, Cambridge, England†

SUMMARY

Bark surface pattern and slash in Dipterocarpaceae were interpreted in terms of structure and seven main Bark Types described (Whitmore 1962a, b) which are general categories consisting of a number of Bark Manifestations that differ slightly in structure, hence in surface pattern and slash, from the general Type. The Bark Manifestations are practical categories distinct in the forest and are described and keyed here. A key is given to the Bark Types.

The kinds of variation in bark are described and their relative importance ascertained from detailed study of a few species. The main survey is based on 103 species in 7 genera (appendix 1). Their bark is described genus by genus, and the bark present throughout life shown diagrammetically (appendix 2 justifies the inductions on which the diagrams are based).

The use of bark for formal taxonomy and forest recognition is reviewed. Bark provides valuable taxonomic information: Symington's taxonomic groups are in main confirmed, and in some cases extended, particularly to include Bornean species. Comment is made on a number of outstanding taxonomic problems of individual species and a few new problems indicated. There is no evidence of adaptive bark differences between species of Rain forest proper and drier forests.

Twenty-one species and many species groups can be recognised in the forest; some previously confused Scaly barks are distinguished; little is added to previous distinctions within Dipterocarpaceae. It is suggested that the use of bark for forest recognition could be very considerably extended in families less well known to foresters.

---

* For parts I and II see *The New Phytologist*, 1962.

† Present address: Department of Botany, The University, Southampton, England.

THE BARK MANIFESTATIONS

General

I have described (Whitmore 1962a) how the surface pattern and slash appearance (oblique tangential section) of tree bark may be interpreted in terms of internal structure divided for convenience into four interacting bark components. 103 species in seven genera of Malayan and Bornean Dipterocarpaceae have been studied (listed in appendix 1); from these seven main *Bark Types* have been described (Whitmore 1962a) and interpreted (Whitmore 1962b) in terms of the relative rates of formation of xylem (wood) and phloem (bark) at the vascular cambium. These Bark Types are general categories and consist of a number of *Bark Manifestations* which have minor differences in the components from the general Type and hence differ slightly in surface pattern and slash. The Types are named after surface appearance (*Smooth,* Fig. 9a, *Dippled,* Fig. 9c, d, *Shallow Fissured,* Fig. 10a, *Deep Fissured,* Fig. 10b, and *Scaly,* Fig. 9b) or slash (*Surface Rotten,* Fig. 10c and *Laminate,* Fig. 10d). In this paper the Bark Manifestations and their taxonomic occurrence will be described.

Non floral characters are of established importance in the forest identification of trees in the tropics and bark surface and slash characters are important amongst others. Indeed in a family like Dipterocarpaceae which seldom flowers floral characters are only of secondary importance. Bark characters are at present used empirically. It is possible that their use for forest recognition can be extended now that the description of bark is rationalised and that bark can be used in studying the taxonomy of the family which is at present imperfectly understood.

The Bark Manifestations are practical categories. Deciding whether one bark is sufficiently different from another to be described as a separate Manifestation is partly subjective and the criterion adopted is that the bark must be distinct in the forest from surface or slash characters (a hand lens may be needed).

The Manifestations just like the Bark Types can be defined by describing the bark components and the results of their interactions. Manifestations differ from each other in one or more of the three grossly varying components, periderms, expansion tissue and phloem proliferation tissue. Periderms play the most important part in determining the surface appearance (Fig. 1 in Whitmore 1962a) and Manifestations usually differ in this component, for instance Manifestations of Shallow Fissured bark. In some barks however, for instance Manifestations of Surface Rotten and Laminate barks, the nature and amount of phloem proliferation tissue also exercises a very important effect on surface appearance. The fourth bark component, the secondary phloem, does not vary.

Variation is continuous and within some Manifestations there are bole barks, observed on a single species or a few trees, which differ in a few features. These I have described as *Variants* of the Manifestations, they are not always easily recognisable in the forest. Some forest-distinctive barks have also been described as Variants not Manifestations because they were suspected to be atypical or because the material examined was poor.

A few Manifestations (Smooth—e, Smooth—f and Shallow Fissured—c, q.v.) have characters intermediate between two Bark Types. I have placed these with the Bark Type they most nearly resemble in bole appearance from a distance.

Some barks do not fit the main Bark Types but have bark components of unusual structure, hence they differ in surface pattern and slash. These may be abnormal or may be additional Bark Types not well represented in this incomplete survey of the Dipterocarpaceae. They are mentioned with the notes on the species bearing them as they are of potential importance in understanding the bark of the whole family, and reference is made to the full diagnosis and discussion of status given in Whitmore (1960).

Names of Manifestations

The Manifestations are distinguished by a letter suffixed to the Bark Type, thus Smooth—a, Scaly—g.

Scheme for description of Manifestations

The visual impression of the bark from a distance is similar for all trees of a Manifestation but there are differences in some of the details of surface and slash. The diagnoses reflect this variability, some features are very precisely defined because they are invariable, others more loosely.

The Bark Type descriptions (Table 1, Whitmore 1962a) are indefinite because they cover the range of the Manifestations. In the Manifestation diagnoses the features of the Type are not repeated. The two descriptions together give a complete account of any bark. In this paper the Key to the Bark Types gives the main diagnostic features of each.

The description of each Manifestation follows the plan:

Diagnosis, with the most important features for identification in italics, under the subheadings:

Periderm(s), Inner Bark Structure (tangential expansion and phloem proliferation tissues), Outer Bark Structure (note that the rhytidome layers are usually developing and sloughing all the time so the number present varies), Sloughing and Surface (configurations, texture and colour),

Variants, species by species,

Occurrence, bole or crown and species group.

Photographs of the bole from a distance and close to and photographs or diagrams of a transverse surface are given to the Manifestations and Variants in Whitmore (1960), here Figs. 9 and 10 a selection of Manifestations of every Type.

Keys

There is a key to the Manifestations of every Bark Type making use of the salient features, a guide to the diagnoses but not supplanting them. The keys assist comprehension of the differences between the Manifestations and make possible the identification of the bark of any of the species examined or any others with one of these Manifestations.

The terms used in the diagnoses of the Manifestations and in the keys to the Bark Types and Manifestations are defined in Whitmore (1960 and 1962a).

KINDS OF VARIATION IN BARK

The basic structures and processes, the same in all trees of a species with bark at the same stage of development, must be distinguished from variable features and there may be developmental changes. Different features of the bark may vary at different taxonomic levels. The relative importance of these kinds of variation was ascertained early in this survey from frequently collected *Shorea,* Red Meranti group species, and from *Shorea albida* (Meranti Pa'ang), *Dipterocarpus costulatus, D. crinitus* and *D. verrucosus.* It is to some extent possible to distinguish inherited and environmental variations, the former are of potential use for forest recognition and taxonomy.

The variation expounded

1. The morphogenesis of bark throughout life was compared on the stems of seedlings, saplings, poles and trees and crown members of increasing girth. The Bark Type sequence is the same but in the crown the changes take place at smaller girths. The difference in phasing can be understood by postulating that the development of a Bark Type depends on the age of a member not its girth; poles grow at a more or less steady rate whereas there is little increase in girth in the crown members of mature trees.

There is considerable variation between trees in the girths at which the bark changes, this may be inherited or environmental. Species differ in their Bark Type sequence and girths of change.

There are often considerable variations in details of the bark between parts of an individual at the same stage, particularly between bole and crown (see 5 below) but also between lower and upper bole. These I ascribe to the difference in environment between the lower levels and canopy level of rain forest.

2. Inherited geographical variation. This would be expected to be most conspicuous in polymorphic species, and individuals from widely separated localities for instance Malaya and Borneo, perhaps as a sign of incipient speciation; however it proved to be uncommon. The only species of many examined in both Malaya and Borneo which shows it is *Hopea beccariana* and of *Shorea leprosula, S. macroptera, S. parvifolia, S. pauciflora* and *Dipterocarpus costulatus* examined all over Malaya only *S. parvifolia* shows geographical variation. The only geographical variation due to differences in the environment noticed was the tendency for trees to mature smaller and to become gnarled on ridges or in shallow or sandy, infertile soil.

3. Variations between individuals due to the cyclical development and sloughing of rhytidome layers is common with Scaly barks and may have inherited or environmental causes, in many cases I have not examined sufficient material to say which.

4. Slight differences in environment might produce variations in bark from tree to tree. Such variations are minimised in this survey by using trees from within the more or less uniform environment of Rain forest. There may be small inherited variations which will not be distinguishable.

Within a locality in the Rain forest minor differences occur in bark surface pattern, ridge width, fissure size, details of surface texture and sculpturings, in scale shape and size and the number of rhytidome layers present together. These limit the detail which can be usefully recorded in forest descriptions. Bark structure also shows variations, in periderm pattern and outer bark structure (particularly the degree of rotting), perhaps dependent mainly on micro-climate, in expansion tissue, dependent on the xylem/phloem relative growth rate, and in phloem proliferation tissue, still unexplained. Similar variations to these have been found between trees from different localities.

5. Some exposed trees have been examined to discover the potential variability of bark between open and Rain forest habitats but it would be difficult to study barks from such trees alone.[1]

(i) The variations found in the open are that the outer bark tends to be thicker with more rhytidome layers present together. The thicker layer of dead tissues is subject to stronger fissuring forces and desiccation is greater than in the forest; thus barks become fissured or more strongly fissured.

(ii) Environmental fluctuations are greater and the surface tends to become rugose and grey in colour.

(iii) Bark Types tend to develop at smaller girths than in the forest.

---

1. Hence difficult to study bark in England where most specimens of many broad leaved species grow in hedgerows and park land.

Similar differences were found between bark in the crown and on the bole where there are additional differences due to the extra strains set up by the bent shape and the exposure to wind of the crown members.

THE PROCEDURE FOR EXAMINATION

The species were investigated in the laboratory in the groups suggested by Symington (1943) which is the most natural subdivision of the family available, and natural subgroups were investigated together.

Within each group the procedure adopted after some trial was first to determine from the collected samples, the descriptions and any photographs the Bark Types present on the boles of the sampled trees than to work out the Bark Type sequence with the help of the published generalised descriptions (Foxworthy 1927, 1932, Symington 1943, Wood 1957).

Tables showing Bark Type sequence through life, species by species, are reproduced here, they also show at a glance the number of individuals sampled and their girths. Details of their construction are given in appendix 2. In some species paucity of material, particularly of small individuals, renders the Table incomplete.

The second step in the analysis was carefully to examine the samples of each Bark Type species by species and to record the structure on a table by the presence or absence of separate features. This led to the concepts of bark structure described in Whitmore (1962a). The diagnoses of the Manifestations and their Variants were made from these analysis tables; several of them are reproduced in Whitmore (1960) to show the magnitude of variation within and between Manifestations and Bark Types.

Once the extent of variation between trees had been established (see above) generalisations were made about the bark present at a particular girth from the examination of only a few individuals. The extent to which the data can be extrapolated to cover the whole girth range is investigated in appendix 2.

For each species group a short note is given on the present *Taxonomic status,* then follows the *Argument* with my findings on Bark Type sequence, the Bark Manifestations and any unusual features of bark structure, and finally the *Conclusions* which can be drawn on the taxonomy of the group, its subdivisions and particular critical species, and how the group can be distinguished in the forest from others with which it has previously been confused.

The Manifestations which are unique are noted and by referring to the diagnoses of these Manifestations the reader can discover the bark features whereby the trees can be recognised in the forest.

KEY TO BARK TYPES

A Expansion tissue uniform, continuous at surface in wedges and or fingers confluent externally into a pseudocortex,

B Some periderms forming scollop shaped rhytidomes 2–3 mm. thick of varying extent greater than 2–3 cm.; sloughing as scollops or large fractions thereof; surface dippled, scroll marked

DIPPLED BARK Fig. 9c, d

(*Shorea* Meranti Damar Hitam, *Vatica*).

BB Periderms single or 2–3 very near surface and almost touching; sloughing apparently absent; surface entire

SMOOTH BARK Fig. 9a

(young members of all groups; mature members *Anisoptera, Dipterocarpus, Hopea* Smooth and Mata Kuching, *Shorea*).

AA Expansion tissue localised in wedges or in clusters of fingers, tangential extent at inner bark surface usually 30% (rarely continuous, pseudocortex present); periderms not parallel to cambium for more than 1–3 cm. on TS; rhytidome of several thin layers completely and irregularly superimposed; surface closely, more or less regularly, V section fissured

SHALLOW FISSURED BARK Fig. 10a

(*Shorea* Red Meranti, Meranti Damar Hitam, Meranti Pa'ang).

AAA Expansion tissue disperse, tangential extent at inner bark surface about 10%,

C Periderms regular, always continuous, completely separating living tissues from dead; rhytidome layers extensive, sheet-like, outer bark clearly demarcated,

D Periderms frequently penetrated by fibres; 2–10 rhytidome layers present together, outer bark coherent, very dark; surface coarsely, closely fissured; sloughing as small, adherent, chunky scales

DEEP FISSURED BARK Fig. 10b

(*Hopea* Fissued Barked).

DD Periderms not penetrated by fibres; 1–2 (3) rhytidome layers present together; outer bark otherwise; surface not coarsely fissured, fissures scattered or close; sloughing usually as large, loose or adherent, layer-thick scales

SCALY BARK Fig. 9b
(*Balanocarpus, Dipterocarpus, Dryobalanops, Hopea* Scaly Barked, *Shorea* Red Meranti, Balau and Meranti Damar Hitam).

CC Periderms irregular, not always continuous or completely separating living tissues from dead; no regular rhytidome layers, outer bark appearance of progressive rotting from surface inwards,

E Compound laminae throughout bark; periderms pale coloured; inner edge of outer bark more or less parallel to cambium
LAMINATE BARK Fig. 10d
(*Anisoptera*).

EE Compound laminae absent, simple laminae sometimes present; periderms dark coloured; inner edge of outer bark following surface configurations, not parallel to cambium
SURFACE ROTTEN BARK
Fig. 10c
(*Shorea* Meranti Pa'ang).

MANIFESTATIONS OF SMOOTH BARK

Key to the Manifestations of Smooth bark

A Compound laminae present in inner bark; stone cell clusters filling pseudocortex; ..... *g, Anisoptera.*

AA Not as above,

B Expansion tissue in well defined wedges below regular superficial fissures. 3 mm. wide × 2 mm. deep, 2 cm. apart.

C Periderm thick (2 mm.), reticulate, occupying all but a narrow band of the pseudocortex
e, Shorea, Meranti Pa'ang.

CC Periderm not as above, ... *f, Shorea, Meranti Pa'ang.*

BB Expansion tissue in abundant fingers, surface not as above,

D Surface with finely striate, net-like pattern due to rupturing of outer periderms; periderms paper thin;
b, all groups.

DD Surface not as above; periderms not paper thin,

E Surface quite smooth, without fine sculpturings,

F Restricted to twigs (and probably seedlings and saplings too); surface purple brown; not sloughing ..... *a, all groups.*

FF Mature boles; not purple brown; sometimes sloughing

G Phloem proliferation tissue parenchyma only
j, most Smooth and Mata Kuching Hopeas.

GG Phloem proliferation tissue parenchyma and conspicuous stone cells
some c, Shorea, Red Meranti.

EE Surface finely sculptured,

H Mature periderms radially striate, hard, brittle, thick (c.0.4 mm.), can be chipped away; surface sometimes finely grid-cracked
d. Shorea, Meranti Damar Hitam.

HH Mature periderms not as above, cannot be chipped away; surface never grid-cracked,

I Surface rugulose or rugose due to fine sculpturings
some c. Shorea, Red Meranti.

II Surface fine sculpturings not as above,

J Surface fine sculpturings in form of fine, close, vertical lines less than 1 mm. deep and wide ..... *k, Vatica.*

JJ Surface fine sculpturings in form of short, superficial fissures to 1–2 mm. deep and wide,

K Phloem proliferation tissue usually of varying amounts in different tangential zones of fibrous part of bark, sometimes white with silica deposited,
h, Dipterocarpus.

KK Phloem proliferation tissue uniform, never siliceous,
Hopea vesquei (j).

MANIFESTATION Smooth—a

Diagnosis: Periderm: single superficial. Inner bark structure: mature bark structure not yet developed; an earlier stage present. Sloughing: apparently nil. Surface: *quite smooth; purple brown.*

Occurrence: Restricted to twigs up to 8 cm. girth, probably also on seedlings and saplings though bark of these was not examined. Probably present in all species groups; its apparent absence from some may be because no small twigs were examined or because there had been no recent growth flush and the twig bark had changed on ageing.

Discussion: Further examination may show that this is the bark present before periderm has developed when the epidermis forms the surface. The stages in the development of mature bark structure are described in Whitmore (1960 Chapter 8b).

MANIFESTATION Smooth—b

Diagnosis: Periderms: several, close, paper thin. Inner bark structure: crown structure immature; bole as Type (expansion tissue of tangentially elongate stone cells and or parenchyma; phloem proliferation tissue usually extensive, large circular stone cells and parenchyma). Sloughing: as Type. Surface: finely sculptured—*outer periderms rupturing and forming an open net pattern on the surface.*

Variants:

1. *Shorea waltoni* (Red Meranti): Inner bark: phloem proliferation tissue: circular stone cells aligned in inconspicuous tangential sheets—c.f. Smooth—c also a few conspicuous sheets of radially elongate stone cells.

2. *Shorea*, Meranti, Damar Hitam species: Periderm: thick on bole, to 0.3 mm.—c.f. Scaly—d.

Occurrence: Crowns and some young boles, perhaps all groups; seen in *Anisoptera; Balanocarpus; Dipterocarpus* and *Shorea* all groups.

MANIFESTATION Smooth—c

Diagnosis: Periderms: 1–2 present together. Inner bark structure: as Type (expansion tissue of tangentially elongate stone cells and parenchyma; phloem proliferation tissue usually widespread of parenchyma and *large circular stone cells*). Outer bark structure: thin rhytidome layers to 1–2 mm. thick. Sloughing: as Type. Surface: either finely sculptured rugose, rugulose, or not sculptured, smooth with small lenticels.

Variant:

1. *Shorea mecistopteryx* (Red Meranti): Inner bark: phloem proliferation tissue in the fibrous part as tangential sheets of radially elongate stone cells, interrupted outwards by the broad expansion tissue fingers where these merge with the pseudocortex, hence not forming long continuous sheets not dominating appearance of cut transverse surface.

Occurrence: Restricted to boles; *Shorea*, Red Meranti.

MANIFESTATION Smooth—d

Diagnosis: Periderms: usually only one; *phellem thick (to 0.4 mm.)*, radially striate, soft and pale when first formed but soon becoming *brittle and dark;* phelloderm absent, or thin (but occasionally to 0.2 mm.); phellem may be chipped away, sometimes to reveal the bright phelloderm—the 'scrape'. Inner bark structure: as Type (expansion tissue mainly of parenchyma or small stone cells, phloem proliferation tissue absent or localised). Outer bark structure: mainly thin; periderm single, superficial; in places, especially crown, a thin rhytidome (0.5 mm.) where parts of a former periderm persist. Sloughing: as Type. Surface: periderm becoming finely sculptured:—rugulose, rugose, finely grid-cracked (5 mm. × 3–4 mm.), or longitudinally striate (in crown). Lenticels along lines of periderm rupture, periderm tissue powdery here.

Occurrence: Bole and crown; *Shorea*, Meranti Damar Hitam.

MANIFESTATION Smooth—e

Diagnosis: Periderm: superficial, firm, dark sheet with inwards a zone, 2 mm. thick, of convoluted, anastomosing, dark, hard 'phellem' tissue interspersed with paler bands of 'phelloderm,' together making up a *hard dark reticulated layer*. Inner bark structure: Pseudocortex only a few mm. thick, the inner part of the very thick periderm probably formed from and in pseudocortical tissue. Expansion tissue in *well defined wedges, no fingers*. Phloem proliferation tissue: small, scattered, tangential laminae, mentioned in all the published generalised descriptions but absent or only slightly developed in the samples examined (then simple laminae, sheets of stone cells); other phloem proliferation tissue restricted to outermost phloem blocks. Outer bark structure: see periderm. Sloughing: apparently absent. Surface: dark coloured, *with regular, superficial fissures* (3 mm. wide × 2 mm. deep) above the wedges but not penetrating into inner bark; ridges 2 cm. wide with small, scattered lenticels, otherwise smooth and firm.

Occurrence: Bole, *Shorea ochracea*, and perhaps other species of Meranti Pa'ang.

Discussion: The distinction of 'phellem' and 'phelloderm' is not certain as no phellogens have been made out. This Manifestation is described from a single tree. It is conceivable that the thick reticulated periderm, its main distinctive feature, is a pathological condition, although the tree appeared quite healthy, and that further research will show Smooth—e and —f to be identical.

MANIFESTATION Smooth—f

Diagnosis: Periderms: 1–2 present together. Inner bark structure: *same as Smooth—e with wider pseudocortex.* Outer bark structure: thin rhytidome layers, to 1–2 mm. Sloughing: apparently absent. Surface *same as Smooth—e.*

Occurrence: Bole and crown; *Shorea bracteolata, S. symingtoniana* and perhaps other species of Meranti Pa'ang.

Discussion: This Manifestation differs from Smooth—e, the other smooth bark of the Merantis Pa'ang's in the periderms and the outer bark which resemble Smooth—c.

MANIFESTATION Smooth—g

Diagnosis: Periderm: single, superficial, 0.20 mm. thick, pale in colour. Inner bark structure: *tangential laminae of compound structure, throughout,* varying in stage of development from one phloem block thick and tangentially short to thicker and more or less continuous; laminae interrupted by fingers and by pseudocortex where this penetrates inwards; *pseudocortex more or less filled with stone cell clusters,* not laminate; expansion tissue in broad fingers developing from pairs of rays. Sloughing: apparently absent. Surface: superficial fissures 4–10 mm. wide × 2 mm. deep, wholly periderm bounded, not in any way disrupting the overall smooth bole appearance; pale, at periderm.

Occurrence: Crowns and boles; *Anisoptera.*

Discussion: Periderm same as Smooth—c except for the pale colour. Laminae not developed in inner bark at 1 ft. girth on bole (*A. scaphula*), developing at 3 ft. (*A. laevis*).

MANIFESTATION Smooth—h (Fig. 9a)

Diagnosis: Periderms: usually 2, sometimes 1 only; strongly small-undulate on TS and LS. Phellem hard, sclerified, pale coloured; phelloderm thick (to 0.5 mm.). Inner bark structure: as Type (expansion tissue: parenchyma; *phloem proliferation tissue:* extensive, small stone cells not in clusters greater than one matrix block, *usually of variable amount in different tangential zones of the bark,* increasing outwards); silica sometimes deposited in matrix. Sloughing: as Type. Surface: finely sculptured: *rough with short (to 5 cm.) close (few mm.) superficial fissures (1–2 mm. wide and deep) developing in the thickness of the outer bark.*

Occurrence: Boles of immature individuals and probably mature tree crowns of *Dipterocarpus.*

Discussion: Inner bark: expansion tissue and phloem proliferation tissue are the same as Scaly—e.

MANIFESTATION Smooth—j

Diagnosis: Periderms: as Smooth—c. Inner bark structure: as Type (expansion tissues as Smooth—c; *phloem proliferation tissue: parenchyma only*). Outer bark structure: as Smooth—c. Sloughing: as Type. *Surface: smooth, entire, no fine sculpturings.*

Variant:

1. *Hopea vesquei:* Surface: finely sculptured—close regular superficial fissures.

Occurrence: Boles, *Hopea.* Smooth and Mata Kuching.

MANIFESTATION Smooth—k

Diagnosis: Periderms: as Smooth—c. Inner bark structure: as Type (expansion tissue as Smooth—c; *phloem proliferation tissue: parenchyma only) silica often deposited.* Outer bark structure: as Smooth—c. Sloughing: as Type. *Surface: finely sculptured: close, fine, vertical lines less than 1 mm. deep and wide.*

Occurrence: Boles, *Vatica.*

MANIFESTATION OF DIPPLED BARK

MANIFESTATION—a (Fig. 9c; 9d shows the much more strongly dippled bark of *Agathis alba*)

Diagnosis: Periderms: pattern: as Type; structure: 0.2 mm. thick. Inner bark structure: as Type. Outer bark structure: thin, or with 2 mm. thick scollops, 2–6 cm. in diameter, varying between trees. Sloughing: as Type. Surface: as Type.

Variants:

1. *Shorea:* Inner bark: phloem proliferation tissue absent.

2. *Vatica:* Inner bark: phloem proliferation tissue widespread, of parenchyma, white and silicified.

Occurrence: Boles; *Vatica* and *Shorea* Meranti Damar Hitam (*S. faguetiana* and *S. multiflora*) where it is probably intermediate between Smooth and Scaly bark.

MANIFESTATIONS OF SHALLOW FISSURED BARK

Key to the Manifestations of Shallow Fissured bark

A Expansion tissue localised in well defined wedges below fissures which penetrate into inner bark (though usually lined by periderm(s)),

B Pseudocortex present in outer inner bark or outer bark; outer bark essentially a superficial skin of close, anastomosing or almost touching periderms; 1–3 mm. thick; sloughing apparently absent from boles; bole appears smooth-fissured
a, Shorea Red Meranti (bole & crown) and Meranti Damar Hitam (crown only).

BB Pseudocortex absent; outer bark not a superficial skin; 3–11 mm. thick; sloughing always present; bole appears coarsely fissured
b, Shorea, Red Meranti
e, Shorea talura, Meranti Pa'ang.

AA Expansion tissue not as above; fissures not penetrating into inner bark,

C Surface coarsely fissured; ridges rugose; outer bark to 17 mm. thick, of up to 12 rhytidome layers; pseudocortex absent; expansion tissue in clustered fingers
d, Shorea gibbosa, Meranti Damar Hitam.

CC Surface shallow fissured; ridges smooth; outer bark 1–3 mm. thick, never more than 3–4 rhytidome layers; thin pseudocortex present; expansion tissue in uniformly distributed fingers ..... *c, Shorea macroptera, Red Meranti.*

MANIFESTATION Shallow Fissured—a

Diagnosis: Periderms: *multiple structure,* thickness variable (0.03 mm.–0.20 mm.), phellems black and usually leathery, phelloderm either apparently absent, or 0.25 mm. thick. Several, close (0.5–1.0 mm. apart, rarely more); pattern as Type. Inner bark structure: *pseudocortex present;* expansion at first by fingers and wedges then by wedges only; phloem proliferation tissue: as Type. Outer bark structure: *essentially a superficial skin, 3 mm. thick or less,* usually dipping in at, and bounding the fissures. Sloughing: *on boles apparently absent;* in crowns absent or as layer-thick, brittle, thin, scales, adherent before sloughing. Surface: as Type; *fissures penetrating inner bark;* ridges smooth, sometimes microlichen flecked; surface firm, dark coloured, at a periderm; bole smooth-fissured, becoming coarsely fissured on old trees.

Variants:

1. *Shorea parvifolia* (Red Meranti): Periderms: phelloderm absent or inconspicuous. Inner bark: no phloem proliferation tissue in fibrous part. There are two phases:

(*a*) Trees to about 6 ft. girth.

Bole appearance: smooth, shallow fissured, blotched with microlichen flecks. Fissures wide-V section, shallow (5–7 mm. wide × 2 mm. deep), regular; ridges: flat, firm, with slightly raised edges.

(*b*) Trees above about 6 ft. girth.

Bole appearance: variably, coarsely fissured. Fissures wider and deeper, less regular than before (to 10 mm. wide by 5 mm. deep); the ridges lose their continuous vertical and smooth appearance and sometimes fissure further, the surface becomes rugose but remains quite firm.

A conspicuous feature of this species is what Symington (1943) called 'small warty portions of the bark'. These are often present, mainly on young trees to about 6 ft. girth, damar often drips from them. They are formed by the bole swelling over a zone (average size 30 cm. broad × 15 cm. high but sometimes tangentially greater) and bursting the normal outer bark which remains as a rough fringe to the swelling which becomes surfaced by fresh periderms.

2. *Shorea leprosula* (Red Meranti): Periderms: distinct red brown phelloderms present. Inner bark: phloem proliferation tissue in scattered tangential sheets; a few dammar channels present in phloem rays stretching from xylem to surface. Outer bark: periderms develop beneath fissures first and spread outwards beneath ridges, hence there are more periderms at fissure sides than under ridge centres; periderms, ruptured by subsequent fissure increases and only 1–2 innermost are continuous beneath fissures; periderms furthest apart and hence rhytidome layers thickest at fissure edges, becoming closer towards ridge centres. Subsequent enlargement of expansion tissue wedges below fissures forces fissure edge tissue outwards so that ridges become slightly concave in section. There are two phases:

(*a*) Trees to about 5 ft. girth.

Bole appearance: smooth-fissured; fissures 5 mm. wide × 3 mm. deep, ridges 2–3 cm. wide with small lenticels and raised marks continuous across several ridges.

(*b*) Trees above about 5 ft. girth.

Bole appearance: coarsely fissured, surface rough. Fissures become compound, getting progressively wider, to as much as 20 mm.; smooth ridges progressively wider separated. Tissue interpolated at fissures sometimes form a mass of cork tissue which comes to fill the fissures except for a narrow central groove and may protrude above the general level so emphasising the concavity of the ridges.

Occurrence: Crowns, *Shorea* Red Meranti and Meranti Damar Hitam (*S. gibbosa*); boles, *Shorea* Red Meranti, *S. parvifolia* and *S. leprosula.*

Discussion: Sloughing: outer bark almost free of fibres, no strong connections between rhytidome layers although periderms of multiple structure, thus sloughing easy, down to a periderm and outer bark fairly thin.

MANIFESTATION Shallow Fissured—b

Diagnosis: Periderms: *multiple structure,* thickness variable (0.03 mm.–0.40 mm.), phellems black and usually leathery, phelloderms absent or in conspicuous isolated lenses, 0.4 (1.0) mm. thick, and also sometimes in strips along fissure edges. Pattern: as Type. Inner bark structure: as Type (expansion tissue in wedges, tangential extent 30 (25–30) %). Outer bark structure: 3 or more rhytidome layers usually present together, thickness variable, outer bark 3 mm. or more, rarely as much as 11 mm., thick. Sloughing: ridge-wide, chunky or layer-thick elongate scales, adherent before sloughing. Surface: as Type, ridges concave in section when phelloderm strips have formed; *fissures penetrating inner bark;* ridge surfaces firm or not, powdery. Bole appearance coarsely fissured.

Variant: *Shorea rubella* (Red Meranti): Periderms: much larger scollops of tissue enclosed, 4 cm. wide × 5–7 mm. thick; brown not black coloured. Outer bark: very thick, 10–14 mm. Surface: fissures coarser than above.

Occurrence: Restricted to boles; *Shorea.* Red Meranti.

Discussion: Sloughing: the scales are chunky, and adherent before sloughing because there are no definite localised planes of sloughing at or near the multiple structure, fibre-penetrated periderms.

MANIFESTATION Shallow Fissured—e (Fig. 10a)

Diagnosis: Periderms: single sheets; several, undulate, anastomosing, variously separated. Inner bark structure: *narrow band of pseudocortex; expansion tissue in uniformly distributed fingers*—uniseriate files of tangentially elongate stone cells; phloem proliferation tissue extensive, *small circular stone cells formed in most phloem blocks.* Outer bark structure: *1–3 mm. thick,* only partially penetrated by fissures. Sloughing: small chunky or layer-thick, thin, scales; sloughing sometimes apparently absent. Surface: *regular, superficial fissures* with slightly raised edges disrupting the overall smooth appearance of bole; ridges smooth, surface firm, powdery or not.

Occurrence: Boles only, *Shorea macroptera* (Red Meranti).

Discussion: Periderm separation variable hence outer bark from 'surface skin' of —a to thicker, like —b. Surface pattern is similar to *S. parvifolia,* —a.

MANIFESTATION Shallow Fissured—d

Diagnosis: Periderms: thick (0.4 mm.), dark brown, *single sheets;* anastomosing on TS; undulate but not anastomosing on LS. Inner bark structure: expansion tissue in *fingers localised in clusters,* of tangentially elongate stone cells only, tangential extent about 40%; phloem proliferation tissue localised, of parenchyma. Outer bark structure: *many (to 12) rhytidome layers; to 17 mm. thick;* formed of unevenly overlapping scollop-section strips of thickness varying from 1.5–4.0 mm. Sloughing: elongate, *chunky scales.* Surface: fissures not penetrating inner bark; ridges rugose, with loose powdery surfaces; bole appears coarsely fissured.

Occurrence: Boles only, *Shorea gibbosa* (Meranti Damar Hitam).

Discussion: Outer bark coherent and long persistent, no definite sloughing planes develop hence scales are chunky, contrast with Scaly —d (same species group) which has sloughing planes within the phellems.

MANIFESTATION Shallow Fissured—e

Diagnosis: The only sample available was too badly damaged to ascertain characters of the outer bark: the inner bark structure is of this Bark Type. There is a full discussion in Whitmore (1960, pp. 304–6). Periderms: present, more or less continuous. Inner bark structure: as Type (expansion tissue in wedges of 30% tangential extent; phloem proliferation tissue absent). Outer bark structure:—. Sloughing:—. Surface: as Type; bole coarsely boat-shape fissured.

Occurrence: Boles, *Shorea talura* (Meranti Pa'ang); crown not examined.

MANIFESTATION OF DEEP FISSURED BARK

MANIFESTATION—a (Fig. 10b)

Diagnosis: See Table 1 (Whitmore 1962b) and key to the Bark Types p. 327 above.

Variant:

1. *Shorea beccariana* (Malayan trees 180 & 197): Periderms: closely anastomosing on LS and TS. Outer bark structure: rhytidome layers narrow imbricating. This is so similar to the Bornean tree seen (488) and to the other species in all respects except the closely anastomosing periderms (the anastomoses do not coincide with the fissure edges) that, on the evidence available, it is included in the same Manifestation; further material is needed to decide whether the periderm difference is consistent and if there are other differences, hence whether this really is the same Manifestation.

Occurrence: Fissured Barked *Hopeas.*

MANIFESTATIONS OF SCALY BARK

Key to the Manifestations of Scaly bark

A Phellem 2 zoned, inner dark blackish brown and outer biscuit coloured layers; surface at periderm, pale when new becoming very dark by erosion ..... *g, Dryobalanops.*

AA Phellem 1 zoned, dark or pale; surface at periderm or not,

B Expansion tissue in radially short fingers, more numerous outwards,

C Phloem proliferation tissue entirely parenchymatous; radial-oblique fingers sometimes present; phelloderm pale, conspicuous and relatively thick (0.3 mm.)
c. Shorea, Balau.

CC Phloem proliferation tissue with conspicuous, pale stone cells; radial oblique fingers absent; phelloderm inconspicuous, thin, or absent,

D Surface grid-cracked ..... *b, Shorea, Red Meranti.*

DD Surface often with more or less regularly distributed close fissures but no cross cracks
a, Shorea, Red Meranti.

BB Expansion tissue, if present, in fingers stretching from near cambium to surface and becoming wider outwards,

E Phloem proliferation tissue always extensive usually of varying amounts in different tangential zones sometimes distorting secondary phloem structure, sometimes white, silicified; surface with powdery bloom ..... *e, Dipterocarpus.*

EE Phloem proliferation tissue absent or extensive, constant in amount throughout thickness of bark, never distorting secondary phloem structure; surface shiny without powdery bloom,

F Phellem 0.4 mm. thick; 0, 1, or, rarely, 2 rhytidome layers present together
d, Shorea, Meranti Damar Hitam.

FF Phellem 0.1–0.2 mm. thick; 1–2 rhytidome layers present together, rarely 0
f, Scaly Hopea, Balanocarpus.

MANIFESTATION Scaly—a

Diagnosis: Periderms: several; on TS sometimes anastomosing about every 5–7 cm.; on LS anastomoses greater than 15 cm. apart; usually simple structure, rarely multiple; phelloderm absent or present, continuous and inconspicuous or in isolated, conspicuous lenses. Inner bark structure: expansion tissue in radially short fingers, more abundant outwards, tangential extent about 5% only; phloem proliferation tissue extensive, *a few conspicuous simple laminae usually present*, of small radially elongate stone cells, more or less uniform in amount throughout bark, not distorting secondary phloem. Outer bark structure: up to 3, occasionally more, thick (2–3 mm.), sheet-like rhytidome layers present together. Sloughing: as several layers of thick, more or less elongate, layer-thick or chunky scales. Surface: firm, powdery; usually with *more or less regularly distributed and close square section fissures;* ridges variously rough; bole more or less regularly fissured.

Variants:

1. *Shorea kunstleri:* Periderms multiple sheets in structure.

2. *Shorea andulauensis:* Periderms: structure: phellems locally undulate, single at scollop bottoms, multiple at their sides. Inner bark structure: expansion tissue apparently absent; phloem proliferation tissue localised into tangential sheets of small, circular stone cells. Outer bark structure: rhytidome layers scollop shaped, to 17 cm. long × 5 cm. wide × 2–4 mm. thick in middle; overlapping unevenly on TS and LS, but more or less forming continuous sheets; tissues becoming loosely powdery on ageing. Sloughing: rhytidome layers sloughing entire as scollop shaped scales, or fissuring and shedding in pieces. Surface: fissures narrow, localised in zones.

Discussion: The surface appearance is within the range of Scaly—a the differences in inner bark structure can only be made out with difficulty in the forest so this is considered to be a Variant not a different Manifestation.

3. *Shorea singkawang, S. leptoclados* and butts and overmature boles of other Red Meranti species: Periderms: one superficial, in places with another scolloping one. Outer bark structure: heterogeneous, thin areas, and areas with one rhytidome layer. Surface: heterogeneous, smooth with scattered scales or with zones of irregularly fissured, elongate-scaly bark.

4. *Shorea leptoclados:* Outer bark tissues becoming pale, cream coloured, free from tannins. Sloughing: papery flakes, free or in bundles. Surface: dull purple, either at periderm; or not, cream (note similarity with Variant 2 of Scaly—c).

5. *Shorea pauciflora* (563): Sloughing: as Variant 4.

Occurrence: Bole and crown; *Shorea* Red Meranti; crown *S. albida* (Meranti Pa'ang).

MANIFESTATION Scaly—b

Diagnosis: Periderms: several, scolloping regularly on TS and LS; phelloderm apparently absent. Inner bark structure: expansion tissue as Scaly—a; phloem proliferation tissue: widespread, of circular stone cells *conspicuous like sand grains on cut TS;* sometimes in tangential sheets. Outer bark structure: 2–3 scollop shaped rhytidome layers, average size 3 cm. wide × 9 cm. long. Sloughing: of all rhytidome layers, variously as ridge-wide, layer-thick or slightly chunky, more or less square scales. Surface: rough, powdery; *grid-cracked,* cracks 2–3 cm. apart.

Occurrence: Boles: *Shorea acuminata* and *S. quadrinervis* (Red Meranti).

MANIFESTATION Scaly—c

Diagnosis: Periderms: pattern variable, TS and LS either distantly or not scolloping, or, rarely, closely scolloping and forming small (c 4 cm.) scollop shaped rhytidome layers. Structure: periderm thickness variable (mean 0.40 mm. (0.01–1.20 mm.)); phellem dark brown or black, phelloderm *continuous, pale, conspicuous and relatively thick* (mean 0.3 mm. (0.00–0.80 mm.)) sometimes of layers of alternating orange and cream tissues. Inner bark structure: expansion tissue: tangential extent 8 (0–18) %, in fingers of tangentially elongate stone cells becoming more abundant outwards and often clustered; *radially oblique stone cell fingers often present;* extensive parenchymatous phloem proliferation tissue, sometimes becoming more abundant outwards. Outer bark structure: rhytidome layers sheets, or elongate strips, or rarely scollop shaped; 0,1,2 or occasionally more present together; thickness varying from 1.5–7.0 mm.; tissues usually same colour as inner bark, rarely becoming pale. Sloughing: scales layer-thick, usually large, either cracking or fissuring before sloughing, or not—hence either elongate or isodiametric. Surface: usually near periderm, surface dull, powdery, with hue of dead phloem tissues, or sometimes at or weathering down to a periderm, then very dark in colour; fissures absent, or present and as variable as the Type (sometimes mere cracks); sometimes surface scroll marked.

Variants: Some of the Variants differ considerably from the Manifestation but were only seen on one or a few trees; if they prove typical of their species their status need reconsidering.

1. *Shorea geniculata* (one tree, perhaps a typical), *S. humutensis, S. laevifolia* and *S. laevis* (sometimes): Outer bark: of 2–4 rhytidome layers. Sloughing: scales usually elongate, adherent. Surface: more or less regularly fissured, fissures of irregular section, penetrating several rhytidome layers; hence bole impression 'fissured'.

Discussion: The essential feature of this Variant is the thick outer bark; this depends on the structure of the periderms. The property of the periderms which hinders sloughing of the first two species is not known. The latter two have on all the trees examined thin (0.04 mm.) phelloderm or none and fibres penetrating the mature periderms, which are not continuous but in 4 cm. lengths; hence the rhytidome layers persist for some time, not sloughing until the fibres have rotted through.

2. *S. guiso, S. ochrophloia:* Outer bark tissue becoming pale, cream or fawn coloured and loose, soft and powdery. Sloughing: not quite down to the periderm; hence bole with a characteristic yellow-grey tinge.

Discussion: The essential feature of this Variant is the physiological change which takes place in the rhytidome after periderm formation. Note the similarity with Variant 4 of Scaly—a.

3. *S. foxworthyi:* A similar change to the above, but caused by weathering and only affecting the thin film of phloem tissue outside the outermost periderm.

4. *S. inappendiculata:* Periderms: scolloping on TS and LS, cleanly rupturing fibres. Outer bark: rhytidome layers 4–7 mm. thick × 3–4 cm. wide × 7–12 cm. or more long. Sloughing: elongate, adherent, layer-thick scales, whole scollops or large fractions of scollops. Hence: surface scroll marked, fresh surfaces powdery, later eroding down to periderm, so colour darkening. The two trees seen were both similar, with these unique features; they were exposed at a trackside and are possibly atypical.

5. *S. sp. nov. 269:* Periderms with blackish phellem and cream phelloderm; hence scrape strikingly coloured. Surface not powdery, very dark coloured.

Occurrence: Boles, *Shorea*, Balau.

Discussion: This is a broadly phrased diagnosis which encompasses the variable mature bark of the 17 species of the Balau group of *Shorea* examined. The variations are mainly in periderm pattern and structure and these cause variations in outer bark structure (thickness and shape of rhytidome layers), sloughing pattern (scale size, shape and persistence) and surface (fissuring).

MANIFESTATION Scaly—d

Diagnosis: Periderms: seldom more than 2 present together, distantly scolloping (33 cm.) on TS and LS; *thick (to 0.4 mm.) mostly phellem, phelloderm thin or apparently absent; becoming dark coloured, hard and brittle on maturing.* Inner bark structure: tissues yellowish becoming green towards cambium; expansion tissue either apparently absent or in abundant fingers, tangential extent 15 (4–30)%, each becoming wider outwards, of parenchyma or small stone cells in which are sometimes set short radial files of tangentially elongate stone cells; phloem proliferation tissue absent, localised or widespread, of parenchyma or circular stone cells only. Sometimes with damar channels exuding liquid damar when cut. Outer bark structure: *usually heterogeneous; partly with 1 (rarely 2)* sheet like *rhytidome layer(s)*, 3–4 mm. thick, *partly with none*, outer bark thin and superficially fissured; sometimes mainly thin. Sloughing: elongate, ridge-wide, layer-thick scales; sloughing plane within periderm, scales loose hanging before sloughing. Surface: at periderm, *dark coloured, not powdery*, sometimes turning grey, usually heterogeneous, rhytidome a single layer or absent; narrow square section fissures (less than 5 mm. wide × 5 mm. deep), or cracks, irregularly distributed; marks of scollops remaining as scroll marks (frequency variable) after sloughing: these fissured areas interpersed with smooth areas, *often finely lenticellate*, which become larger on old trees, to dominate appearance: sometimes with black or yellowish pendent, fine damar stalactites. Visual impression: dark, heterogeneous, smooth and scaly.

Variants:

1. *Shorea balanocarpoides* (355): Inner bark: expansion tissue occupying 60% of surface, in abundant, wide fingers.

2. *Shorea hopeifolia* (306), *S. multiflora* (171): Inner bark: expansion tissue apparently absent; phloem proliferation tissue extensive. Outer bark: rhytidome layers 6–7 mm. thick. These are overmature trees (respective girths 12 ft. and 15 ft.). The cut surface of the inner bark is similar to Scaly—a in appearance.

Occurrence: Boles, *Shorea*, Meranti Damar Hitam.

Discussion: Periderms: few fibres connect the inner and outer bark through these thick periderms hence the rhytidome layers tend to hang loose before sloughing. The sloughing plane is within but very near the outside of the phellem.

Damar is often extruded through the inner bark and through cracks in the innermost periderm and may spread out over the outer surface of this periderm and so perhaps hasten the separation and sloughing of the rhytidome layer. Thus the surface may have a thin damar coating and this contributes to the dark, dull bole colour. In some species the damar is exextruded as far as the outer surface of the bark where it hardens in contact with the air and forms conspicuous drips, diagnostic of their species (see Symington, 1943).

MANIFESTATION Scaly—e (Fig. 9b)

Diagnosis: Periderms: 1 superficial periderm, in places with another deeper 1 or rarely 2; not anastomosing or distantly, and forming very large (50 cm. across) or, rarely, smaller (15 cm.) scollops; periderms pale; average thickness 0.6 mm.; phellem usually hard and sclerified, continuous phelloderm usually present, and fawn so not conspicuous or clearly demarcated. Inner bark structure: expansion tissue variable in amount, apparently absent or in fingers of parenchyma, rarely with a few files of tangentially elongate stone cells too, usually widening outwards; occupying tangential extent 10 (0–30) %; some rays becoming wider than others; rarely pseudocortex present; phloem proliferation tissue extensive, of small stone cells *amount usually variable in different tangential zones of the bark: sometimes, especially in outer parts. distorting radial arrangement of secondary phloem; silica sometimes deposited.* Outer bark structure: heterogeneous; thin areas and others with 1 (rarely 2) rhytidome layer(s). Sloughing: scattered layer-thick scales, usually large and more or less isodiametric, loose hanging or adherent before sloughing. Surface: firm, powdery; fissures usually absent, except in species with several continuous rhytidome layers; *usually with close set round lenticels;* occasionally a few scroll marks; *surface sometimes gently undulate with depressions and bulges;* visual impression: heterogeneous, smooth with variously scattered scales.

Variants:

1. *Dipterocarpus appendiculatus:* Outer bark: several rhytidome layers present together all over bole. Sloughing: of small loose hanging, elongate scales all over bole. Surface: tendency to fissure over whole hole so visual impression scaly-fissured.

2. *D. costulatus, D. rotundifolius:* intermediate between the 'typical' species and *D. appendiculatus.*

On the available data the differences between *D. appendiculatus* and the other species are not sufficiently clear cut to consider the bark as a different Manifestation. Examination of other fissured and scaly-fissured species (for instance *D. chartaceous, D. obtusifolius, D. rigidus,* and *D. tuberculatus*—the last three from Burma) might necessitate such a step.

3. *D. crinitus:* Periderm: 1.0 mm. thick with a very thick (0.8 mm.), pale, easily visible phelloderm.

4. *D. sublamellatus:* Periderm: thin, 0.2 mm.

5. *D. cornutus, D. verrucosus:* Inner bark: phloem proliferation tissue so distorting secondary phloem that a pseudocortex is formed in some trees.

6. *D. verrucosus:* Periderm: thin, 0.1 mm.; rhytidome layers thin, only 2 mm.; surface tinged reddish.

Occurrence: Boles; *Dipterocarpus.*

Discussion: Inner bark; expansion tissue and phloem proliferation tissue are the same as Smooth—h; further the expansion tissue is, like Scaly—d, very variable in amount between individuals and species. Amount of phloem proliferation variable between different trees and different species. Sometimes tangentially adjacent, proliferated phloem blocks become aligned into sheets just visible as fine lamellae to the unaided eye, these are much finer than the 'simple laminae' of Scaly—a and —b. Tissues just below the superficial periderm tinged green in a few samples presumably due to the presence of chlorophyll. The differences between species in appearance is largely due to differences in details of the periderm pattern and structure, hence in the sloughing pattern (scale size, thickness, closeness, and whether loose hanging or adherent), but there is considerable variation and overlap between species. Surface: the size and closeness of the lenticels varies between species.

MANIFESTATION Scaly—f

Diagnosis: Periderms: distantly scolloping, c.5 cm. on TS, greater than 17 cm. on LS; structure: *0.1–0.2 mm. thick, phellem hard, black, phelloderm absent or thin (0.04–0.02 mm.).* Inner bark structure: expansion tissue apparently absent or in fingers widening outwards or not, tangential extent 10 (0–19) % also sometimes a few rays with short radial lengths of tangentially elongate stone cells, increasing in number outwards; phloem proliferation absent or present and extensive, parenchymatous. Outer bark structure: *rhytidome layers,* broad sheets or elongate strips, *1 or 2 present together, or rarely none;* outer bark tissues mid brown. Sloughing: close or scattered, elongate or isodiametric, loose hanging or adherent scales. Surface: dark coloured, commonly blackish brown, at a periderm so not powdery, fissures present, as variable as the Type (q.v.); scales not fissures dominating appearance.

Variants: The considerable variability between the species of *Hopea* examined is discussed with the notes on the genus.

1. *H. helferi:* Surface powdery, not at a periderm.
2. *Balanocarpus heimii:* Inner bark structure: expansion tissue absent except sometimes for a few clustered, short, parenchymatous fingers, more abundant outwards; phloem proliferation tissue absent or present and more abundant outwards. Outer bark structure: rhytidome layers elongate strips. Sloughing: close, elongate, loose (rarely adherent) scales. Surface: close, irregular section fissures.

Occurrence: Boles; Scaly Barked *Hopea; Balanocarpus.*

MANIFESTATION Scaly—g

Diagnosis: Periderms, pattern: TS and LS; either sheet like not scolloping or, occasionally, distantly (7 cm.) scolloping; structure: *continuous not penetrated by fibres at all* or phellem (first formed) penetrated then phelloderm (later formed) rupturing fibres; thin (0.2 mm. (0.04–0.5 mm.)), *phellem two zoned with inner impervious dark blackish brown and outer biscuit coloured* layers; phelloderm absent or thin (0.02 (0.0.4) mm.), inconspicuous, merging with phloem. Inner bark structure: expansion tissue in fingers, tangential extent 9 (4–13) %, usually parenchyma, fingers either becoming more numerous or widening outwards, sometimes a few connate; widespread, scanty phloem proliferation tissue, forming small stone cells and, or, parenchyma, and varying numbers of extensive, tangential sheets of radially elongate stone cells, *0.2–0.4 mm. thick and visible as fine lamellations to unaided eye.* Outer bark structure: bole heterogeneous; either several, extensive, sheetlike (rarely scollop-form) rhytidome layers, or 1, or 0, forming irregularly, never in zones, up bole; *rhytidome layers commonly continuous with inner bark at top end,* otherwise completely free. Sloughing: in one or more layers, irregularly over bole; scales elongate, commonly large (60 cm. × 10 cm.), *curling up at their edges* on desiccating and *loose hanging except at top ends,* or smaller, or adherent; *sloughing plane within phellem, pustular lenticels often developing and assisting rupture.* Surface: fissures present or absent, square or irregular section, irregularly scattered, small pustular lenticels often present, bright reddish purple when new, hence *fresh surfaces with purplish tinge; at a periderm, always pale when new sometimes becoming very dark brown or black by erosion* of part of phellem.

Variant:

1. *Dryobalanops rappa:* Periderms: like Scaly—c in structure.

Occurrence: Boles; *Dryobalanops.*

Discussion: The plane in which the periderm forms, and the pustular lenticels actively assisting sloughing are unique to this bark. Scales are able to curl up as the tissues dry out because no fibres connect one rhytidome layer with another.

MANIFESTATIONS OF SURFACE ROTTEN BARK

Key to the Manifestations of Surface Rotten bark

A Laminae present in inner bark, usually long and occupying most of bark, sometimes short and scattered; periderms almost continuous though irregularly undulate.

B Fissures and cracks sparse or absent; outer bark with thick and thin areas; laminae always throughout whole inner bark .... *c.*

BB Fissures present, though of irregular distribution and size; outer bark thick everywhere; laminae as above or small and scattered ..... *b.*

AA Laminae absent; periderms absent or localised as narrow, elongate, tangential strips at ridge sides ..... *a, Shorea albida.*

MANIFESTATION Surface Rotten—a (Fig. 10c)

Diagnosis: Periderms: *absent, or localised* as scattered, elongate, tangential strips penetrating into ridges from fissure sides. Inner bark structure: expansion tissue apparently absent; phloem proliferation tissue, extensive stone cells and parenchyma, but *tangential laminae absent.* Outer bark structure: *very variable in thickness,* sometimes absent, to 9 mm. thick, *following surface contours;* dark coloured, variously rotten tissue; *not delimited inwards by periderm.* Sloughing: either as elongate scales of various thicknesses and size, just bundles of fibres, seldom cut off by a periderm or, where outer bark soft and the fibres rotten, as more or less isodiametric small, chunky scales. Surface: surfaces black and firm where periderm bounded, elsewhere soft and powdery, fissures regularly distributed, in shape just irregular furrows in the phloem to 10 mm. deep × 5 (10) mm. wide × 20–30 cm. long, *sides rough with torn fibre bundles;* ridges anastomosing; *appearance fibrous-fissured.*

Occurrence: Boles, *Shorea albida* only.

Discussion: The absence or only localised development of periderms means that surface configurations are more or less completely controlled by the inner bark structure, hence the obviously fibrous nature of the ridges and scales. The absence of laminae is in marked contrast with Manifestations—b and —c.

MANIFESTATION Surface Rotten—b

Diagnosis: Periderms: usually continuous, sometimes with scattered gaps, pattern variable, together may form a closely anastomosing reticulum throughout the outer bark; thickness variable, often strongly undulate. Inner bark structure: phloem proliferation tissue: simple laminae present, either scattered and short, or, more often, occupying most of the bark and greater than 20 cm. in extent on TS and LS; interlaminar phloem blocks often with parenchyma proliferation tissue, expansion tissue either in fingers interrupting the laminae or apparently absent and the laminae continuous sheets. Outer bark structure: no well defined rhytidome layers; usually with continuous periderm at boundary with inner bark, this boundary irregular and not parallel to cambium. Sloughing: elongate, layer-thick or chunky scales. Surface: surface firm and black and at a periderm or not, and powdery; appearance often dominated by scales not fissures; *fissures irregular furrows of variable section and penetration; irregular distribution;* variable between individuals.

Occurrence: Boles; *Shorea,* Meranti Pa'ang, most species.

Discussion: The anastomosing, reticulate periderm pattern is very similar to Smooth—e (also Meranti Pa'ang); it differs in the thinner and more widely separated periderms. Inner bark: identical with Surface Rotten—c where strongly laminate. Surface: the ridges do not have the roughly fibrous structure of Surface Rotten—a.

Shorea bracteolata, the only species with this Manifestation collected several times, had some trees with scattered and other with extensive laminae. The amount of lamination did not vary much between different parts of a tree, nor did it seem to be correlated with girth. This evidence suggests that the amount of lamination is variable between individuals of a species.

MANIFESTATION Surface Rotten—c

Diagnosis: Periderms: continuous, extensive, every one lying along the side of a stone cell sheet. Inner bark structure: expansion tissue apparently absent or as scattered fingers. Phloem proliferation tissue: *strongly developed simple laminae more or less filling inner bark*, between them the phloem blocks sometimes with parenchyma proliferation tissue. Outer bark structure: heterogeneous; thin, or thick with sheet like rhytidome layer(s); inner edge more or less parallel to cambium. Sloughing: isodiametric, usually layer-thick scales. Surface: surface dark, firm at a periderm; loose scales in one or occasionally two layers, close or scattered over bole surface; *cracks and fissures sparse or absent.*

Occurrence: *Shorea*, Meranti Pa'ang, on butts, and lower boles sometimes extending over whole boles.

Discussion: This Manifestation is dominated by the inner bark structure; the strongly developed laminae determine the arrangement of the periderms, hence the structure of the outer bark and the sloughing pattern, as well as the surface configurations. This Manifestation may perhaps be either an overmature stage or a reaction of the tree to peculiar environmental conditions.

MANIFESTATIONS OF LAMINATE BARK

Key to the Manifestations of Laminate bark

A Surface closely (1–3 cm.) fissured, ridges rough, with large, powdery, brownish-yellow areas; sloughing of small scales; laminae coarse (about 0.45 mm. thick) ..... *a, section Pilosae.*

AA Surface with widely spaced (5–8 cm.) fissures, or smooth with scattered fissures, ridges more or less flat, mostly firm, yellowish-cream in colour; sloughing of mid-sized, flat scales; laminae fine (about 0.25 mm. thick) ..... *b, section Glabrae.*

The evidence on which these Manifestations are distinguished is fully discussed in Whitmore (1960, p. 205).

MANIFESTATION Laminate—a (Fig. 10d)

Diagnosis: Periderms: usually continuous; one more or less delimiting inner edge of outer bark, remains of another one creeding away nearer surface. Inner bark structure: as Type; *laminae coarse, about 0.45 mm. thick*, about five fibre blocks included. Outer bark structure: as Type. Sloughing: small, chunky or layer-thick scales, 1–3 (5) cm. wide. Surface: *fissures close, ridges, 1–3 (5) cm. wide, surfaces usually very rough;* either at a periderm and firm, yellowish-cream or not and powdery, brownish-yellow.

Occurrence: *Anisoptera*, Pilosae section (? all).

MANIFESTATION Laminate—b

Diagnosis: Periderms: continuous; one superficial, with or without another deeper one too. Inner bark structure: as Type; *laminae fine, about 0.25 mm. thick*, about 4 fibre blocks included. Outer bark structure: locally thin, thick areas as Type. Sloughing: *flat, ridge-wide (5–8 cm.) scales*, usually layer-thick, less often chunky; some areas not sloughing. Surface: *wide spaced fissures; ridges 5–8 cm. wide usually more or less flat; surface may become smooth with scattered fissures and scales;* usually at a periderm, firm, yellowish-cream.

Occurrence: *Anisoptera*, Glabrae section.

ANISOPTERA

Taxonomy

Anisoptera Korth is a comparatively small clearly defined genus of about 14 distinct species although the specific limits are sometimes unelear (*A. oblonga*). Two sections of the genus are recognised with very distinct floral characters (Heim 1822, Symington 1943, Wyatt-Smith 1955), section Glabrae, *A. laevis* and *A. scaphula*, and section Pilosae, with all the other known species.

Argument

The Bark Type sequence is shown on Fig. 1. All the species are charaeterised by Laminate bark on mature trees and have the diagnostie appearance of the Type. There is no evidence that Laminate bark is succeeded by another Type, the Manifestation may change.

Conclusions

This examination confirms the findings of previous botanists that *Anisoptera* is a homogeneous group of species, Laminate bark is not found elsewhere. Fig. 1 shows a clear difference between the two generic sections. *A. laevis* and *A. scaphula* differ from the other species in:

1. The very large size reaehed (Wood, 1957 (under *Shorea superba*) records that the largest known dipterocarp is an *Anisoptera* probably *A. laevis*),
2. Manifestation Laminate—b, not Laminate—a, is developed on trees between 6 ft. and 11 ft. girth. Even if Laminate—b changes later to —a the two seetions differ in the girth range where they both oceur.

This clear cut difference has not previously been recognised, neither Symington (1943) nor Wyatt-Smith (1955) distinguish between speeies on bark eharacters; it coincides with the accepted taxonomic division and should be easy to see in the forest (see key to Manifestations); in particular the two commonest Malayan species *A. curtisii* and *A. laevis* can be distinguished on bark characters alone.

BALANOCARPUS

Taxonomy

Balanocarpus Bedd. had become a repository for dipterocarps with wingless fruits, long reeognised unsatisfactory, before Symington (1933, 1938) removed most of the speeies to more natural systematie positions in *Shorea* and *Hopea*. The only Malayan species left is *B. heimii* King with no close relatives and as similar

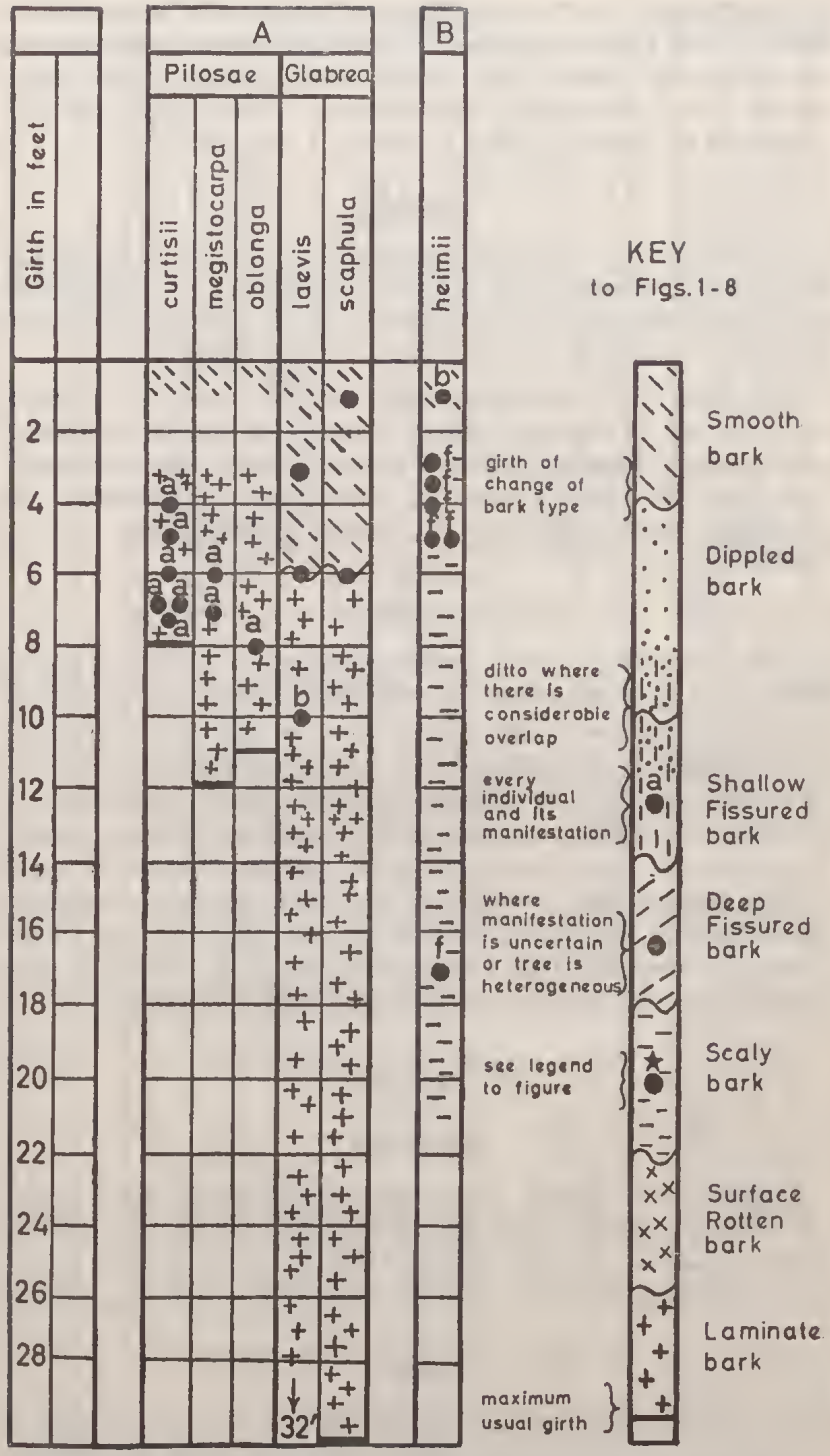


Fig. 1. (*A*) Anisoptera *and* (*B*) Balanocarpus, *bark sequence through life and Key to Figs. 1–8.*

Construction explained in appendix 2.

to the Euhopea and Pierrea groups of *Hopea* as to *Balanocarpus* Bedd. Desch (1941) includes *B. heimii* with *Hopea* in his account of dipterocarp timbers and a recent analysis of the anthocyanins of the leaves (Bate-Smith and Whitmore 1959) shows the two genera to be similar in these biochemical characters.

Argument

The Bark Type sequence is shown on Fig. 1. The sapling has the common Manifestation Smooth—b. Scaly bark has developed by 3 ft. girth and is very similar to Scaly *Hopea* bark, it is considered a Variant of the same Manifestation, Scaly—f.

The inner bark structure is unique with fibre blocks of different sectional size in different tangential sheets, so that the cut transverse surface sometimes appears streaked. Faint radial striations are visible on radial longitudinal surfaces and ripple marks on tangential longitudinal ones, a feature otherwise seen only in *Hopea ferrea.*

Conclusions

The mature bark is the same Manifestation as the field group Scaly Barked *Hopea* with fine structural differences, it can be confused in the forest; it is distinct from *Shorea* Balau with which it has sometimes been confused. Scaly Barked *Hopeas* have variable bark and from the material available I have been unable to decide whether this is taxonomically significant. Without further investigation I cannot equate *B. heimii* to one or several of these species but they are no doubt, as Symington remarked, closely related. Most of the Scaly Barked *Hopeas* are Euhopea and I conclude therefore that the true relationship of *B. heimii* is here rather than with Pierrea (the Smooth Barked field group).

DIPTEROCARPUS

Taxonomy

Dipterocarpus Gaertn. f. is a well defined homogeneous genus of about 80 species. There are five artificial sections differing in fruit characters, these do not have the same significance as the natural subgroups of *Shorea,* all the species have much in common.

Argument

Forest observations of 25 species show that the 11 described here cover the range of the genus. The Bark Type sequence is shown on Fig. 2. Manifestation Smooth—b is a widely occurring bark, it is probably intermediate here to Smooth—h, unique, and to Scaly—e, also unique.

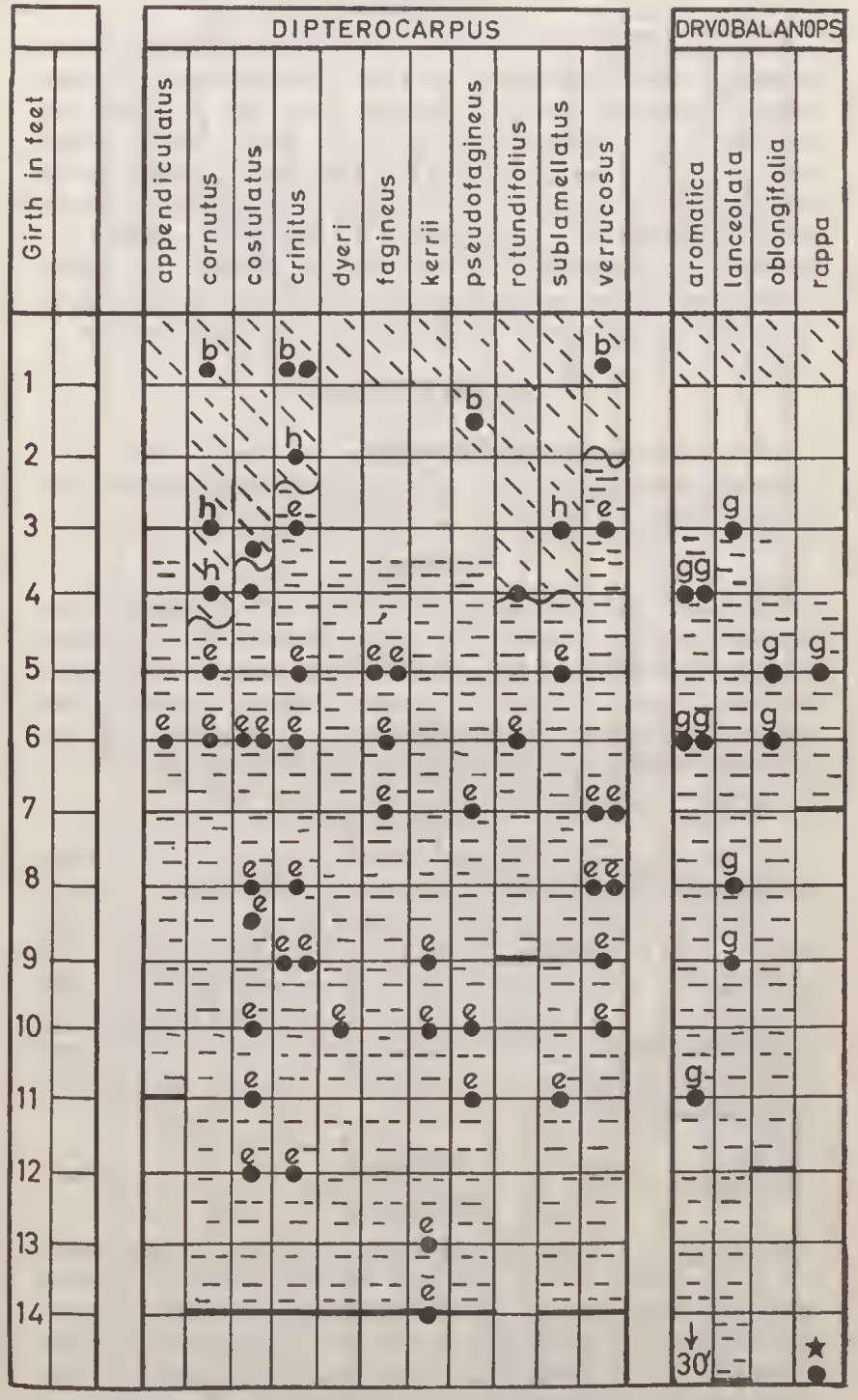


Fig. 2. Dipterocarpus and Dryobalanops, *bark sequence through life.* Construction explained in appendix 2; key on Fig. 1.

* *Dryo. rappa* G. 15 ft.: See text.

Conclusions

Previous findings are confirmed, all the species of *Dipterocarpus* in Malaya have similar bark, the same Manifestations with some minor Variants, in the same sequence. The slash of mature tree bark, Scaly—e, is distinctive in the forest due to various unique features of the inner bark structure. The surface pattern though can be confused with Scaly—a, Variant 3. A number of species are distinguished as Variants. From its bark *Dipterocarpus* is a natural homogeneous genus which cannot be divided. I am unable to draw any sharp and constant distinction between the bark of the closely related species *D. fagineus* and *D. pseudofagineus*.

DRYOBALANOPS

Taxonomy

Dryobalanops Gaertn. f. is a homogeneous well defined genus of nine known species.

Argument

The Bark Type sequence, Fig. 2, shows that an unique Manifestation Scaly—g is present on mature trees of the four species examined and the published descriptions show it on three more. One tree (*D. rappa,* girth 15 ft.) had a bark with different periderm pattern hence surface appearance; it is thought to be abnormal and overmature (diagnosis, Whitmore 1960, pp. 373–4).

Conclusions

Dryobalanops has an unique Manifestation on mature trees, individual trees differ from each other particularly in details of the sloughing pattern as is common in Scaly barks, and this variation overlaps any differences there may be between species. The genus can be distinguished in the forest on bark characters from *Dipterocarpus, Shorea* Balau, and the Scaly Barked *Hopeas* which it resembles (Symington 1943). Previous conclusions are confirmed, on bark characters *Dryobalanops* is a natural homogeneous group of species.

HOPEA

Taxonomy

Hopea Roxb. (about 100 species) is, like *Shorea,* a heterogeneous genus and there is considerable variation between species in forest, herbarium and wood anatomical characters. The last complete revision was by Brandis (1895), now manifestly inadequate; Symington (1934, 1939) made what revisions he could but was hampered by the poor knowledge of the Bornean flora; his tentative subdivisions were not of equal status and some species cannot be referred to any of them. These subdivisions do not correlate well with the timber or forest characters and so in 1943 he

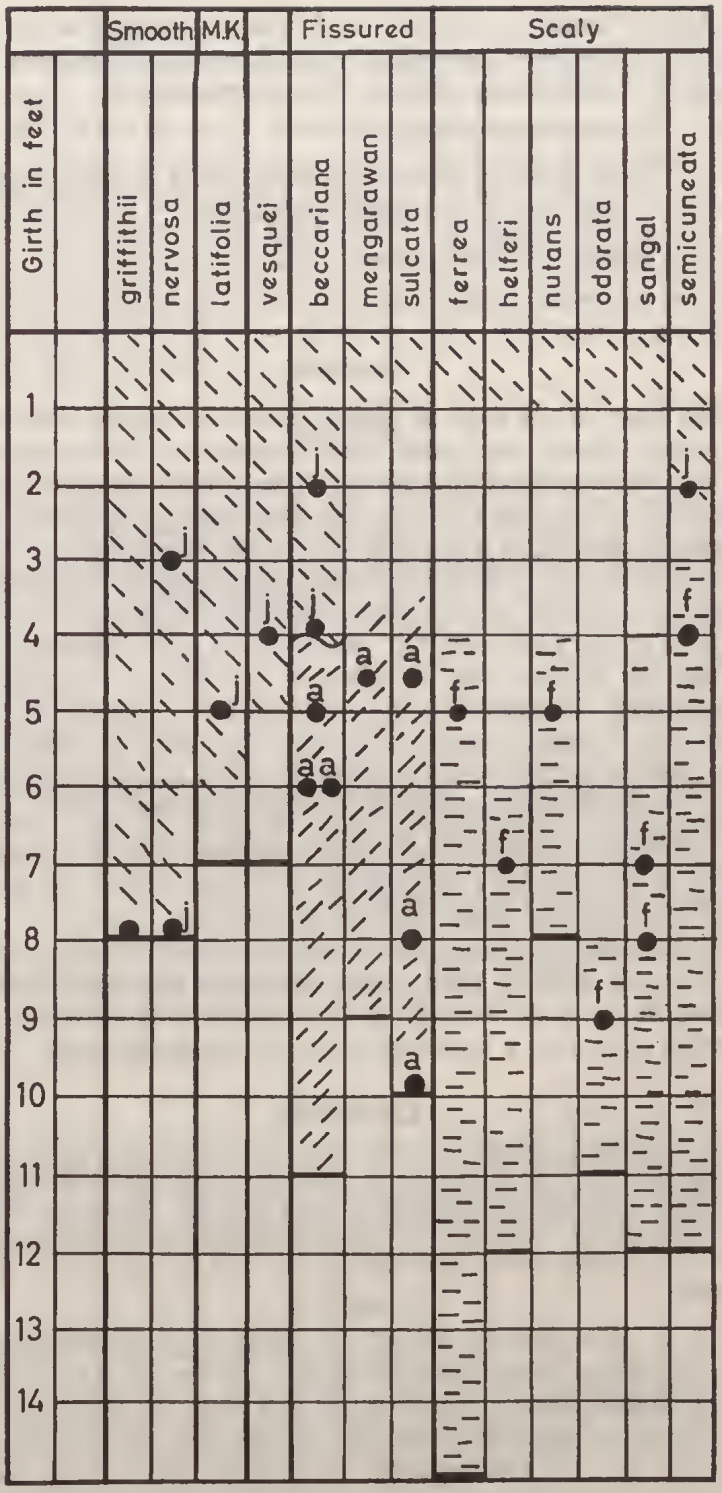


Fig. 3. Hopea, *bark sequence through life.*

Construction explained in appendix 2; key on Fig. 1. M.K. = Mata Kuching group.

proposed 'tentative arbitrary field groups' cutting across the generic subdivisions and using forest characters of buttress, stilt roots, bark and damar exudate. The groups are:

1. Smooth Barked *Hopeas*
2. Mata Kuching *Hopeas* (a segregate of 1 with damar in globular or stalactitic exudations)
3. Fissured Barked *Hopeas*
4. Scaly Barked *Hopeas.*

Argument

The study of the bark of natural groups of species in Dipterocarpaceae shows that, with the exception of *Shorea* Meranti Pa'ang, all or most of the species of the groups have many bark characters in common. Hence the bark survey of *Hopea* is of particular interest. If it is possible to show the species of Symington's field groups have similar bark this will suggest that they are the natural groups and the information will assist in the pending revision of the genus and the description of new Bornean species (Wood for instance has described a new genus, *Neohopea,* in manuscript). Unfortunately I have not much material, in some cases only a single sample of a species, nevertheless if these samples have a lot of bark characters in common the induction is clear; I cannot though propose any new groupings.

The Bark Type sequence is shown on Fig. 3. I have no material showing the scaly bark reported (Symington, 1943) for large trees of the Smooth and Mata Kuching groups.

All the species have similar secondary phloem structure except in the Scaly Barked group where there are differences between species in the shape and size of fibre blocks in cross section and whether they have a surrounding crystal sheath or not.

Conclusions

The species with similar bark coincide exactly with Symington's 'tentative arbitrary field groups' and there are no bark features common to the whole genus. The conclusion is that these, rather than the existing taxonomic sections, are the natural subgroups of *Hopea.*

1. The Smooth Barked and Mata Kuching *Hopeas* have together a unique Manifestation, j, of Smooth bark and are indistinguishable. The barks of two trees (girths 5 ft. and 6 ft.) of undescribed species (*sp. A* (the code name at Kepong) and *sp. 324* (not matched at Kepong, specimen deposited there)) and of the Bornean *H. vesquei* with Smooth bark were examined and undoubtedly belong to one or other of these groups; the two former species are not shown on Fig. 3.

2. Fissured Barked *Hopeas* all have the same Manifestation, Deep Fissured—a. of a unique Bark Type. Further research might show that the Bornean tree of *H. beccariana* (488) is not the same species as the Malayan ones (180, 197).

3. Scaly Barked *Hopeas* are on the evidence available one Manifestation, f, of Scaly bark but there are differences in surface pattern (Symington, 1943) suggesting there may be other Manifestations; this is the only species group in which differences in secondary phloem between species have been seen. Further data is needed to see whether this group is homogeneous and natural.

SHOREA

Shorea Roxb., the largest and economically most important genus of Dipterocarpaceae, has about 170 species. It is not a homogeneous genus but contains representatives of several more or less closely related groups some of which might be considered worthy of generic rank. The established taxonomic sections (Brandis, 1895) are patently unsatisfactory today. Symington (1943) using Malayan material divided *Shorea* into four natural subdivisions differing considerably from Brandis' sections, but was not prepared to give them definite botanical names or status until the whole genus was revised taxonomically. This revision still has not been made. Desch (1936, 1941) independently established four groups based on timber characters which closely correspond to Symington's subdivisions, but Bate-Smith and Whitmore (1959) found no significant differences between the groups in the anthocyanin pigments of mature leaves. I have studied the bark of Symington's natural subdivisions separately.

Shorea, Balau group

Taxonomy

This group approximates to section Eushorea, Brandis (1895), but has never been satisfactorily defined botanically. Symington (1943), mainly on Malayan species, describes three botanical subgroups indistinguishable in the forest and from wood anatomy.

Argument

The Bark Type sequence is shown on Fig. 4. An unique Scaly bark (Manifestation—c) develops from Smooth bark (Manifestation—b) at small girth and persists. The bark of *sp. nov. 555* is quite distinct, and of uncertain affinity.[1] In the crown there is an

[1] Inner bark as Scaly but periderm pattern unique; surface appearance reminiscent of *Tristania* (Myrtaceae)—see Whitmore (1960, p. 32). A herbarium specimen of this tree, collected at Lungmanis, North Borneo, is at CGE.

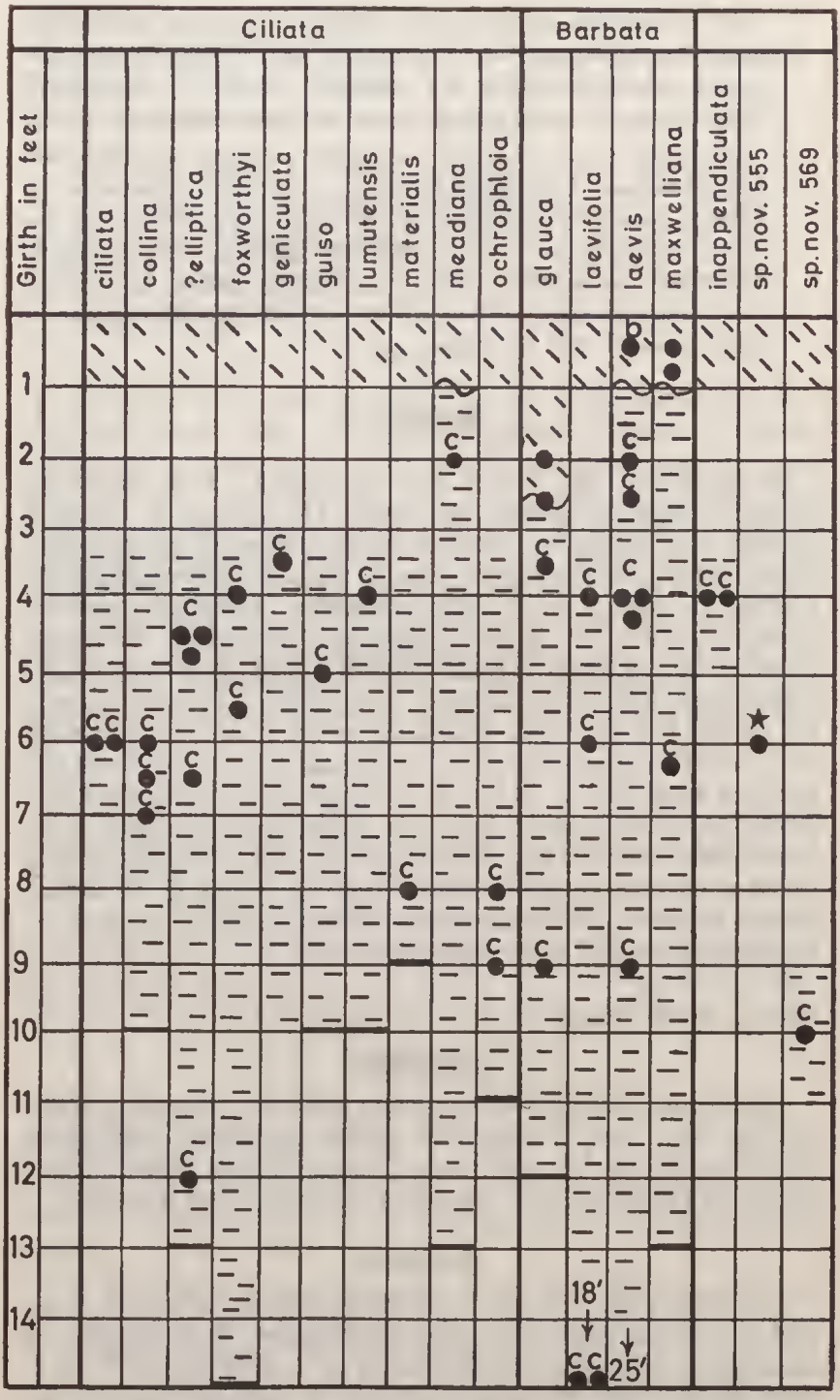


Fig. 4. Shorea, Balau group, *bark sequence through life.*
Construction explained in appendix 2; key on Fig. 1.
* *S. sp. nov.* 555 G. 6 ft.: see text.

intermediate grideracked stage between Smooth and Scaly which is unique and diagnostic. In *S. laevifolia, S. laevis* and *S. glauca* the secondary phloem fibre blocks are of various sizes as seen on transverse section. Intercalary proliferation tissue from rays and phloem blocks has aligned many of them into slightly convex, short, imbricating, tangential plates with smaller blocks at the ends than centre, the included parts of the phloem rays are not widened. *S. geniculata* approaches this condition. The pellucid conducting phloem occupies about one-third of the inner bark, more than in any other group examined.

Conclusions

Sixteen Balau species examined have the unique Manifestation Scaly—e, one species seen once has a bark of uncertain affinity. Although there is the considerable and overlapping environmental variation between species and individuals which is common amongst Scaly barks a number are quite distinct Variants and more could probably be distinguished by further study.

There are a number of constant differences between this Scaly bark and Scaly *Hopea, Balanocarpus* and *Dryobalanops* with which it has sometimes been confused in the forest. Some species and small groups of species are distinctive (Symington has already described the Malayan ones).

The species examined are of the Barbata and Ciliata botanical subgroups, these are not clearly distinct on bark characters, there is overlapping variation. Thus three of the four Barbata species (*S. glauca, S. laevifolia* and *S. laevis*) have a unique arrangement of the fibre blocks but the Ciliata species *S. geniculata* approaches this condition; two Barbata species (*S. laevifolia, S. laevis*) and two Ciliata species (*S. geniculata, S. lumutensis*) have fissured, thick outer bark. *S. maxwelliana* (Barbata) has neither of these features.

The bark of the new undescribed species (*sp. nov. 555* and *sp. nov. 569*[1]) and *S. inappendiculata* (Borneo) does not have either of the Barbata features and hence they are probably in the Ciliata subgroup; the two undescribed species, if typical, have specific bark.

Shorea, Meranti Pa'ang group

Taxonomy

A natural homogeneous group corresponding closely to section Anthoshorea Brandis, though Brandis enumerated here many species now known not to belong.

---

1. Herbarium specimens at BO, CGE, L, SAN and SING.

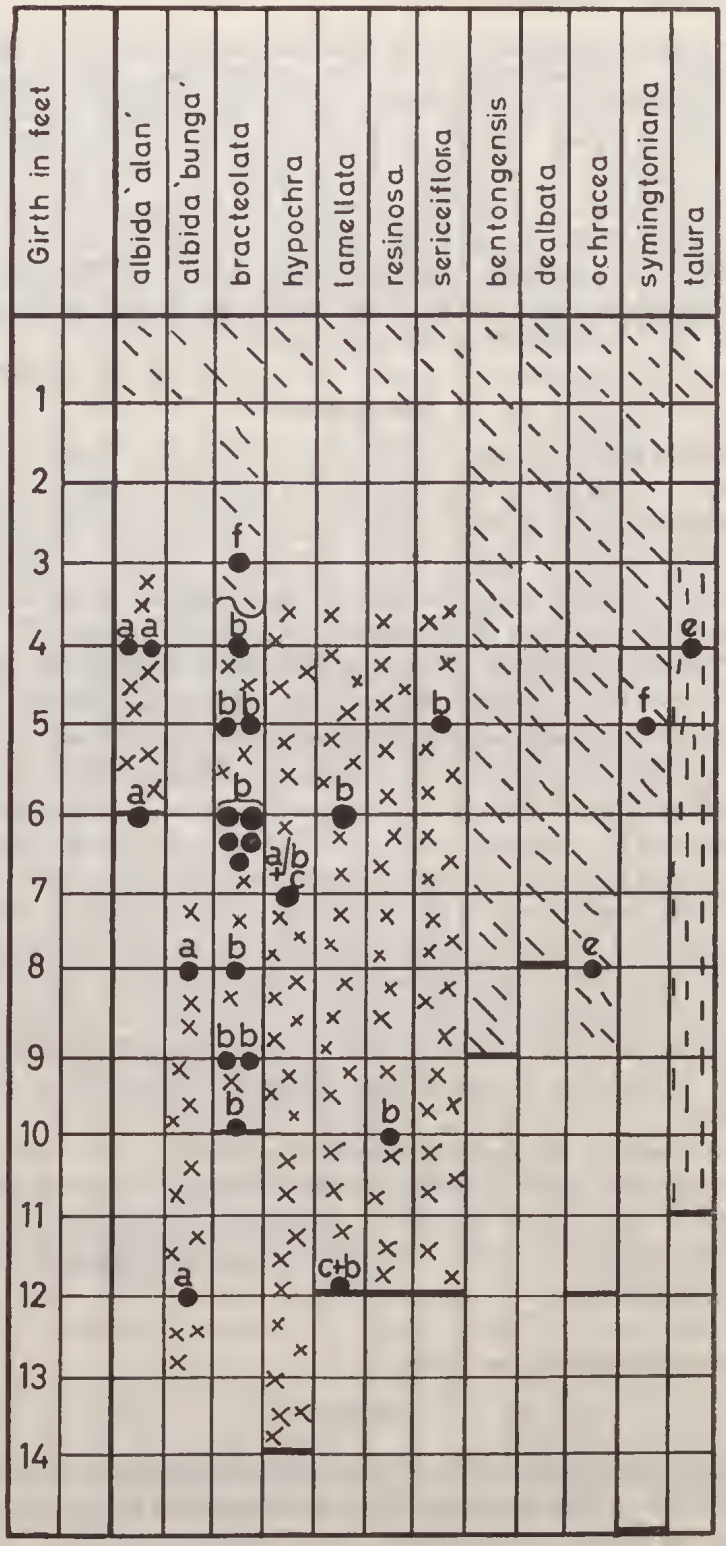


Fig. 5. Shorea, Meranti Pa'ang group, *bark sequence through life.* Construction explained in appendix 2; key on Fig. 1.

Argument

The survey initially presented difficulties not encountered in other groups as there is much greater variation between boles and between the parts of each bole, so that samples from the butts of standing trees are less often typical of the whole bole. The Bark Type sequence is shown on Fig. 5. Six species change from Smooth to Surface Rotten bark, unique to the group, before mature girth is reached and remain at this; the surface appearance of this Bark Type is highly variable. Three species retain Smooth bark throughout life; of these I examined *S. symingtoniana* and found the Manifestation unique (Smooth--f); *S. bentongensis* and *S. dealbata* are shown on Fig. 6 on the basis of Symington's (1943) description. *S. ochracea* remains Smooth with a unique Manifestation (Smooth—e) until at least 8 ft.; the bark at larger girths remains undetermined. All these Manifestations have features of the periderms and of the secondary phloem structure in common (see the diagnoses). *S. talura* has fissured bark, provisionally assigned to the Shallow Fissured Type as a unique Manifestation, e.

Conclusions

No bark features are common to all the species. Four of the eleven have different, unique Bark Manifestations on mature trees (*S. albida* Surface Rotten—a, *S. ochracea,* Smooth—e, *S. symingtoniana,* Smooth—f, *S. talura,* Shallow Fissured—e), the other seven have Surface Rotten, Manifestation—b or —c, and are indistinguishable in the forest. *S. talura,* incompletely studied, seems to differ completely from the other species which do have a few features in common. Surface Rotten bark is quite distinct from Laminate (*Anisoptera*), see key to the Bark Types, though the two have sometimes been confused.

There are no bark features by which the group as a whole is recognisable in the forest, most species have variously developed simple laminae, though not always as conspicuous as the published descriptions suggest, throughout most of their life, hence the slash is pale yellowish.

Even the six species with Surface Rotten—b bark are not easily told by surface appearance because this Manifestation has extremely variable surface appearance.

Meranti Pa'ang, then, is a heterogeneous group on bark. *S. albida,* tentatively divided into two botanical forms with different ecology and timber is not divisible and the species belongs to this group on bark despite its timber classification as a Red Meranti or Red Selangan (= Balau) (Browne, 1955, pp. 137, 151).

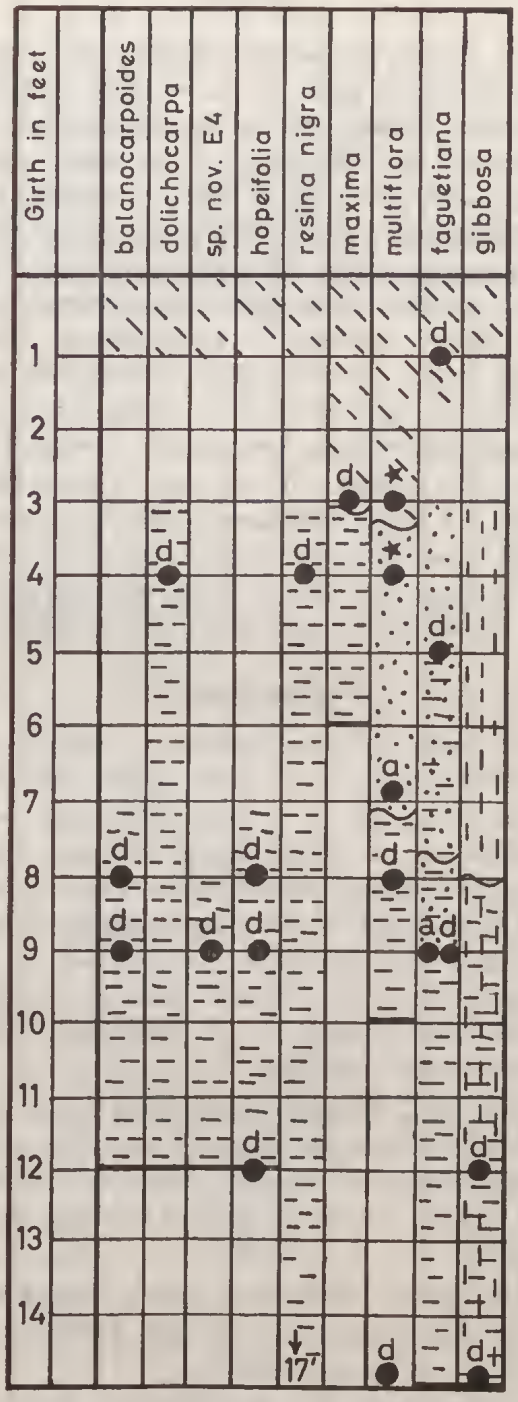


Fig. 6. Shorea, Meranti Damar Hitam group, *bark sequence through life.*

Construction explained in appendix 2; key on Fig. 1.

* *S. multiflora:* Dippled -a at 3 ft., Smooth -d at 4 ft. *'E4'* is the code name at Kepong for an undescribed Malayan species, my reference collection is Whitmore 655 (at CGE).

Shorea, Meranti Damar Hitam group

Taxonomy

This is a natural homogeneous group assembled by Symington (1938) from various *Shorea* and *Balanocarpus* species. He named it Richetia for convenience though it has not been validly published or given rank such as genus or section.

Argument

The Bark Type sequence is shown on Fig. 6. There is a general similarity, bark changing from Smooth (unique Manifestation—d) to Scaly (unique Manifestation—d) at about 3 ft. girth, with some variations. Dippled bark was seen on *S. faguetiana* at 9 ft. and *S. multiflora* at 3 ft. and 7 ft. girth. On the latter it was at girths intermediate to Scaly on the former well within the girth range of Scaly bark; nevertheless the structure indicates that it is probably always intermediate to Scaly on a particular tree (Whitmore 1962a, b). This Manifestation is shared with *Vatica*, from which there are only fine differences.

S. gibbosa alone possesses a Shallow Fissured bark usually replaced by Scaly on very large trees, the Manifestation, d (Fig. 6), is unique.

Conclusions

An unique bark, Scaly—d, is present on all these Meranti Damar Hitam species at some stage of their mature life and holds them together as a homogeneous botanical group. Smooth—d and Shallow Fissured—d barks are also unique and some of their features are shared with Scaly—d, this adds to the homogeneity. Smooth—d and Scaly—d are easily recognised in the forest and Dippled sometimes so. The Scaly species cannot be told from each other. *S. gibbosa* with Shallow Fissured—d is the only species recognisable from its bark.

Shorea, Red Meranti group

Taxonomy

This is the most heterogeneous of Symington's groups and cannot be identified with any single defined botanical group, nevertheless there is ample justification for recognising it as natural.

Symington recognised three subgroups in Malaya based on floral characters, these he noted are of taxonomic rather than practical value because the differences have not been correlated with differences in wood anatomy. He noted some bark differences and predicted that there might be other forest differences, a prediction which has been amply justified.

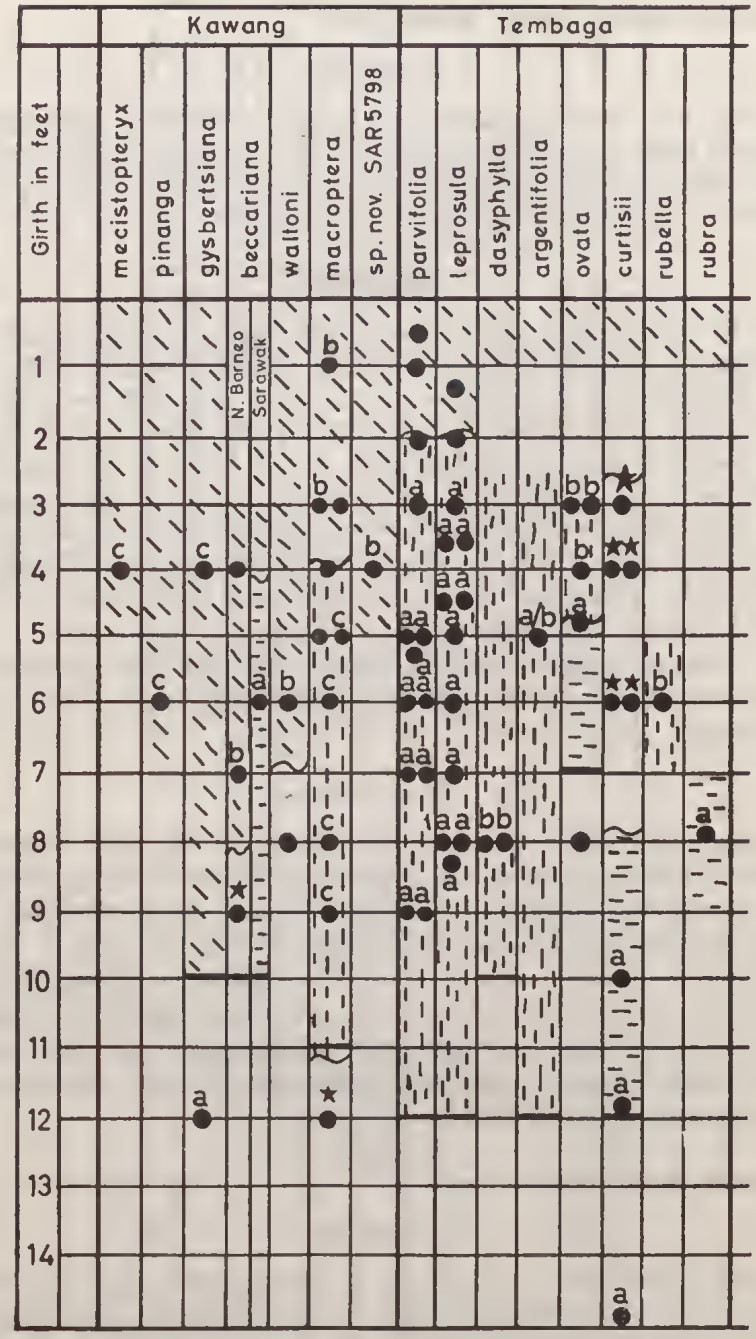
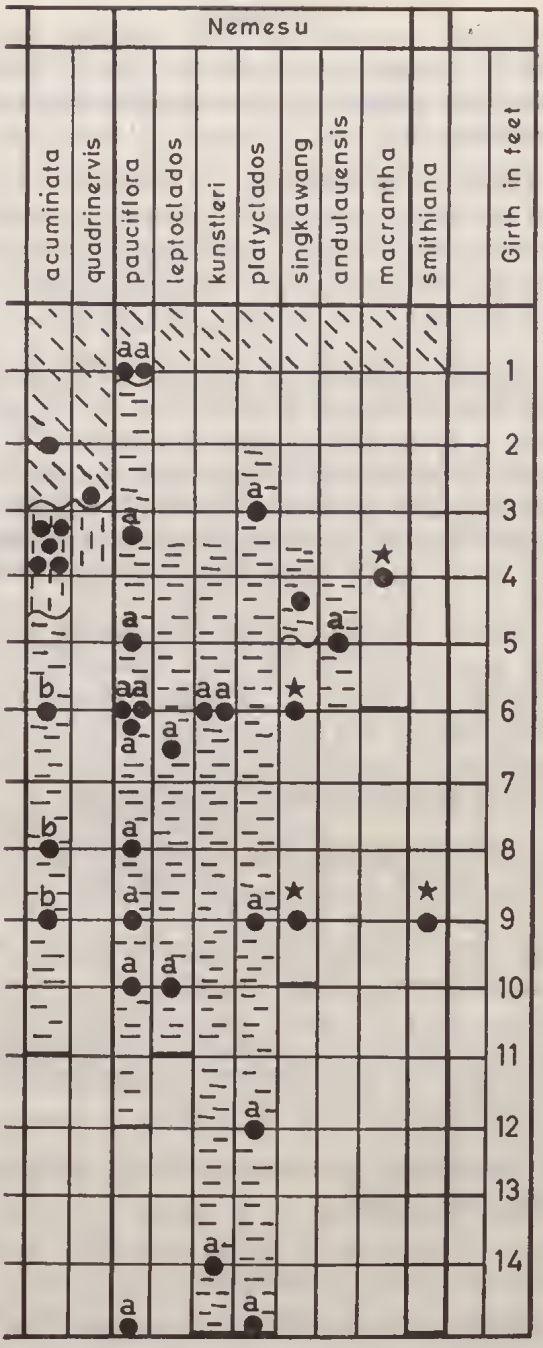


Fig. 7. Shorea, Red Meranti group, *bark sequence through life.* Construction explained in appendix 2; key on Fig. 1.

**S. beccariana* G. 9 ft., *S. macroptera* G. 12 ft., *S. macrantha* G. 4 ft.: these differ in periderm pattern, hence in surface and slash, and are thought to be abnormal because overmature or exposed trees; for full diagnosis and discussion see Whitmore (1960), pp. 246, 248–249, 266–7. **S. singkawang:* at least some



trees change bark in the girth range 5–10 ft. to bark with a pale, dippled, rugose surface, not mentioned in published descriptions so perhaps atypical; see Whitmore (1960), pp. 264–5. **S. curtisii* and *S. smithiana:* see text.

Argument

The Bark Type sequence is shown on Fig. 7. The species examined have been arranged in a number of subgroups each with a common sequence:

1. The Kawang subgroup (left of figure) retains Smooth bark of the unique Manifestation Smooth—c throughout life or at least well into mature life. In this subgroup are *S. beccariana, S. mecistopteryx, S. pinanga, S. waltoni, S. gysbertsiana, S. macroptera, S. sp. nov. SAR 5798.*

2. Tembaga subgroup (centre) has some species changing from Smooth to Shallow Fissured bark of the unique Manifestation—a at about 2 ft. girth (*S. parvifolia, S. dasyphylla, S. rubella, S. leprosula, S. argentifolia*), and other species becoming Scaly later (*S. ovata, S. rubra*). *S. curtisii* has a bark intermediate in structure between Shallow Fissured and Scaly at small girths, this is diagnosed in Whitmore (1960 p. 259).

3. Nemesu subgroup (right) with Smooth bark changing to Scaly (unique Manifestation—a), without a fissured phase, at less than 1 ft. girth and persisting through life, old trees sometimes smooth with only scattered scales. The species are: *S. pauciflora, S. kunstleri, S. singkawang, S. macrantha, S. leptoclados, S. platyclados, S. andulanensis.*

4. *S. acuminata* and *S. quadrinervis* form a small group remaining Smooth to about 3 ft. girth then passing through a short-lived Shallow Fissured phase which by 4 ft. girth develops into a unique Manifestation (Scaly—b) of Scaly bark which persists for the rest of life.

5. *S. smithiana* has a bark of completely different construction from any other dipterocarp examined[1] which cannot be related to any of the seven Types.

The full arguments for including the species in these groups are given in Whitmore (1960).

Conclusions

Red Meranti is a group heterogeneous in bark but the slash of all species has a general similarity. There are three main bark subgroups and a fourth small subgroup within which the Bark Type sequence and Manifestations are the same and *S. smithiana* does not fit.

---

[1] Pseudocortex present; expansion tissue in wedges; sheet like rhytidome layers; sloughing apparently absent. Full diagnosis and illustrations Whitmore (1960 pp. 271–2).

Within each subgroup there are variations between individual species; this is the most variable group studied, 11 out of the 26 examined can be distinguished from each other on gross bark morphology. In the forest the subgroups and distinctive species are recognised, the similar slash is insufficient for recognition of the whole group.

The Malayan species examined show a close correspondence between the bark subgroups and Symington's floral subgroups.

All the species of his Pauciflora subgroup fit my Nemesu subgroup (mature trees Scaly) except *S. acuminata* which must be considered as a separate subgroup with the closely related Bornean *S. quadrinervis.*

Most of the species of his Parvifolia subgroup fit my Tembaga subgroup (mature trees Shallow Fissured), the exceptions are *S. macrantha* and *S. singkawang* which on the available evidence I put in Nemesu and *S. macroptera* in Kawang.

No species occur in Malaya of my Kawang bark subgroup except *S. macroptera* which is not typical of it.

Thus although wood anatomy does not support Symington's floristic subgroups bark characters do. We may predict that when the genus is revised the Red Merantis will be formally divided along the lines suggested by Symington for the Malayan species and confirmed and extended here.

I can comment as follows on a number of outstanding taxonomic problems of individual Red Meranti species.

1. I suspect (Browne 1955, personal observation (Whitmore 1960), Corner observations) two taxa are confused under the name *S. beccariana,* one from Sarawak with Scaly bark with laminae on mature trees and one from Brunei and North Borneo Smooth on mature trees. The former, if it develops Scaly bark at small girth, belongs to my Nemesu bark subgroup, the latter is a Kawang species.

2. *Shorea parvifolia* is a polymorphic species which Symington (1943) considered to have several, more or less distinct forms through its range. He tentatively defined three forms in Malaya which, however, I found difficult to distinguish in the herbarium and I am unable to distinguish between them on bark though confirm a known difference in the bark of the Selangor form.

3. Symington (1943, footnote p. 85) notes that *S. parvifolia, S. dasyphylla* and *S. ovata* are very closely related and liable to be confused where they grow together. They are however easily distinguished on bark.

4. *S. rubra* Wood Msc. known from sterile collections from Brunei has been suspected to be an extreme form of *S. parvifolia,* but it has different bark. It is included in my Tembaga bark subgroup because of this putative relationship (Whitmore 1960 p. 261).

5. *S. acuminata* and *S. quadrinervis* have similar bark and are distinct from other species.

The taxonomic relationships from their bark of the new Bornean species examined are:—Kawang subgroup: *S. waltoni* Ashton (Msc.), *S. sp. nov. SAR 5798;* Tembaga subgroup: *S. rubella* Ashton (Msc.), *S. rubra* Wood (Msc.); Nemesu subgroup: *S. andulauensis* Ashton (Msc.).

VATICA

Taxonomy

Vatica Linn. is a clearly defined natural group of some 90 species, closely related to but distinct from *Cotylelobium.* There are striking differences between species in fruits and some taxonomists have been tempted to recognise several genera, but leaf, flower and wood anatomy are all similar and subdivision is not justified. Van Slooten (1927) in the most recent monograph recognises several subgenera but Symington (1943) reduces even these to artificial sections (cf *Dipterocarpus*).

Argument

The Bark Type sequence is shown on Fig. 8. A unique Manifestation, Smooth—k is present on most species. Scaly bark occurs sometimes on big trees (more commonly than Symington, 1943 suggests); my material was too poor to spot the Manifestation (starred on Fig. 8). Dippled bark—a was seen once, differing in fine structure from *Shorea* Meranti Damar Hitam also bearing it. Scroll marks referred to in the published descriptions can develop with either Scaly or Dippled bark. Symington describes the phelloderm as reddish or purplish, this was not seen.

Conclusions

The species are very similar and cannot be distinguished from each other on bark characters though in favourable conditions the genus can be recognised. The two 'subgenera' covered by the survey (Isauxis (Arn.) Brandis and Synaptea (Griff.) Brandis) are indistinguishable, what differences there are in Bark Type sequence between species run across this division, reinforcing Symington's suggestion that the 'subgenera' are no more than artificial sections.

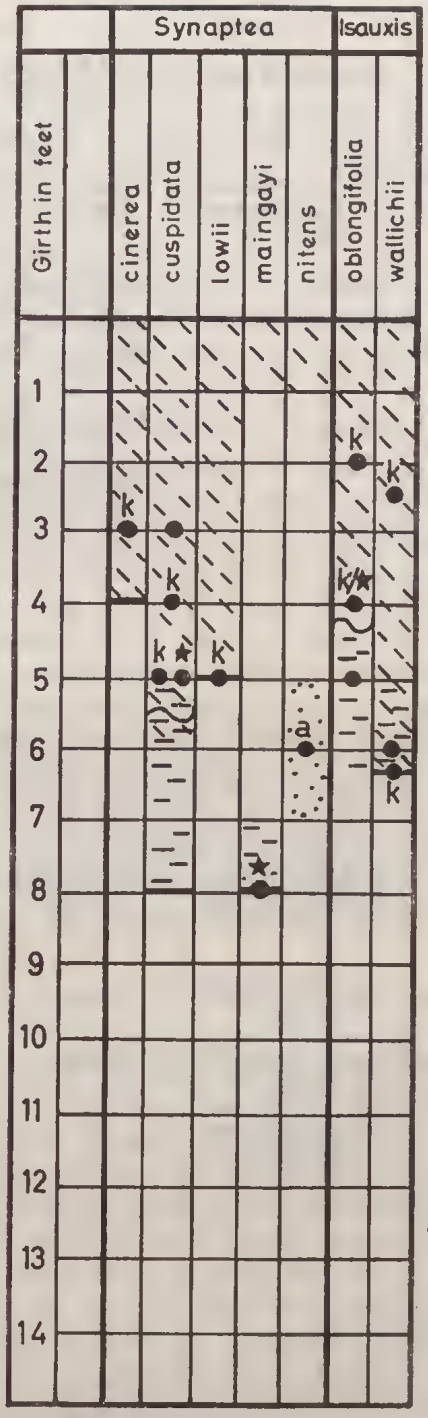


Fig. 8. Vatica, *bark sequence through life.*

Construction explained in appendix 2; key on Fig. 1.

* *V. cuspidata* G. 5 ft., *V. oblongifolia* G. 4 ft. and 5 ft.: see text.

TABLE 1. Taxonomic occurrence of Bark Types and Manifestations on boles.

SMOOTH BARK	DIPPLED BARK	SHALLOW FISSURED BARK	DEEP FISSURED BARK
a *	a Shorea, Meranti Damar Hitam and Vatica	a Shorea, Red Meranti	a Hopea, Fissured
b **		b Shorea, Red Meranti	
c Shorea, Red Meranti		c Shorea, Red, Meranti	
d Shorea, Meranti Damar Hitam		d Shorea, Meranti Damar Hitam	
e Shorea, Meranti Pa'ang		e Shorea, Meranti Pa'ang	
f Shorea Meranti Pa'ang			
g Anisoptera			
h Dipterocarpus			
j Hopea, Smooth and Mata Kuching			
k Vatica			
SCALY BARK	**SURFACE ROTTEN BARK**	**LAMINATE BARK**	
a Shorea, Red Meranti	a Shorea, Meranti Pa'ang	a Anisoptera	
b Shorea, Red Meranti	b Shorea, Meranti Pa'ang	b Anisoptera	
c Shorea, Balau	c Shorea, Meranti Pa'ang		
d Shorea, Meranti Damar Hitam			
e Dipterocarpus			
f Hopea, Scaly and Balanocarpus			
g Dryobalanops			

* seedlings and saplings, probably all species groups.

** probably all species groups, mainly young plants.

CONCLUSIONS ON BARK TAXONOMY

General

Table 1 shows the occurrence on boles of the seven main Bark Types; it is seen that three (Deep Fissured, Surface Rotten, Laminate) are restricted to single species groups, a fourth, Shallow Fissured, to *Shorea*, and the other three are found in more than one species group but that with very few exceptions the Bark Manifestations arc restricted.

Hence, as already noted, it is at the level of the Manifestations that most of the differences between species groups and specics occur and so at this level that there are differences in bark useful for identifying trees.

Only Manifestation Smooth—a, Smooth—b, Dippled—a Scaly —f occur in morc than one species group.

I have discovered that the fine details of secondary phloem structure (except Scaly *Hopea*, q.v.), and often the structure of the expansion tissue, phloem proliferation tissue and periderms also, are constant within a species group so that all the Manifestations of every species group are alike in these fine details. This applies to Dippled—a and Scaly—f and to some extent to Smooth—b barks too; these Manifestations occur in more than one species group but with microscopic differences.

Smooth—a bark is found on all seedlings, saplings and small twigs, and has not been fully studied, Smooth—b bark is mainly restricted to small members. The tangcntial strains in these parts are highest (see Whitmore 1962b) and the resulting extensive expansion tissue obscures the differences between species groups.

Formal taxonomy

The species have been studied in the most natural groups yet recognised, which are those proposed by Symington (1943) but not all validly published. This survey has shown differences in bark betwcen the groups and similarities within them. The taxonomic groups and the bark groups are identical suggesting that these are indeed the natural groups of Dipterocarpaceae. I do not consider that the differences I have detected between groups are the result of inadequate sampling (between 2/5 and 1/10 of the species of the groups) but that I have sampled enough species for my conclusions to have this taxonomic application. The danger of arguing in a circle (from studying taxonomic groups, finding Manifestations are restricted to them, then arguing that these must therefore be the natural groups) is obviated by the caution exercised in creating Manifestations, any incompletely understood bark has been described as a Variant of a described Manifestation.

Within the species groups variation is at two levels, between taxonomic subgroups and between individual species, and is in the girth at which the bark changes and in the Manifestations or Variants present. The conclusions I draw have already been detailed with the notes on each species group. In summary I find that I agree on the whole with Symington's conclusions on the taxonomic nature of the groups. I find bark differences accentuate the taxonomic divisions of *Anisoptera* and *Shorea,* and within *Shorea,* where I agree on the whole with his subdivisions of Red Meranti and extend them, and find the other divisions distinct though of varying homogeneity. I agree with him that *Dipterocarpus* and *Vatica* are unnaturally subdivided, that *Balanocarpus* should not be kept separate from *Hopea* and within *Hopea* itself I find his 'tentative arbitrary field groups' correlate better with bark characters than the taxonomic subdivisions. *Dryobalanops* I confirm is a homogeneous natural genus. The groups of *Shorea* and some of those of *Hopea* are as distinct as the other genera on their bark, but one needs to consider carefully the purpose of one's taxonomy before creating new genera to accommodate these differences.

Concerning individual species:

1. Ten new undescribed species have been examined and their relationships discovered from their bark (see *Hopea* and *Shorea,* Red Meranti, Meranti Damar Hitam and Balau).

2. I can state, about known problems of taxonomy, that:

   (i) *Dipterocarpus fagineus* and *D. pseudofagineus* appear neither more nor less similar than other *Dipterocarpus* species, although they are taxonomically very close related.

   (ii) The closely related *Shorea parvifolia, S. ovata* and *S. curtisii* (Red Meranti) are clearly distinct.

   (iii) *Shorea rubra* is distinct from the closely related *S. parvifolia.*

   (iv) *Shorea albida* is a White Meranti despite its timber classification as Red Meranti or Balau; the two tentative taxonomic forms are indistinguishable.

3. Geographical Variation.

   (i) Infraspecific.

      (*a*) Two taxa of different distribution seem to be confused under the epithet *Shorea beccariana* (Red Meranti).

      (*b*) Of the three putative Malayan forms of *S. parvifolia* only one has slightly different bark from the others.

(*c*) There may be bark difference between Malayan and Bornean trees of *Hopea beccariana* (Fissured *Hopeas*).

(ii) Interspecific. It has been suggested (Richards, 1952, p. 58) that species restricted to tropical Rain forest often have thinner bark than species from drier forests. In this survey, however, no systematic differences have been noticed between dipterocarp species of Burma, Indochina, Thailand and extreme north-west Malaya—the Burmese floristic element —which occur in dry, deciduous, dipterocarp forests and fire climax *Schima*-bamboo forests (Symington 1943)[1] and species of more easterly distribution restricted to the lowland, everwet, evergreen, Rain forests of Malaya, Sumatra and Borneo. A few species occur in both these floristic divisions (e.g. *Dipterocarpus kerrii*). If there is a difference in bark between members of these floristic elements it is infraspecific or phenotypic and is not universal; there are bark differences between exposed and forest living trees of the same species already described above.

These conclusions on the formal taxonomy of the species and species groups of Dipterocarpaceae will have to be weighed with the other evidence when the family is revised, a task which, as in Symington's day, still awaits the full collection and description of the Bornean dipterocarps.

Forest Recognition

Bark Types cannot be confused; they are quite different in details of bark surface pattern and slash and usually in impression from a distance. Bark Manifestations are by definition distinct in the forest. Thus it follows from the occurrence of Bark Types and Manifestations (Table 1) that nearly all the species groups are distinct in the forest in the bark present on mature boles and sometimes from pole bark too.

The exceptions are:

Scaly—f, found on *Balanocarpus* and the Scaly Barked field group of *Hopea,* but these taxa should perhaps be lumped.

---

1. These species are *Shorea hypochra, S. sericeiflora, S. talura* (Meranti Pa'ang), *Dipterocarpus dyeri,* and *Hopea ferrea, H. helferi,* and *H. odorata* (Scaly Barked *Hopea*).

Dippled bark: *Shorea,* Meranti Damar Hitam and Scaly Barked *Hopea*—but small trees only as this is a transient Manifestation.

The homogeneous species groups have a distinctive bark gestalt from which they can be recognised in the forest. In heterogeneous groups the subgroups or the individual species are recognised separately. In this survey these gestalts have been analysed more completely than previously, in all out of the 103 species examined mature trees of 21 species can be recognised from bark alone and many of the others can be identified down to a small group of species (of recognised taxonomic status or not) within their group. Not many species have been added to the list which Symington (1943) and Wood (1957) distinguish but the descriptions are fuller; a few differences which do not seem to hold are contradicted.

Clear differences are stated between the Scaly bark of *Shorea* Balau, *Dipterocarpus,* Scaly *Hopea* plus *Balanocarpus* and *Dryobalanops* which have sometimes been confused in the forest (Symington, 1943); the reasons for the similarity of these Manifestations were analysed in Whitmore (1962a).

New distinctions are made and old confusions are sorted out because of the critical descriptive scheme and glossary adopted (Whitmore 1960 part 3). The Dipterocarpaceae because of their paramount importance are better known in the forests of Malaya and Borneo than any other family, there are no works comparable to Symington (1943) and Wood (1957) for any other family (except perhaps Henderson and Wyatt-Smith, 1956, on *Calophyllum* (*Myrtaceae*)) and it is therefore likely that the scheme and glossary developed for this survey would extend the value of bark for forest recognition very considerably were it applied to other families of trees.

ACKNOWLEDGEMENTS

Primarily I should like to thank Mr. E. J. H. Corner who first interested me in tropical botany and who suggested and supervised this study. Special thanks are also due to Professor H. B. Gilliland (Singapore) and Dr. K. R. Sporne (Cambridge) who supervised me part of the time and to the Conservators of Forests and their staffs in Malaya and British Borneo for stimulating discussion and considerable help in the forests. The investigations were financed by grants from St. John's College, Cambridge, University of Cambridge (Frank Smart Studentship), Colonial Development and Welfare funds (grant CDW(R)806) and the Ministry of Education (State Studentship), and were conducted in the Botany Schools of Cambridge and Singapore and the forests of Malaya and Borneo.

REFERENCES

BATE-SMITH, E. C. AND WHITMORE, T. C. (1959) Chemistry and taxonomy in the Dipterocarpaceae. *Nature, Lond.* **184:** 795–796.

BRANDIS, D. (1895) An enumeration of the Dipterocarpaceae. *J. Linn. Soc. (Bot.)* **31:** 1–148.

BROWNE, F. G. (1955) *Forest trees of Sarawak and Brunei.* Kuching.

DESCH, H. E. (1936) Commercial timbers of the Malay Peninsula: I The genus *Shorea. Malay For. Rec.* **12.**

DESCH, H. E. (1941) Dipterocarp timbers of the Malay Peninsula. *Malay. For. Rec.* **14.**

FOXWORTHY, F. W. (1927) Commercial timber trees of the Malay Peninsula. *Malay For. Rec.* **3.**

FOXWORTHY, F. W. (1932) Dipterocarpaceae of the Malay Peninsula. *Malay. For. Rec.* **10.**

HEIM, F. (1892) Recherches sur les Dipterocarpacées.

HENDERSON, M. R. & WYATT-SMITH, J. (1956) *Calophyllum* Linn. *Gdns.' Bull.* **15:** 285–377.

RICHARDS, P. W. (1952) *The tropical rain forest.* Cambridge.

SLOOTEN, D. F. VAN (1927) The Dipterocarpaceae of the Dutch East Indies: IV The genus *Vatica. Bull. Jard. bot. Buitenz.* Serie 3: **9:** 66–137.

SYMINGTON, C. F. (1933) Notes on Malayan Dipterocarpaceae: I. *Gdns.' Bull.* **7:** 129–159.

SYMINGTON, C. F. (1934) Notes on Malayan Dipterocarpaceae: II. *Gdns.' Bull.* **8:** 1–40.

SYMINGTON, C. F. (1938) Notes on Malayan Dipterocarpaceae: IV. *Gdns.' Bull.* **9:** 319–354.

SYMINGTON, C. F. (1939) Notes on Malayan Dipterocarpaceae: V. *Gdns.' Bull.* **10:** 336–386.

SYMINGTON, C. F. (1943) Foresters' Manual of Dipterocarps. *Malay. For. Rec.* **16** Singapore. (published by the Japanese as *'Syonan (2603)'*).

WHITMORE, T. C. (1960) *The systematic morphology of bark in the Dipterocarpaceae.* Dissertation for degree of Doctor of Philosophy, Cambridge University. (Copies in University Library and Botany School, Cambridge, England, and Forest Research Institute, Kepong, Malaya).

WHITMORE, T. C. (1962a) Studies in systematic bark morphology: I Bark Morphology in Dipterocarpaceae. *New Phytol.* **61:** 191–207.

WHITMORE, T. C. (1962b) Studies in systematic bark morphology: II General features of bark construction in Dipterocarpaceae. *New Phytol.* **61:** 208–220.

WOOD, G. H. S. (1957) Common dipterocarp trees of North Borneo. Unpublished manuscript of North Borneo For. Rec. 5. Privately circulated from Sandakan to far eastern Forest Departments.

WYATT-SMITH, J. (1955) The Dipterocarpaceae of Brunei, North Borneo and Sarawak: 1 *Anisoptera. Malay. Forester* **18:** 70–79.

APPENDIX 1

Alphabetical list of species studied

The groups of *Shorea* are indicated as R (Red Meranti), D (Meranti Damar Hitam), P (Meranti Pa'ang) and B (Balau). Numbers refer to my own series, the location of the herbarium specimens is given in the text.

Anisoptera Korth.

A. curtisii Dyer

A. laevis Ridl.

A. megistocarpa V.Sl.

A. oblonga Dyer

A. scaphula (Roxb.) Pierre

Balanocarpus Bedd.

B. heimii King.

Dipterocarpus Gaertn.f.

D. appendiculatus Scheff.

D. cornutus Dyer

D. costulatus V.Sl.

D. crinitus Dyer

D. dyeri Pierre

D. fagineus Vesq.

D. kerrii King

D. pseudofagineus Foxw.

D. rotundifolius Foxw.

D. sublamellatus Foxw.

D. verrucosus Foxw. ex V.Sl.

Dryobalanops Gaertn.f.

D. aromatica Gaertn.f.

D. lanceolata Burck

D. oblongifolia Dyer

D. rappa Becc.

Hopea Roxb.

H. beccariana Burck

H. ferrea Lanessan

H. griffithii Kurz.

H. helferi (Dyer) Brandis.

H. latifolia Sym.

H. mengarawan Miq.

H. nervosa King

H. nutans Ridl.

H. odorata Roxb.

H. sangal Korth.

H. semicuneata Sym.

H. sulcata Sym.

H. vesquei Heim

H. sp. nov. 'A'.

H. sp. nov. 324.

Shorea Roxb.

S. acuminata Dyer (R).

S. albida Sym. (P).

S. andulauensis Ashton (Msc.) (R.)

S. argentifolia Wood (Msc.) (R).

S. balanocarpoides Sym. (D).

S. beccariana Burck (R).

S. bentongensis Foxw. (P).

S. blumutensis Foxw. (D).

S. bracteolata Dyer (P).

S. ciliata King (B).

S. collina Ridl. (B).

S. curtisii Dyer ex King (R).

S. dasyphylla Foxw. (R).

S. dealbata Foxw. (P).

S. dolichocarpa V.Sl. (D).

S. sp. nov. 'E4' (D).

S.? elliptica Burck (B).

S. faguetiana Heim. (D).

S. foxworthyi Sym. (B).

S. geniculata Sym. (B).

S. gibbosa Brandis (D).

S. glauca King (B).
S. guiso (Blanco) Bl. (B).
S. gysbertsiana Burck (R).
S. hopeifolia (Heim) Sym. (D).
S. hypochra Hance (P).
S. inappendiculata Burck (B).
S. kunstleri King (R).
S. laevifolia (Parijs) Endert (B).
S. laevis Ridl (B).
S. lamellata Foxw. (P).
S. leprosula Miq. (R).
S. leptoclados Sym. (R).
S. lumutensis Sym. (B).
S. macrantha Brandis (R).
S. macroptera Dyer (R).
S. materialis Ridl. (B).
S. maxima (King) Sym. (D).
S. maxwelliana King (B).
S. meadiana Sym. (B).
S. mecistopteryx Ridl. (R).
S. multiflora (Burck) Sym. (D).
S. ochracea Sym. (P).
S. ochrophloia E. J. Strugnell (B). ex Sym. (R).
S. ovalis (Korth) Bl. (R).
S. ovata Dyer (R).
S. parvifolia Dyer (R).
S. pauciflora King (R).
S. platycarpa Heim. (R).
S. platyclados V.Sl. ex Foxw. (R).
S. pinanga Scheff. (R).
S. quadrinervis V.Sl. (R).
S. resina-nigra Foxw. (D).
S. resinosa Foxw. (P).
S. rubella Ashton (Msc.) (R).
S. rubra Wood (Msc.) (R).
S. sericeiflora Fischer et Hutch. (P).
S. singkawang (Miq.) Burck. (R).
S. smithiana Sym. (R).
S. symingtoniana Wood (Msc.) (P).
S. talura Roxb. (P).
S. waltoni Ashton (Msc.) (R).
S. sp. nov. SAR 5798 (R).
S. sp. nov. 555 (B).
S. sp. nov. 569 (B).

Vatica Linn.

V. cinerea King.
V. cuspidata (Ridl.) Sym.
V. lowii King emend. Sym.
V. maingayi Dyer
V. nitens King
V. oblongifolia Hk.f.
V. wallichii Dyer

APPENDIX 2

Note on construction of figures 1–8 showing relation between girth and Bark Type on the bole

These figures show at a glance the Bark Type sequence on the bole throughout the life of the tree, the number of individuals sampled and their girths. There is a column for every species and these are arranged across the figure from left to right; increasing girth is down the page.

The Bark Types present over the whole girth range are shown by difierent shadings, as far as they can be reasonably induced from the data.

Every individual sampled is shown by a dot and its Bark Manifestation indicated where determined. Starred individuals are explained in the legends. No Manifestation is shown when an individual is heterogeneous, beyond the normal range of its Bark Type, or undetermined; the reader must refer to Whitmore (1960) for detailed discussion.

The Bark Type sequence of a species and the Manifestation of an individual are discussed more fully in Whitmore (1960) where necessary; it is not possible to reproduce these details here.

The Bark Type sequence has been induced from the published generalised descriptions and my own observations. These two sources are complementary; in most cases they indicate identical bark at every girth. In some cases accurate personal observations make it possible to define an otherwise vague published description. In the absence of personal observations I cannot always interpret the published descriptions with certainty as the terms used are not defined.

The following rules have been followed in inducing the Bark Type sequence throughout life:—

1. There are often considerable differences from one individual to another in the girth at which the Bark Type changes; this accounts for the occasional discrepancies between the *generalised* description of the species and the description of an *individual* tree. On the figures the bark is shown to change Type at a median girth between the extremes observed; where the range is considerable an intermediate zone is shown.

2. It is unlikely that Scaly, Surface Rotten and Laminate barks are succeeded on very big trees by any others and, although the published generalised description may not describe the bark of very big trees and no personal observations were made, they are extrapolated to the maximum usual girth of the species. It is possible and likely, however, that the Bark Manifestation changes, first on the butt, later spreading up the bole as the tree ages. Other Bark Types are extrapolated upwards an arbitrary 1 ft. above the largest individual observed (see 4. below), unless the published generalised description is sufficiently precise to warrant greater extrapolation.

3. The Bark Type of poles (individuals below about 3½ ft. girth) can only be induced from my own observations as the published generalised descriptions are restricted to mature trees. In many cases no observations were made, but the bark is likely to remain Smooth to at least 1 ft. girth and is so shown on the figures. The girth at which Smooth bark is replaced is usually somewhere in the girth range of large poles (girth range 1 ft.–3½ ft. for emergent species). No Bark Type is shown for large poles or small trees unless individuals were seen.

4. I have extrapolated the Bark Type of the smallest tree examined downwards an arbitrary 1 ft. in girth, where the Bark Type on small individuals is in doubt. This allows for an error in estimation of the girth (not likely to be greater than ± 9 ins.) and for the variation expeeted between individuals (see above).

5. No Bark Type preeedes Smooth so no downward limit is fixed for the extrapolation from the smallest Smooth barked tree seen.

6. *The maximum usual girth*, ealculated from the published data, is shown on the figures where possible, by an horizontal line (this is considerably less than the *maximum recorded girth*); the bark present above this girth is only shown for speeies where individuals were seen.

a

b

c

d

Fig. 9. *Examples of Bark Manifestations.*

(*a*) *Smooth* -h (*Dipterocarpus*), note surface fine sculpturings; (*b*) Scaly -e (*Dryobalanops*); (*c*) Dippled -a (*Shorea*, Meranti Damar Hitam); (*d*) Coarsely Dippled bark of *Agathis alba* (Lam.) Foxw.

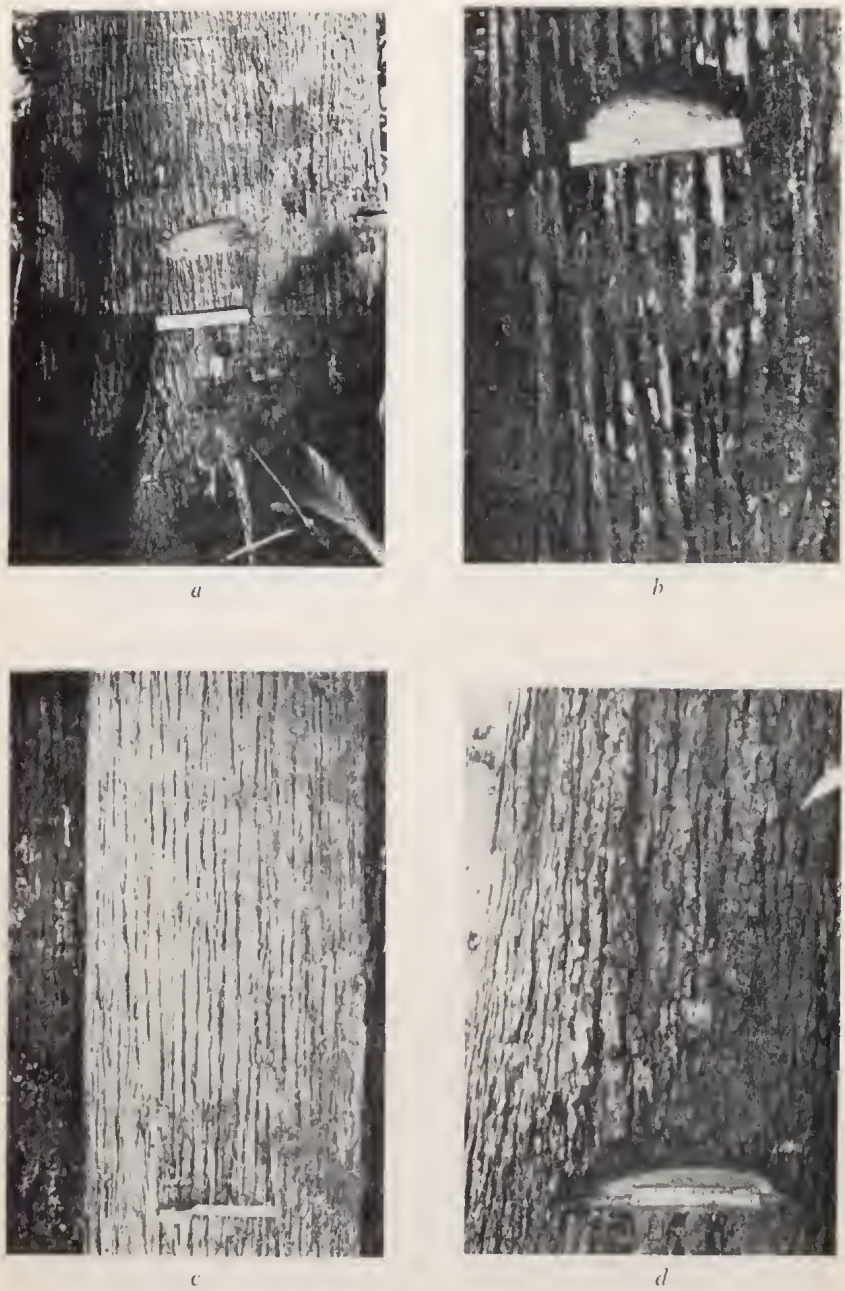


Fig. 10. *Examples of Bark Manifestations.*

(*a*) Shallow Fissured -c (*Shorea*, Red Meranti); (*b*) Deep Fissured -a (*Hopea*, Fissured Barked); (*c*) Surface Rotten -a (*Shorea*, Meranti Pa'ang), note fibrous fissured surface; (*d*) Laminate -a (*Anisoptera*, Pilosae), note scaly-fissured surface and laminate slash.

THE

GARDENS' BULLETIN

SINGAPORE

Vol. XIX, Part III 10th December, 1962

CONTENTS

To be purchased at the Botanic Gardens, Singapore
Price: $3

Published by Authority

PRINTED BY LIM BIAN HAN, ACTING GOVERNMENT PRINTER, SINGAPORE

1962

On a small collection of Bryophytes collected by Professor H. B. Gilliland in Eastern New Guinea

By ANNE JOHNSON

SMALL COLLECTIONS of mosses from West New Guinea have been recorded by Dixon, Brotherus, Fleischer and Reimers; while a large collection from Mt. Wilhelmina was made by Brass and Myer-Drees and recorded by Bartram (1942). A small collection of liverworts was collected by Takari Tuyama in Vogelkop in 1943 and was recorded by Hattori (1951). Records of an extensive collection of mosses from Eastern Papua were made by Bartram (1957). Records from the Territory of New Guinea of mosses collected by the Count and Countess Nils and Greta Gyldenstolpe in the Mt. Hagen district were given by Bartram (1953). Further collections in the Highlands of Eastern New Guinea were made by Hoogland in 1953 and Robbins in 1957. These collections were recorded by Bartram (1959).

The bryophyte flora of New Guinea is immensely rich and very imperfectly known (Bartram, 1959). Although it has a considerable affinity with the flora of the rest of Malaysia, there are a large number of endemic species; while alpine and sub-alpine species show a close relationship with the flora of Australia, Tasmania and New Zealand.

Professor Gilliland's collection was made in September 1960 in two places:—*Chimbu* and the *Daulo Pass* (6,000–8,170 ft.) Australian Territory of New Guinea. The numbers assigned to the bryophytes are accession numbers of the Bryophyte Herbarium of the University of Singapore.

Hepaticae

Marchantia polymorpha L.—Daulo Pass, no. 687.

Marchantia geminata Nees.—Daulo Pass, nos. 703, 710; "forma typica", with female heads bearing exceedingly long purple hairs, ventral scales similar to "Tjibodas type" (Burgeff, 1943).

Riccardia pinguis (L.) Gray—Chimbu, no. 696.

Nardia hasskarliana (N. ab Es.) O. Lind.—Daulo Pass, no. 693.

Plagiochlia teysmanni Sande Lac.—Daulo Pass, nos. 714, 711.

Eulejeunea Spr. sp.—Daulo Pass, no. 702, a slender species, hyaline papilla proximal to apical tooth, the lobes several times larger than the lobules.

Musci

Fissidens zollingeri Montg.—Chimbu, no. 700.

Campylopodium euphorocladium (C.M.) Besch.—Daulo Pass no. 706.

Campylopus richardii Brid.—Daulo Pass, nos. 704, 713.

Thysanomitrium comosum Hsch. et Rw.—Daulo Pass, no. 691.
Leucobryum subsanctum Broth.—Daulo Pass, nos. 701, 712.
Barbula consanguinea (Thw. et Mitt.) Jb.—Chimbu, no. 697.
Mniomalia semilimbata (Mitt.) C. Mull.—Daulo Pass, no. 694.
Symphysodon splendens (Hsch. et Rw.) Broth.—Daulo Pass, no. 709.
Neckeriopsis gracilenta (Lac.) Fleisch.—Chimbu, no. 698.
Ectropothecium aurifolium Bartr.—Daulo Pass, no. 707.
Ectropothecium falciforme (Dz. et Mb.) Jaeg.—Daulo Pass, no. 690.
Ectropothecium sp.—Chimbu, no. 708.
Isopterygium albescens (Schwaeg.) Jaeg.—Daulo Pass, no. 705.
Pogonatum junghuhnianum (Dz. et Mb.) v.d.B.—Daulo Pass, no. 688.
Pogonatum microphyllum (Dz. et Mb.) v.d.B. et Lac.—Chimbu, no. 695; Daulo Pass, no. 692.

Of the species listed above, *Marchantia polymorpha* and *Riccardia pinguis* are cosmopolitan, while *Thysanomitrium comosum* Hsch. et Rw. has a general tropical distribution. *Ectropothecium aurifolium* is endemic being previously recorded from Lake Habbema in West New Guinea (Bartram, 1942). The majority of the rest of the species are Malaysian in distribution some extending as far as the Pacific Islands (*Fissidens zollingeri, Campylopodium euphorocladium,* and *Mniomalia semilimbata*), Japan (*Campylopus blumii*) or East Africa (*Campylopodium euphorocladium*). The alpine and sub-alpine element is not represented, since no collection was made above 8,170 ft.

Relevant Papers

Arens, P. (1953) Bemerkungen zu einigen von C. E. Carr in Neuguinea gesamelten Moosen. Blumea 7 (2) 339–341.

Bartram, E. B. (1942) Third Archbold Expedition Mosses from the Snow Mountains, Netherlands New Guinea. Lloydia 5 245–292.

Bartram, E. B. (1953) Additional mosses from N.E. New Guinea. Svensk. Bot. Tidskr. 47 (3) 397–401.

Bartram, E. B. (1957) Mosses of Eastern Papua, New Guinea. Brittonia 9 (1) 32–56.

Bartram, E. B. (1959) Contributions to the mosses of the highlands of Eastern New Guinea. Brittonia 11 (2) 86–98.

Burgeff, H. (1943) Genetische Studien an Marchatia, p. 282, Jena.

Dixon, H. N. (1937) On a small collection of mosses from New Guinea. Annales Bryologici 10 16–19.

Fleischer, M. (1900–1922) Die Musci der Flora von Buitenzorg, vols. 1–4, Leiden.

Hattori, S. (1951) On a small collection of Hepaticae from Dutch New Guinea. Bot. Mag. (Tokyo) 64 112–119.

Meijer, W. (1959) Notes on species of Riccardia from their type localities in Western Java. Jour. Hattori Bot. Lab. 21 61–78.

Noguchi, A. (1953) Mosses of Mt. Sarawatet, New Guinea. Jour. Hattori Bot. Lab. 10 1–23.

Schiffner, V. (1900) Die Hepaticae der Flora von Buitenzorg. vol. 1, Leiden.

Van der Wijk, R. (1958) Precursory Studies on Malaysian Mosses. II. A Preliminary Key to the Moss Genera. Blumea 9 (1) 143–186.

A Short Note on some Soil Algae from New Guinea

By Anne Johnson

Small samples of soil from the Australian Territory of New Guinea were received together with bryophytes collected by Professor H. B. Gilliland in 1960. These samples were kept in polythene bags and, owing to transport difficulties, did not reach this laboratory until one year after their dispatch. The soil was carefully separated from the bryophytes which have been described in a previous paper. Two sets of soil cultures were set up:—

(i) moist cultures, i.e. samples of soil placed in sterile petridishes and exposed to continuous light;

(ii) liquid cultures in nutritive medium, following the method of John (1942).

In both types of culture there was vigorous growth of algae and there was considerable correspondence between algae which appeared in moist and liquid culture of the same sample.

Four samples were obtained from localities on the Daulo Pass, 6,000–8,000 ft.; while a fifth was obtained from Chimbu. In all cases the soil was collected from 1–2 cm. of the surface.

Chlorophyceae

Chlorococcales

Chlorococcum humicolum (Naeg.) Rabenh.
Liquid culture, soil from Chimbu.

Scenedesmus obliquus (Turp.) Kutz
Liquid culture, soil from Chimbu.

Dactylococcus stage of Scenedesmus obliquus (Turp.) Kutz. (see Grintzesco (1902))
Liquid culture, soil from Daulo Pass, 6,000–8,000 ft.

Cyanophyceae

Chroococcales

Chroococcus varius A. Br.
Liquid culture, soil from Daulo Pass, 6,000–8,000 ft.

Chamaesiphonales

Dermocarpa hemisphaerica Setchell & Gardner
Moist culture, epiphytic on *Lyngbya mesotrichia Skuja* from Daulo Pass, 6,000–8,000 ft.

Nostocales

Lyngbya mesotrichia Skuja
Moist culture and liquid culture from Daulo Pass, 6,000–8,000 ft.

Phormidium jadinianum Gomont
Moist and liquid culture from Daulo Pass, 6,000–8,000 ft.

Symploca elegans Kutzing ex Gomont

Moist culture, soil from Chimbu.

Nostoc linckia (Roth) Bornet ex Born. et Flah.

Moist and liquid culture, soil from Daulo Pass, 6,000–8,000 ft.

Nostoc microscopicum Carm. ex Born. et Flah.

Moist culture, soil from Daulo Pass, 6,000–8,000 ft.

Scytonema pseudopunctatum Skuja

Moist culture, soil from Daulo Pass, 6,000–8,000 ft.

Discussion

The pH of the samples of soil from the Daulo Pass and Chimbu was about 5.3 when they reached the laboratory. The pH of the nutritive solution used in the liquid culture was 5.6. There was no change in the pH of the moist culture over a two month growing period. Most of the liquid cultures showed a gradual rise of pH to 6.2 in some cases. In a few liquid cultures with sparse growth there was little change in pH.

While cultures of soil algae are of little direct value from an ecological point of view, they are almost essential in obtaining a complete algal flora of a soil (Tiffany, 1951). In the soil, algae are so very small and widely dispersed they are easily overlooked. In the moist cultures, samples of soil were given additional light over 24 hours/day which led to enhancement of algal growth; while in liquid cultures additional nutrients were also supplied. These cultures tell us little of the relative abundance of the different algae in the natural habitat, but they do indicate which species of algae are present in these particular soils.

The results given above indicate the occurrence of eight species of blue-green algae but only two species of Chlorophyceae. No diatoms were recorded. This may be due to the scarcity of diatoms in the habitat, or to the fact that the method of culture is unsuitable for diatom growth. Their complete absent even from moist cultures suggests the former. Lund (1945) has indicated that diatoms are absent in acid soils.

The relative large numbers of species of Cyanophyceae in tropical soils was noted for Ceylon by Fritsch (1907, 1907*) and in Lahore and Simla by Ghose (1923). This was considered to be due to their preference for high temperatures, damp atmosphere. Their blue-colour may act as a screen against intense light while lowland forms are able to withstand desiccation. Highly mucilaginous blue-green algae (e.g. Nostoc spp.) are most suited to damper upland conditions. Fritsch (1907) found slimy forms at Nuwara Eliya and Hakgalla at a height of 6,000 ft. and more.

References

FRITSCH, F. E. (1907) The Role of Algal Growth in the Colonisation of New Ground and in Determination of Scenery. Georgr. Jour. 30 531–548.

FRITSCH, F. E. (1907*) A general consideration of the sub-aerial and Freshwater Algal Flora of Ceylon. Proc. Roy. Soc. (Lond.) B 79 197–254.

GHOSE, S. L. (1923) A Systematic and Ecological Account of a Collection of Blue-Green Algae from Lahore and Simla. Jour. Linn. Soc. Bot. 46 333–346.

GRINTZESCO, J. (1902) Recherches experimentales sur la morphologie et physiologie de Scenedesmus acutus Meyen, Bull. Herb. Boissier 11, 2 217 et seq.

JOHN, R. P. (1942) An Ecological and Taxonomic Study of the Algae of British Soils. I The distribution of surface-growing algae. Annals Bot., N.S. 6 323–349.

LUND, J. W. G. (1945) Observations on soil algae. New Phytol. 44 196–219.

TIFFANY, L. H. (1951) Ecology of Freshwater Algae. Chronica Botanica 27 303–305.

Precursory Studies on the Epiterranean Soil Algae of Singapore and Malaya

By ANNE JOHNSON

Introduction

ALGAE ARE PRESENT in Malayan soils to a depth of several centimeters or sometimes to one meter. Deeply buried subterranean forms probably have their origin from the soil surface having been washed down by the rain, aided by the movement of soil animals and by cultivation. These algae are undoubtedly in complete darkness and must survive as saprophytes (Tiffany, 1951). In general they are of little importance in soil economy. On the other hand, the truly epiterranean forms which remain at or near the soil surface are exceedingly important since they can increase the organic content of the surface layers of the soil by photosynthesis, while certain Nostocaceae can contribute to the fertility of the soil by nitrogen fixation (De, 1939). Soil algae are exceedingly important ecologically particularly in tropical regions as first colonisers of bare ground. Many algae assist in the actual disintegration of a rock surface to form soil, in addition to forming an organic matrix suitable for higher plant growth. (Fritsch, 1907; Treub, 1888).

Investigation of surface algae in Europe include those of Petersen (1935); Bristol (1920); James (1935) and John (1942). In America Coyle (1935); Booth (1941); Lowe & Moyse (1934); Moore & Carter (1926) and many others have made studies of the soil flora of different districts. Valuable contributions to our knowledge of the soil algae of Ceylon were made by Fritsch (1907, 1907 a, 1907 b). Ghose gives an account of the Cyanophyceae of Lahore and Simla (1923). As far as I am aware the only paper on Malayan soil algae is that of Bristol (1919).

II. The Soil Samples and their mode of collection and culture

The technique of collection and culture was very similar to that used by John (1942), but various details were modified to suit local conditions.

Soil samples were taken from the top, second, third and fourth centimeter below the surface of the soil with the usual precautions to prevent contamination or mixing of the layers. Each sample was examined microscopically and any algae were recorded. For each soil sample two series of cultures were set up. *Moist cultures* consisted of soil placed to a depth of 1 cm. in sterile petri dishes, moistened with sterile distilled water, and exposed to continuous light. *Liquid cultures* consisted of small quantities of soil introduced

into a nutritive solution in conical flasks under sterile conditions. The nutritive solution used was Knop's solution (Pringheim, 1951, p. 349) at either full- or half-strength. Liquid cultures were also exposed to continuous light supplied by flourescent strips of the warm daylight type.

Sub-cultures were made (i) by re-inoculating fresh Knop's solution in flasks, (ii) by plating on to Knop's agar or peptone agar, (iii) by inoculation with a sterile needle on to agar slopes in tubes.

III. General description of soils examined

Soil samples were taken from the following six localities:—

Locality 1. Hard exposed ground, University of Singapore.

This soil consisted of dark brown excrusting surface layer about 2 mm. thick, beneath which was a red clay soil about 3 cm. deep. At 3–4 cm. depth the soil was lighter in colour. The pH of all soil samples was approximately 6.4.

Locality 2. Exposed silt, 300 yards from the sea, Dungun, Trengganu.

This soil is a medium brown silt with a fair amount of organic content. The first 4 cm. are more or less homogeneous, apart from a very narrow surface layer. The pH of all soil samples was approximately 6.1.

Locality 3. Exposed cleared building site, Cluny Road, Singapore.

The first three centimeters were of a medium brown colour and consisted of about 34 per cent silt and 62 per cent clay. Beneath this was a heavier red soil with a slight increase in the silt content. The pH of all soil samples was approximately 6.3.

Locality 4. Botanic Gardens Jungle, in forest with heavy leaf litter.

The first centimeter consisted of a dark brown layer with abundant humus, tree roots and dead leaves. The second centimeter consisted of a lighter zone but still with many tree roots. Beneath this was a pale beige crumbly clay soil with fewer roots. The pH of all soil samples was approximately 6.3.

Locality 5. Sunlit Path, MacRitchie Reservoir.

The soil was a homogeneous sticky clay of a pale gamboge colour. The pH of all soil samples was approximately 5.3.

Locality 6. MacRitchie Reservoir Forest, under heavy leaf litter.

The soil was a dark clay rich in tree roots and organic matter. The pH of all soil samples was approximately 5.7.

IV. Examination of initial samples

In soil taken from the natural habitat, soil algae are often sparse, frequently only spores or more or less dormant cells are available; and they are easily overlooked when present in small numbers in a large mass of soil. (Tiffany, 1951). In soil from five of the above localities no algae were observed in any of the top four centimeters. However locality 1 showed an abundant growth of surface algae in the field consisting of *Scytonema javanicum (Kurtz) Born.*, together with *Gloeotheca sp., Oscillatoria sp.* and a little *Microcoleus vaginatus (Vauch.) Gomont.* The second centimeter showed a few coccoids and minute flagellates while no algae could be found in the lower soil layers.

V. Examination of moist cultures

Moist cultures are the best imitation of natural conditions (John, 1942). The growth of soil algae is encouraged by exposure to light over a twenty-four hour instead of a twelve hour period. After a month or two the growth of soil algae on the surface becomes apparent. Later in some cases fern prothalli or seedlings of higher plants make their appearance. The development of a surface layer of algae is slower in soil from deeper layers.

The following is a list of algae which grew in the moist cultures over a five month period. The number in brackets indicates the mean depth from which the soil sample was taken.

Chlorophyceae

Pleurococcus naegelii Chodat
Sunlit path, MacRitchie Reservoir (2.5 cm.).

Trentepohlia torulosa De Wildemann
Sunlit Path, MacRitchie Reservoir (3.5).

Vaucheria sessilis (Vauch.) D.C.
Botanic Gardens Jungle (0.5).

Xanthophyceae
Tribonema bombycinum (Ag.) Derb. et Sol.
Sunlit Path, MacRitchie Reservoir (0.5).

Cyanophyceae
Chroococcus varius A.Br.
Sunlit Path, MacRitchie Reservoir (3.5).

Chroococcus sp.
University of Singapore (0.5).

Lyngbya sp.
Sunlit Path, MacRitchie Reservoir (0.5) and (3.5).

Lyngbya mesotrichia Skuja
Expose silt, Dungun (2.5).

Symploca elegans Kütz.
Exposed cleared building site, Singapore (1.5).

Microcoleus vaginatus (Vauch.) Gomont
Exposed silt, Dungun (1.5); University of Singapore (0.5).

Aulosira pseudoramosa Bharadw.
University of Singapore (0.5).

Scytonema javanicum (Kütz.) Born.
University of Singapore (0.5), (1.5), (2.5); Exposed cleared building site (3.5).

Tolypothrix fragilis (Gardn.) Geitler
University of Singapore (3.5).

Tolypothrix arenophila West, W. & G.S.

Exposed silt, Dungun (0.5).

In these cultures ten different species of Cyanophyceae, three species of Chlorophyceae and one of Xanthophyceae were observed. There were no diatoms. These results are similar to those of Esmarch (1914) who obtained mostly blue-green algae from moist cultures and no diatoms.

It is to be noted that soil from MacRitchie Reservoir Forest (Locality 6) did not develop any identifiable algae in moist culture, although some minute colourless flagellates were observed. The soil in this locality is in heavy shade and is covered with a dense layer of large leaves throughout the year. It is not surprising that the pigmented algae are relatively sparse. Similarly no algae were obtained from the lower levels of the soil from the Botanic Gardens jungle where similar conditions are found.

VI. Examination of Liquid Cultures

The conditions in liquid cultures differ markedly from those of the natural environment. An additional supply of mineral substances is supplied to the soil, in addition to an abundant supply of water. Determination of the abundance of soil algae on growth in cultures is subject to error in that they favour the more hydrophytic plants (Petersen, 1935) in addition to selecting out those algae which are particularly adapted to the culture environment. Nevertheless, since all operations are carried out under sterile conditions, the medium is autoclaved, etc., all algae which appear in such cultures must have been present in the original soil habitat. Therefore this method indicates at least some of the algae spores, cells and other bodies must occur in the natural environment but does not indicate the relative abundance of these organisms.

The following is a list of the algae which grew in the liquid cultures. In most of the cultures a green or blue-green colour was observable from seven to fourteen days after inoculation, but this colour appeared earliest in those cultures of soil from nearest the surface. The composition of the cultures was recorded at intervals of one month. After two to three months staling phenomena commenced and sub-culturing was necessary.

Chlorophyceae

Palmella miniata Naeg.
Exposed cleared building site, Singapore (1.5), (2.5), (3.5).

Ourococcus bicaudatus Grobety
MacRitchie Reservoir Forest (3.5).

Pleurococcus naegelii Chodat
University of Singapore (0.5), (1.5), (2.5), (3.5); Exposed silt, Dungun (0.5); Exposed cleared building site (0.5); Botanic Gardens Jungle (1.5); Sunlit Path, MacRitchie Reservoir (0.5), (1.5), (2.5), (3.5).

Trochisia aspersa (Reinsch.) Hansg.
MacRitchie Reservoir Forest (0.5), (1.5).

Vaucheria sessilis (Vauch.) D.C.
Botanic Gardens Jungle (0.5).

Cyanophyceae

Chroococcus multicoloratus Wood
Botanic Gardens Jungle (1.5), (2.5), (3.5).

Chroococcus varius A.Br.
Sunlit Path, McRitchie Reservoir (1.5), (2.5), (3.5).

Gloeotheca sp.
Exposed silt, Dungun (1.5).

Synechococcus cedrorum Sauvageau
MacRitchie Reservoir Forest (2.5), (3.5).

Oscillatoria sp. 1. (1.3 wide, slightly capitate and twisted)
University of Singapore (0.5), (1.5), (3.5).

Oscillaoria sp. 2. (very coiled, strongly capitate)
Exposed silt, Dungun (0.5), (1.5), (2.5), (3.5).

Phormidium angustissimum West, W. et G.S.
Botanic Gardens Jungle (0.5).

Lyngbya mucicola Lemm.
Exposed cleared building site, Singapore (0.5), (1.5), (2.5), (3.5).

Microcoleus vaginatus (Vauch.) Gomont
University of Singapore (0.5), (1.5).

Microchaete tenera Thuret
University of Singapore (1.5).

Scytonema javanicum (Kiitz.) Born.
University of Singapore (1.5).

Summary and Conclusion

Samples of soil from five localities on Singapore Island and one in the Federation of Malaya were cultured under sterile conditions. "Moist cultures" were the best imitation of natural conditions but continuous light was supplied. In these cultures three species of the Chlorophyceae, one of the Xanthophyceae and ten of the

Cyanophyceae were observed. There were no diatoms. No algae appeared in the cultures from a forest locality.

"Liquid cultures" differed widely from the conditions of the natural environment since they favoured the growth of hydrophytic organisms particularly adapted to the nutrient medium supplied. In these cultures five members of the Chlorophyceae and eleven members of the Cyanophyceae were recorded.

All the algae recorded must have been present at least as spores in the natural environment but no conclusions of their relative abundance can be made.

References

BOOTH, W. E. (1941) Algae as pioneers in plant succession and their importance in erosion control. Ecology 22 38–46.

BRISTOL, B. M. (1920) On the algal-flora of some desiccated English soils. Ann. Bot. 34: 36.

BRISTOL, B. M. (1919) On a Malayan form of Chlorococcum humicola (Naeg) Rabenh. Jour, Linn. Soc., Bot. 44 473–82.

COYLE, E. E. (1935) Algae of some Ohio soils. Abstr. Doctoral Diss., Ohio State Univ. 17 217–227 (fide Tiffany, 1951).

ESMAECH, F. (1914) Untersuchungen über die Verbreitung der Cyanophyceen auf und in verscheidenen Boden. Hedwigia 55 224.

FRITSCH, F. E. (1907) The role of algal growth in the colonisation of new ground and in the determination of scenery. Geogr. Jour. 30 531–548.

FRITSCH, F. E. (1907a) A general consideration of the sub-aerial and freshwater algal flora of Ceylon. Proc. Roy. Soc. London. B 79 197–254.

FRITSCH, F. E. (1907b) The subaerial and freshwater algae of the tropics. Ann. Bot. 21 235–275.

GHOSE, S. L. (1923) A systematic and ecological account of a collection of blue-green algae from Lahore and Simla. Journ. Linn. Soc. London, Bot. 46 333–346.

JAMES, E. J. (1935) An investigation of the algal growth in some naturally occurring soils. Beih. Bot. Centralbl. 53 A 419.

JOHN, R. P. (1942) An ecological and taxonomic study of the algae of British soils. I The distribution of surface growing algae. Ann. Bot., N.S., 6 323–349.

LOWE, C. W. & MOYSE, A. V. (1934) An investigation of some Manitoba soils for the presence of soil algae. Trans. Roy. Soc. Canada 28 119–152.

MOORE, G. T. & CARTER, N. Further studies on the subterranean algal flora of the Missouri Botanic Garden. Ann. Missouri Bot. Gdn. 13 101–140 (1936).

PETERSON, J. B. (1935) Studies in the biology and taxonomy of soil algae. Dansk. Bot. Archiv. 8 no. 9.

TIFFANY, L. H. (1951) in G. M. Smith, Manual of Phycology, Ch. 15 303–306.

TREUB, M. (1888) Notice sur la nouvelle flore de Krakatau. Ann. Jard. bot. Buitenzorg 7 213.

Taxonomic Notes on Ficus L., Asia and Australasia Addendum II

By E. J. H. Corner

Botany School, University of Cambridge

Summary

New species and varieties.—subgen. Urostigma, *F. microcarpa* Linn. f. var. *rigo* (Bailey) Corner; subgen. Ficus secl. Ficus, *F. aureocordata* Corner; sect. Rhizocladus Endl., *F. ampulliformis* Corner, *F. hypobrunnea* Corner, *F. convexa* Corner, *E. ovatacuta* Corner; sect. Kalosyce, *F. diandra* Corner; sect. Sycocarpus Miq., *F. moderata* Corner, *F. virescens* Corner, *F. megaleia* Corner var. *multinervia* Corner and var. *subuncinata* Corner, *F. uncinata* Becc. var. *subbeccarii* Corner *F. scortechinii* King var. *lanceata* Corner.

New subsections.—subgen Ficus sect. Sycocarpus Miq. subsect. *Papuasyce* Corner (type, *F. itoana* Diels) and subsect. *Lepidotus* Corner (type. *F. griffithii* Miq.).

Sect. Sycocarpus subsect. Pomifera Corner is reduced to sect. Neomorphe King ser. Auriculatae Corner.

The recent Royal Society Expedition to North Borneo, 1961, has produced three interesting new species and four new varieties, illustrative of the richness of the Bornean flora in this genus. One species, *F. diandra,* was found within a few miles of Kuching. Exploration of New Guinea forests is producing now a crop of climbing species of sect. Rhizocladus, and I have taken the opportunity to illustrate the figs of some species of this intricate section.

subgen. Urosigma Miq.

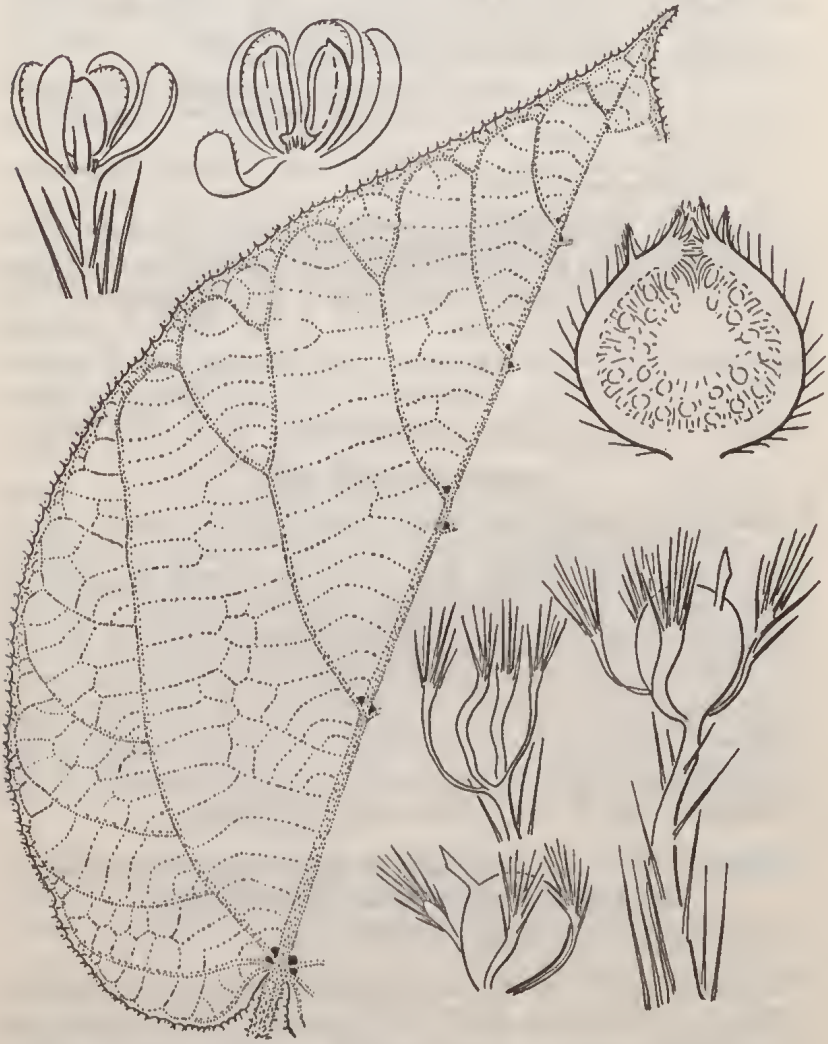
F. microcarpa Linn. f. var. **rigo** (Bailey) Corner comb. nov.—*F. rigo* Bailey, Queensl. Agric. J. 1 (1897) 235.—*F. retusa* L. var. *rigo* (Bailey) Diels, Bot. Jahrb. 67 (1935) 183.—A few trees of this variety are planted in the main streets of Port Moresby. They differ from typical *F. microcarpa* in the absence of copious aerial roots from the branches, by the rather broad and obtuse leaves, and by the slightly larger figs which ripen yellow to orange without becoming pink, red, or purple. In the herbarium it would seem impossible, without field-notes, to distinguish v. *rigo* from v. *latifolia* (Miq.) Corner.

subgen. Ficus sect. Ficus subsect. Eriosycea (Miq.) Corner ser. Auratae Corner subser. Auratae Corner

Corner, Gard. Bull. Sing. 17 (1960) 420.

F. aureocordata Corner sp. nov.—Frutex foliis spiraliter dispositis. Ramuli et petioli pilis rigidis aureobrunneis 1–2 mm. longis vestiti; lamina supra appresse pallide scabrido-pilosa; nervi et nervuli subtus pilis pallidis –0.5 mm. longis vestiti. Ramuli 5–6 mm. crassi. Lamina –32 × 21 cm., ovato-cordata, apice –15

mm. longo subacuminato, basi late et alte cordato, ciliato-dentata, membranacea, supra scabrida, subtus hispidula, sicco flavescens; costis lateralibus utrinsecus 5–6, subtus valde elevatis, glandulis axillaribus praeditis, marginem versus furcatis et inarcuatis; intercostis subtus elevatis, breviter pilosis, haud velutinatis; areolis planis glabris; costis basalibus utrinsecus 2–3, –½ laminae elongatis, glandulis basalibus 2–4 praeditis; petiolo 8–12 cm. longo. Receptacula 17 mm. lata, axillaria sessilia subconoidea, pilis flavidis 1–2 mm. longis dense hispida; bracteis basalibus ?, eruptis; bracteis lateralibus paucis, –3 mm. longis, appresse pilosis; bracteis apicalibus erectis, appresse pilosis, ut in cono 3 mm. alto confertis; setis internis –2.5 mm. longis, aureis, copiosis; cellulis scleroticis in pariete tenui nullis.



Text-Fig. 1. *F. aureocordata* Corner, leaf, × ½; fig. × 2; male and gall-flowers, × 10. (Hans Winkler 895).

Flores masculi in ordinibus duobus instructi, prope apicem sessiles bistaminati, alteri pedicellati unistaminati; tepalis 4 spathulatis albidis; staminibus haud v. vix mucronatis, liberis, pilis confertis ad basim filamentorum. Flores cecidiophori sessiles v. pedicellis setosis –4 mm. longis praediti; tepalis 3–4, albidis, apicem versus dense setosis, lineari-spathulatis; ovario flavidulo sessili. Flores feminei ? Cystolitha nulla. Hans Winkler Pl. born. 895, Bt. Raja (112° 30′ E, 0° 30′ S), Borneo occid., 1,250 m. alt. in silva; typus, herb. Leiden.

Though known from the single collection, this is a distinct species, peculiar in retaining lateral bracts on the fig. It comes in leaf-shape between *F. bruneiensis* Corner and *F. eumorpha* Corner, but the male flowers ally it with *F. aurata* Miq. It increases the number of species of ser. *Auratae* to ten, of which nine are endemic in Borneo.

subgen. Ficus sect. Rhizocladus Endl. ser. Ramentaceae Corner subser. Pantonianae Corner

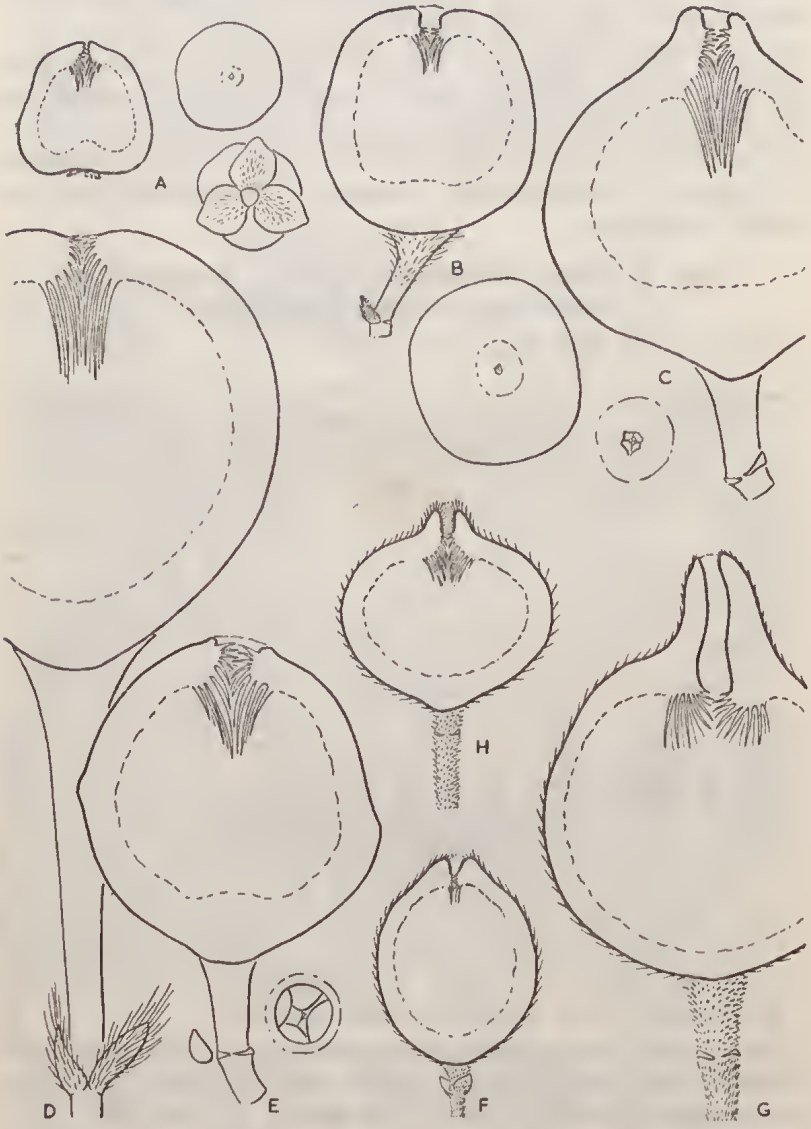
Corner, Gard. Bull. Sing. 18 (1960) 4.

F. ampulliformis Corner sp. nov. (Text-Fig. 2, H)—Scandens, foliis distichis. Ramuli, petioli, costae subtus pilis albidis v. brunneolis –1 mm. longis appressis tenuiter vestiti. Ramuli 2 mm. crassi. Stipulae –6 mm. longae, caducae, appresse pilosae. Lamina 2.5–5 × 1.5–3 cm., elliptica, subacuta, basi cuneato, valde coriacea marginibus incurvatis, scabrida, sicco dura fuscobrunnea; costis lateralibus utrinsecus 4, obliquis, subtus elevatis, inarcuatis; intercostis 0–3, laxis, subtus vix elevatis; costis basalibus utrinsecus 1, ad ½ laminae; petiolo 5–10 mm. longo. Receptacula axillaria binata hispidula, subglabrescentia; pedunculo 3–5 mm. longo; bracteis basalibus mox caducis; pedicello 0.5–1.5 mm. longo; corpore receptaculi 8–10 mm. lato, depresso-globoso, ostiolo ad basim papillae apicalis 1 mm. altae immerso; setis internis nullis, vel paucis minutis; cellulis sclerotieis in parietc copiosis. Flores masculi pedicellati, ordinibus 2 v. 1 instructi; antheris submucronatis. Flores cecidiophori sessiles v. pedicellati; tepalis 3–4, lineari-spathulatis, rubris, liberis; ovario sessili ochraceo subindurato. Cystolitha amphigena. F. A. W. Schram, BW 7743, Kebar valley, West New Guinea, in silva c. 700 m. alt.; typus herb. Leiden.

This species is very distinct in its subseries from the small, stiff, subacute, and scabrid leaves with few veins and from the characteristic shape of the fig which recalls that of *F. villosa* Bl.

F. hypobrunnea Corner, sp. nov. (Text-Fig. 2, F)—Scandens, foliis distichis. Ramuli, stipulae, petioli, costae subtus, et receptacula pilis brunneis v. flavidis 0.5–1 mm. longis appressis vestiti. Ramuli 1.5–2 mm. crassi. Stipulae –8 mm. longae, dense sericeae. Lamina 2.5–5.5 × 1.2–2.5 cm., lanceolato-elliptica, subacuta, basi angustato rotundato v. subcuneato, coriacea laevis,

marginibus vix incurvatis; costis lateralibus utrinsecus 5–6, oblique inarcuatis, supra vix impressis; intercostis 2–5, subtus leniter elevatis; areolis planis; costis basalibus utrinsecus 1 (–2), ad 1/3–½ laminae; petiolo 3–6 mm. longo. Receptacula axillaria solitaria, dense appresse pilosa, maturitate rubra; pedunculo 1 mm. longo; bracteis basalibus 1 mm. longis, ovatis, caducis; pedicello 1.5 mm. longo; corpore receptaculi 7 mm. lato, sicco



Text-Fig. 2. Figs of sect. Rhizocladus, × 3. A, *F. amblisyce* Corner, three figs (v. Royen 3775). B, *F. pantoniana* King var. *colobocarpa* Diels, two figs (Clemens 2124). C, *F. floccifera* Diels, (Carr 13493). D, *F. camptandra* Diels, (Buwalda 4993). E, *F. pantoniana* King, (Carr 15830). F, *F. hypobrunnea* Corner, (BW 9283). G, *F. baeuerleni* King var. *vulcaniformis* Corner, (NGF 3458). H, *F, ampulliformis* Corner, (BW 7743).

subellipsoideo, ostiolo minuto immerso; setis internis copiosis, –0.5 mm. longis, albidis; cellulis sclerotics in pariete copiosis. Flores feminci sessiles; tepalis 3–4 rubris, anguste spathulatis v. ovatis, liberis. Semina 1.2–1.5 mm. longa, compressa, anguste alata. Cystolitha amphigena. F. A. W. Schram, BW 9283, Oereb, div. Hollandia, New Guinea, in silva; typus, herb. Leidcn.

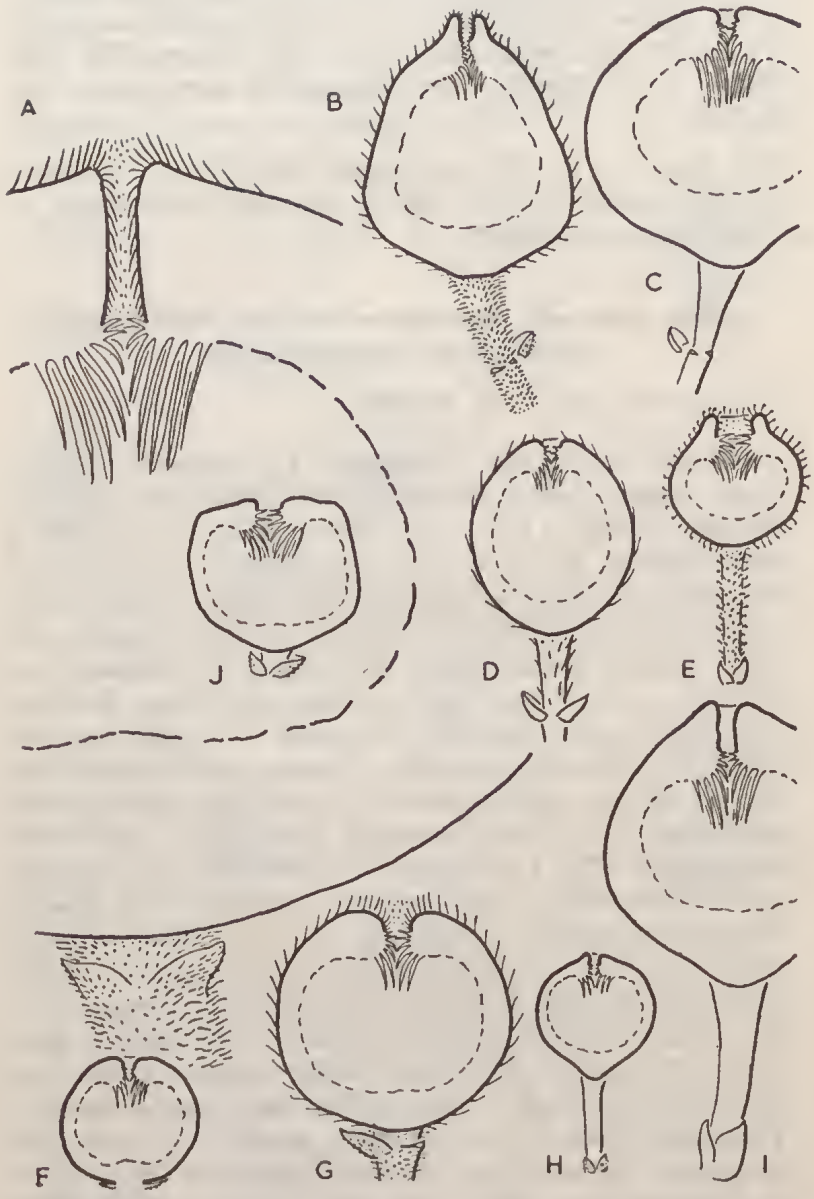
This is near to *F. amblisyce* Corner, but differs in the densely hairy, pedunculate and pedicellate fig, the smaller basal bracts, and the copious internal bristles.

subgen. Ficus sect. Rhizocladus Endl. ser. Ramentaceae Corner subser. Irritantes Corner

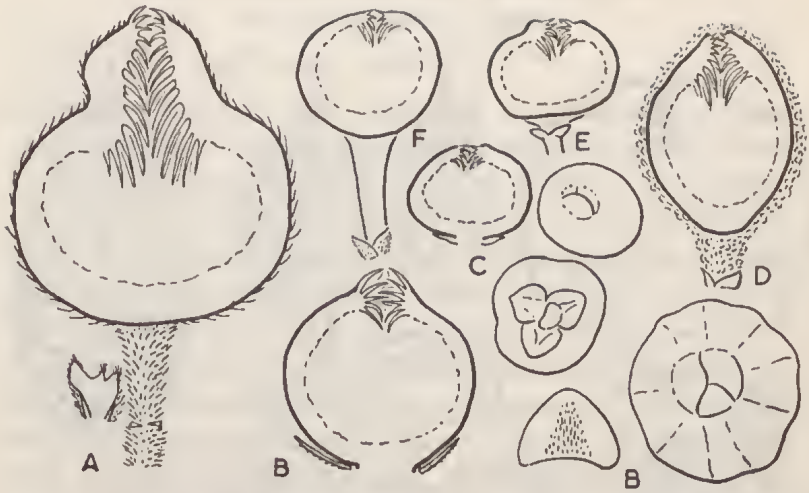
Corner, Gard. Bull. Sing. 18 (1960) 4.

F. convexa Corner sp. nov. (Text-Fig. 3, D)—Scandens, foliis distichis. Ramuli, petioli, et costae subtus primo pilis rigidis irritantibus brunneis 1.5–2.5 mm. longis strigosi; nervulis pilis albidis puberulis. Ramuli 2 mm. crassi. Stipulae –10 mm. longae, appresse puberulae, ad carinam pilis rigidis paucis affixis. Lamina –8 × 3.8 cm., ovato-elliptica v. ovato-lanccolata, subacuta v. obtuse subacuminata, basi cordato v. rotundato, rigide coriacea, convexa, inter costas bullata, marginibus decurvatis, subscabrida; costis lateralibus utrinsecus 5–7, supra imprcssis, subtus valde elevatis; intercostis –7, supra valde impressis, subtus vix elevatis; areolis glabris v. puberulis; costis basalibus utrinsecus 1, ad ¼–1/3 laminae; petiolo 5–10 mm. longo; bathyphyllis 1.5–3.5 cm. longis, ovato-cordatis, tenue coriaceis, bullatis, aequalibus, costis lateralibus utrinsecus 3–4 praeditis. Receptacula axillaria; pedunculo 0–1 mm. longo; bracteis basalibus 1.5–2.5 × 2–3 mm., ovatis acutis caducis, sparsim puberulis; pedicello 1–5 mm. longo; corporc receptaculi 7–9 mm. lato, subgloboso v. subellipsoideo, tenue appresse pilosa, ostiolo alte immerso; setis internis nullis v. paucis minutis; cellulis scleroticis in pariete crasso nullis. Flores feminei sessiles v. pedicellati; tepalis 3–4 rubris liberis. Scmina 1.5–2 mm. longa, comprcssa, angustc alata. Cystolitha amphigena. Brass 31121, in silvis montanis 2,400 m. alt., Mt. Otto, Terr. New Guinea; typus, hcrb. Leidcn. NGF 6350 (leg. H. S. McKee 1352), Goroka, 2,500 m. alt., Tcrr. New Guinea. Corner et Womersley s.n., Goroka, Daulo Pass, 2,400 m. alt., bathyphylla.

This may be a high mountain statc of *F. insculpta* Summerh., but in addition to the smaller, more convex, and bullate leaf the smaller fig is pedicellate, lacks the flattcned apex of *F. insculpta*, and also the sclcrotic cells in the fig-wall.



Text-Fig. 3. Figs of sect. Rhizocladus, × 3. A, *F. sphaerocarpa* Corner, (Carr 13553). B, *F. villosa* Bl., (Sing. F.N. 25824). C, *F. sagittata* Vahl, (Sing. Bot. Gard.). D, *F. convexa* Corner, (Brass 31121). E. *F. uncinulata* Corner, (Sing. F.N. 30699). F, *F. recurva* Bl. var. *ribesioides* (Wall.) King, (Sing. F.N. 28605). G, *F. recurva* Bl. var. *lasiocarpa* Corner, (Sing. F.N. 27816). H, *F. recurva* Bl. var. *elegantior* Corner, (Sing. F.N. 30126). I, *F. recurva* Bl. var. *bridelioides* Corner, (Sing. F.N. 25941). J, *F. urnigera* Miq., (Sing. F.N. 25948).



Text-Fig. 4. Figs of sect. Rhizocladus, × 3. A, *F. balanota* Diels, (Schlechter 17601). B, *F. sageretina* Diels, (Schlechter 18238). C, *F. excavata* Wall., three figs, (Sing. F.N. 29990). D, *F. araneosa* King, (King's Coll. 3565). E, *F. callicarpides* Corner, (Anderson 9890). F, *F. lanata* Bl., (Koord. 40149).

subgen. Ficus sect. Rhizocladus Endl. ser. Distichoideae Corner

Gard. Bull. Sing. 18 (1960) 5.

F. ovatacuta Corner sp. nov. (Text-Fig. 5, A)—Scandens, foliis laxe spiraliter instructis v. subdistichis. Ramuli et petioli pilis appressis brunneis –1 mm. longis vestiti, costa subtus sparsim appressc pilosa v. glabra. Ramuli 1.5–2 mm. crassi. Stipulae 6–10 mm. longae, glabrae, ad novellas persistentes. Lamina 3–6 × 1.5–3.2 mm., ovata, acuminato-acuta, basi rotundato subcordato v. late cuncato, coriacea, sicco brunnca; costis lateralibus utrinsecus 5–7, subtus vix elevatis; intercostis 0–2, laxis, areolis planis; costis basalibus utrinsecus 1, brevibus; petiolo 5–11 mm. longo. Receptacula axillaria glabra subsessilia rubescentia; bracteis basalibus 1.5 mm. longis, ovatis subacutis glabris; pedicello vix evoluto; corpore receptaculi 10–13 mm. lato (15–17 mm., vivo), subgloboso, ostiolo plano; setis internis et cellulis scleroticis nullis. Flores feminei sessiles v. pedicellati; tepalis 3–4, spathulatis, liberis, rubris. Flores neutri sessiles ostiolares. Semina ? Cystolitha amphigena sed supra sparsa. Brass 31624, in silva montana 1,950 m. alt. pr. Parosa, Okapa, Eastern Highlands, Terr. New Guinea; typus, herb. Leiden.

The large subsessile figs, the ovate-acute leaves, and the appressedly hairy twigs readily distinguish this species which seems to be nearer to *F. distichoidea* than to *F. phatnophylla.*

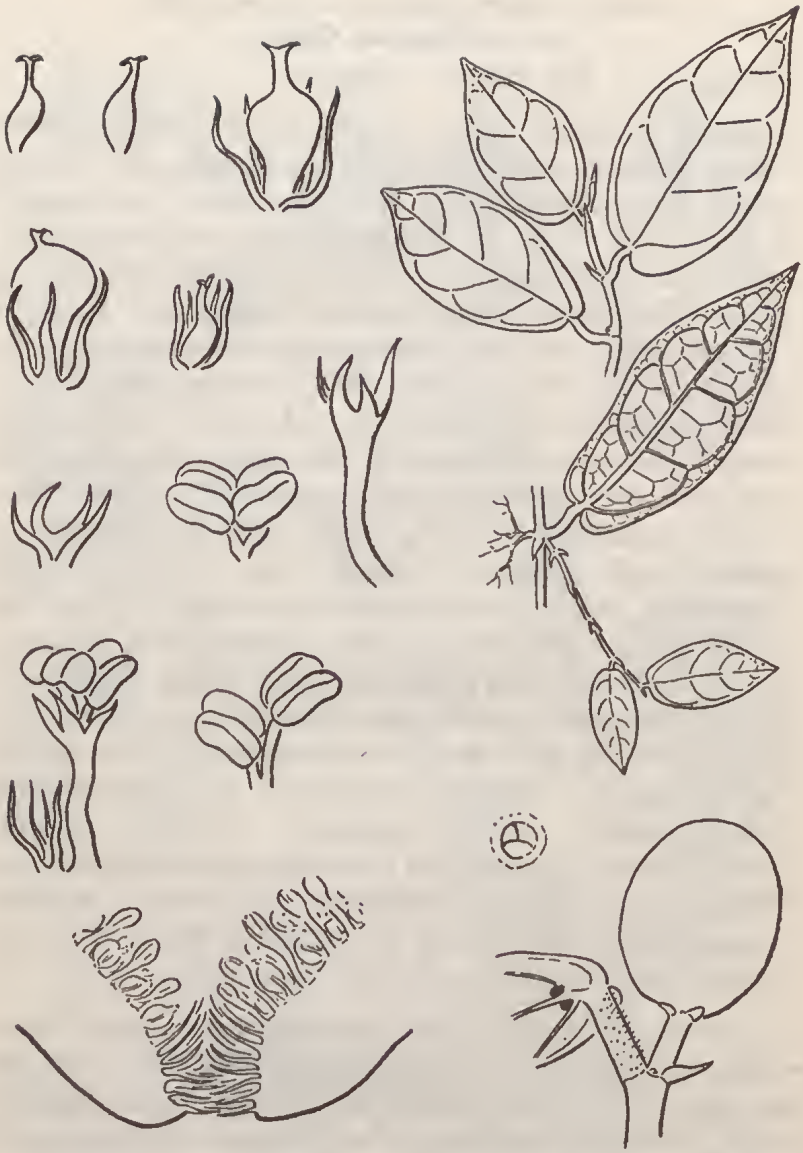
Text-Fig. 5. Figs of sect. Rhizocladus ser. Distichoideae, × 3. A, *F. ovatacuta* Corner, a fig and two leaves (Brass 31624). B, *F. phatnophylla* Diels, one leaf, (Ledermann 9406). C, *F. agapetoides* Diels, a fig and three leaves, (Carr 15799). D, *F. phatnophylla* Diels var. *glochidioides* Corner, (v. Leeuwen 10166). E, *F. calodictya* Summerh., one leaf, (Hoogland 4801). F, *F. distichoidea* Diels var. *megacarpa* Corner, a fig showing the large male flowers, and one leaf, (Carr 16031). G, *F. distichoidea* Diels, (Carr 12112).

Ficus L. subgen. Ficus sect. Kalosyce Miq.
ser. Apiocarpeae Corner

Corner, Gard. Bull. Sing. 18 (1960) 22.

F. diandra Corner sp. nov. (Text-Fig. 6)—Scandens, radicibus affixa, glabra v. novellis puberulis brunneo-pruinosis. Ramuli 1–1.5 mm. crassi. Stipulae 4–7 mm. longae, persistentes. Lamina 4–9 × 2–4.2 cm., elliptica v. ovato- v. obovato-elliptica, acute, basi anguste cordata, saepe subinaequilateralis, coriacea integra, haud scabrida; costis lateralibus utrinsecus 3–5, angulo lato orientibus, inarcuatis, supra obscuris, haud impressis, subtus vix elevatis, intercostis nullis: costis basalibus utrinsecus 1–2 brevibus: petiolo 4–20 mm. longo. Receptacula axillaria solitaria v. ad ramulos efoliatos –15 mm. longos, pallide marmorata, maturitate rubro-aurantiaca; pedunculo 1.5–4 mm. longo; bracteis basalibus 3, 1–1.5 mm. longis, ovatis acutis subcaducis; pedicello nullo; corpore receptaculi 12–14 × 11 mm. (vivo) ellipsoideo, minute brunneo-furfuraceo, ostiolo 2 mm. lato leniter immerso, bracteis 3 apicalibus planis occluso; setis internis et cellulis scleroticis parietalibus nullis. Tepala 3–4 (masc.), 4–5 (cecid.), membranacea, pallide rosea. Flores masculi dispersi copiosi, fl. cecid. superantes; pedicellis 0.5–2 mm. longis; tepalis lanceolatis, breviter gamophyllis. Flores cecidiophori sessiles; tepalis lanceolato-filiformibus brevissime connatis; ovario brunneo indurato sessili v. breviter stipitato; stylo breviter bilobato. Flores fem. ? Cystolitha hypogena. Sarawak, ad basim trunci *Durionis zibethini,* ad viam Kuching-Matang. S. 13740 (typus, herb. Cantab.), leg. E. J. H. Corner 26 Sept. 1961.

To place this species in sect. *Kalosyce* (one stamen) seems wrong. Sect. *Rhizocladus* Endl. ser. *Distichae* Corner seems the right place for the bistaminate flower. In other points, however, as the marbled fig, the pedicellate male flowers, the membranous tepals, and the bifid stigma, the species agrees with sect. *Kalosyce,* and it is very close to *F. warburgii* Elm. which has usually one, rarely two, stamens. *F. warburgii* differs specifically in the obtuse, obovate lamina with cuneate base, the more numerous lateral nerves (5–8 pairs), and the larger fig with long pedicel. Both species may, nevertheless, be relics, much diminished in stature, of the bistaminate ancestors of sect. *Kalosyce* as would link it with ser. *Distichae* and ser. *Trichocarpeae.* The indurate gall-ovary of both species recalls that of *F. hederacea* Roxb. in ser. *Distichae.* Female flowers and seeds are still unknown in both *F. diandra* and *F. warburgii.*



Text-Fig. 6. *F. diandra* Corner; leaves × ½; fig, × 2; fig-apex, × 4; male and gall-flowers, × 10.

subgen. Ficus sect. Sycocarpus Miq.

Corner, Gard. Bull. Sing. 18 (1960) 37.

The numerous species of this section are the most difficult to classify. The discovery of two new and demonstrative species, *F. moderata* and *F. virescens,* on Kinabalu raises the hope that others will be found equally elucidating. *F. virescens* emphasizes the importance of geographical distribution in a section of recent evolution, as seems to be the state in *Sycocarpus;* its allies *F. treubii* King, *F. francisci* Winkler, and *F. cereicarpa* Corner are

also endemic in Borneo. On this note I take the opportunity to revise the classification of *F. oligodon* Miq. (*F. pomifera* Wall. ex King).

subsect. **Papuasyce** Corner subsect. nov.—Semina 1.2–1.5 mm. longa, lentiformia, subcompressa, vix carinata, hilo non prominenti. Perianthium rubrum saccatum, ovaria feminea et cecidiophora albida obtegens. Stamina 2 (–1), libera. Receptacula pedunculata, basi tribracteata, bracteis lateralibus nullis; setis internis nullis; cellulis scleroticis in pariete receptaculi nullis v. paucis. Folia plus minus coriacea integra spiraliter disposita. Cystolitha hypogena. New Guinea, *F. itoana* Diels (typus), *F. microdictya* Diels.

In my earlier paper, cited above, I instituted subsect. *Pomifera* Corner, with *F. oligogon* as type, to include also *F. itoana, F. microdictya,* and *F. griffithii* Miq. In the meantime I have learnt from J. T. Wiebes, at the Rijksmuseum v. Natuurlijke Historie in Leiden, who is studying the fig-insects that I have managed to collect, that the fig-insects of *F. oligodon* agree with those of *F. auriculata* Lour. in sect. *Neomorphe* King, whereas those of *F. itoana* and *F. microdictya* agree with the fig-insects of sect. *Sycocarpus* subsect. *Auriculisperma* Corner (Solomon Isl.) and subsect. *Dammaropsis* (New Guinea). This confirms the botanical evidence. *F. oligodon* has very much the same distribution on the Asiatic mainland as *F. auriculata,* but *F. oligodon* extends down into the Malay peninsula as far as the south of Selangor and Pahang. Here it has the typical form which, in floral detail, agrees exactly with sect. *Sycocarpus,* particularly with *F. itoana.* In Burma, Indochina, and Thailand, however, it intergrades with *F. auriculata* in leaf-shape, hairiness, and the critical construction of the perianth, which is saccate and entirely covering the ovary in *F. oligodon,* and composed of three short separate tepals in *F. auriculata.* The fact is that, in this prime respect in the classification of the genus, the one species belongs in sect. *Sycocarpus* and the other in sect. *Neomorphe;* the allies of the first are with it on the Asiatic mainland, while its false allies are in New Guinea with their relatives.

The first reaction might be to join sect. *Neomorphe* with sect. *Sycocarpus,* but this would be neither useful nor beneficial. *Sycocarpus* hangs together in enormous complexity in eastern Malaysia and its origin is not to be sought in modern *Neomorphe.* The alternative, which I assume, is that *F. oligodon* represents a parallel in floral evolution to *Sycocarpus.* Confirmation lies in *F. variegata* Bl. var. *chlorocarpa* King (sect. *Neomorphe*) which in south China has also developed the saccate perianth covering the ovary and is in fact so similar to *F. oligodon* that it is generally necessary to examine the flowers in order to distinguish herbarium-material. *F. rivularis* Merr. (Philippines) of sect. *Ficus* is another peculiar species convergent in this way on *Sycocarpus.*

Accordingly, I reduce subsect. *Pomiferae* Corner and ser. *Pamiferae* Corner to sect. *Neomorphe* ser. *Auriculatae* Corner. I erect

subsect. *Papuasyce* for the two New Guinea species, and another subsect. *Leptotus* (below) for the aberrant *F. griffithii*. Nevertheless, *F. oligodon* must still be keyed out in sect. *Sycocarpus;* its exclusion from subsect. *Papuasyce* scarcely alters the definition. Parallel evolution is rife in *Ficus,* but this is the most perplexing case. Entomology has come to the rescue.

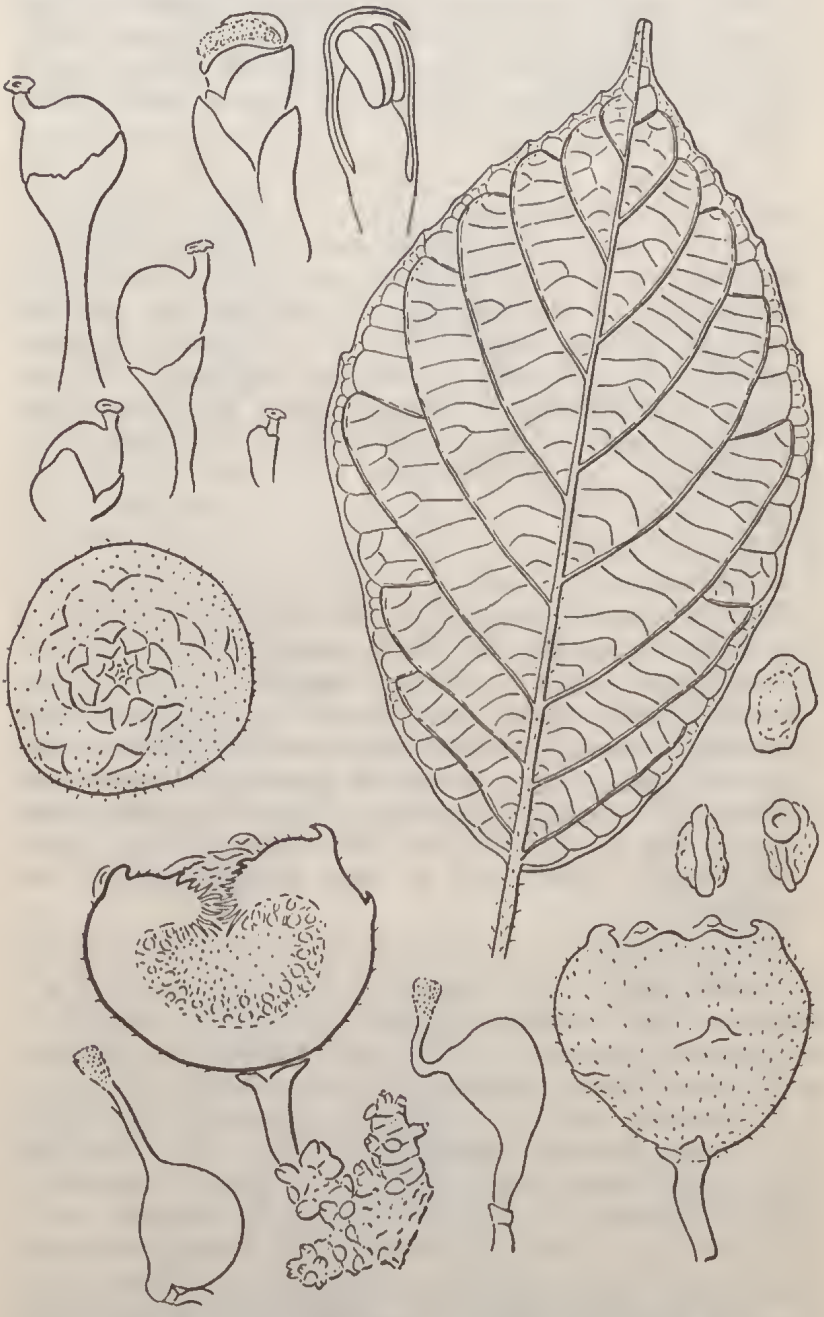
subsect. **Lepidotus** Corner subsect. nov.—ser. *Lepidotae* Corner Gard. Bull. 18 (1960) 39.—Semina 1 mm. longa, lentiformia, subcarinata, hilo non prominenti. Perianthium rubrum saccatum, ovaria feminea et cecidiophora obtegens. Stamen 1. Receptacula bracteis lateralibus praedita; setis internis et cellulis scleroticis nullis. Folia membranacea spiraliter disposita. Cystolitha hypogena. Burma, Thailand, *F. griffithii* Miq.

subgen. Ficus sect. Sycocarpus Miq. ser. Tuberculifasciculatae Sata subser. Hispidae Corner

F. moderata Corner sp. nov. (Text-Fig. 7)—Arbor –9 m. alta, sparsim ramosa, cauliflora; foliis spiraliter instructis, interdum oppositis. Ramuli et petioli pilis patentibus pallidis v. brunneolis –1.5 mm. longis tenue vestiti; nervi subtus puberuli, glabrescentes. Ramuli 3–4 mm. crassi, fistulosi. Stipulae –15 mm. longae, caducae, lanceolatae, glabrae v. basim versus pilosae. Lamina 8–21 × 4.5–11 cm., elliptica v. obovata, subacuminata, apice obtuso subcaudato –15 mm. longo, basi late cuneato v. anguste subcordato, saepe leniter asymmetrico, integra v. apicem versus dentata, laevis, tenue subcoriacea, sicco brunnea; costis lateralibus utrinsecus 6–8, obliquis; intercostis 4–11, regulariter instructis, subtus elevatis; costis basalibus utrinsecus 2, brevibus, raro ad 1/3 laminae extensis; petiolo 9–25 mm. longo, glandula subnodali praedito. Receptacula ad ramulos ramosos cauliflores –5 cm. longos dense aggregata, maturitate flava, primo brunneolo-pilosa; pedunculo 4–14 mm. longo; bracteis basalibus 2–3 mm. longis, ovatis subacutis; pedicello nullo; corpore receptaculi 15–23 mm. lato (20–30 mm., vivo), subturbinato, bracteis lateralibus ovatis apicibus incurvatis 1–3, 2–3 mm. longis, ad parietem affixis, circum ostiolum 5–8 mm. latum bracteis numerosis occlusum lateralibus pluribus insertis; setis internis nullis; cellulis scleroticis ut lamina angusta in pariete receptaculi. Flores masculi ordinibus duobus instructi; stamen 1. Flores cecidiophori sessiles v. pedicellati; perianthio saccato ovarium primo includenti dein disrupto. Flores feminei sessiles v. breviter pedicellati; perianthio ut collare brevissimo; stylo glabro v. setis 1–2 praedito. Semina 1 mm. longa, carinata, hilo prominenti, obscure subtuberculata v. gibbosa. Cystolitha hypogena. RSNB 2592, in silvis secundariis pr. Kundasan 1,200 m. alt., North Borneo, (typus, herb. Kew); RSNB 2594 (recept. cecidioph.).

This has the leaves of *F. congesta* Roxb. and the yellow figs with lateral bracts of *F. hispida* Linn. f. In bridging, therefore,

the two subseries Congestae and Hispidae it is another example of the importance of the region of Kinabalu to the study of *Ficus*. *F. hispida* is known merely from two collections in Borneo, one in West Koetai, the other without local detail, and I have not seen it myself in Sarawak, Brunei, or North Borneo. *F. congesta* has no certain record from Borneo.



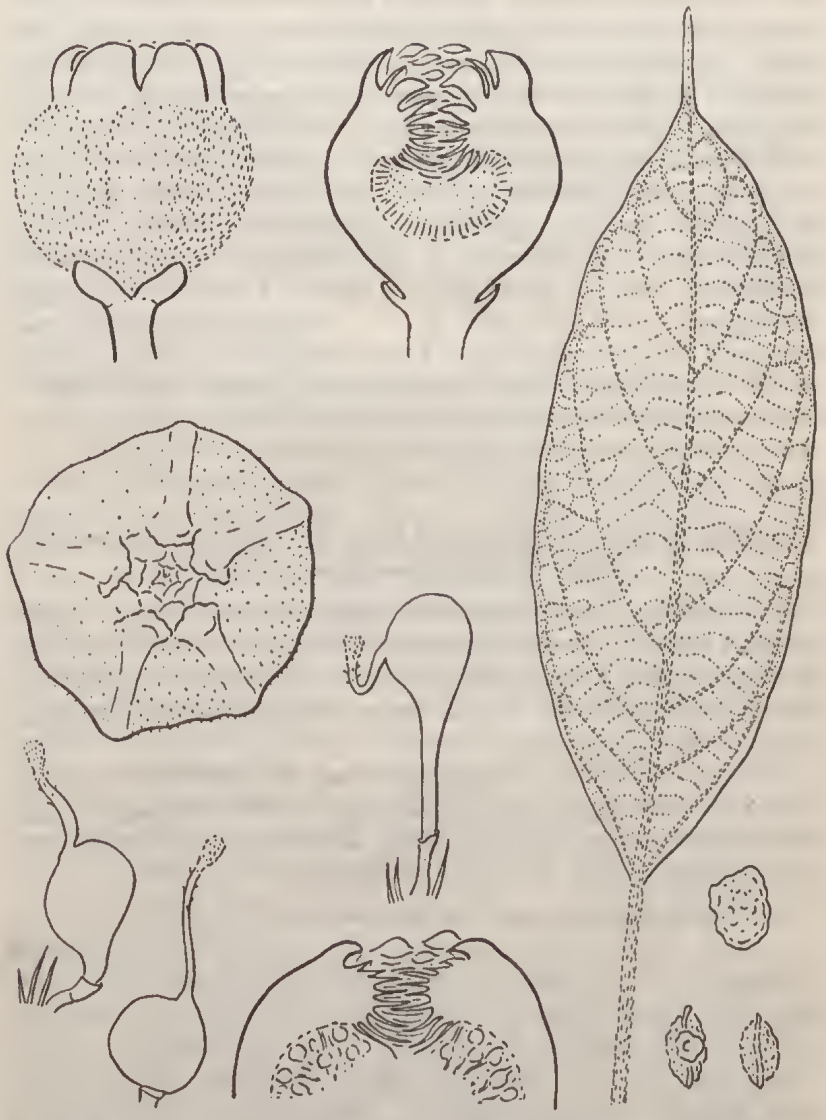
Text-Fig. 7. *F. moderata* Corner; leaf, × ½; figs, × 1; flowers and seeds, × 10. (RSNB 2592, 2594).

subgen. Ficus sect. Sycocarpus Miq. ser. Tuberculifasciculatae Sata subser. Fulvidulae Corner

F. virescens Corner sp. nov. (Text-Fig. 8)—Arbor –13 m. alta cauliflora. Folia spiraliter instructa v. opposita. Ramuli, petioli, stipulae, costae subtus, et receptacula juvenilia pilis fulvidulis appressis 0.5 mm. longis vestiti; lamina superne glabra. Ramuli 2–4 mm. crassi, lente glabrescentes, fistulosi. Stipulae –15 mm. longae, caducae. Lamina 12–30 × 4–12 cm., anguste elliptica, ad apicem acuminatum abrupte caudatum 12–30 mm. longum angustata, basi cuneato symmetrico, integra v. subdenticulata, tenue subcoriacea, superne laevis, subtus subscabrida, in sicco superne grisea, subtus cinereo-viridis et valde punticulata; costis lateralibus utrinsecus 5–7, subtus acute elevatis; intercostis –11, vix elevatis, confertis; costis basalibus utrinsecus 1 brevibus; petiolo 15–70 mm. longo, glandula subnodali praedito. Receptacula ad ramulos efoliatos caulifloros sine internodis elongatis –30 cm. longos, basi 1–3 cm. crassos, aggregata, maturitate flavo-brunnea, glabrescentia; pedunculo 5–22 mm. longo, glabro; bracteis basalibus 3, ternata, 2.5–4 mm. longis, glabris; corpore receptaculi 14–15 mm. lato (20–22 mm., vivo), subellipsoidea, bracteis lateralibus nullis, apicem versus 5–6-costato, ostiolo inter 5–6 bracteis apicalibus umbonatis immerso, ostiolo in statu juvenili bracteis numerosis parvis in disco –10 mm. lata praedito et bracteis 5–6 erectis marginalibus circumdato; setis internis copiosis 0.5 mm. longis; cellulis scleroticis in pariete receptaculi nullis. Flores masculi ordine uno instructi, stamine uno. Flores cecidiophori juveniles perianthio saccato ovarium tegenti. Flores feminei sessiles v. breviter pedicellati; perianthio ut collare angusto stipitem ovarii complectanti; stylo puberulo. Semina 1 mm. longa, hilo prominenti, reticulato-subtuberculata. Cystolitha hypogena. RSNB 965, in silva prope rivulum 900 m. alt., Kinabalu (east ridge), 25.vii.61, (typus, herb. Kew.); RSNB 2543, pr. flum. Liwagu 1,200 m. alt., 29.viii.61.

This species resembles *F. treubii* King in so many respects that, confronted with it in the herbarium, one might regard it as a sapling state with radial arrangement of the leaves on stouter twigs and incipient geocarpy. Having studied two living and full-grown trees, I realise that it is distinct in both the radial construction and in the cauliflory, and this conclusion is confirmed by such details as the longer peduncle, larger basal and apical bracts, larger fig-body, shorter female perianth, and less hairy style. It elucidates, in fact, the peculiarity of *F. treubii* among the geocarpic figs of Borneo in subser. Geocarpicae because it represents the ancestral state with the more massive spiral construction and relates thereby *F. treubii* with subser. Fulvidulae, of which *F. cereicarpa* Corner and *F. francisci* Winkl. are also endemic in Borneo.

The peculiarities of *F. treubii* are the absence of conspicuous lateral bracts, the distinct peduncle and collar of basal bracts, the abundant internal bristles, the oblique lateral nerves, and the greenness of the dried leaf; these are the characters which ally it with *F. virescens*. In both the sides of the seed are conspicuously roughened whereas in the three other species of subser. Fulvidulae they are nearly or quite smooth. This is a detail the importance of which is not clear. In view of the close correspondence in other respects and of the striking series of cauliflorous forms from large multibracteate figs of *F. cereicarpa* to the small figs of *F. virescens*



Text-Fig. 8. *F. virescens* Corner; leaf, × ½; figs (the upper two immature), × 2; female flowers and seeds, × 10. (RSNB 965).

and the geocarpy of *F. truebii* with distichous leaves, I remove *F. treubii* from subser. Geocarpicae, where I had tentatively placed it, to subser. Fulvidulae.

F. virescens also resembles *F. schwarzii* Koord. (*F. miquelii* auct.) and *F. scortechinii* King. They are both advanced species with slender distichous construction of the twigs, as in *F. treubii*. The mature fig of *F. virescens* is very similar to that of *F. scortechinii*, while the young fig resembles that of *F. schwarzii*. The ribbing of the fig-body towards the prominent peripheral apical bracts in *F. virescens* and *F. scortechinii* indicates the incorporation of the lateral bracts in the apical rosette; thus, this feature, the significance of which had not been clear to me, marks the change-over from the fig with lateral bracts to that without, and places *F. virescens* in this respect between *F. cereicarpa* and *F. treubii*. The same feature appears in the geocarpic *F. ternatana* Miq. and *F. pleyteana* Corner, also of distichous habit with short, pale brown, appressed hairs as in *F. treubii*. They both differ, however, in the abundant sclerotic cells in the fig-wall, as well as in the brown colour of dried leaves, and they are species of eastern Malaysia from the Moluccas to New Guinea; they are probably convergent with *F. treubii*, as the eastern *F. arfakensis* King is convergent in the subseries of *F. congesta*. *F. schwarzii* may belong to this subseries, where I have classified it, but the position of *F. scortechinii* needs further investigation, particularly in Borneo where the new variety v. *lanceata* here described suggests that its more generalised form may yet exist.

subgen. Ficus sect. Sycocarpus Miq. ser. Tuberculifasciculatae Sata subser. Geocarpicae Corner

F. megaleia Corner Gard. Bull. Sing. 18 (1960) 57. var. **multinervia** Corner v. nov.—Ad omnes partes pili –1 mm. longi fulvi dense appressi. Costae laterales utrinsecus 14–24; basales 4–6 plus 9–11. RSNB 970, in locis terrae delapsae, 900 m. alt., Kinabalu, 25.vii.61 (typus herb. Kew.).

This is probably a wide-spread variety on Kinabalu; it was collected several times without number by the Clemens, but the lamina is too large for the making of convenient specimens. The hanging pink young leaves are conspicuous.

var. **subuncinata** Corner var. nov.—Ramuli et petioli pilis fulvis 1–2 mm. longis curvato-ascendentibus vestiti. Costae laterales utrinsecus 7–9; basales 3–4 plus 6–7. Receptacula sicca 10–12 mm. lata, semper glabra. RSNB 1576, in locis terrae delapsae, 1,500 m. alt., Kinabalu (east ridge), 31.vii.61, (typus herb. Kew.).

Six trees, to 3 m. high, were found. They had the large leaves with strongly, and asymmetrically, cordate base as in *F. megaleia* but the glabrous figs of *F. uncinata*, of which they would pass in the herbarium as v. *pilosior*.

F. uncinata Becc. var. **subbeccarii** Corner v. nov.—Ramuli, petioli et costa (subtus) pilis appressis fulvis v. fusco-brunneis 0.5–1 mm. longis vestiti; subtus nervulis pallidis minoribus. Stipulae 10–20 mm. longae, persistentes, lanceolatae. Lamina 10–30 × 4.5–10.5 cm., obovata, apice –15 mm. longa acuminata, basi anguste asymmetrico, uno latere anguste cuneato, altero cuneato-subcordato, integra, superne pilis sparsis appressis scabrida; costis lateralibus utrinsecus 4–7; intercostis –8, subtus elevatis, regulariter instructis; basalibus 2 plus 4. Receptacula sicca 14–20 mm. lata, hispido-strigosa. Semina 0.6 mm. lata. RSNB 1619, ad ripem flum. Mamut, 1,200 m. alt., 4.viii.61, (typus, herb. Kew.); RSNB 2541, ad ripem flum. Liwagu, 1,200 m. alt., 29.viii.61.

F. beccarii differs from the varieties of *F. uncinata* with hairy figs, such as var. *strigosa*, only in the characters of the leaf, particularly its smooth upperside and symmetric base. I have studied a great many plants of both in the forest and seen no intermediate until I met with these two plants on Kinabalu; they have the almost symmetric leaf of *F. beccarii* but the scabrid and appressedly hairy upperside of *F. uncinata*. Hasty collecting of these startling, but awkward, geocarpic species gives the impression of a few distinct species; actually they are all extremely variable and in need of much further field-study.

subgen. Ficus sect. Sycocarpus Miq. ser. Tuberculifasciculatae Sata subser. Tuberculifasciculatae

F. scortechinii King var. **lanceata** Corner var. nov.—Arbor –3 m. alta. Internodi et nervi in juventute pilis pallidis, plus minus appressis, –0.5 mm. longis, sparsim vestiti, glabrescentes aliter glabra. Folia opposita vel spiraliter instructa, dein subdisticha. Lamina 6–20 × 1.6–4 cm., lanceolata, attenuato-acuta, basi cuneato, apicem versus serrulata v. integra; costis lateralibus utrinsecus 6–10; petiolo 5–10 mm. longo. Receptacula ad ramulos paniculato-ramosos –8 cm. longos, 4–6 mm. latos, basi 10 mm., in cumulis caulifloris –15 cm. latis affixa, maturitate rubrocarnea; pedunculo 10–20 mm. longo; bracteis basalibus 0.5–1 mm. longo; corpore receptaculi 7–9 mm. lato (11–13 × 10–12 mm., vivo), saepe irregulariter tuberculato, ad apicem subdepressum valde costato; setis internis et cellulis sclerotieis nullis. Perianthium femineum ut collare brevissimum; stylo puberulo v. subglabro. RSNB 2815, in silva, 1,500 m. alt., Kinabalu pr. Tenompok, 6.ix.61, (typus herb. Kew.).

If I had not carefully collected this, I should have taken it to be a mixture of the leaves of *F. tarennifolia* and the figs of *F. scortechinii*. It is less hairy than *F. scortechinii*, the figs being glabrous from the first. Because of the characteristic ribbing of the figs and of the manner in which they are borne, I refer the collection to *F. scortechinii*, even though this species of Burma, Thailand, and Malaya has not been found in Borneo. The warts, commonly present on the figs, do not seem to be caused by insects.

INDEX

New Taxa and Names in **Bold-faced** Type.